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Foreword

Seeds have been considered as a high value low volume product. Seeds alone contribute 20-25% crop productivity. Government of Nepal has formulated Seed Act, Seed Regulation, National Seed Policy and Seed Vision (2013-25) for creating enabling environment for seed production and marketing. National Seed Policy has assumed assurance of quality production and supply, export promotion and import substitution. Efforts made in the past is not sufficient to meet the in-country demand of seeds especially of horticultural crops: potato, vegetable and spice crops. Realizing this situation, 15th National Horticulture Seminar was held on 10-11 Mangsir 2081 (25-26 November, 2024) at Warm Temperate Horticulture Center, Kirtipur, Kathmandu with the theme of ***"Strengthening Seed Sector of Potato, Vegetable and Spice Crops"***. The seminar was organized by Nepal Horticulture Society, Lalitpur in collaboration with National Centre of Potato, Vegetables, and Spices Crop Development (NCPVSCD), Kirtipur and National Centre of Fruit Development (NCFD), Kirtipur. The Nepal Horticulture Society feels very proud to publish the proceedings with the financial support of NCPVSCD, Kirtipur. The proceeding has altogether 45 papers covering keynote speeches, strategic and scientific areas and cross-cutting issues of seed sector of potato, vegetable and spice crops. Recommendation has been made on policy and strategic level, program/implementation level and cross-cutting issues.

To bring this proceeding in this shape, Editorial Committee along with the officials of the NCPVSC, Kirtipur worked very hard. I sincerely express my gratitude and thanks to the respected secretary of Ministry of Agriculture and Livestock Development Dr. Govinda Prasad Sharma for his good wishes messages for the success of the seminar and sincere thanks to the editorial team and NCPVSC team for untiring and commendable works they performed. I also express my sincere thanks to the organizing committee and different sub-committees for their hard work commitments for the success of the seminar and publication of this proceedings. I also acknowledge and appreciate the keynote speakers and authors of different papers for their valuable contribution. The institutions and individuals who supported the seminar and publication of the proceedings are highly acknowledged.

I hope this proceeding will be very useful to horticulture researcher, planners, development workers, private seed entrepreneurs, students and many others who are involved in vegetable seed sector of potato, vegetable and spice crops and also it contributes a lot in the promotional and developmental activities of seed sector of potato, vegetable and spice crop.

Thank You

Gopal Prasad Shrestha
President
Nepal Horticulture Society

Editorial

Strengthening the seed sector of potato, vegetables, and spice crops is essential for enhancing agricultural productivity, ensuring food security, and promoting economic growth in Nepal. Quality seeds are the cornerstone of successful crop production, directly influencing yield, disease resistance, and adaptability to diverse agro-ecological conditions. The National Seed Vision 2013–2025 underscores the need for a holistic and pragmatic approach to develop Nepal’s seed system, focusing on variety development, seed multiplication, processing, marketing, and quality control to achieve self-sufficiency and reduce dependency on imports.

Investments in seed infrastructure, skilled human resources, and public-private partnerships are critical to scaling up seed production and improving seed replacement rates, particularly for vegetables where the target is over 90 percent replacement. Strengthening institutional capacity and regulatory frameworks will ensure the availability of genetically pure, high-quality seeds to farmers, thereby increasing crop yields and farmers’ income. Furthermore, fostering collaboration between national research bodies and private seed companies, along with international partnerships, can accelerate the development and dissemination of improved seed varieties tailored to Nepal’s diverse agro-climatic zones.

Ultimately, a robust seed sector for potato, vegetables, and spices will not only boost domestic production but also position Nepal as a competitive seed production hub in South Asia, opening avenues for export and regional cooperation. This strategic focus aligns with Nepal’s broader agricultural development goals, aiming to transform the seed sector into a sustainable, resilient, and inclusive system that supports farmers and contributes to national food security and economic prosperity.

The facts, figures, subject matters as well as the opinion expressed in the papers are purely of the respective author(s) and the Editorial Committee has nothing to do in it except that it did general editing works to bring it to an orderly shape. The institutions and individuals who supported the publication work of the proceedings are highly acknowledged and the Committee hopes for their continued cooperation and help in the future too.

The Editorial Committee

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Seminar Synopsis

The 15th National Horticulture Seminar, 2024

Background

Good seed in good field yields abundance

“सुबिजम् सुक्षेत्रे: जायते सम्पद्यते:”

Seed is the only viable input in agriculture and horticulture as well. In potatoes, if quality seed potato is used, about 2 metric tons of yields per hectare can be increased and Nepal becomes self-sufficient in potato. In overall vegetable production, seed plays a very important role and same is the case with spices. To review the present seed production and distribution system in Nepal and set future strategies and programs in the seed sector of potato, vegetable and spice crops, the present seminar was organized jointly by Nepal Horticulture Society (NHS), National Center for Potato, Vegetable and Spice Crops Development (NCPVSCD) and National Center for Fruit Development (NCFD).

The horticultural sector in Nepal has high prospect for addressing the insufficiencies of food security, nutrition and entrepreneurship development in the country. Among horticultural crops, vegetable, potato and spice crops are high-value crops commodity in Nepal. Vegetable crop production solely depends on the various kinds of hybrid varieties (HV) and open-pollinated varieties (OPV) of vegetable seeds qualitatively and quantitatively. Both HV and OPV of vegetable seeds have economic viability and market potential. There is huge diversity among native vegetable landraces/genotypes indicating wider market potentialities.

In this context, Nepal Horticulture Society in collaboration with National Center for Potato, Vegetable and Spice Crops Development and National Center for Fruit Development jointly organized 15th National Horticulture Seminar on "Strengthening Seed Sector of Potato, Vegetable and Spice Crops" dated from 10-11 Mangsir 2081 (25-26 November 2024) at Warm Temperate Horticulture Center (WTHC), Kirtipur in Kathmandu.

Aim of the Seminar

This seminar aims to bring together policymakers, external development partners, farmers, vegetable seed producers, academicians, researchers, scientists, government officials, INGOs, NGOs, journalists, and private sectors to exchange information, experiences and research results on all aspects of specialized and interdisciplinary areas of climate change, biodiversity, varietal potentiality, production and marketing system in the seed (Potato, Vegetable and Spice crops) sector. The seminar provides an opportunity for everyone to network, exchange ideas and present their research, latest innovations, achievements, trends, practical problems and challenges. This information will be useful to formulate policy, plan, program and projects for viable and appropriate adaptation options.

Theme of the Seminar

Strengthening Seed Sector of Potato, Vegetable and Spice Crops

Composition of Different Committees

To commemorate the seminar in an elegant manner the following different committees had been formed to cooperate and coordinate with each other to execute the activities of the seminar gracefully:

Program Schedule

Date: 25-26th November 2024 [10-11 Mangsir, 2081]

Venue: Seminar Hall of Warm Temperate Horticulture Center, Kirtipur, Kathmandu

Session	Time	Activity	Responsible Person
Day 1 [25th Nov. 2024]		Master of Ceremony	Ms. Yam Kumari Shrestha

Session		Time	Activity	Responsible Person
Registration and Breakfast		08:00-09:00	Registration on NHS and NCPVSCD Counter and take breakfast - All Participants	Ms. Shova Sharma Ms. Tara Sharma Ms. Sapna Khapung Mr. Padam Aidi Ms. Nanu Thapa Ms. Pratibha Aryal Ms. Heera Phuyal
Inaugural Session	Formal Start	09:00-09:30	Chairperson	Mr. Gopal Prasad Shrestha President, NHS
			Taking Seats	Chief Guest: Mr. Ramnath Adhikari, Hon'ble Minister, MoALD Special Guest: Dr. Jay Bahadur Tandon, Hon'ble Member (Agriculture Sector), NPC Special Guest: Dr. Govinda Prasad Sharma, Secretary (Agriculture Development), MoALD Special Guest: Dr. Rajendra Prasad Mishra, Secretary (Livestock Development), MoALD Special Guest: Dr. Doj Raj Khanal, Executive Director, NARC Special Guest: Prof. Dr. Kishor Chandra Dahal, Dean, IAAS/TU Special Guest: Prof. Dr. Arjun Kumar Shrestha, Dean, AFU Special Guest: Mr. Shiva Sundar Shrestha, President, NAF Guests: Joint Secretaries, DG, DDGs, Institutions' Chiefs, Horticulturists, Farmers, Agri-Entrepreneurs, Students, Scientists and all Participants
			Bouquet, Badge, Garland	Chief Guest and Special Guests
			National Anthem	All Participants
			Welcome Address and Program Information	Ms. Januka Pandit, Chief, NCPVSCD
			Inauguration	Hon'ble Minister, MoALD
	Thematic Papers	09:30-09:50	Prospects, Progress and Challenges of Vegetable Seed Crops in Nepal	Mr. Indra Raj Pandey, Immediate Past President, NHS
		09:50-10:10	Prospects and Challenges of Spice Seed Crops in Nepal	Mr. Mohan Bahadur Thapa, Past President, NHS
		10:10-10:30	Status and Way Forward on Potato and Tuber Crops Seeds in Nepal	Ms. Januka Pandit, Chief, NCPVSCD
		10:10-10:45	Seed Management and its Impact on Processing for the Potato Industry	Mr. Shyam Prasad Dhakal, Potato Crop Specialist, FCFPL
	Award Distribution	10:45-11:15	I. Gauri Rani-Shiva Nepali Pradhan Excellence Award in Horticulture Education (M.Sc. Ag.)	Hon'ble Minister, MoALD
			II. Madan Rai Best Organic Grower of the Year Award	Hon'ble Minister, MoALD

Session		Time	Activity	Responsible Person
			III. Anant Bahadur Shrestha Best Apple Grower of the Year Award Across Himalayas Districts	Hon'ble Minister, MoALD
			IV. Best Vegetable Seed Producer of the Year Award	Hon'ble Minister, MoALD
	Letter of Appreciation	11:15-11:55	Honor to the experts for their contribution to the horticulture sector of the country	Hon'ble Minister, MoALD
	Speeches	11:55-12:10	Few Words	Farmers
		12:10-12:15	Remarks	Mr. Shiva Sundar Shrestha, President, NAF
		12:15-12:25	Remarks	Dr. Govinda Prasad Sharma Secretary, MoALD
		12:25-12:35	Remarks	Hon'ble Member, NPC
		12:35-12:55	Special Speech for Guidance	Chief Guest, MoALD
		12:55-13:05	Vote of Thanks and Closing Remarks	Chairperson
Break		13:05-14:00	LUNCH	All Participants
			Master of Ceremony	Ms. Reeti Singh, SHDO, NCPVSCD
Second Session	Thematic Paper		Chairperson	Mr. Bhairab Raj Kaini, Former Joint Secretary, MoALD
		14:00-14:10	Present Seed (PVSCs) Production and Distribution System and Future Perspective in Nepal	NCPVSCD
		14:10-14:20	Present Status of Vegetable and Spice Seed Research, Varietal Development and Future Perspective in Nepal	NHRC/NARC
		14:20-14:30	Present Status of Seed Potato Research, Varietal Development and Future Perspective in Nepal	NPRP/NARC
		14:30-14:40	Vegetable Seed Policy, Legislation, Seed Vision and Varietal Status in Present Context	SQCC
		14:40-14:50	Discussion on Thematic Papers	All Participants
		14:50-14:55	Closing Remarks	Chair Person

Day 1 (25 November 2024): Presentation of Strategic Papers

Session III (Strategic Papers: Central Farm/ Centers): Parallel Session (Seminar Hall, WTHC, Kirtipur)

Session		Time	Activity	Responsible Person
Third Session	Central Farm Level Strategic Paper		Master of Ceremony	Dr. Ranjana Rawal, Scientist, NARC
			Chairperson	Mr. Mohan Bahadur Thapa, Past President, NHS

Session		Time	Activity	Responsible Person
		15:00-15:10	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Cardamom Development Center, Fikkal, Ilam
		15:10-15:20	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Potato Crop Development Center, Nigale, Sindhupalchowk
		15:20-15:30	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Vegetable Crops Development Center, Khumaltar, Lalitpur
		15:30-15:40	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Vegetable Seed Production Center, Rukum
		15:40-15:50	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Tropical Horticulture Center, Nawalpur, Sarlahi
		15:50-16:00	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Citrus Fruit Development Center, Tansen, Palpa
		16:00-16:10	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Temperate Horticulture Center, Marpha, Mustang
		16:10-16:20	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Center, Jaubari, Ilam
		16:20-16:30	Discussion and tea	All Participants
		16:30-16:35	Closing Remarks	Chair Person

Session IV (Strategic Papers: Province Level): Parallel Session (Seminar Hall, NCFD, Kirtipur)

Session		Time	Activity	Responsible Person
Fourth Session	Province Level Strategic Paper		Master of Ceremony	Ms. Ranju Maharjan, HDO, DoA
			Chairperson	Mr. Rajendra Koirala, DDG, DoA
		15:00-15:10	Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province	Koshi Province, MoLMAC/ADD
		15:10-15:20	Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province	Madhesh Province, MoLMAC/ADD
		15:20-15:30	Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province	Bagmati Province, MoLMAC/ADD
		15:30-15:40	Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province	Gandaki Province, MoLMAC/ADD
		15:40-15:50	Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province	Lumbini Province, MoLMAC/ADD

Session		Time	Activity	Responsible Person
		15:50-16:00	Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province	Karnali Province, MoLMAC/ADD
		16:00-16:10	Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province	Sudurpashchim Province, MoLMAC/ADD
		16:10-16:20	Discussion and tea	All Participants
		16:20-16:25	Closing Remarks	Chair Person

Day 2 (26 November 2024): Presentation of Strategic Papers

Session I (Strategic Papers: Provincial Farm/ Centers): Parallel Session (Seminar Hall, NCFD, Kirtipur)

Session		Time	Activity	Responsible Person
First Session	Provincial Farm Level Strategic Paper	08:00-08:30	Registration and Breakfast	All Participants
			Master of Ceremony	Mr. Dinesh Prasad Sapkota, SHDO, PMAMP
			Chairperson	Mr. Kaushal Kumar Poudel, Former General Secretary, NHS
		08:30-08:40	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Center, Phaplu, Solukhumbu
		08:40-08:50	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Tropical Horticulture Nursery Development Center, Janakpur
		08:50-09:00	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Center, Panchkhal, Kavrepalanchok
		09:00-09:10	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Center, Sindhuli
		09:10-09:20	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Center, Trishuli, Nuwakot
		09:20-09:30	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Center, Daman, Makawanpur
		09:30-09:40	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Center, Boanch, Dolkha
		09:40-09:50	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Development Center, Juphal, Dolpa
		09:50-10:00	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Development Center, Darma, Humla
		10:00-10:10	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	Horticulture Development Center, Dadeldhura
		10:10-10:20	Discussion and tea	All Participants
		10:20-10:25	Closing Remarks	Chair Person

Session II (Strategic Papers: Project and Private Level): Parallel Session (Seminar Hall, WTHC, Kirtipur)

Session		Time	Activity	Responsible Person
Second Session	Project and Private Level Strategic Paper	08:00-08:30	Registration and Breakfast	All Participants
			Master of Ceremony	Mr. Bikash Kharel, HDO, NCPVSCD
			Chairperson	Ms. Sabnam Shivakoti, Joint Secretary, MoALD
		08:30-08:40	Current Status and Programs of Seed (Potato, Vegetable and Spice Crops)	PMAMP, Khumaltar, Kathmandu
		08:40-08:50	Current Status and Programs of Seed	ASDP, Birendranagar, Surkhet
		08:50-09:00	Current Status and Programs of Seed	REED, Harihar Bhawan, Lalitpur
		09:00-09:10	Current Status and Programs of Seed	FANSEP, Harihar Bhawan, Lalitpur
		09:10-09:20	Potential Vegetable Crops for Hybrid Seed Production and its Strategies	Mr. Damodar Poudel, SEAN
		09:20-09:30	Vegetable Seed Production and Maintenance	Mr. Keshab Pandey, Live Seeds, Kavre
		09:30-09:40	Vegetable Seed Production and Maintenance	Cooperative, Surkhet
		09:40-09:50	Discussion and tea	All Participants
		09:50-10:00	Closing Remarks	Chair Person

Day 2 (26 November 2024): Presentation of Technical Papers

Session III (Technical Papers: Potato, Vegetable and Spice Seeds): Parallel Session (Seminar Hall, WTHC, Kirtipur)

Session		Time	Activity	Responsible Person
Third Session	Scientific/ Technical Paper		Master of Ceremony	Mr. Toya Nath Joshi, PPO, NCPVSCD
			Chairperson	Prof. Dr. Kishor Chandra Dahal, Dean, IAAS/TU
		10:05-10:15	Horticulture in Vedic Civilization: A perspective on Vegetable Seed Conservation	Mr. Basu Dev Kaphle Programme Coordinator, ASDP, Surkhet
		10:15-10:25	Hybrid Seed Production Technology of Tomato	Dr. Surendra Lal Shrestha, NHS
		10:25-10:35	Hybrid Seed Production Technology of Cucumber	NHRC/ NARC
		10:35-10:45	Seed Production Technology of Pre-basic Seed (PBS) Potato and True Potato Seed (TPS)	Mr. Bijay Giri, Potato Crop Development Center, Nigale, Sindhupalchowk
		10:45-10:55	Vegetable Seed Genetic Resources, Conservation and Challenges	Dr. Bal Krishna Joshi, NAGRC/ NARC
		10:55-11:05	Propagation, Diversification and Value Chain Issues in Root and Tuber Seeds	Mr. Sanjay Dhimal, NHS
		11:05-11:15	Diseases Management of Vegetable Seed Crops	Dr. Shrinkhala Manandhar, NARC

Session		Time	Activity	Responsible Person
		11:15-11:25	Insect pests Management of Vegetable Seed Crops	Dr. Kashi Nath Chiluwal, NARC
		11:25-11:35	Soil Management of Vegetable Seeds	Dr. Shree Prasad Vista, NARC
		11:35-11:45	Tissue Culture Production of Cardamom Seed/ seedlings	Agriculture Research Center, Pakhribas, Dhankuta
		11:45-12:00	Discussion on Scientific Papers	All Participants
		12:00-12:05	Closing Remarks	Chair Person
Break		12:05-13:00	LUNCH	All Participants

Session IV (Technical Papers: Cross cutting Issues of Seeds): Parallel Session (Seminar Hall, NCFD, Kirtipur)

Session		Time	Activity	Responsible Person
Fourth Session	Technical/ Cross Cutting Issues		Master of Ceremony	Mr. Puruswattam Bahadur Rauniyar, AEO, NCPVSCD
			Chairperson	Dr. Tika Ram Chapagain Chief, NHRC/NARC
		10:30-10:40	Emerging Pestilence of Solanum fruit fly (<i>Bactrocera latifrons</i>): A Pest to Akbare Chili Production in Nepal	Dr. Debraj Adhikari, PQPMC, Lalitpur
		10:40-10:50	Cardamom seeds related paper	TCP/ FAO
		10:50-11:00	Vegetable Seed related thesis paper	TU
		11:00-11:10	Vegetable Seed related thesis paper	AFU
		11:10-11:20	Akabare Chili and Srijana Tomato Hybrid Seed Production Technology and Conservation of Seeds	Mr. Rudra Bahadur Bisankhe, Jorsallah Cooperatives, Kavre
		11:20-11:30	Vegetable Seed Production under Precision and Protected Environment	Dr. Arun Kafle, Project Director, FANSEP, Lalitpur
		11:30-11:40	Online Application Platform for Farmer to Demand Agricultural Program: A Case of Kavre District of Nepal	Mr. Sujan Amgai, Chief, BDC, Bhandara, Chitwan
		11:40-11:50	Biotechnology Practices in Vegetable Seed Crops	Dr. Deepa Singh Shrestha, NAGRC/ NARC
		11:50-12:00	Post-harvest Management in Vegetable Seed Crops	Mr. Saroj Adhikari, HRS, Malepatan, Pokhara
		12:00-12:10	Effect of Potassium Levels on Growth, Yield and Quality of Potato	Mr. Bijay Giri, Potato Crop Development Center, Nigale, Sindhupalchowk
		12:10-12:20	Discussion on Technical Papers	All Participants
		12:20-12:25	Closing Remarks	Chair Person
Break		12:25-13:00	LUNCH	All Participants

Session V (Poster Presentation and Evaluation: Seminar Hall, WTHC, Kirtipur)

Session		Time	Activity	Responsible Person
Fifth Session	Poster Session		Coordinators	Dr. Ramita Manandhar, NHS Dr. Puspa Raj Poudel, IAAS Mr. Ganapati Pandey, NHS
		13:00-14:30	Poster Presentation, Observation and Evaluation	All Participants

Session VI (Closing Session: Seminar Hall, WTHC, Kirtipur)

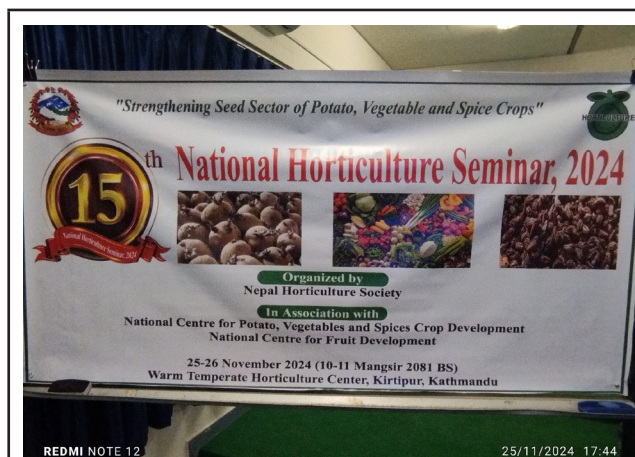
Session		Time	Activity	Responsible Person
Closing Session	Closing Ceremony		Master of Ceremony	Ms. Shobha Sharma
		14:30-14:35	Chairperson	Ms. Januka Pandit Chief, NCPVSCD
			Taking Seats: Chief Guest, Special Guests and Guests	Chief Guest: Dr. Govinda Prasad Sharma, Secretary (Agriculture Dev.), MoALD Special Guest: Dr. Rajendra Prasad Mishra, Secretary (Livestock Dev.), MoALD Special Guest: Dr. Doj Raj Khanal, Executive Director, NARC Special Guest: Prof. Dr. Kishor Chandra Dahal, Dean, IAAS/ TU Special Guest: Prof. Dr. Arjun Kumar Shrestha, Dean, AFU Guests: Joint Secretaries, DG, DDGs, Institutions' Chiefs, Horticulturists, Farmers, Agri-Entrepreneurs, Students, Scientists and all Participants
		14:35-14:45	Welcome and Summary of Seminar	NCPVSCD
		14:45-15:00	Award Distribution to the Posters	Chief Guest
		15:00-15:10	Speech from the Special Guest	ED, NARC
		15:10-15:20	Speech from the Chief Guest	Secretary, MoALD
		15:20-15:25	Vote of Thanks	Mr. Mahesh Chandra Acharya, Chief, NCFD
		15:25-15:30	Closing Remarks	Chair Person
AGM of NHS		15:30 pm Onwards 21st Annual General Meeting of Nepal Horticulture Society followed by Farewell Dinner		

Seminar Highlights

Day One: 10th Mangsir 2081 (25th November 2024)

The 15th National Horticulture Seminar commenced on 10th Mangsir 2081 for two days in the Warm Temperate Horticulture Center, Kirtipur, Kathmandu with the theme of "Strengthening Seed Sector of Potato, Vegetable and Spice Crops". The chief guest, Honorable Agriculture Minister Mr. Ramnath Adhikari, Ministry of Agriculture and Livestock Development (MoALD) inaugurated the seminar. The chairperson of the opening session was Mr. Gopal Prasad Shrestha, President of Nepal Horticulture Society (NHS). Among the special guests were Dr. Govinda Prasad Sharma, Secretary, MoALD, Dr. Doj Raj Khanal, Executive Director, Nepal Agriculture Research Council, Er. Jagannath Tiwari, Director General, Department of Agriculture and Prof. Dr. Kishor Chandra Dahal, Dean,

IAAS/TU. The chief guest inaugurated the conference by watering the plant and presented certificates and prizes to the Best Vegetable Seed Grower of the Year-2081 Award (Ms. Gopa Budha Magar, Chaurjahari-10, Rukum West), Dr. Ananta Bahadur Shrestha Award in the Best Apple Grower of the Year-2081 (Neeraj Tulachan, Thasang-01, Mustang) and Subhadra-Madan Rai Award in the Best Organic Vegetable Grower of the Year-2081 (Mr. Deu Bahadur Tamang, Panchpokhari Thangpal-03, Sindhupalchok). Also he awarded two topper students with the Gauri Rani-Shiva Nepali Pradhan Excellence Award in Horticulture Education (MSc. Ag)-2081 for the year 2079/80 (Ms. Nisma Dhakal, IAAS/T.U., Kathmandu and Ms. Shreeti Udas, AFU, Chitwan). On this occasion ten veteran horticulture experts were honored as well for their contribution to the development of horticulture sector of the country.



15th National Horticulture Seminar commenced on 10th Mangsir, 2081



Chief Guest Hon. Minister, MoALD, Mr. Ramnath Adhikari addressing the seminar



Chief guest, special guest, guest and chairperson taking seat in the seminar



Participants on the Inaugural Session of the 15th National Horticulture Seminar

Ms. Januka Pandit, Chief of the National Center for Potato, Vegetable and Spice Crops Development welcomed the chief guest, special guests, guests and all participants. After that she presented the Keynote speech on Potato and Tuber Seed Crops. Likewise, Keynote speeches on Vegetable Seed Crops was given by Vegetable Expert Mr. Indra Raj Pandey, another Keynote speech on Spice Seed Crops were given by Spice Crops Expert Mr. Mohan Bahadur Thapa and the fourth Keynote speech on Potato Processing Industry was given by Potato Crop Specialist Mr. Shyam Prasad Dhakal. After the inaugural address of honorable minister and secretary of the MoALD, Mr. Gopal Prasad Shrestha, president and chairperson of the inaugural session with his closing remarks declared the end of the inaugural session. The master of ceremony was facilitated by Ms. Yam Kumari Shrestha, SFDO, NCFD.

The inaugural ceremony was witnessed by 225 participants including students from Tribhuvan University, Institute of Agriculture and Animal Science, Agriculture and Forestry University and delegates and representatives from different agriculture institutions and was followed by thematic paper presentation sessions entitled "Strengthening Seed Sector of Potato, Vegetable and Spice Crops".



Chief Guest Hon'ble Minister, MoALD presenting the Best Vegetable Seed Grower Award of the year 2081



Chief Guest Hon'ble Minister, MoALD presenting the Best Organic Grower Award of the year 2081



Chief Guest presenting the MSc. Ag. (Horticulture) Topper Student Excellence Award of the year 2081



Chief Guest Hon'ble Minister, MoALD honored the veteran horticulture expert Mr. IR Pandey of NHS



Chief Guest Hon'ble Minister, MoALD honored the veteran horticulture expert Mr. MK Rai of NHS



Group Photo with the awardee and honored horticulture experts in the 15th NHS-2081

Thematic Paper Session

There were four thematic papers presented in this session. The first paper covered present seed (potato, vegetable and spice crops) production and distribution system and future perspective in Nepal, the second one regarding vegetable and spice seed research and varietal development, the third one seed potato research and varietal development and the fourth one about the vegetable seed policy, legislation, seed vision and varietal status in the country were presented. Thematic session was facilitated by a chairperson and each paper was assisted by one rapporteur. There were 200 participants in the thematic session which was followed by strategic paper session.



Dr. Januka Pandit, Chief, NCPVSCD, presenting the thematic paper



Special Guest Dr. Govinda Prasad Sharma, Secretary, MoALD addressing the seminar

Strategic Paper Session

There were two strategic paper sessions where seven Central farm level strategic papers regarding Current Status and Programs of Seed (Potato, Vegetable and Spice Crops) in the farm/centers and four Province level strategic papers in Status, Strategy, Policy and Programs of Seed from the province were presented. Each strategic paper session was facilitated by a chairperson and each paper was assisted by one rapporteur. There were about 150 participants in the technical session.

Day Two: 11th Mangsir 2081 (26th November 2024)

Provincial Strategic Paper Session

Day two was started with the provincial strategic paper session. There were seven provincial farm level strategic papers regarding vegetable seed status in the farms and four project and private level strategic papers regarding program of seed crops implemented in the command areas were presented. Each session was facilitated by a chairperson and each paper was assisted by one rapporteur. The strategic session was followed by technical paper session.

Technical Session

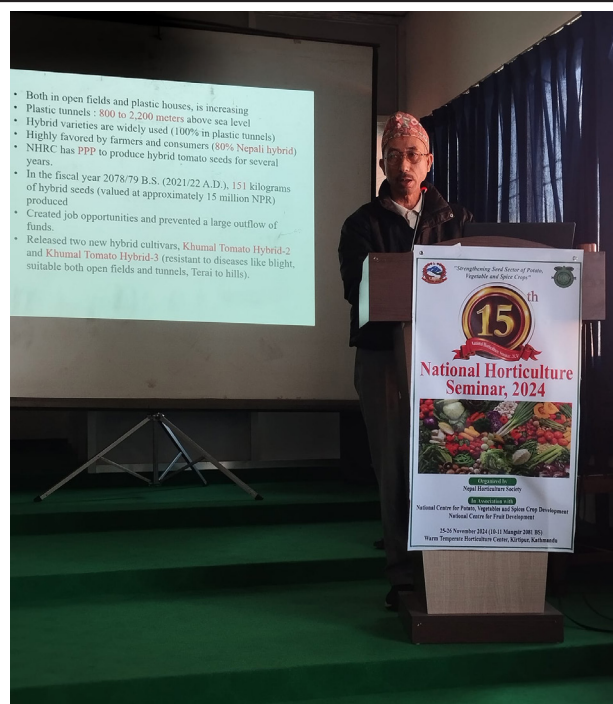
There were altogether 45 paper presenters in total and they presented technical papers in their respective fields. Each technical session was facilitated by a chairperson and each paper was assisted by one rapporteur. The technical session was followed by group discussion and interaction on the paper presented in the technical sessions for preparing a way forward document that would serve as a guidelines document for the strengthening seed sector of potato, vegetable and spice crops in the future. There were 186 participants in the technical session.



Mr. Basu Dev Kaphle, Programme Coordinator, ASDP, Surkhet presenting a paper on A perspective on Vegetable Seed Conservation in Vedic Civilization



Dr. Bal Krishna Joshi of NAGRC/ NARC presenting his paper on Vegetable Seed Genetic Resources, Conservation and Challenges



Dr. Surendra Lal Shrestha of NHS presenting a paper on Hybrid Seed Production Technology of Tomato



Mr. Sujan Subedi from National Horticulture Research Center presenting a paper on hybrid cucumber seed production

Closing Session

The session was chaired by the chief of NCPVSCD Ms. Januka Pandit and the chief guest was Dr. Govinda Prasad Sharma, the secretary of MoALD. In this session the summary of seminar was presented with the recommendations. After the closing address of the chief guest Dr. Govinda Prasad Sharma, secretary of MoALD, Ms. Januka Pandit ended the session and wrapped up the 2-days seminar with her closing remarks. There were altogether 200 participants in the closing session.



Technical Panels in the Technical paper presentation on the 2nd day of the 15th NHS, 2081



Participants at the closing ceremony of the 15th National Horticulture Seminar, 2081



Closing ceremony addressing by the Chief Guest Dr. Govinda Prasad Sharma, Secretary, MoALD



Mr. Gopal Prasad Shrestha, President, NHS ending the session with closing remarks

Consequential of the Seminar

- Germplasms conservation of vegetables
- Separate institution needed for research and development of spice crops
- Promotion program for increasing productivity of potato
- Potato Day celebration (May 30)
- Revision of Procurement Act for buying quality seed
- Prepare a yearly source seed balance sheet and repair broken link among breeder, foundation and improved seed
- Master plan for seed sector development
- Collaboration for germplasms exchange
- Expedite variety registration process and promote PPP for private sector led variety registration
- Development of potato variety suitable for processing.
- Strengthening farm infrastructure

- Accelerate varietal registration and seed certification process
- Assurance of breeder seed
- Seed and saplings production plan according to farmers' demand
- Central level farm should have a mandate for floriculture development
- Strong linkage between central and local level government
- Human resource development in province and local level farm/centers
- Formulation of policies regarding vegetable seed sector development
- Priorities vegetable seed production program
- Strategic action plan needed for development of center of excellence
- Export promotion of Cardamom and ginger
- Budget allocation for research and development (RandD) promotion of existing hybrid varieties
- Support private sector for RandD
- Need strong collaboration with central government
- Capacity development of human resources
- Availability of quality seed
- Implement certification system of produced seed
- Emphasize mass production of seeds as per the demand
- Awareness and capacity building should be focused for seed production and management
- Internal quarantine protocol should be implemented strictly
- Degeneration of TPS seed quality
- Protecting land races with geographical indication tag and farmers right
- Production of quality planting materials in root and tuber crops
- Survey and surveillance for insect pest management
- Location specific research on protected horticulture
- Cardamom sapling production support through TCP
- Future research of fruit fly in Akbare variety of chili
- Increase in extension coverage as a result of digitalization

Prospect, Progress and Challenges of Vegetable Seed Crops in Nepal

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Nepal Horticulture Society

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Abstract

Nepal is situated in the temperate region in the southern alp of high Himalayas. Nepal has diverse agro-climatic conditions with four distinct seasons (spring, rainy, autumn and winter) and has five agro-ecology and physiographic regions (High Himalaya, High Mountain, Middle Mountain, Siwalik and Terai). Except Terai other regions have four aspects, which makes at least 30 major agro-climatic zones that favours the seed production of all kinds of vegetable. Nepal has vast number of vegetables biodiversity adopted in different agro-ecology. Monsoon rain from Arabian sea and Bay of Bengal and winter rain from Mediterranean Sea and presence of many rivers, rivulet, lakes, ponds and wetlands makes feasible water managements. Combined with micro-climates and vegetable species and varieties there is huge prospect of seed production to attend self-sufficiency and export on demanded quantity and quality to neighbouring counties and could contribute to reduce trade imbalance. All major food crops grown in the world can be grown in Nepal including vast number of vegetables. Geo-physical settings, agro-ecological variations and vegetable bio-diversities provide vivid prospects for vegetable seed production in Nepal with comparative advantages.

Despite the suitable climate, comparative advantages with long history of vegetable seed, development, the growth of domestic vegetable seed industry has remained slow after 1990, due to policy constrains and organizational anomalies. The research and development work on vegetable and vegetable seed is inadequate and extension program is not effective during recent years. There are different challenges and gaps to propel such huge prospect and to realize the benefit of vegetable seed sector. Governments, donors and development partners are interested in fresh vegetable production; however, they do not give priorities to Nepali Seed but promotes use of imported hybrids. Despite increasing area and production of fresh vegetable during the past three decades, Nepali market largely relies on imports to fulfil national demand of vegetable seed. This paper suggests rectifying the distorted scenario with the reformation of organization and policy with the proactive initiation of the Ministry of Agriculture and Livestock Development.

Keywords: Agro-Biodiversity, Challenges, Prospects, Reformation, Vegetable-seeds

Introduction and Physical Settings of Nepal

Geo-physical settings, agro-ecological comparative advantages and vegetable bio-diversities provides vivid prospects for vegetable seed production in Nepal. However, organizational anomalies, weak policies, strategies and programs are hindering to realize benefit from vegetable seed sector as the main challenges. Nepal is situated in the southern aLp of high Himalayas in Asia at South Asia region. The country is almost rectangular in shape and is enclosed between 26° 22" to 30° 27" North latitude and 80° 4" to 88° 12" East longitude.

Nepal is surrounded by India on three sides and China's Tibet Autonomous Region to the north. Nepal measures about 800 kilometres from east to west along its Himalayan axis and varies by 150 to 250 kilometres north south across. Nepal has an area of 147,181 square kilometres with the land area of 92.94 % and 7.06 % water areas and 30.91% is under cultivation. Nepal's land altitude varies from 60 m from sea level to 8848.86 m the top of the world, Mount Everest. Nepal has five physiographic regions from vegetable seed production point of view, which are briefly described in the subsequent subsections:

1. Himalayan region

This region lies along north east to west with 8848.86 m Mount Everest (Sagarmatha) including trans-Himalayan region with Alpine climate, often semi-arid valleys of Humla, Jumla, Dolpa, Mustang, Manang and Khumbu. The cultivable altitude ranges from 2500 m to 4500 m which resembles with Tibetan plateau with dry and cool valleys. The average daily temperature during winter (December /January) fluctuates between (minus) -9° C to 10° C. Summer temperature varies from 10° to 21° C which favour for specific temperate vegetable seed production.

This area provides special comparative advantage for seed production of vegetables like, cauliflower snowball groups, cabbage, carrot, broad leaf mustard (Marpha), radish (Tokinasi) and many other temperate vegetables for lower altitude areas of Nepal and export to India, Bangladesh and even to gulf countries.

2. High mountain region

The elevation ranging between 2000 to 2500 m is mostly the top of Mahabharata range. The average temperature during summer varies from 10-15 °C and it goes beyond -0 °C during winter and snow fall and snow cover is common. Seed production of low chiling varieties of cabbage, cauliflower, carrot, radish, broad leaf mustard, etc. can be grown to achieve self-sufficiency in many vegetable crops.

3. Middle mountain region

Hills are extended across east to west elevation ranging between 600 to 2000 meters. The summer temperature ranges between 20 ° to 35 °C with hot and warm weather. Winter temperature ranges between 0 ° at higher altitude to 15 °C at lower altitude and generally cool and warm. Seed production of majority of sub-tropical varieties of vegetables are possible. This region has the highest comparative advantage for domestic market and export oriented commercial vegetable seed production to other parts of Nepal and to export to neighbouring counties such as India and Bangladesh.

4. Siwalik region

Siwalik regions varies from 300-600m is a highland region between the Mahabharata and Chure mountain ranges in Nepal. The Siwalik hills extend in a narrow east-west belt, only 15–20 km in width, which marks the northern boundary of the plains of Terai and the southern boundary of middle-hill Mountains. Though day temperature resembles with Terai, however, night temperature is cooler than Tarai that favours for cultivation and seed production of vivid crops. Siwalik is the prime source of sediments for the plain of Terai. Torrents flowing down the steep gradients erode material from the fragile rock and transport it downstream. The streams slow down as they flow onto the plain, and in consequence they deposit their burden of silt, thereby filling or clogging the streambeds and raising their levels. This aggravates flooding problems is prominent in the plains. Siwalik is subject to severe erosion that creates gullies and promotes landslides. Line spacing is not uniform.

5. Terai, Inner terai and low river basins

The elevation of Terai, inner terai and low river basin areas varies from 60 to 600 meter. The elevation of terai plain varies from 60-300 meter and inner tarai and river basins and large tars, and plain lands varies between 300 to 600 meters. All these areas have high summer temperature ranging between 30° - 41°C and winter average temperature ranging between 15° to 20°C with minimum between 5° to 10°C. Cold wave and foggy days make trembling cold in some parts of Terai sometimes during winter. These areas are suitable for seed production of vegetables such as tomato, eggplant, and sweet pepper, many cucurbitaceous vegetables such as cucumber, many other gourds, peas, beans okra etc.

Nepal has four distinct seasons (spring, rainy, autumn and winter), four aspects of High Mountain, Middle Mountain and Siwalik (East, West, North and South) providing at least 30 micro-climatic zones with agro biodiversity. Nepal receives monsoon rain during summer from Arabian Sea and Bay of Bengal and winter rain from Mediterranean Sea. There are three main production seasons like dry season (mid Feb. to mid-June): rainy season (mid-June to mid Oct): and winter season (mid Oct. to mid Feb). (Rohwerder, 2016.) Many rivers, rivulets, lakes, ponds and wetlands provides vast water management feasibility. In all these ecological zones varied ethnicity with different but coexisting groups of people live in national harmony with eco-cultural interdependent synergy and with ethnobotanical wisdom for food and livelihood. Almost all types of world climate are available in Nepal and a wide range of indigenous crops and livestock co-exist for foods and livelihood. This offers comparative advantages and opportunities to Nepal.

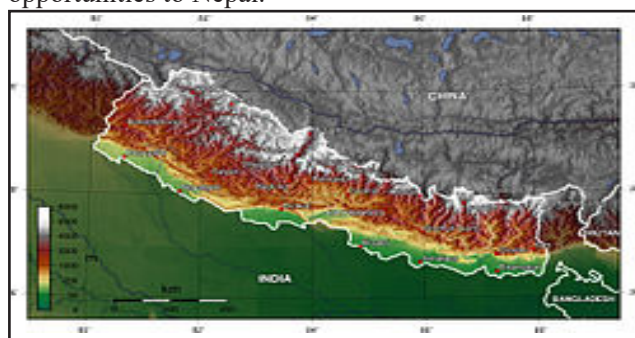


Figure 1: Physical map of Nepal

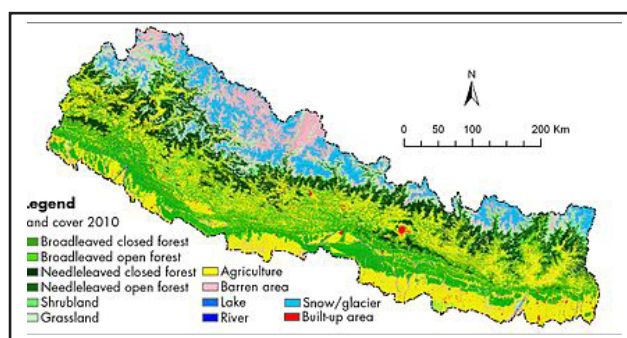


Figure 2: Physiographic settings (HMG/Nepal, 1983)

Vegetable Biodiversity of Nepal

In Nepal a wide range of vegetable biodiversity exist with food plants of 172 families, 296 genera, 599 species and 35 sub-species. Out of 599 species of food plants 400 species belong to horticultural groups of which 200 species are vegetable crops (Regmi, PP 1982). Among 200 species of vegetables, around 50 species were in cultivation during eighties (Pandey, 1995). The recent listing of vegetable species in use have increased to 133 with 57 leafy, 14 stem, 36 fruit, 11 legumes and 15 root and tubers (Pandey I.R and Prahalad Thapa, 2017). The cultivation of these vegetables is omnipresent in different parts of Nepal in different seasons and agro-ecological zones. Many species are maintained and used by people as local land races and their seeds are locally selected, produced and preserved.

1. Vegetables domesticated from wild relatives

Nicoli Ivanovich Vavilov (1936) reported that out of eight Centers of plant origin, five centers are around Nepal and probably the crops may have also originated from Nepal.

Center of Origin	Major species found (Examples only)
Chinese center of origin	<i>Brassica rapa</i> , <i>Cucumis sativus</i> , <i>Cucurbita moschata</i> , <i>Phaseolus vulgaris</i> , <i>Raphanus sativus</i> , <i>Solanum melongena</i>
Ind-Burmese center of origin	<i>Dioscorea alata</i> , <i>Lactuca sativa</i> , <i>Luffa acutangula</i> , <i>Momordica charantia</i> , <i>Solanum melongena</i> , <i>Trigonella foenum</i> , <i>Trichosanthes anguina</i>
Central Asian Center of origin	<i>Allium cepa</i> , <i>Allium sativum</i> , <i>Daucus carota</i> , <i>Coriandrum sativum</i> , <i>Pisum sativum</i> , <i>Raphanus sativus</i> , <i>Vicia faba</i> ,
Asia minor center	<i>Beta vulgaris</i> , <i>Pisum sativum</i> , <i>Cucurbita pepo</i> ,
Mediterranean Center of origin	<i>Beta vulgaris</i> , <i>Brassica oleracea</i> , var. <i>capitata</i> , <i>Pisum sativum</i> , <i>Allium cepa</i> , <i>Allium sativum</i>

2. Wild species of vegetable crops recorded in Nepal

36 species of 11 kinds of vegetables domesticated from wild relatives (Colocasia 3 species, Amaranths 4 species, Chenopodium 2 species, Pisum 3 species, Allium 3 species, Ipomea 5 species, Dioscorea 4 species, Mentha 3 species, Trigonella 3 species, Solanum 2 species, Curcuma 5 species) Still there are 26 wild relatives of 9 families to be recorded and as per gene bank there are many mores.

3. The prospects of vegetable seed crops

The agro-climatic boons and vegetable biodiversity if combined and harnessed properly, seed production of vast number of vegetables are possible. High value and highly nutritious vegetables are the most favoured crops. Hence, vegetables are specific agricultural/horticultural commodities, and their promotion could significantly drive rural economic growth and to contribute to food and nutritional security. There is huge prospect of seed production and export of such crops on demand and quality basis to neighbouring countries and trade imbalance could be reduced to minimal. Seed as low volume and high value crops joint venture with foreign seed companies and export to abroad is also possible.

The agricultural sector and food security are important dimensions of Vedic economics. 'Krishi Mulashcha: Jeevanam' (agriculture is the root of life), "Uttam Kheti, Madhyam Byapar, Nicha Nokari (supreme farming, mediocre trade, lowly the civil service)", "Ghokanti Vidhya Dhawanti Kheti" (learning by memorizing, farming by tending) are popular proverbs that characterize the Vedic wisdoms of adorable agricultural and learning values. All the agriculture related activities and functions are described in Veda, under different Kanda, shukta Richa/Mantra and all the procedure from sowing to harvest with good seed in good field as, "सुबिजम् सुक्षेत्रे: जायते सम्पद्यते:" (Good seed in good field yields abundance) such Vedic Richas are in Veda.

Review of Vegetable Sector Development and Progress

1. Vegetables in ancient Nepal

Nepal has Arya-Mongol civilization with multi-culture and vivid ethnicities. The culture, civilization and history of Nepal has been influenced by its position in the aLp of Himalayas. Comfortable climate is bestowed by nature Nepal has been inhabited by Rishis and noble people since the beginning of civilization. During ancient time cow herders (Gopal Bansi) who came to Nepal valley (present Kathmandu) from the Ganges Plain of modern-day India and sheep herders from Tibet and inhabited in northern Nepal. It is now a multi-ethnic, multi-cultural, multi-religious and multi-lingual country and the people in common are Nepali. Gopal Bansi, Mahisapalaka, Lichchhavi, Kirats, Thakuris, Malla and Shaha ruled Nepal since ages (History of Nepal Wikipedia 2015). Nepal's physiographic

and agro-ecological setting, due to altitudinal variation and multi-sphere facings favours for different ethno-bio diversities. In the later part of the civilization in addition to native people the Indo-Aryans from south and Mongols from north also came to Nepal and settled in different altitudes suitable to their climatic requirements. Thus, whosoever came to this part of the earth also brought plant materials including vegetables. Thus, domestication and cultivation of different vegetables as integral part of civilization and agricultural system goes back to the Vedic era and continued to scatter in local states and royal units. Whatsoever local states and royal units existed, subsistence agriculture was the means of livelihood, and they preserved seeds of crop plants and vegetables.

The British Empire in India and unification of Nepal in 18th century by Prithvi Narayan Shah impacted on vegetable diversities in Nepal. Modernization of agriculture in India started during Mughal regime and it flourished during British regime, and it impacted in Nepal as well. Unofficial entrance of some seeds of vegetables to Nepal through pilgrimage and ex-army returnees from India and world wars also enriched vegetable diversities in Nepal. However, the recorded reports of some exotic vegetable introduction and cultivation in the manorial gardens of Rana (the then *de-facto* rulers of Nepal) could be traced back to mid-19th century when Nepal's Rana Prime Minister Mr. Jung Bahadur Rana and his dignitaries received the European vegetable seeds as gift during his visit to the United Kingdom and Europe during B.S 1907 (1850). Such vegetables were cultivated in Rana's gardens, however, with permission and grace of Ranas slowly these vegetable seeds leached out to the local farmers of Kathmandu valley through the gardeners of Rana Palaces and the cultivation of temperate vegetables such as cauliflower, cabbage, turnip etc. became popular in Kathmandu valley. Along with these crops indigenous vegetables like broad leaf mustard, (Rayo), Pyuthane radish, Pumpkin, Gourds, Colocasia, Yam, Cowpeas, Beans, were cultivated for family use and for the sale in local markets of Kathmandu (Swastika Development Consultant, 1994) since long. Individual farmers saved seed by selection and continued vegetable diversities in ancient Nepal.

2. History of vegetable research and extension in Nepal

After Jung Bahadur Rana, Chandra Samsher (JBR)¹ contributed establishing Agricultural Council as the first government entity for agricultural development including vegetable in B.S 1978 (1921) Demonstration farm established in Singh durbar during B.S 1994 (1937). During 1997 (1940) agricultural farms/nurseries established in Tahachal and Balaju and testing of some exotic and indigenous vegetables started in these farms. Seeds of different vegetables such as tomatoes and cabbage were produced. At present Tahachal is used for some other purposes and Balaju Nursery converted to modern Park. Government opened vegetable seed store during 1998 (1942) in New Road near Taleju temple to sell seeds to general farmers. During B.S.2004 (1948) first agricultural farm outside Kathmandu valley in Parwanipur/ Bara was established where vegetable research for tropical region was one of the important initiatives.

Rana regime ended on February 1951 and new democratic era started in Nepal. The Agriculture Council established in 1937 was converted to the Department of Agriculture in B.S 2010 (1952) with Horticulture Section within it to look after the development of fruits, vegetables and flowers. During B.S 2010 (1952) Horticulture Section established two plant introduction units (1) Putali Bagaicha Singh Durbar and (2) Plant Introduction Unit Godavari to introduce exotic vegetables and fruits and study their adaptability. During the same year the first Horticultural Farm was established in Kakani to study fruits, vegetables and flowers. United States Overseas Mission in 1952 and Mountaineering Troops from Japan in 1953 had been the two principle formal sources to import exotic vegetable varieties. Japanese Mountaineering Troop gifted some vegetable seeds of Radish, carrot, turnip etc. to the government and Radish White Neck was commercialized in and around Kakani areas of Nepal. During 2049 this strategic farm was handed over to another Ministry.

Nepal started planned development from B.S 2013 (1955/56) when the first five-year plan was implemented with high priority to agriculture for better and efficient use of resources. During first five-year plan period from 1952 to 1956, studies and trials conducted by horticultural section recommended some new vegetable varieties for general cultivation and seeds were made available to common people from seed store at Basantpur, New Road Kathmandu. During B.S 2010 (1952) Tribhuvan Gram Vikas was conceptualized and with the first five-year plan Tribhuvan Gram Vikas was implemented since B.S 2014 to 2017. During this period several horticulture farms were established in different ecological belts of Nepal. "Tribhuvan Gram Bikash (Tribhuvan Rural Development)" with block development approach and Block Development Officers (BDOs) and Gram Sewak and Gram Sevika (Village Development Workers) were posted in village level for rural awareness and community development. This was an integrated community development model including agriculture, health and sanitation, adult education, home science. This program introduced different vegetables in rural Nepal with people's participation. Youth clubs, 4-H clubs, cottage industries were the components of this program. During second five-year plan (1962/63-1964/65), government opened different agriculture/horticulture farms /stations in the different agro-ecological zones of Nepal.

During second plan period horticulture units were opened in agriculture farm/stations of Terai. New horticulture farms were opened in Daman/Makawanpur, Dhunibeshi/Dhading and Baitadi with the help of Indian Cooperation Mission (ICM). Near to these farms/stations, vegetable productions were demonstrated and extended. Mainly home gardening was emphasized which slowly developed to produce vegetable for the local markets and haat bazar. In Terai agriculture farms were established in Nepalgunj, Bhairahawa, Janakpur, and Terahara. In the hills horticultural farm/stations were established in Dhankuta, Kirtipur/Kathmandu, Trishuli/Nuwakot, Pokhara/Kaski and Bhagetada/Doti. These farm/ stations were mandated to test, multiply and sale /distribute the horticultural planting materials (fruit saplings and vegetables seeds). By the end of this plan total horticultural farm stations reached 14. District Agriculture Development Offices (DADOs) were established for agriculture extension and development. The programs of horticulture in the farm/ stations were controlled by horticulture section of (DoA). All these farm centers were responsible for vegetable research, seed production and distributed through extension network and sale directly from farm gate. Farm/centers and DADOs promoted vegetable production for home consumption and local sale. From B.S 2018 to 2023 fruits, vegetable, flowers were under the horticulture section of the Department of Agriculture.

The Department of Agriculture was reorganized in B.S 2023 (1966/67) forming five different departments (Department of Agriculture Education and Research, Department of Agriculture Extension, Department of Livestock Development, Department of Horticulture and Department of Fisheries). Department of Horticulture was housed in Kirtipur with two major sections viz. Fruit Development Section and Vegetable Development Section. Kirtipur was the main center of research and development for fruits, vegetables, potato and flower. Horticulture farms of different agro-eco-zones were under the Department of Horticulture (DoH). Vegetable research, seed production and seed sale used to be done by these horticultural farms, and some seeds were sold from Basantpur seed store as well. District Agriculture Development Offices (DADO) also purchased vegetable seed from horticulture farm stations and Basantapur Seed Store for demonstration in the farmer's field.

3. Planned growth of vegetable seed sector in Nepal

During B.S. 2023 to 2029 Department of Horticulture established several horticulture farm/stations with the following four major objectives:

- Collection, evaluation and selection from indigenous land races and exotic germplasm to develop vegetable varieties suitable to different agro-ecological zones and seasons.
- Generation of improved and appropriate production technology, plant protection and seed production techniques for developed new improved varieties
- Market oriented fresh vegetable production demonstration in accessible areas and;
- Seed production demonstration in the remote areas where fresh vegetable marketing was difficult.

During B.S 2029 (1972) five different departments were merged to one Department of Agriculture establishing four national programs e.g. (1) Fruit Development Section, (2) Vegetable Development Section, (3) National Citrus Development Program and (4) National Potato Development Program with establishment of additional farms e.g. Horticulture farm Panchkhal and Tropical Horticulture Farm Sarlahi, Nabalpur. To strengthen vegetable research and seed production Vegetable Research and Seed Production Center Khumaltar (2030/31), Vegetable Seed Production Center Rukum (2035/36) and Vegetable Seed Production Center Dadeldhura (2038/39) were established. To strengthen vegetable research and seed production program, eight major centers for vegetable research and farmer's field vegetable seed production zones were identified and adopted. Vegetable Seed Production Center Khumaltar, Horticulture Farm Sarlahi, Horticulture Farm Panchkhal, Agriculture Station Dhankuta, Horticulture Farm Mustang and Dolpa, Vegetable Seed Production Center Rukum and Dadeldhura were identified as the eight major centers for research and development. In addition, British aided Agriculture Center Lumle and Pakhribas were also added in the research and seed production. First Agriculture year was celebrated during B.S. 2032. From this year, farmers field contract seed production of major vegetable varieties was started under the technical guidance of these Farm/centers in Bhaktapur, Nuwakot, Sarlahi, Dhankuta, Tehrathum, Bhojpur, Mustang, Dolpa, Rukum /Salyan and Dadeldhura and in the target areas of Lumle and Pakhribas. Agriculture Input Corporation (AIC) was given the responsibility of vegetable seed marketing from B.S 2032. Seed buying contract used to be done by AIC and foundation/source seed supply and field supervision by VDD, designated farm centers seed testing labs and respective DADOs. The eight farm/centers recognized as centers of excellence for vegetable research, variety development, maintenance and breeders and foundation seed production are presented in Table 1.

Table 1: Farm/Centres selected for vegetable research and variety development

S.N.	Name of Center	Altitude (masl)	Micro-climate	Priority crops for research/seed production
1	Horticulture Farm Dhankuta	1200-1400	High rainfall, high humidity and warm winter	Radish, Mid-season cauliflower, Broad Leaf Mustard, Pea, Cress, Spinach etc.,
2	Horticulture Farm Sarlahi	200	High rainfall, high humidity, hot summer, mild winter	Early cauliflower, radish, all solanaceous and cucurbitaceous crops, beans, cowpeas
3	Vegetable Seed production Center Khumaltar	1350	High rainfall, high humidity, frosty winter, warm spring through summer	Radish, Cauliflower, Broad Leaf Mustard, Beans, Swiss Chard, cress, spinach, turnip, tomato, eggplant, onion, Chili, Capsicum
4	Horticulture Farm Panchkhal	865	High rainfall, high humidity, hot summer, foggy winter	Bean, Rajma bean, Bitter gourd, Cucumber, Squash, Eggplant, Tomato
5	Horticulture Farm Mustang	2522	Low rainfall, snow in winter, low humidity, mild summer	Late cauliflower, Cabbage, Carrot, Broad leaf Mustard (Marpha), Late Radish
6	Horticulture Farm Dolpa	2242	Low rainfall, snow in winter, low humidity, mild summer	Late cauliflower, Cabbage, Carrot, Broad leaf Mustard (Marpha), Late Radish
7	Vegetable Seed Production center Rukum	1440-1500	Mild rainfall, high humidity, chilly winter, warm summer	Radish, Mid-Season Cauliflower, Broad Leaf Mustard, Beans, Cress, Spinach, Turnip, Tomato, Eggplant, Sweet pepper, Onion, Peas, Carrot, Squash
8	Vegetable Seed Production Center Dadeldhura	1400	Mild rainfall, high humidity, warm summer, chilly winter	Radish, Mid-Season Cauliflower, Broad Leaf Mustard, Beans, Cress, Spinach, Turnip, Tomato, Eggplant, Sweet Pepper, Onion, Peas, Squash

Besides above seven farms, two British aided farms- Lumle Agricultural Center (LAC) and Pakhribas Agricultural Center (PAC) also were linked and coordinated for vegetable research, development and seed production.

From the beginning of sixth five-year plan (1980/81) onward different donors supported to gearing up the research and development in vegetable sector. These projects further strengthened the approach initiated by VDD during fifth five-year plan and continued till eighth five-year plan. Ten projects supported vegetable development, some of them worked with the government and some of them worked with other donor funded projects (Annex 1). In addition to the projects listed in annex 1, High Value Agriculture Project (HVAP), Improved Seed for Farmers Program (ISFP), Kishan ko Lagi Unnat Biu Bijan Karyakram (KUBK), Project for Agriculture Commercialization and Trade (PACT), National Agriculture Research and Development Fund (NARDF) and Raising Incomes of Small and Medium Farmers Project (RISMFP) implemented by government also supported in the field of vegetable seed production and marketing.

During B.S 2029 to 2048 the vegetable seed production was under the unified command of the Vegetable Development Division/Directorate (VDD). Quality supervision and seed production chain was maintained and seed balanced sheet used to be prepared by VDD in the coordination and collaboration with farm/centers. Seed field supervision was the joint function of VDD, Seed Quality Division (seed labs), District Agriculture Development Offices (DADO) and Agriculture Inputs Corporation (AIC) to maintain distinctness, uniformity and stability of the varieties in seed production. Vegetable seed production was heading towards self-sufficiency and vegetable seed export was also propelling.

4. Seed production crops and varieties identified at different districts

Vegetable seed production is long term enterprise compared to fresh vegetable production. Many vegetables are consumed during juvenile phase and have shorter production period. On the contrary, all the vegetable seed production has longer period and have to pass from juvenile to reproductive phase. Climate is the main decision-making factor for seed production. The climates of Terai, Inner Terai, river basin areas and foothills are suitable for the seed production of tropical and sub-tropical vegetable like cucurbits, okra, chili, tomato, eggplant and many

legumes. Mid-hills are suitable to produce mid- season cauliflowers, radish, peas, beans, spinach, cress, onion, etc. Higher mountain has temperate climate and is suitable to produce high chiling varieties of cruciferous crops, carrot, beet root, etc. Many kinds of vegetable seed can be grown in different parts of the country in different seasons adjusting the sowing and flowering time. There are some vegetables which need both vernalization and long day condition for flowering and maturity.

In addition to climate, accessibility and marketing possibility of fresh vegetable also affects seed production of vegetable crops. Since the beginning, two principals have been adopted (a) accessible areas for fresh vegetable and (b) remote areas for vegetable seed production. Once the seed production areas become accessible it must push further to remote areas. Therefore, though niche districts are there for vegetable seed production, however, seed production pockets are pushed further to remote villages of the district. For sustainability, production should be concentrated to the area where climate is suitable at the same time it should be profitable compared to foregone crops like cereals. Therefore, suitable districts for important commercial vegetable seed production have been identified during past as ongoing and potential seed production districts for future expansion shown in the table 2 and mapped in figure 3 to 5.

With the long experience of vegetable seed production, the districts have been developed as commercial sites for specific crops and varieties for seed production. The specific niche pockets for niche commodities within the districts are always pushing towards remote villages. The niche districts and potential for vegetable seed production districts are presented in Table 2.

Table 2: Ongoing and potential niche production districts and niche commodities

S.N.	Crops	Ongoing niche districts	Potential new districts
1	Cauliflower (Snowball Group), Carrot, Radish (Tokinasi), Rayo (Marpha), Beet Root, Brussels's Sprout	Jumla, Dolpa, Mustang	Humla, Kalikot, Mugu, Baglung
2	Onion (Baitadi Local)	Baitadi	Darchula
3	Onion (Red Creole and Agri-found Dark Red)	Rukum, Surkhet, Salyan, Dailekh, Palpa	Gulmi, Arghakhanchi
4	Radish (Mino Early and White Neck)	Dadeldhura, Rukum, Salyan, Surkhet, Dailekh, Bhojpur	Doti, Achham, Terhathum
5	Radish (Chalis Dine)	Parbat, Surkhet,	Sunsari, Dang, Terai
6	Cauliflower Kathmandu Local, Jyapu	Rukum, Kavre,	Dolakha, Khotang Sindhupalchowk
7	Pea, Beans, Broad Beans	Rukum, Salyan, Dailekh, Surkhet, Kavre, Rolpa	Lalitpur, All Terai districts
8	Cucumber, Bitter Gourd, Bottle Gourd	Parbat, Surkhet, Kavre	Myagdi, Palpa, Gulmi
9	Tomato (Srijana, ALpsi Gede, CL 1131, Any registered variety)	Dolakha, Kavre, Lalitpur	Parbat, Myagdi and low Hill and Terai
10	Okra, Eggplant, Chili, Sweet Pepper	Surkhet, Sarlahi, Parbat, Kavre, Rukum	Chitwan All Terai districts
11	Cress, Spinach	Dadeldhura, Baitadi, Kavre, Lalitpur	Nuwakot, Ramechhap, Khotang, Kathmandu valley

Note: Based on the need and the districts and pockets should be added in the above table. Some ongoing and potential districts are presented in figure 3 to figure 5.

(A) High chiling long-day vegetables: Cauliflower (Snow Ball Groups), Carrot, Radish (Tokinasi), Beet Root, Rayo (Marpha Chauda Pat)
Ongoing districts: Jumla, Dolpa, Mustang,
Potential districts: Kalikot, Humla, Mugu, Baglung



Figure 3: Temperate region districts and prioritized vegetables

(B) Warm temperate vegetables: Mid-season cauliflower, Beans, Peas, Radish (Mino Early, White Neck, Chalis Dine), Onion (Red Creole, Agri-found Dark Red, Baitadi Loca Rayo Khumal Chauda Pat, Khumal Rato Pat, Manakamana, Tomato (Srijana, Monoprecos, ALpsigede).

Ongoing districts: Baitadi, Dadeldhura, Rukum, Dailekh, Salyan, Surkhet, Parbat, Kavre, Palpa, Rolpa, Syangja, Kaski

Potential districts: Darchula, Doti, Achham, Gulmi, Sindhupalchowk, Lalitpur, Ramechhap,



Figure 4: Warm temperate region districts and prioritized vegetables

(C) Sub tropical vegetables: Cucumber, Bitter gourd, Bottle Gourd, Tomato (Srijana, ALpsi Gede), Okra, Cress, Spinach

Ongoing districts: Parbat, Surkhet, Kavre, Dolakha, Lalitpur, Dadeldhura, Sarlahi,

Potential districts: Myagdi, Nuwakot, Nabalparasi, Sunsari

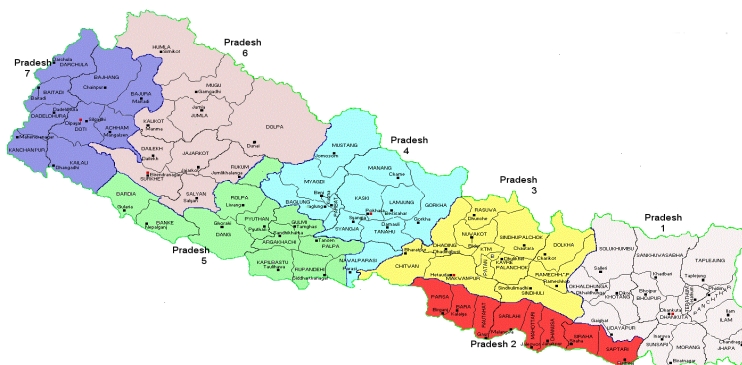


Figure 5: Sub-tropical region districts and prioritized vegetables

Notes: Pradesh 1= Koshi Pradesh, Pradesh 2= Madhesh Pradesh, Pradesh 3= Bagmati Pradesh, Pradesh 4= Gandaki Pradesh, Pradesh 5= Lumbini Pradesh, Pradesh 6= Karnali Pradesh and Pradesh 7 = Sudurpaschim Pradesh

5. Vegetable seed export to Bangladesh

Since B.S 2042 (1985) AIC and some reputed companies started vegetable seed export to Bangladesh. The seeds of Radish Mino Early, Onion Red Creole, Cauliflower Dolpa Snowball, Carrot Nantes Forto produced in Rukum, Rolpa, Mustang, Salyan and Bhaktapur were exported to Bangladesh and India through both formal and informal channels. Seed quality used to be monitored by VDD, DADO and concerned farm/centers as per the standards prescribed by Seed Quality Control Division and seed lab. Specific horticultural farm/centers were designated for specific vegetable variety maintenance, breeder's and foundation seed production and provide source seed to seed producing farmers of their command areas. Quality supervision was done by a joint team of farm /center, horticulturist or agronomist of DADO and representative of AIC. Thus, the seed system was functional. Tri patriate seed buying contractual agreement used to be signed among concerned farm/center, DADO and seed buying agencies e.g. AIC/Private seed companies. The demand of Nepali seed was increasing in Bangladesh, however, after B.S 2050 (1994) organizational set up for seed production and quality supervision mechanism was distorted. Rather maintaining quality and increasing production the exporting agencies/traders started exporting low quality seeds to meet the increased demand in Bangladesh. Bangladesh stopped importing Nepali seed questioning its quality and price and seed business to foreign countries stopped.

6. Complexity of vegetable sector

Vegetable sector must address a large number of species and cultivars to develop varieties adaptable to different agro-ecology, seasons, aspects and altitude. The complexity of the sector may be summarized as follows:

- To develop a new variety, materials collected from indigenous species, land races, distinct mutant clones, germplasms collected from National and International institutes and organization, farmer's varieties, materials from released/registered varieties are to be collected evaluated, selected and go through long process of breeding producers.
- In most vegetables culinary parts are leaves, stems, growing tips, roots, flowers and young fruit. To evaluate the yield and quality of these culinary parts a set of research are required
- For seed production, flowering and seed setting requires vernalization and photoperiodism specific agro-environment and micro-climates for seed production research
- The breeding behaviour of vegetables from highly self-pollinated to highly cross-pollinated make complex and crucial to sustain the system maintaining continuity in varietal development, seed production and marketing with Distinctness, Uniformity and Stability.
- Some vegetables are asexually propagated and needs large quantity of planting materials
- To maintain released/registered variety with distinctness, uniformity and stability and to produce different stages of seed (Breeder's seed, foundation seed and improved/commercial seed) is a herculean task of developing new OP varieties and parental lines for hybrid variety development.

Because of the above complexity to develop new varieties, develop parental lines to produce hybrid seeds, many farm centers for isolation and large number of qualified human resource, their dedication and government commitment is required. Unless bureaucrats, technocrats and top political leaders understand this complexity and are committed and determined the self-sufficiency and export of vegetable seeds are day dreams and will not be realized

Vegetable seed sector challenges

There have been organizational changes in horticulture including vegetable sector since its establishment. Several organizational changes and readjustments took place from B.S 1998 (1942) till today, B.S 2081(2024). The organizational changes and their effect could be summarized as follows:

1. Amalgamation of department of horticulture

During (B.S 2023 to 2029) the Department of Horticulture was in existence and established a number of horticulture stations in remote hills. During 2029 this Department was amalgamated to a single Department of Agriculture. This amalgamation did not affect much as four strong units as (1) Fruit Development Section, (2) Vegetable Development Section, (3) National Citrus Development Program and National Potato Development Program and establishment of some additional farm/centers. The Regional Agriculture Directorate (RAD) was also established and administrative and financial control of horticulture stations was delegated to RAD. However, RAD was not sufficiently empowered and remained as CC office (बोध्यार्थालय) and farm/centres were practically under central management and intact with national system and vegetable and vegetable seed development program ran smoothly.

After 10 years of these arrangements, during 2039 the then Minister of Agriculture Mr. Dev Narayan Yadav realized the slow progress of the horticulture sector and formed an eleven-member committee to expedite the horticulture development under the chairpersonship of Mr. Keshab Bahadur Rajbhandari. The committee reviewed the causes of slow progress and recommended the establishment of a separate Department of Horticulture. However, it did not materialize but some impetus was given to the vegetable sector with project support. During 2047 the interim government of PM Krishna Prasad Bhattarai, Minister of Agriculture and Forestry Mr. Jhala Nath Khanal and Finance Minister Dr. Devendra Raj Pandey established Department of Horticulture and District Horticulture Development Offices in 30 districts. It was a good initiation however, just after one year when new elected government was formed the Department of Horticulture was demolished without proper analysis and concrete reasons. However, during 2040 to 2048 with the support from vegetable seed and fresh vegetable project under the unified command of VDD and other service divisions of the Department of Agriculture, vegetable research, seed production and development was at its apex and was tagged as the golden era of vegetable sector.

2. Establishment of Nepal Agricultural Research Council

To give impetus in agricultural research, a separate autonomous organization "Nepal Agricultural Research Council (NARC)" was established in B.S.2048 (2090/91) and new organizational structures were adopted. It would have been better to make NARC as research and development policy making and grant allocating autonomous body. However, NARC was erected as research implementing organization. Though it could have been put under the Secretary of Agriculture, unfortunately it was put under the agriculture minister and NARC system became politically influenced.

While creating NARC the horticultural farm/centers were divided between NARC and DoA and it was a technical blunder. The division of farm/centers distorted vegetable research and variety maintenance program. Most of the specialized vegetables potato and spice crop research and development farms/stations were kept under DoA and senior horticulture/vegetable experts also remained with DoA. To exemplify Central Vegetable Research and Seed Production Center Khumaltar, Tropical Horticulture Center/Sarlahi, Horticulture Farm/Mustang, Vegetable Seed Production Center Rukum and Vegetable Seed Production Center Dadeldhura, Potato Research Farm Nigale, Cardamom Development Farm Ilam etc. were kept under DoA with no research mandate. The National Citrus Development Program and the National Potato Development Program was split between NARC and DoA.

3. Farm/Centers handed over to other ministries and occupied by security

After 1990, many horticultural farm/centers were given to other Ministries, Private sector and Hospitals (Yagyanpuri Farm Chitwan, Horticulture Farm Kakani, Horticulture Farm Rasuwa and Horticulture Farm Helambu). Some farms are completely or partially occupied by security units during Mao Badi insurgency by Army and Armed Police and not yet returned to the MoALD.

4. Farm/Centers under province

Again, during structural readjustment of government organization after the formation of province some farms from DoA were kept under Provincial Agriculture Directorate. The Farm/Centers under province are also underutilized with limited responsibility of seed, seedling and sapling production without research and variety maintenance mandate. As the result a setback took place in vegetable research and variety maintenance and seed production chain distorted.

5. Downsize of District Agriculture Development Office (DADO)

During structural adjustment District Agriculture Development Office (DADO) and Agriculture Service Centers (ASC) were downsized. In place of DADO, Agriculture Knowledge centers (AKC) were set up with reduced and limited human resources. However, one AKC has to deliver services covering two districts. As envisaged the local governments (Metropolitans, Sub-metropolitans and Municipalities) are not provided with sufficient and trained agriculture/horticulture/livestock technicians and specialist. The testing and demonstrations of developed technology and technical service delivery to the farmers are very weak and ineffective. Whatever research outputs are developed by NARC are not extensively demonstrated and know how is delivered to the farmers for commercialization.

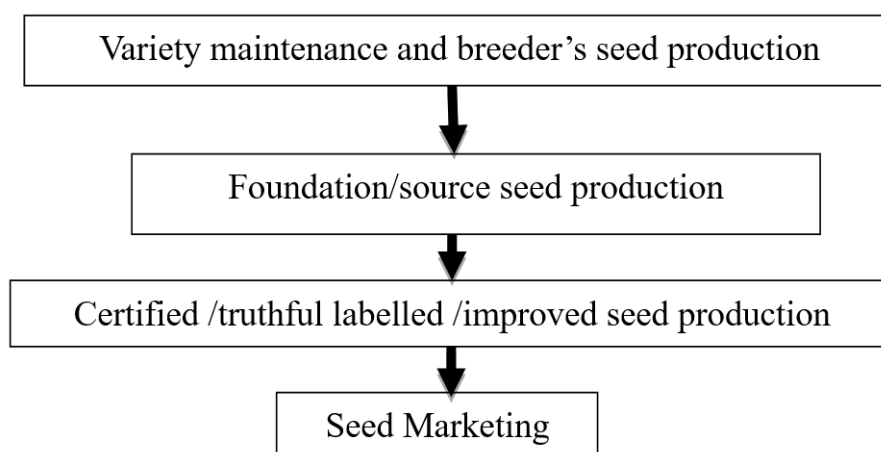
6. Challenges of variety maintenance

The main challenges in variety maintenance appeared when farm/centers were divided among DoA, NARC and provincial directorate and some farms were handed over to other Ministries and organization and occupied by security units. The total 40 vegetable varieties released and registered also not properly maintained because of budgetary and mandatory constraint in DoA/NCPVSCD and Provincial Agriculture Directorate. National Horticulture Research Center (NHRC)/NARC have limited farm/centers and limited human resource.

Variety development, release and registration has no meaning, if not maintained, produced breeder's and foundation seeds and linked to commercial seed production and marketed to fresh vegetable producers. Variety maintenance in designated and appropriate farm/center and breeder's and foundation seed production and its storage and distribution through a coordinating organization is very important for successful vegetable seed production program. During eighties, a common variety maintenance chart was developed denoting farm/centers and varieties to be maintained and procedures to produce breeders and foundation seed in 18 farm/centers (Annex 2). This maintenance scheme implementation was under the command of the then VDD. To facilitate the maintenance of these varieties the variety released year and main distinguishing characters of released varieties were prepared and published as presented in Annex 3. However, such arrangements are not implemented as present and released /registered varieties are at the verge of extinguished. At later stage, with changed context, SQCC has denoted organizations responsible for maintaining crop varieties as presented in Annex 4. This Annex 4 chart is incomplete and suggests only five crop varieties to be maintained such as Tomato, Radish, Rayo, Onion, Pea and Cauliflower Kathmandu Local. Analysis revealed that officially released Nepali vegetable varieties are 40 only and imported registered varieties are 333 (VDD annual Report 2072/73). The detailed list of released and registered varieties is given in Annex 5.

7. Challenges to maintain seed production chain

A sustainable seed production chain consists of four sequential stages: (1) Variety maintenance and breeder's seed production, (2) Foundation/source seed production, (3) Certified /truthful labelled seed production and (4) Marketing of seed with proper bagging and tagging. Responsibility for stage 1 rests with the breeders who are independent professionals or organization. In stage 2, farm/centers and licence holder private companies and producer's organizations such as cooperatives are authorized to produce foundation or source seeds using the nucleus or breeder's seed from authorized agencies (DoA and NHRC/NARC). For stage 3, which is very critical to sustain the seed system, trained farmers of community seed producer groups/cooperatives are the main players. Stage 4 is seed marketing with proper seed handling by business companies. The scientific seed production chain are as follows:



Seed production chain from variety development its maintenance, breeders and foundation seed production and commercial seed production for good quality seed is of prime importance. VDD adopted the system and procedures to maintain seed chain. Each farm/center was made responsible to produce quality breeders and foundation seed production linking to the farmer's field commercial seed production. This chain is very weak rather broken during recent years.

8. Challenges to maintain seed value chain

Variety development, release, registration and maintenance and linking of these results to organized seed production and marketing are the key components of the vegetable seed value chain. Many forms of value chains are operational, however, there is a challenge to establish the appropriate one. Sustainability of the seed value chain is still questioned as key issues. The key issues related to sustainable seed value chains are: (i) inadequate linkage and trust between producers and traders, (ii) marketing of loose seeds by producers without lot number, proper packaging and labelling, (iii) lack of formal seed production and market information channel, (iv) inadequate quality assurance service to producers and traders, (v) inadequate number of seed marketing cooperatives or organizations at local level, (vi) prohibitive cost of seed production for export, (vii) inadequate enabling policy environment, (viii) inconsistency in the supply of source seeds, and (ix) poor capacity of private sector for domestic on-farm quality seed production

and coming into the mainstream of national seed system. Private sector seed production is often undertaken on contractual basis involving individual farmers, and chances of breach of the contract are very high by both parties which distorts the value chain.

9. Challenges and Gaps in Demand and Supply

Fresh vegetables produced in the accessible areas have readily available markets. It gives 3-5 times higher income compared to the cereal crops within a short period of time. Farmers are demanding the varieties that are high yielding, short durational and suitable to different agro-ecological environment and season. Farmer's attraction towards hybrid varieties with guaranteed quality increased because hybrid seeds make the best use of resources, produce high yield and maintain uniform quality of the produce. Such hybrid varieties are not developed in Nepal in highly demanded crops like cauliflower, cabbage, cucurbits and solanaceous crops (except one Var. Srijana and two pipeline varieties in tomato).

The available OP varieties of Nepali seeds also have poor quality, lack farmers of trust, irregular supply. The old varieties in many crops neither selected properly nor replaced by new varieties. Even the seeds of highly self-pollinated crops like peas and beans which can easily be produced in Nepal are also imported and sold in the name of hybrids (sometimes). The reasons for demand and supply gaps may be summarized as follow:

- Development of vegetable hybrid varieties are slow in Nepal because of inadequate vegetable breeders and well-organized hybrid seed development programs
- Dedicated farm/centers divided among NARC, DoA and Province and these farm/centers have functional anomalies due to prohibitive mandate, insufficiency in budget and human resources.
- Limited-Service providers and limited qualified technicians in the seed production areas for supervision for quality assurance and quality checking
- Due to quality deterioration of Nepali seed, import of foreign seed is increasing and farmers are attracted more towards hybrid and imported OP seeds
- The government bureaucracy and political leadership is disconsolate and indolent/passive to rectify the situation.
- Private seed companies are more interested in importing and marketing foreign seed due to better profit margin.

10. Slow progress of National Seed Vision 2013-2025

Government of Nepal has launched National Seed Vision 2013-2025. It has set specific targets to be achieved in hybrid variety development by 2025 as follows:

- Thirty hybrid vegetable variety developed of which 20 by public and 10 by private sector
- Seed replacement rate to reach 90 % by 2025 from 65 % during 2013 by improved seed

National Seed Vision set targets to develop 30 hybrids. However, it has not identified the crops for hybridization in vegetable crops. The target crops for public sector and private sector are not specified. The slow progress of National Seed Vision is due to this unclarity, and low priority given by government. The budget and human resource management is not sufficient in government sector vis a vis to coordination and collaboration with the private sector. The progress of Seed Vision is slow as the government is not providing adequate budget and human resources and appropriate support and collaboration with private sector. The import of huge quantity of hybrids and OP varieties the Nepali varieties are endangered and are at the verge of extinguishment.

11. Challenges to continue past achievements

More than 10 different projects supported vegetable seed sectors in the past (Annex 1). Most of these projects worked as infrastructural projects (building, road and bridge) in project mode. Agricultural projects should work in program mode. Farmers need continuous advice, support and service delivery in agricultural process. Till the donor funding is there, all technical and financial support is provided to the producer farmers and market actors. Linkage of the program with government's regular program and national grid lacked in most projects. After projects phaseout, the achievements made during the project periods decline. For the continuation of the donor supported efforts it should have been functionally collaborated with the line agencies of government program since inception of the project which lacked in most projects due to project design and direct financial arrangements. During the project period government line agencies are dealt as guest artists and after project phaseout vegetable seed producer

cooperatives/groups and private companies face the financial and technical service delivery problems for organizing production and marketing workshops and the preparation of sustainable business model and its implementation. As a result, production, marketing and quality assurance of the vegetable seed production slowly decreased or in some areas it is completely stopped after seed project phaseout. In the market seed demand is increasing, however seed production of Nepali varieties is decreasing after project phaseout.

12. Challenges of quality assurance and import substitution

There are many small-holder farmers in seed production system. The assemblage of such individual farmers produced seeds without strong internal quality control system, seed lots are mixed with both good and bad quality seeds. Thus, Nepali seeds are losing quality assurance and quality confidence. The reasons being:

- Low volume of production and mixed quality standards
- Collection of seed by many middlemen and poachers,
- Poor post-harvest handling and no dry chain followed in the seed supply chain
- Dis-honour of marketing buy-back guarantee by both producers and traders
- Frequent market price fluctuation and contract breach
- Inadequate coordination among concerned line ministries for seed production and export.
- Strong competition with imported vegetable seeds with domestic products.
- Absence of quality certification procedures for export (Quality Standards, Phytosanitary Certification and Quarantine Order Agreeable to importing countries)
- Low investment in vegetable seed research, post-harvest management, including storage and dry chain transportation facilities for vegetable seed (As make it dry and keep it dry)
- Inefficient and ineffective extension and quality maintenance service delivery
- Inadequate supply of quality source seeds and planting materials.

The above reasons impede smooth and regular seed production all over the existing and potential seed production districts. The trend of seed import is increasing year after year. The major reasons being increased demand and less supply of domestic seed. Seeds of 36 different vegetables were imported during 2016 as reported by SEAN 2017 (Annex 5). Import of seed of non-registered vegetable variety was found two third (74.67%) through porous border of India as compared to registered vegetable varieties (25.33%). Therefore, there is ample space prospects of producing seeds of open pollinated vegetable varieties with proper labelling and packaging to decrease seed import in future as two third of import is occupied by open pollinated varieties. Protecting Nepali vegetable varieties and developing Nepali hybrids are the key issues to achieve self-sufficiency in vegetable seed.

Conclusion and Recommendation

Nepal has high prospect and comparative advantages to produce different kinds of vegetable seed, however, the domestic production is not meeting the increased demand of vegetable seed. Almost 50 percent of vegetable seeds in the market are coming from other countries. Farmers are looking for high yielding, high quality vegetable seeds mostly the hybrids. Even the OP variety seeds like peas and beans which has great potentiality of seed production in Nepal are also imported. To achieve modernization of the whole agricultural system reformation and transformation of the present organizational structure and positive attitude of politicians and bureaucrats and their commitments are expected. Instead of blaming Nepali seed importing countries, Nepal first must improve its vegetable seed qualities, maintain standards and seed chain to promote export to reduce the gaps in trade balance and attain self-sufficiency.

Agriculture Perspective Plan (APP), Agriculture Development Strategy (ADS) and have identified fresh vegetable and vegetable seed as priority outputs. High quality seed is the prime technology input for the growth of vegetable sub-sector.

Considering the fact of rapid replacement of Nepali varieties by imported OP and hybrids, research need has crucially emerged for developing new OP varieties and parental lines for hybrid variety development. Popularity of imported hybrids cannot be ruled out in the context of open global economy and the requirements of off-season vegetables. However, this should not be at the cost of Nepali varieties and local species which possess the immense potential of farmer's acceptance and sustaining the seed system and resilient to climate change effect.

Nepal has Himalaya like challenges and herculean tasks to improve and sustain vegetable seed industry. The

physiography, altitudes, aspects and seasons provide comparative advantages and agro biodiversity. The vast number of vegetable species, varieties, land races, and indigenous vegetables are the basis of prospects. Selection, adaptation and development of vegetable crops made so far are the progress made in crop maintenance and seed production are the wealth of nation

Nepal's geographical position, physical setting, varying altitude, aspects provide agro-environment and comparative advantages. Large number of vegetable bio-diversities. However, organizational anomalies and farm/center's mis management, distorted seed production and value chain, could not meet the demand of seed for different agro-ecology and seasons. Imported OPs and hybrids are rapidly replacing the Nepali varieties and land races.

To rectify the organizational anomalies and convert challenges into opportunities and to improve the functioning of farm/centers, reformation/readjustment of present organizational structure is required. Therefore, the following actions are recommended:

- Form a strong Research, Education and Extension Reformation Committee (REERC) at apex level under the chairpersonship of Secretary MoALD, represented by Director General DoA, Executive Director NARC, Chief SQCC, Dean UAF, Dean IAAS/TU, Chairperson SEAN, and Chief / NCPVSCD as Member Secretary.
- REERC and MoALD should formulate organizational readjustment, research, extension and education collaborative system, farms/center management policy/guideline to avoid structural anomalies and streamline vegetable and vegetable seed research and development as one of the priority programs for seed import substitution, attain self- sufficiency and promote export of Nepali vegetable seed
- All farm/centers should be kept under the command of central government with full mandate of research, variety maintenance and different stages of seed production
- Farm/centers are the face of MoALD and should demonstrate modern technology and should be developed as the *show case and Center of Excellence*
- In all 753 local government units, specifically trained agriculture, horticulture technicians and subject matter specialist in Agriculture Knowledge Center in each district should be posted
- Increase investment in vegetable seed research, post-harvest management, including storage and dry chain transportation facilities for vegetable seed (As make it dry and keep it dry).

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Annex 1: Summary of Donor Support in Vegetable and Vegetable Seed Sector with Major Contribution and Achievements

S.N.	Name of Project	Donor	Project year	Main achievements
1	Fresh vegetable and vegetable seed production project	Swiss Assistance through FAO as technical cooperation	1981-1995	During these 15 years and worked in three phases as the counter part of VDD. This project further strengthened the approach initiated by VDD during fifth five-year plan and continued till eighth five-year plan. The commendable impacts of this period were as under: - Supported VDD for variety development evaluating 350 new germplasm and improving already popular 25 varieties and total 72 varieties identified - Based on the mode of pollination and breeding behavior of identified vegetable variety maintenance chart (Annex 2) was developed denoting farm/centers and varieties to be maintained and produce breeders and foundation seed - To ease the variety maintenance work, varietal (morphological) characteristics of identified varieties with their marked genetic trait of the identified documented for the use and reference (Annex 3). - VDD/FAO facilitated to establish Seed Entrepreneur's Association Nepal (SEAN) 1989 and registered in 1991 with 32 members which now spread all over Nepal and seed dealing entrepreneurs are more than 2000. - Supported AIC and strategic government farms to establish seed processing and air-conditioned seed storage facilities
2	Japan International Cooperation Agency	Japan	1983-1987	Introduced protected cultivation of tomato and sweet pepper in half opened plastic tunnel in Khumaltar and proven success
3	Regional Vegetable Research project	RAS/89/4	1987-1988	Contributed in germplasm exchange among Asian countries like China, Korea, Thailand and SAARC countries during
4	South Asia Vegetable Network (SAVERNET)	Taiwan	1991-1993	Introduced different varieties of vegetables for adaptive test, however the conclusive results could not be reached due to administrative anomalies among researchers.
5	Vegetable, Fruits and Cash Crops Development Project, (VFC/Rapti)	USAID	1984-1990	Scale up seed production and marketing by many folds in Rapti zone through No Frills Consultancy. However, due to its negligence in providing quality foundation seed and quality control services, it lost Nepalese radish seed market in Bangladesh. This project failed to collaborate with research and seed chain maintenance.
6	Koshi Hills Seed and Vegetable Project (KOSEVEG)	DFID	1992-1997	Aimed to develop an effective, sustainable and market-oriented seed and vegetable program for increasing household income. The social mobilization process of the project was notably a successful and it supported in forming KOSEPAN and linked the seed growers with national and regional seed traders for sustainability

S.N.	Name of Project	Donor	Project year	Main achievements
7	Community Based Economic Development Project (CBED)	CIDA	1997-2002	CBED adopted the demand-based vegetable seed production program linking seed growers with seed traders through regional seed contracting workshops. It was successful in introducing the seed production practice in the far western hill districts.
8	Market Access for Rural Development (MARD)	USAID	1997-2002	MARD Project supported farmers groups and cooperatives for vegetable seed production and marketing in Surkhet, Dailekh and Nuwakot districts. Due to poor linkage with GoN line agencies the impact could not last long.
9	Seed Sector Support Project (SSSP)	DFID	1998-2003	As a successor of the KOSEVEG project and adopted the same approach for seed production and marketing. The approach was based on contractual seed production agreed by seed producer groups/cooperatives and seed buyers during seed planning workshops. The model was later replicated in other districts (Dadeldhura and Achham). SSSP contributed in enhancing the seed industry of Nepal and is also particularly known for private seed sector growth. It supported processing equipment and laboratory establishment of SEAN Seed Service Center (SSSC), Thankot a well-equipped company owned by more than 50 SEAN members.
10	Participatory Vegetable Seed Project (PVSP)	DANIDA	2001-2003	Vegetable seed production project implemented by NGO – Center for Environmental and Agricultural Policy Research, Extension and Development (CEAPRED) in six districts of Nepal including both hill and Terai district.
11	Vegetable Seed Project (VSP)	SDC	2004-2014	Implemented by CEAPRED, to benefit poor farmers in remote areas by diversifying their income opportunities through vegetable seed production and marketing. Synergistic approach of combining seed production in the remote districts and fresh vegetable in road corridors focusing poor, women and disadvantaged households Institutionalizing farmers groups into seed cooperatives and linking them with entrepreneurs through Pre-contract Marketing Agreement Seed Producers' Central Co-operative Federation Ltd registered as umbrella organization of primary seed cooperatives that facilitates for demand-based production and nationwide marketing of seeds linking with seed entrepreneurs of all over Nepal

Annex 2: Released Vegetable Varieties and Their Distinguishing Characters

S.N.	Crops and varieties	Released year	Distinguishing Characters
1	Cauliflower		
	Sarlahi Dipali	1994	Plants are medium tall of erect habit, green and waxy leaves having rounded apex. Curd is somewhat round, white to creamy white, compact, medium sized weighing 600-700g. Average yield is 15 t/ha.

S.N.	Crops and varieties	Released year	Distinguishing Characters
	Dolpa Snowball	1994	Late variety maturing in 130 days after transplanting, curd round, white, smooth, weight 1.5-2 kg. Suitable for autumn transplanting and spring harvest. A selection from Snowball-16.
	Kathmandu Local	1994	A well-adapted mid-season variety maturing in 110-120 days after transplanting. Wide adaptability to the different conditions. Excellent white to creamy white, flattish compact curd, fine grained, semi-self-protected by outer leaves. Curd weight 1.5-2 kg.
	Khumal Jyapu	2014	Matures 65-80 days after transplanting and have around 1 kg size with better taste, developed by Horticulture Research Division, Khumaltar.
2	Radish		
	Chalis Dine	1994	Variety early, maturing 35-45 days. Roots white 15-25 cm long, pungency very low. Leaves are upright, erect, light green, non-hairy, sweet and shining white.
	Pyuthane Rato	1994	Late season variety, maturity 70-80 days after sowing, root red with white flash, 20-30 cm long, thick tapering. Red neck with light red or whitish red root end.
	White Neck	1994	Maturity 60-65 days. Roots 35 cm long, 6-8 cm diameter, cylindrical, pure white and smooth. Flesh white, mild pungency. Leaves upright, light green in color, top green. Yield 30-40 t/ha.
	Mino Early	1990	Early variety, maturity 45-50 days. Roots pure white, tapering rooted, have tendency to grow above ground level. Pungency mild. Leaf grayish green having deep cuts with spreading habit. Yield 30-40 t/ha.
3	Rayo		
	Tangkhuwa Rayo	1994	Light green leaf with cream white leaf vein, very smooth and wavy leaf margin.
	Khumal Rato Pat	1994	Late variety, matures for first harvest in 60-70 days after transplanting; leaves are green with purple-red pigments, puckered, non-hairy, petioles curved and leaves are also curved to a cup-shape, fleshy, 25-30 cm long and 20-25 cm wide, bolts later than Khumal and Marpha broad leaf; yields 25-30 t/ha green leaves.
	Khumal Chaudapat	1994	Mature for first harvest in 40-50 days after transplanting and continues for another 100-120 days, leaves dark green, fleshy, non-hairy and puckered, 40-50 cm long and 25-30 cm wide, yield 30-40 t/ha green leaves.
	Marpha Chaudapat	1994	Mature for first harvest in 55-65 days after transplanting; leaves light green, non-hairy, puckered, 40-50 cm long and 20-30 cm wide with flat petioles; late bolter; yield 25-30 t/ha green leaves.
4	Turnip		
	Purple Top	1994	Leaves dark green with deep cuts, roots globe shaped white with purple exposed crown. Flesh white, maturity 60-70 days after sowing. Plants top erect. Suitable for autumn plantation.
	Kathmandu Rato	2015	Early variety, root matures in 50-55 days of sowing. Root globe to flattish, outer color red, flesh white, strong flavor.

S.N.	Crops and varieties	Released year	Distinguishing Characters
5	Onion		
	Red Creole	1990	Deep red skinned thick flat bulb, white flash, medium late variety, bulb matures in 160-180 days after transplanting. Bulb weight about 175 g.
6	Tomato		
	Srijana (Registered)	2010	Hybrid variety developed by NARC, bacterial wilt resistant, fruit ovate and 60-80 g weight, uniform and red and heavy yielder, indeterminate variety.
	Roma	1994	Mid-season variety; fruits ready for first harvest in 60-70 days after transplanting. Fruits smooth, uniformed fleshy thick, bi-chambered, less seed content, leaves broader, potato type, plant determinate and bushy.
	Monprecos	1995	Medium early variety, fruit ready for first harvest in 80- 90 days after transplanting, fruits globe shaped, smooth, uniformly red, bi-tri-chambered, firm flash seed content low, plant vigorous, indeterminate, erect.
	NCL-1	1990	Heat resistant and wilt tolerant variety, fruits ready for first harvest in 65-75 days after transplanting, fruits plum shaped to flattish round, firm, thick skinned, yellowish red with a slight green shoulder when ripe, suitable for rainy season and autumn season harvest. Plant semi-determinate to indeterminate depending upon climate. A selection from CL-1131 cultivar.
	Pusa Ruby	1990	Fruits ripe in 60-65 days after transplanting fruits flattish round, uniform red, smooth surface, seed content comparatively higher, determinate growth habit.
6	Carrot		
	Nantes Forte	1990	Very high-quality roots. Suitable for autumn and spring plantation. Excellent internal and external color. Roots 15-20 cm long, cylindrical blunt tipped. Matures in 90-100 days after sowing.
	New Kuroda OP (Registered)	2010	Well adapted variety for tropical and sub-tropical conditions. Roots 15-20 cm long with conical flat shoulder, tapering towards the root end. Bright orange colored surface with few deep eyes. Matures in 80-100 days after sowing.
7.	Cabbage		
	Copenhagen Market	1994	Mid-season variety; mature 70-90 days after transplanting, head round, blue green, 1.5-2.5 kg, good for school garden.
8.	Cowpea		
	Sarlahi Tane	1994	A bit early variety. Pods ready for first harvest in 50-60 days after sowing. Plants climbing, pods 25-30 cm long, light greenish white, seed black when ripe.
	Khupal Tane	1994	Climbing long podded type, pods 30-45 cm long white to greenish white, seeds red when ripe. Needs warm climate for successful results. Yields 6-8 fresh pods t/ha.
9	Pole bean		

S.N.	Crops and varieties	Released year	Distinguishing Characters
	Trishuli Simi-1	1994	Popular climbing type pods 20-25 cm long. Green fleshy, long curved ('S' shaped), fibreless at prime picking period. Seeds light to coffee brown with purple eye ring. Yield 6-8 t/ha. Suitable for autumn and spring through summer harvest.
	Jhange Simi-1	1994	Bush type variety; resistant to common bean mosaic. Maturity 50 days after sowing. Pods dark green and 15 cm long. Yield 5-6 t/ha.
10	Peas		
	Sarlahi Arkel	1994	Early variety, ready for first picking in 60-65 days after sowing; pods deep green 7-8 cm long, well filled with 7-8 grains seeds wrinkled on drying; yields 5-7 t/ha green pods. Suitable for late autumn sowing and early spring harvest.
	New Line Perfection	1994	Mid to late season variety, flowers in 60-65 days of sowing, pods are ready for first picking in 85-90 days of sowing; plant medium tall and vigorous in growth; leaves are dark green and broader; flower borne in double; pods straight green, 7-8 cm long, well filled with 6-7 grains seeds wrinkled on drying. Suitable for autumn plantation.
	Sikkime	1994	Late variety, flowers in 80-85 days and pods ready for first picking in 105-110 days after sowing; plants are tall and vigorous; leaves are light green with very wide leaflets; pods light green, well filled, short with 6-7 grain; seeds are bold, creamy whitish with black helium, smooth on drying, suitable for rainy season in high hills. A selection form Sikkim Local variety.
11	Capsicum		
	Californe	1994	Fruits ready for first harvest in 80-90 days after transplanting; plants 70-75 cm tall, erect somewhat bushy; leaves single entire broader than normal chili, dark green with pointed tip, fruits are 3 to 4 lobed generally. Yields 25-30 t/ha.
12	Chili		
	Jwala	1994	A high yielding variety with long slender fruits, brilliant red when ripe. Selection of Pusa Jwala variety. Slightly earlier than other commercial varieties.
13	Brinjal		
	Nurki	1999	Plant medium, stem and leaves pinkish in color, Thorne less leaves and stem but thrones in fruit petiole. Fruit 15-25 cm long, soft, 4-5 fruits in a bunch. Maturity 60-70 days.
14	Sponge gourd		
	Kantipure	1994	
15	Cucumber		
	Kushle	1994	Early variety, fruits ready for first harvest in 75-80 days after sowing. Fruits straight 15-25 cm long with 6-10 cm diameter; fruit light green with whiter towards distal end
16	Squash		

S.N.	Crops and varieties	Released year	Distinguishing Characters
	Ashare Squash	1994	Fruits are medium sized; flesh is tender and delicious at immature stage when it is used as vegetables. Duration 60-80 days. Yield 20-35 t/ha.
17	Swiss chard		
	Susaag	1994	Duration 60-70 days. Yield 20-35 t/ha.
18	Bitter gourd		
	Hariyo Karela	1994	Fruits are dark green, Duration 90-100 days. Yield 20-25 t/ha.
19	Lady's finger		
	Parbati	1994	An early heavy yielding variety, more tolerable to yellow vein mosaic virus. Plant medium tall. Fruits fleshly, medium green in color. Well, adapted for spring, summer and rainy season harvest. A selection of Parvati Kranti variety.
20	Spinach		
	Haripate	1994	Plants ready for harvest in 50-60 days after sowing, leaves erect, smooth, vigorous, and green to dark green, petioles and lower base pinkish. Suitable for autumn and spring sowing.

Annex 3: Crop and Variety-Wise Maintenance Chart at Various Farms and Stations Developed During Sixth Five-Year Plan

S.N.	Farm/Station and Crop	Variety
1	VSPC Dadeldhura	
	Knol Khol	White Vienna
	Radish	Mino early
	Turnip	Improved White
	Broad leaf mustard	Khumal Red Leaf
	Tomato	Monprecos
	Peas	NLP,
	French bean	Contender, Kentucky Wonder,
	Cucumber	Local,
2	VSPC Rukum	
	Cauliflower	Kathmandu Local
	Radish	Mino early
	Turnip	Purple Top White Globe
	Broad leaf mustard	Khumal Broad Leaf
	Cress	Local
	Onion	Red Creole
	Sweet pepper	California Wonder
	Tomato	Pusa Ruby
	Peas	Arkel
	French bean	Contender
	Squash	Black Zucchini
3	H. Farm Pokhara	
	Radish	Mino Early
	Okra	Pusa Selection I

S.N.	Farm/Station and Crop	Variety
	Sponge gourd	Pusa Chillo
4	H. Farm Marpha	
	Cauliflower	Snow Ball
	Radish	Tokinasi
	Turnip	Purple Top White Globe
	Broad leaf mustard	Marpha Broad Leaf
	Peas	Arkle
	Bean	Carlos's favorite
	Cress	Local
	Cabbage	Large Late Drum Head, Copen Hagen Market, Pride of India
	Carrot	Nantes Forte
	Swiss Chard	Ford Hook Giant
	French bean	Kentucky Wonder
5	AS Lumle	
	Knol Khol	White Vienna
	Cauliflower	Kathmandu Local
	Radish	Pyuthane Red, 40-days
	Spinach	Patane
	Peas	Arkle, Sikkime
	Coriander	Local
	Fenugreek	Kasuri
	Eggplant	PPL
	Squash	Grey Zucchini
	Cucumber	Bhaktapur Local,
6	VSPC Khumaltar	
	Cauliflower	Kathmandu Local
	Radish	Mino Early
	Turnip	Purple Top White Globe
	Broad Leaf Mustard	Khumal Broad Leaf
	Peas	New Line Perfection, Sikkime
	French beans	Kentucky Wonder
	Tomato	Monprecos,
	Okra	Pusa Sawani
	Spinach	Patane
	Squash	Grey Zucchini
	Cress	Local
	Broad bean	Local
	Chili	Dandicut and Kathmandu Local
	Swiss Chard	Ford Hook Giant
	Fenugreek	Kasuri
	Cowpea (Asparagus bean)	Khumal Tane (Red seed)
	Cucumber	Bhaktapur Local,
7	H. Farm Sarlahi	
	Peas	Arkle, Boonville, NLP,

S.N.	Farm/Station and Crop	Variety
	Tomato	Pusa Ruby, Roma, CL 1131, Pusa Early Dwarf
	Okra	Pusa sawani, Parwani Kranti
	Sweet pepper	California Wonder
	Beet spinach	All green
	Cucumber	Poinsett
	Eggplant	Nurki, Sarlahi Green
	Watermelon	Sugar-baby
	Cauliflower	Pusa Deepali
	Radish	Pusa chetki
	Fenugreek	Kasuri
	Chili	Pusa Jwala
	Eggplant	Nurki, PPL, Sarlahi Green
	Cowpea	Sarlahi Black
	Pumpkin	Local
	Bitter gourd	Pusa Domousami,
	Bottle gourd	Pusa Summer Prolific Long
	Sponge gourd	Pusa Chillo
	Ash gourd	Local
8	Agriculture Station Dhankuta	
	Cauliflower	Kibo Giant
	Radish	White Neck
	Broad leaf mustard	Khumal Broad Leaf
	Peas	New Line Perfection
	Beans	Contender
	Tomato	Monprecos
	Capsicum	California Wonder
	Onion	Red Creole
	Turnip	Purple Top White Globe
	Cress	Local
	French bean	Kentucky Wonder
9	AS Pakhribas	
	Broccoli	Green Sprouting
	Cauliflower	Kathmandu Local
	Radish	Mino Early, 40-days
	Broad leaf mustard	Khumal Broad Leaf, Tangkhuwa
	Cress	Local
	Table beet	Detroit Dark Red
	Chili	Akabare
	Sweet pepper	California Wonder
	Peas	Boonville, Sikkime
	French bean	Kentucky Wonder
	Cowpea	Kathmandu Red
	Bitter gourd	Coimbatore Long
	Squash	Black Zucchini
	Sponge gourd	Local

S.N.	Farm/Station and Crop	Variety
10	H. Farm Panchkhal	
	Eggplant	Pusa Kranti
	Cucumber	Kusume, Bhaktapur Local
	Bitter gourd	White Long
	Bean	Four Seasons
11	H.S. Parawanipur	
	Peas	Arkle
	Pumpkin	Local
	Tomato	Marglobe
	Eggplant	Sarlahi Green
	Bottle gourd	Pusa Summer Prolific Long
12	Agriculture station Jumla	
	Cabbage	Golden Acre
13	Agriculture station Dolpa	
	Cauliflower	Snow Ball 16
	Carrot	New Kuroda
	Broad leaf mustard	Marpha Broad Leaf
14	H. Farm Janakpur	
	Radish	Chetki
	Peas	New Line Perfection
	Okra	Pusa Selection I
	Chili	Cyanne
	Eggplant	Pusa Kranti
15	Ag. Farm Palpa	
	Cauliflower	Early Snow Ball
	Radish	Pyuthane
	Onion	Nasik Red
16	Ag Station Nepalgunj	
	Tomato	Money Maker
	Eggplant	Pusa Purple Cluster
17	H. Farm Dailekh	
	Broad Leaf Mustard	Marpha Broad Leaf
	Onion	Agri-found Dark Red
18	H. Farm Sindhuli	
	Chili	Yatsufusa
	Eggplant	Pusa Purple Round

Annex 4: Organizations Responsible for Maintaining Crop Varieties in Nepal as Proposed By SQCC

Crop	Variety	Variety maintenance organisation
Tomato	Sirijana hybrid	Horticulture Research Division, Khumal, NARC
Tomato	Pusa Ruby	Sarlahi Horticultural Farm (DoA)
Tomato	NCL	Horticulture Research Station, Malepatan, NARC
Radish	Mino Early	Agriculture Research Station Dailkeh, NARC
Radish	Pyuthane Red	Horticulture Farm (DoA), Palpa
Radish	40 days	Regional Agriculture Research Station Lumle
Radish	Tokinashi	Horticulture Research Station, Jumla (NARC)

Rayo	Marpha Broad Leaf	Horticultural Farm Mustang (DoA)
Rayo	Khupal Red Leaf	Vegetable Seed Production Center, Dadeldhura
Rayo	Khupal Broad Leaf	Horticulture Research Division, Khupal, NARC
Onion	Red Creole	Agriculture Research Station Dailkeh, NARC
Pea	Sarlahi Arkel	Regional Agriculture Research Station Nepalgunj (NARC)
Pea	Sikkime	Regional Agriculture Research Station Lumle
Cauliflower	Kathmandu Local	Horticulture Research Division, Khupal, NARC

Annex 5: Number Of Released and Registered Vegetable Varieties

S.N.	Crops	No. of Released Nepali varieties	No. of Registered imported varieties	Total
1	Cauliflower	4	46	50
2	Radish	4	14	18
3	Turnip	2	1	3
4	Broad Leaf Mustard	4	4	8
5	Onion	2	6	8
6	Tomato	4	29	33
7	Carrot	1	5	6
8	Cabbage	1	31	32
9	Asparagus bean	2	4	6
10	French bean	2	1	3
11	Peas	3	0	3
12	Sweet pepper	1	2	3
13	Hot pepper	1	15	16
14	Eggplant	1	7	8
15	Sponge gourd	1	7	8
16	Cucumber	2	36	38
17	Squash	1	11	12
18	Swiss Chard	1	0	1
19	Bitter gourd	1	20	21
20	Okra	1	2	3
21	Spinach	1	3	4
22	Broccoli	0	11	11
23	Water Melon	0	3	3
24	Pumpkin	0	3	3
25	Bottle gourd	0	5	5
26	Ridge gourd	0	3	3
27	Coriander	0	5	5
28	Asparagus	0	1	1
29	Parsley	0	3	3
30	Knol-khol	0	2	2
31	Pakchoi	0	4	4
32	Lettuce	0	4	4
33	Sugar beet	0	1	1
34	Chinese cabbage	0	4	4
	Total	40	293	333

Source: Annual Report of VDD 2072/73 page 128-142

Prospects and Challenges of Spice Seed Crops in Nepal

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Abstract

Spices are an integral part of Nepali cuisine and culture, used in various forms for pickling, preservation, coloring, flavor, pungency, and aroma. Major commercially grown spices in Nepal include large cardamom, ginger, garlic, turmeric, chilies, and onions, while tree spices like cinnamon and Timur (*Zanthoxylum*) are increasingly being cultivated beyond their natural habitats. Spices are marketed as whole seeds, barks, leaves, buds, stigmas, rhizomes, or in ground form. Nepalese households regularly use a mix of indigenous and imported spices in daily cooking. The country has 72,076 hectares under spice cultivation, yielding around 566,202 metric tons annually, with ginger occupying the largest area and production share. Large cardamom dominates spice exports, contributing 82% of the total export value, followed by ginger (11%) and other spices (7%). There is considerable potential to increase production of coriander, fennel, aniseed, onion, and specialty chilies such as 'Akabare Khursani.' Tree spices like cinnamon and Timur show strong promise in the mid-hills, while high-value saffron could be explored in mountain regions. Nepal's diverse agro-ecological zones offer significant opportunities for expanding spice cultivation. This overview highlights the current status, prospects, and challenges of the spice sector in Nepal.

Keywords: Cultivation, Export, High value, Market, Production.

Introduction

Nepal, roughly trapezoidal in shape, stretches 800 km in length and 200 km in width, covering an area of 147,181 sq. km. It is situated between latitudes 26° and 31°N, and longitudes 80° and 89°E. This unique physiographic position has given rise to diverse climatic conditions, contributing to the country's rich biodiversity (Pradhan et al., 2016). Among the agricultural crops cultivated in Nepal, spice crops stand out for their significant biodiversity. According to the International Standards Organization (ISO), spices are defined as "any of the aromatic vegetable products used in cooking, seasoning, and preserving foods." In simpler terms, spices are natural plant products primarily used to flavor, season, or add pungency to foods and beverages (Ferrel, 1985). Spices encompass various dry parts of aromatic plants, including roots (e.g. sweet flag), bark (e.g. cinnamon), rhizomes (e.g. ginger), leaves (e.g. bay leaf), shoots and leaves (e.g. coriander), flower buds (e.g. clove), stigmas (e.g. saffron), fruits (e.g. nutmeg), seeds (e.g. cumin), fruit pods (e.g. vanilla), and resinous exudates (e.g. asafoetida), which are traded globally as spices.

Spices, condiments, and herbs primarily contribute taste, flavor, and aroma to food. While most spices thrive in tropical to subtropical climates, certain varieties, such as saffron, black cumin, and Jimmu, grow in temperate regions. As a result, almost every country cultivates at least one type of spice or herb. Of the 109 spices listed by the ISO, India is known to grow 52, while Nepal produces around 30 species, either in their natural habitat or through cultivation (Ravindran, 2006; Sharma, 2013). Spices-both indigenous and imported - are commonly used by Nepalese people, either on a daily or weekly basis or during special social functions. Quality seeds play a vital role in successful spice cultivation. A quality seed meets all essential attributes, including genetic purity, physical purity, germination ability, vigor, seed health, moisture content, size, weight, and color.

Spices are used in various forms and ways, pickles (peppers, garlic, ginger and chilies), as preservatives (clove, black pepper and mustard seeds/powder), coloring (turmeric, chilies and saffron), spice oils (ginger oils) for the preparation of soft drinks and the oleoresins obtained from black pepper, ginger, capsicum, turmeric, fenugreek and cardamom are used for pungency, flavour and aroma in meat and food processing industries. The intrinsic quality of spices and herbs varies with variety, location, time and stages of harvest, processing methods, etc. Resinous part, which is the non-volatile portion, is made up of different polymers. The main flavoring effect in many spices is

pungency. Several valuable pigments are found in spices. These pigments are extracted and used as natural colorants in the food industry. Some of the spices, which yield colour pigments, are turmeric, paprika and saffron.

Spices are marketed as whole seeds, barks, leaves, buds, stigmas, and rhizomes or grounded of all these spices. Apart from these plant parts, majority of these spices are extracted for essential oils and oleoresins. Ginger oil and ginger oleoresin are the two main ginger products in the international markets (Bhatiya et al., 1999). In comparison to cereals and other food commodities spice trade is almost balanced due to the major role of cardamom and ginger. Cinnamon (*Dalchini*) is also contributing to some extent in trade balance. Nepal pepper (*Timur*) which has been exported in large volume and value usually does not come under Ministry of Agriculture and Livestock Development (MoALD) statistics, but it is the most exportable spice commodity. Spices contribute about 7.7% of the total national AGDP and 2.3% of national GDP (Sharma et al., 2019). Efforts made for the promotion of spices is quite inadequate to cope with the fulfillment of increasing demand. About thirty spices have been in use in Nepal (Table 1). Some of them are imported from India and overseas countries and most of them are cultivated or available under *in-situ* conditions of Nepal.

Table 1: List of spices commonly used in Nepal

S.N.	English name	Nepali name	Botanical name	Parts used
1	Turmeric	Besar/Haledo	<i>Curcuma longa</i> L.	Rhizome
2	Chili	Khursani	<i>Capsicum frutescence</i> L.	Fruit
3	Fenugreek	Methi	<i>Trogonella foenum graecum</i> L.	Seed
4	Garlic	Lasun	<i>Allium sativum</i> L.	Leaf and bulb
5	Onion	Pyaj	<i>Allium cepa</i> L.	Leaf and bulb
6	Coriander	Dhaniya	<i>Coriandrum sativum</i> L.	Leaf and seed
7	Ginger	Aduwa	<i>Zingiber officinale</i> Rosc.	Rhizome
8	Cumin	Jeera	<i>Cuminum cyminum</i> L.	Seed
9	Black cumin	Himali jeera	<i>Bunium persicum</i> Bioss	Seed
10	Black pepper	Marich	<i>Piper nigrum</i> L.	Berry
11	Indian cassia	Tejpat	<i>Cinamomum tamala</i> Neesand Eberm	Leaf and bark
12	Cinnamon	Dalchini	<i>Cinnamomum zeylanicum</i> Blume.	Bark
13	Clove	Lwang	<i>Eugenia caryophyllus</i> Bullock and Harrison	Flower bud
14	Cardamom (Large)	Alainchi	<i>Amomum sabulatum</i> Roxb.	Fruit and seed
15	Cardamom (Small)	Sukmel	<i>Elettaria cardamomum</i> Maton.	Fruit and seed
16	Nutmeg	Jaiphal	<i>Myristica fragrans</i> Houttuyn	Kernel
17	Mace	Jaipatri	<i>Myristica fragrans</i> Houttuyn	Aril
18	Bishop's weed	Jwano	<i>Trachyspermum ammi</i> L.	Seed
19	Aniseed	Saunf (masino)	<i>Pimpinella anisum</i> L.	Seed
20	Black mustard	Katherayo	<i>Brassica nigra</i> (L.) Koch	Seed
21	Asafoetida	Hing	<i>Ferula asafoetida</i> L.	Resin from rhizome
22	Saffron	Kesar	<i>Crocus sativa</i> L.	Stigma
23	Mint	Pudina	<i>Mentha arvensis</i> L.	Leaf
24	Leek	Chhyapi	<i>Allium ampeloprasum</i> var. <i>porrum</i>	Leaf and bulb
25	Nepal pepper	Timur	<i>Zanthoxylum armatum</i> DC	Fruit
26	Fennel	Sounf (moto)	<i>Foeniculum vulgare</i> Mill.	Seed
27	Dill	Nepali soof	<i>Peucedanum graveolens</i> (L.) CB Clarke.	Seed
28	Caraway	Himali soop	<i>Carum carvi</i> L.	Seed
29	Nigela	Mungrelo	<i>Nigella sativa</i> L.	Seed
30	Jimmu	Jimmu	<i>Allium hypsistum</i> L.	Leaves

Source: Sharma, 2013.

Involvement of Development Organization

In Nepal, there are two apex organizations for research and development of spices: (i) National Ginger Research Program, Kapurkot, Salyan under Nepal Agricultural Research Council (NARC) and (ii) National Center for Potato, Vegetables and Spice Crops Development, Kirtipur and its collaborating stations e.g. Spices Development Center, Panchkhal, Kavrepalanchok, under Bagmati Province and Cardamom Development Center, Fikkal, Ilam under Department of Agriculture. Apart from Government organization, Cooperatives, NGOs and INGOs are also involved in developing entrepreneurship on seed and seedlings production, edible parts production and processing of spices. Cooperatives in Palpa, Pyuthan and Ilam at community levels and Nepal Ginger Producers and Traders Association (NGPTA) at Dhulabari, Jhapa are also taking part in production and trading of ginger from eastern region. Federation of Large Cardamom Entrepreneurs of Nepal (FLCEN), Birtamod, Jhapa also taking part on promotion and trading of large cardamom in the country. It has already made the network on major cardamom producing districts.

All the spices defined and listed above have not been dealt with by MoALD and the mandated organization for spices. Cinnamon (*Dalchini*) and Nepal pepper (*Timur*) come under Ministry of Forest and Environment (MoFE). For the promotion of all these spices "A Separate Institution" needs to be formed and spices should get due priority for research and development in the country. Special courses should be taught in agricultural universities. All the Nepalese spices mentioned above need to be dealt with by one organization.

Cultivation Area and Production Status of Spice Crops

Most of the spices are shade-loving that can be grown in between the rows of orchard or inter cropped with other vegetable crops, which increases the cropping intensity as well reduces the risk of crop failure. According to the data available from MoALD in the FY 2021/22, total area under spice crops is 72,076 Ha with a production of 5,66,202 MT and ginger occupies highest area and production in Nepal (Table 2). Globally ginger is the single spice crop of Nepal showing fourth position in the world ranking during the year 2022 (FAOSTAT, 2022). Presently, five spices have attained a commercial production scale and some spices such as onion, coriander, fenugreek, saffron, vanilla, cinnamon, *Timur* etc. are coming up. Seed spices particularly cumin, black cumin, bishop's weed, aniseed, black mustard, fennel, dill, caraway, nigella, *Timur* and other spices cinnamon, saffron, are limited in backyard or *in-situ* conditions.

Table 2: Area, production and yield of spice crops in Nepal for the last three years.

S.N.	Crops	FY 2021/22			FY 2020/21			FY 2019/20		
		Area (Ha)	Prod ⁿ (MT)	Yield (MT/Ha)	Area (Ha)	Prod ⁿ (MT)	Yield (MT/Ha)	Area (Ha)	Prod ⁿ (MT)	Yield (MT/Ha)
1.	Large Cardamom	15975	8714	0.55	15668	8289	0.53	16565	9545	0.58
2.	Ginger	22441	287813	12.83	21912	279206	12.74	23500	298945	12.72
3.	Garlic	9943	74763	7.52	9784	72490	7.41	10185	73859	7.25
4.	Turmeric	10847	111014	10.24	10340	105719	10.22	9795	99907	10.20
5.	Dry Chili	12870	83898	6.52	12525	87731	7.00	10276	68025	6.62
TOTAL		72076	566202	7.86	70229	553435	7.88	70321	550281	7.83

Source: SINA, MoALD (FY 2019/20 - 2021/22)

Trade Status of Commercial Spice Crops

More than 50% of total spices import is basically from India and obviously major market destination are also India. However, total spice trade would be more than that because of illegal entries from the open borders. Overall exports of spices are equivalent to the value of NRs 5851.2 million against the import value of NRs. 15362.1 million in 2021/22. Large Cardamom is the first spice commodity which shares 82% export value followed by ginger (11%) and the rest of the spices 7 percent. Regarding importing four spice commodities i.e. pepper, cumin, capsicum/chili and small cardamom shares 38% of import value while including onion import shares are 79% (Table 3).

Cardamom and ginger are among the top 10 trade commodities prioritized by the Industrial Policy 2010 and plans to provide additional incentives and facilities for the promotion of these spice crops (MoCS/GoN. 2010) and ADS 2015 has also given due priorities on these spices.

Spice crops should be promoted for commercial production that could help in minimizing the trade imbalance and increasing income and employment opportunities in the country. Spice export, especially large cardamom and ginger is always a significant part of the total agricultural export of the country (Table 4 and 5).

Table 3: Trade status of commercial spice crops in Nepal in the fiscal year 2021/22.

S.N.	Spices	Import Status		Export Status		Trade Balance (NRs. '000)
		Volume (Kg)	Value (NRs. '000)	Volume (Kg)	Value (NRs. '000)	
1.	Annise, Fennel	609,680	118,705	0	0	-118,705
2.	Capsicum	10,837,532	1,770,153	0	0	-1,770,153
3.	Cinnamon	434,967	108,019	2,529,835	230,495	122,476
4.	Cloves	166,169	86,061	0	0	-86,061
5.	Coriander	9,886,611	1,198,976	0	0	-1,198,976
6.	Cumin	8,462,717	2,078,051	0	0	-2,078,051
7.	Fenugreek	2,229,233	213,085	0	0	-213,085
8.	Garlic	1,355,184	187,245	0	0	-187,245
9.	Ginger	615,276	129,157	11,958,893	641,457	512,300
10.	Large Cardamom	175	304	5,367,443	4,813,465	4,813,161
11.	Nutmeg	76,793	38,727	0	0	-38,727
12.	Onion	173,829,390	6,446,509	155,513	21,563	-6,424,946
13.	Black Pepper	2,030,224	1,180,353	27,505	19,307	-1,161,046
14.	Saffron	74	7,744	0	0	-7,744
15.	Small Cardamom	467,349	724,656	0	0	-724,656
16.	Vanilla	1	21	0	0	-21
17.	Turmeric	2,847,071	418,383	10,525	5,406	-412,977
18.	Spice mixtures	2,363,784	656,012	1,124,815	119,541	-536,471
	Total	216,212,230	15,362,161	21,174,529	5,851,234	-9,510,927

Source: SINA, MoALD (2021/22)

Table 4: Export situation of major spice crops of Nepal for the last three years

S.N.	Crop	F.Y. 2021/22		F.Y. 2022/23		F.Y. 2023/24	
		Quantity (MT)	Value (Rs. '000)	Quantity (MT)	Value (Rs. '000)	Quantity (MT)	Value (Rs. '000)
1.	Large Cardamom	5367.4	4813465	9991.14	8276850	5018.34	7940964
2.	Ginger	11958.8	641456	23013.68	1222233	10779.49	1176169
3.	Turmeric	10.5	5407	14.88	6381	27.20	14006

Source: FTS, DoC/MoF (2021/22 - 2023/24)

Table 5: Import situation of major spice crops of Nepal for the last three years

S.N.	Crop	F.Y. 2021/22		F.Y. 2022/23		F.Y. 2023/24	
		Quantity (MT)	Value (Rs. '000)	Quantity (MT)	Value (Rs. '000)	Quantity (MT)	Value (Rs. '000)
1	Garlic	10496.06	1240801	10435.354	1246457	18605.24	2483050
2	Turmeric	2847	418383	1867.78	304372	1748.97	361765
3	Onion	168540.57	6170571	180190.24	6750923	51544.38	2153633

Source: FTS, DoC/MoF (2021/22 - 2023/24)

Prospects and Challenges of Spices in Nepal

1. Prospects

The global demand for organic products has significantly increased, creating new opportunities in the international

spice trade, particularly in Europe, which leads the market for organically produced spices. Nepal, with its diverse agro-climatic zones—from tropical lowlands to temperate highlands—is well positioned to capitalize on this trend by cultivating a wide variety of high-value spices. Compared to cereals and other staples, spices offer considerably higher returns per unit of land, time, and input. Major commercial spices include large cardamom, ginger, turmeric, garlic, onion, and chili. Additionally, seed spices such as coriander, cumin, fennel, fenugreek, bishop's weed, and black mustard grow well in the Terai and mid-hill regions. Tree spices like cinnamon and Timur (*Zanthoxylum armatum*) can be promoted through sustainable cultivation in community forests using silvi-horti systems, which not only reduce soil erosion but also enhance rural livelihoods. In the high mountain regions, favorable temperate conditions support the production of premium spices such as saffron, Jimmu, and Himali Jeera.

As culinary habits evolve globally and the use of spices expands, Nepal must respond by identifying high-yielding, export-oriented varieties and supporting the production of quality planting materials through the adoption of modern technologies. The widespread migration of youth has left many cultivable lands fallow; reclaiming these lands for scientific spice cultivation should be a national priority. There is also an urgent need to establish oil and oleoresin extraction facilities to process abundant raw materials like ginger, turmeric, chili, cardamom, cinnamon, and Timur (Thapa et al., 2016). This high-value, low-volume commodities are ideally suited for air freight, allowing Nepal to access premium markets in Europe and North America. The Agricultural Development Strategy (ADS, 2015) supports the development of competitive agricultural value chains, positioning spices as a strategic sector to enhance value addition and benefit smallholder farmers.

To realize this potential, targeted promotion is needed: cumin, coriander, and fennel in the Terai and valleys; cinnamon and Timur in the mid-hills; and saffron in high-altitude areas. Developing value-added spice products under a distinctive Nepalese brand could enhance market identity and international competitiveness. Among Nepal's unique offerings, *Akabare Khursani*—a highly pungent chili from the eastern hills—stands out for its exceptional capsaicin content and oleoresin with recognized medicinal properties. Its reputation as one of the finest varieties globally underscores Nepal's capacity to lead in niche spice markets. Strengthening the productivity, processing, and value addition of spice crops will be crucial for improving rural incomes and enhancing Nepal's agricultural trade balance in the years ahead.

2. Challenges

- Nepal does not have improved high yielding varieties and scientific cultivation practices.
- Nominal research and development work is being done in spices related farms with minimum human resources, despite having enormous suitable climates for spice crops production.
- Farmers have insufficient knowledge of modern seed production practices, including isolation distance, rouging, pest and disease management, and post-harvest handling. Extension services specific to spices are weak or non-existent in the country. Spice sector is not getting due priorities as per its importance in employment generation, earning foreign currency and potential in balancing international trade.
- Low access to market and its information for all the stakeholders concerned.
- Inherent nature of slow seed germination and initial growth pattern.
- High incidence of diseases like wilt, blight, powdery mildew and gummosis etc.
- The number of insect pests' attack spice crops like aphids, cutworms, borer, thrips, scales and nematodes etc.
- Low productivity in the spice sub-sector in comparison to other horticultural crops.
- There is limited government policy and institutional focus on promoting spice seed systems. Certification, subsidy programs, and incentives for private sector involvement in spice seed production are largely absent. Increase in the import of spices due to low production and changes in the standard of living of people and increasing demand.
- Unlike cereal crops, spice seed production has attracted little interest from the private sector due to low economies of scale, perishability, and lack of assured markets.

The prospects and challenges of some major specific commercial spice crops are dealt hereunder (Table 6).

Table 6: Prospects and Challenges to specific spice crops

Spice Crops	Prospects	Challenges
Large Cardamom	- Propagated by three methods i.e., seed, sucker and micro-propagation /tissue culture - Five varieties are registered	- Lack of high yielding disease resistant varieties - Cross pollinated crop/seed propagation do not give true to type variety - Mass production of improved tissue culture seedlings - Use of suckers from old plantation without knowing the disease incidence - Planting of available land races from unknown source without considering climate and altitudes is one of the major issues
Ginger	- Propagated by rhizome - Kapurkot Aduwa-1 and Kapurkot Aduwa-2 have been released for commercial production - Best suited in agro-forestry system	- No seed formation, - Danger of rhizome rots disease - Difficulty to identify disease free rhizome - High price of seed rhizome
Turmeric	- Propagated by rhizome - Kapurkot Haledo-1 and Kapurkot Haledo-2 have been released for commercial production - It is also a shade-loving crop and can be grown as intercropped with fruit orchard - Suitable for agro-forestry systems	- No seed formation - Quality disease free planting materials are lacking - Risk of rhizome rot disease, leaf spot diseases are the major problems of its cultivation
Onion	- Propagated by bulb - Utilized in every kitchen irrespective of economic status of the family - Propagated by seeds/seedlings - Red Creole is released, Nasik-53, Baitadi Local and five hybrid onions varieties are registered for cultivation	- Lack of improved seed - High cost of inputs - High post-harvest loss - Significant amount of onion is being imported from China, India and other countries - Very poor storage facilities to growers
Garlic	- Propagated by bulb - Cultivated from Terai to the high altitudes - Variety cultivated at high altitudes is called 'Bhote Lasun. - Terai Lasun' and 'Bhote Lasun' are common in use - White-skinned bulb or corm is sub divided into several cloves	- Lack of quality genotypes - Substance cultivation - Labour intensive farming
Black Pepper	Propagated by three methods: seeds, runner and terminal shoots	- Seeds not planted within 20 days after harvest germination decline - Runner and terminal shoots-difficult for rooting
Chili	- Propagated by seeds - Single variety 'Jwala' released 15 hybrid chili varieties registered for commercial production	- Thrips, mites, aphids and pod borers are the major insect pests - Fruit rot, die-back, bacterial wilt, powdery mildew and mosaic are the major diseases
Coriander	- Two open pollinated varieties Lotus and Suravi and three hybrid varieties have been registered after the adaptation trial - Intercropped with sugarcane as catch crop before the full growth of sugarcane	- Aphids and cutworms are the major insect pests - Fusarium wilt, stem galls and powdery mildews are the major diseases

Spice Crops	Prospects	Challenges
Cumin	- Propagated by seeds - Owing to low water requirements farmers can cultivate in drought affected areas where most of other crops cannot be grown	- Cross pollinated crop - Variety is not guaranteed - Powdery mildew is prevalent
Saffron	- Propagated through corms - Grown in dry temperate region altitude ranging from 2500 to 2800 masl - Temperate climate in the high mountain regions has provided special opportunities to grow saffron, <i>Jimmu</i> and <i>Himali Jeera</i>	Farmers of Jumla and Humla have initiated growing this crop but have not yet have attained commercial production
Vanilla	- A member of orchid family - Perennial and climbing vine grown up to 20 meters long with Aerial roots for support - A single vine can produce 100 to 150 pods - Second to saffron in price and can be grown in indoor at pots for home consumption	- Labour intensive crop because it needs hand pollination for pod formation - Lack of identified varieties and unavailability of planting materials - Lack of technical knowhow to technical manpower and farmers

Way Forward

1. Establish a dedicated institution for spice research and development

A specialized institution should be created with a focus on spice research and development, prioritizing the sector to unlock its potential and address the needs of spice farmers across Nepal.

2. Utilize agroforestry systems for spice cultivation

Most spice crops are shade-loving and can be successfully intercropped with fruit trees, making them ideal candidates for agroforestry systems. This approach can help improve land use efficiency and support sustainable farming practices.

3. Promote commercial production of spice crops

Spice crops should be actively promoted for commercial production, as they offer significant potential for enhancing agricultural trade balance, creating employment opportunities, and boosting rural incomes.

4. Establish oil and oleoresin extraction plants

The establishment of extraction plants for oils and oleoresins (from ginger, turmeric, chili, cardamom, timur, and cinnamon) should be prioritized, leveraging the ample raw materials available to add value to the spice sector.

5. Introduce specialized courses on spices in agricultural universities

Agricultural universities should offer specialized courses on spice cultivation and processing to create a pool of skilled professionals who can serve both government and private sectors.

6. Mass production of improved tissue culture seedlings for cardamom

Efforts should be focused on the mass production of high-quality, disease-free tissue culture seedlings of cardamom to ensure consistent, true-to-type varieties that command better market prices.

7. Increase the area and productivity of improved ginger varieties

The high-quality ginger varieties developed by the Nepal Agricultural Research Council (NARC) should be promoted both nationally and internationally. Expanding the area and improving productivity will help meet domestic and international demand.

8. Promote cumin cultivation in water-scarce areas

Cumin, with its low water requirements, can be an ideal crop for areas lacking irrigation infrastructure. Encouraging its cultivation will help diversify spice farming and boost production in water-scarce regions.

9. Cultivate cinnamon in tropical climates for commercial production

Cinnamon cultivation should be promoted in tropical climates, as it thrives in these environments and has significant potential for commercial-scale production.

10. Expand cinnamon cultivation for processed products

A targeted program should be launched to increase cinnamon cultivation, focusing on commercial production for processed products like cinnamon tea, cinnamon oil, and cinnamon powder.

11. Promote high-value spice crops in geographically suitable areas

High-value spice crops like saffron should be promoted in high-altitude hill regions, while vanilla should be cultivated in tropical areas, leveraging Nepal's diverse geographical conditions to maximize the potential of these crops.

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Status and Way Forward on Potato and Tuber Crops Seeds in Nepal

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Abstract

Potato is cultivated in all geography and in all four seasons in Nepal, and is a high value crop. Total area of potato production in Nepal is 203812 ha, and the production is 3487816 mt, with 17.11 mt/ha productivity, and Bhaktapur district has the highest productivity of potato (23.4 mt/ha). During the twenty years of time period, area has been increased by 1.88% annually, whereas production has been increased by 4.04% annually and productivity has been increased by 2.12% annually. Import of seed potato is the very negligible. There are 21 varieties of potato which are registered/released in Nepal, among them three varieties are suitable for industrial purposes. Productivity of potato varieties ranges from 10 to 39.4 metric tons per hectare. Altogether, there are eight organizations having license for Pre-Basic Seed production in Nepal, where two are government and six are private organizations. Annually, the demand of PBS in Nepal is 0.8 to 1.0 million, whereas annual PBS production is around 0.8 million. There are two varieties of sweet potato registered, and different genotypes has been conserved, vines are the planting materials for sweet potato. Quality deterioration of parental lines of True Potato Seed (TPS), difficulty to maintain the seed cycle of potato, varietal development, requiring highly technical skill to produce TPS and PBS are the major challenges in seed potato in Nepal, whereas the cultivation in marginal land, unorganized markets, inadequate post-harvest technology are the major problems in other tuber crops in Nepal. To make Nepal self-sufficient in potato, efforts have to be given for either productivity increasement or area expansion. For both, the seed cycle has to be maintained for using certified seed by the farmers to increase production of potato in Nepal.

Keywords: Post Harvest, Pre-Basic Seed, Productivity, Seed Cycle, Varietal Development.

Introduction

Agriculture is the foundation for income, employment and livelihood of the people in Nepal (MoF, 2023). Contribution of agriculture to Gross Domestic Product (GDP) is 24% and around 62% households are engaging in agriculture as major occupation for their livelihood (MoF, 2024). Potato is one of the important crops which occupies 4% area among the major agricultural commodities in Nepal, and it is cultivated in all geography of Nepal, i.e. from terai to hill and high hills (MoALD, 2024). In comparison with paddy, wheat and maize; potato occupies 4th position in area and 2nd position in production (MoALD, 2024). Contribution of potato to agriculture GDP is 6.35% (MoALD, 2023). It is cultivated in all four seasons of the country: winter; early spring; late spring and autumn. It is a high value crop having nutritional value, environmental value and consumption value. It is rich source of nutrients having many vitamins and minerals (Navarre et al, 2009; Wijesinha-Bettoni and Mouillé, 2019). Potato requires less water compared to rice, wheat and maize (Adhikari et al, 2025; Devi et al, 2020), and this crop can contribute to food security with low requirement of water indicating its environmental value. Potato is consumed in diversified ways like it is suitable to all vegetables for culinary purposes, and also it is used as industrial products (Giampiccoli et al, 2013; Booysen, 2010).

Status of Potato

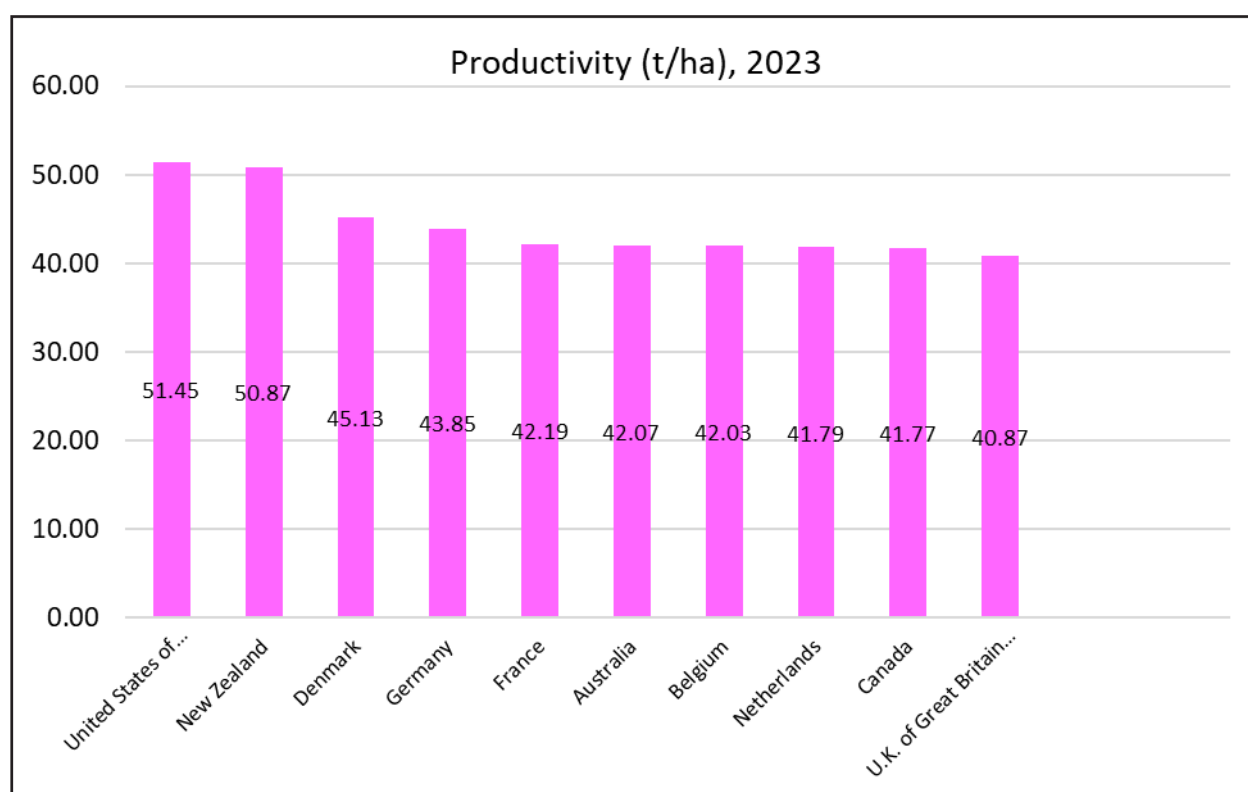
1. Status of potato in the world

According to FAOSTAT 2025, total potato harvesting area and total production of potato in the world is 16799111 hectare (ha) and 383082607.37 tons (t), respectively. In the world, 153 countries are producing potatoes, where China and India are the top first and second countries in area and production of potato. Nepal occupies 15th position in area and 22nd position in production of potato in the world. In case of productivity, United States of America and New Zealand are the top first and second countries, where their productivities are 51.45 tons per ha (t/ha) and 50.87 t/ha, respectively (figure 1). Similarly, Nepal occupies 95th position in the world. The average productivity of potato of the world is 21.40 mt/ha (FAOSTAT, 2025).

Table 1: Top potato producers in the world, 2023

SN	Country	Production (tons)
1	China	93491819
2	India	60142000
3	Ukraine	21358630
4	United States of America	19992090
5	Russian Federation	19374441
6	Germany	11607300
7	Bangladesh	10431736
8	France	8606490
9	Pakistan	8319767
10	Egypt	6869331

Source: FAOSTAT, 2025

Potato Producers having highest productivity, 2023

Source: FAOSTAT, 2025

Figure 1: Potato Producers with Top Productivity, 2023

2. Status of Potato in Nepal

2.1 Area, Production and Productivity of Potato in Nepal

Total area, production and productivity of potato in Nepal are 203812 ha, 3487816 mt and 17.11 mt/ha. Among all districts of Nepal, Jhapa has highest area of potato crops (15792 ha), Jhapa has highest production of potato (258357 mt), and Bhaktapur has the highest productivity of potato (23.4 mt/ha) (MoALD, 2024).

Figure 2 depicts the area, production and productivity of potato from 2003/04 to 2022/23. The figure shows that the area has been increased by 1.88% annually, whereas production has been increased by 4.04% annually and productivity has been increased by 2.12% annually (MoAD, 2017; MoALD, 2024). Increase in area, production and productivity may be due to promotional program of government of Nepal in potato crops, by means of technology transfer, capacity building, research in varietal development and other ways.

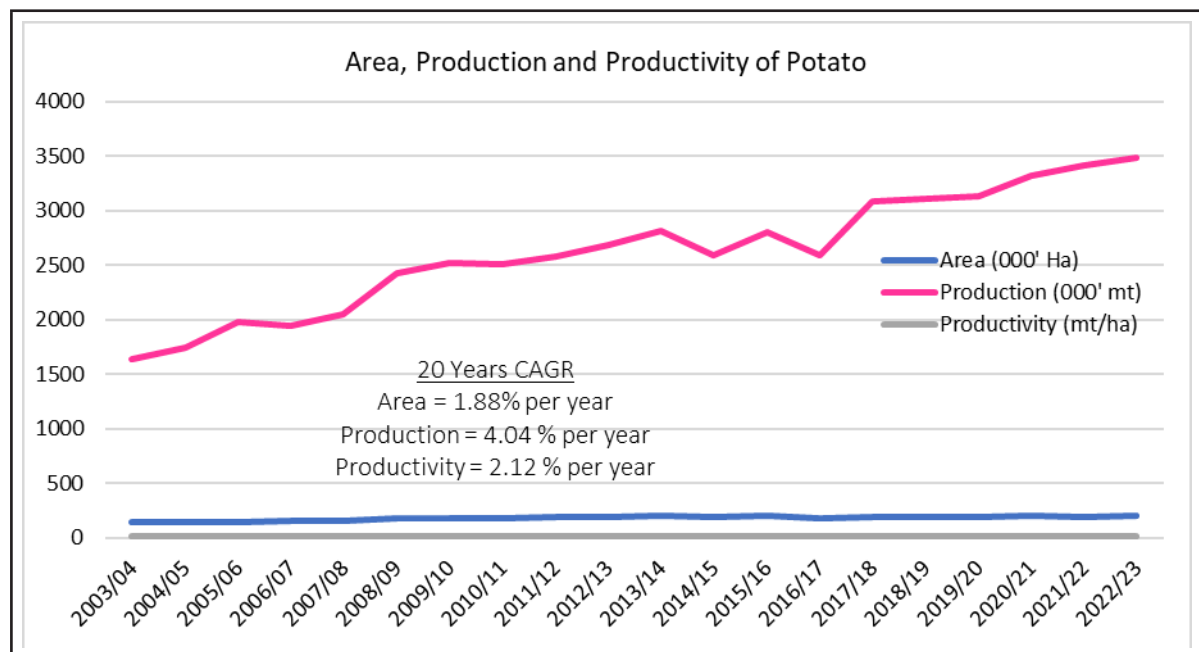


Figure 2: Area, Production and Productivity of Potato in Nepal, 2003/04-2022/23

Source: MoAD, 2017; MoALD 2024

Figure 3 explains the potato production areas occupied by seven provinces of Nepal in 2022/23. Koshi province has the highest area compared to other percentages, where Koshi alone occupies 30% area followed by Madhesh (15%), and Bagmati (20%). Sudurpaschim province has low percentage of potato production area, which is 7% only. Similarly, figure 4 shows the potato production occupancy of seven provinces in percentages. In production aspect of potato, Koshi is top (30%) followed by Madhesh (14%), and Bagmati (22%) whereas the Sudurpaschim province has only 7% occupancy in production of potato among all provinces in Nepal. Figure 5 shows the productivity of potato in mt/ha in all seven provinces in 2022/23 of Nepal. Bagmati has highest productivity of potato (19.09 mt/ha) followed by Gandaki (17.49 mt/ha) and Karnali (17.20 mt/ha). Lumbini has the lowest productivity of potato (15.57 mt/ha). In the area and production, the position of three provinces is same, and the Sudarpaschim has low share in area and production, however in productivity the figure is different, where Bagmati occupy first position. The differences in figures may be due to effects of many factors like inputs, technology, climatic variations and others.

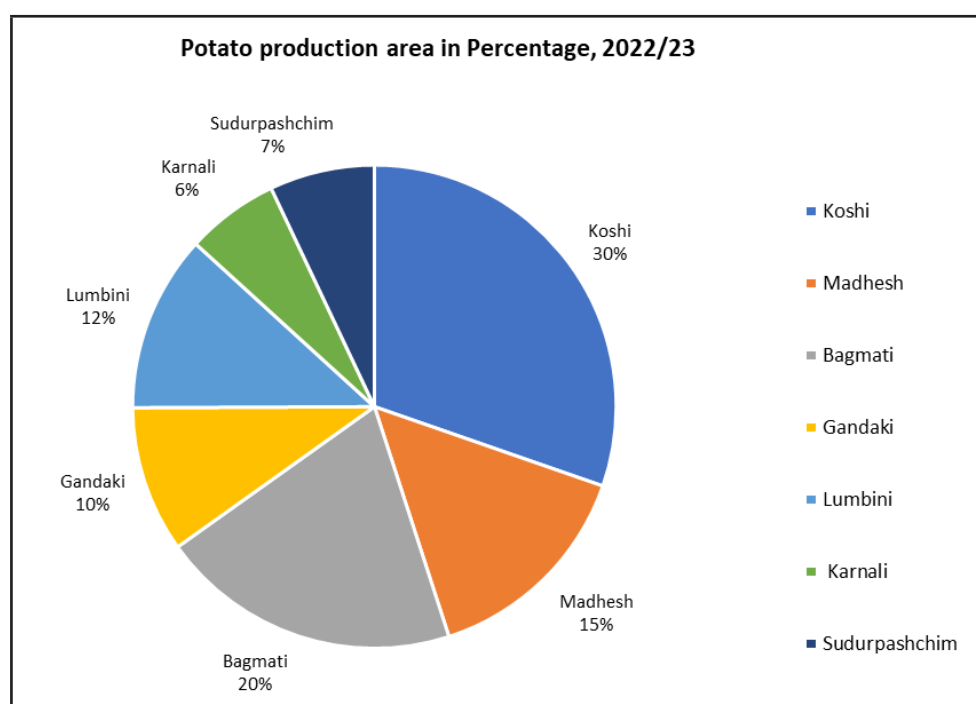
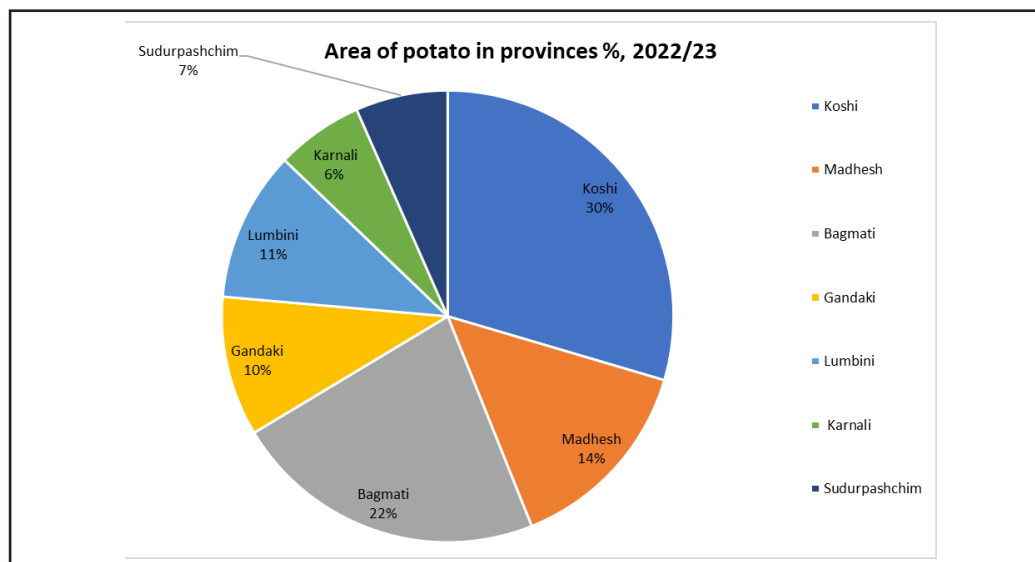


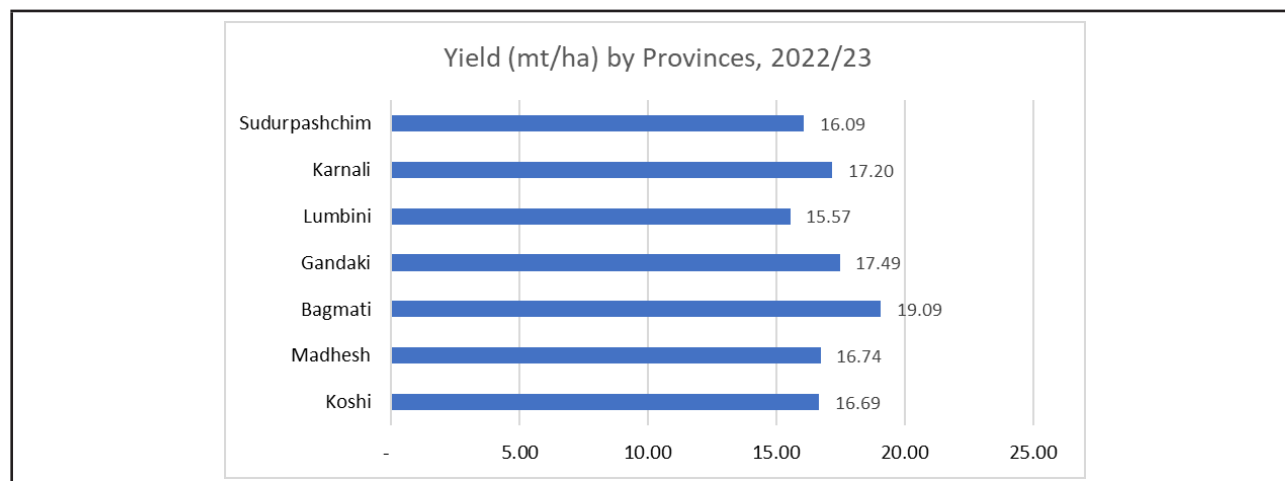
Figure 3: Potato production area (%) in seven provinces

Source: MoALD, 2024



Source: MoALD, 2024

Figure 4: Potato production (%) in seven provinces



Source: MoALD, 2024

Figure 5: Productivity of potato (mt/ha) in seven provinces

2.2 Export-Import Status of Potato

Nepal has exported potato and its industrial products to Australia, Japan, Italy and Seychelles where the export value is NPR 7347 (000' NPR). Nepal has imported potato and its industrial products from India, Bangladesh, China, Indonesia, United States, United Kingdom, Australia, Hong Kong, and Korea, where the import value is NPR 6711542 (000' NPR). However, the share of seed potato is very negligible (0.0015% of the total import value of potato and its industrial products), and the import of seed potato is only from India (DoC, 2024).

Varieties of potato in Nepal

Altogether, there are 21 varieties of potato which are registered/released in Nepal. Table 2 explains the registered/released varieties of potato in Nepal; these 18 varieties are suitable for table purposes. Productivity of these varieties ranges from 10 to 39.4 metric tons per hectare. For T.P.S., the productivity ranges from 30 to 40 metric tons per hectare. The data justifies that there are prominent varieties for potato production, national average productivity of potato is 17.11 metric tons/hectare, however the productivity gap may be due to management practices in potato.

Similarly, there are three varieties of potato which are for suitable for industrial purposes (table 3).

Table 2: Registered/Released Varieties of Potato in Nepal

SN	Variety	Recommended Area	Productivity (mt/ha)	Duration (Days)
1	Kufri Jyoti	hills and high-hills	23	110
2	Kufri Sinduri	terai and low-hills	23	110-120

3	Desire	terai, low-hills, mid-hills and high-hills	18	90-120
4	Janakdev	mid-hills and high-hills	39.4	110
5	Khumal Seto 1	mid-hills and high-hills	38.7	110
6	Khumal Rato 2	Terai	36.2	95
7	Khumal Laxmi	mid-hills and high-hills	24-28	120-140
8	I.P.Y. 8	Terai	25-27	110-120
9	Khumal Ujjawal	mid-hills and high-hills	25	100-120
10	Khumal Upahar	terai and mid-hills	24	100-120
11	T.P.S. 1	terai and mid-hills	35-40	110-120
12	T.P.S. 2	terai and mid-hills	30-35	110-120
13	Khumal Bikash	mid-hills and high-hills	25.75	100-110
14	Cardinal	terai and hills	18-30	80-110
15	Rojita	high-hills	10-14	120-140
16	M.S. 42.3	terai and hills	10-24	100-120
17	Khumal Rato -4	mid-hills and high-hills	27.84	110
18	Khumal Seto – 3	terai and mid-hills	29.91	115

Source: SQCC, 2024

Table 3: Industrial varieties of potato

Variety	Recommended Area	Productivity (mt/ha)	Duration (days)
Averstone Russet	Terai, Mid-hill (Bagmati, Gandaki, Lumbini)	26.37	90-120
Innovator		20.02	<90
Sagitta		29.94	<90

Source: SQCC, 2024

Similarly, there are many local varieties of potato like Kathmandu local, Jumli local, Bajhang local, Tharu local, Chingand local, Bung local and many more, however the registration/release of these local varieties has to be done.

Seed production status of potato and othe tuber crops

Altogether, there are eight institutions working for Pre-Basic Seed (PBS) potato production in Nepal, where six are private organizations and two are government organizations. Annually, the demand of PBS in Nepal is 0.8 to 1.0 million, whereas annual PBS production is around 0.8 million (NCPVSCD, 2023). Capacity of the PBS producing organizations in total is 1.4 million PBS. This figure reveals that Nepal can export the PBS by fulfilling the domestic demand. For this, the gaps between production of PBS and potentiality of its production amount have to be assessed. These all institutions have received license for producing PBS in Nepal. Private organizations had started to produce PBS by receiving license since after the implementation of Potato Pre-Basic (PBS) Seed Production and Certification Standard for Private, Government and Non-Government Sector (SQCC, 2024). Similarly, the annual demand of True Potato Seed (TPS) is 40-50 Kg (NCPVSCD, 2023). This demand has been raised since few years back due to the true to the type of the seed and free from virus as compared to other types of seeds. Potato Development Program (Nigale) is producing the TPS in the farm and has been taken to the farmers of Dang, Pyuthan and other areas of the country.

There are 2 varieties of sweet potato registered, and 48 different genotypes has been conserved in National Potato Research Program (NPRP) and, vines are the planting materials for sweet potato. In case of other tuber crops, there are local landraces, where the registration process has to be started.

Legal arrangements for potato and tuberr crops

There are many policy documents promoting potato and tuber crops seed sector like Plant Quarantine and Protection act, 2007/Plant Quarantine and protection regulation, 2010, Seed Act 2045; Seed Regulation, 2069, Seed Certification Directives, 2017, Potato Pre-Basic (PBS) Seed Production and Certification Standard for Private, Government and Non-Government Sector, 2022, Hybrid Seed Production and Certification Standard, 2021 etc.

Ministry of Agriculture and Livestock Development (MoALD) has the overall responsibility of growth and

development of agriculture and livestock sector. National Center for Potato, Vegetables and Spice Crops Development (NCPVSCD) has the mandate of working as focal center on potato like technical backstopping, and others.

The Seed Quality Control Center has been established to be involved in seed development, formulate seed policies and programs, and check the quality of seeds provided to farmers by various agencies, verify seeds, determine quality, and control them.

NCPVSCD has the overall responsibility of providing technical expertism and supporting to policy formulation regarding potato, vegetable and spice crops in the country. It has four satellite farm centers located in different geography of the country. Among four farm centers under NCPVSCD, Potato Development Centre (PDC), Nigale, is responsible for quality potato seed production – Pre-Basic Seed, Basic Seed and True Potato Seed for Nepal. Similarly, PDC, Nigale is working in germplasm conservation of potato, action research, providing technical services to the local levels and farmers. Large Cardamom Development Centre, Fikkal, Illam is also producing PBS, however the production quantity is low compared to PDC, Nigale.

Similarly National Potato Research Program (NPRM), Nepal Agricultural Research Council (NARC) has the leading role in research aspects of potato and potato sector. NPRM is working on research aspects of potato like: varietal improvement, seed production, soil fertility and agro-techniques, insect-pest, disease and weed management, organic potato production, post-harvest, and socio-economic research. Seed Quality Control Center (SQCC) has the role of quality regulation of seed, to ensure the farmers for using quality seeds.

Ministry of Agriculture and Livestock Development (MoALD) has been implementing various programs to seed sector of potato by its under organizations like NCPVSCD, SQCC, projects and federal conditional budget transferring to provincial and local levels. These programs are capacity buildup, seed cycle maintenance, varietal development, collection and conservation of varieties including local varieties, insurance to potato. Projects are also supporting to both table potato and seed potato, like Prime Minister Agriculture Modernization Program (PMAMP), Food and Nutrition Security Project (FANSEP), and others. Potato is one of the national priority agriculture commodities of PMAMP, where there are two Superzones (in Kavre and in Dadeldhura) and twenty Zones. For the Superzones, areas have to be. In the Superzones, one is in Kavre district and another is in Dadeldhura district of Nepal.

Potato zones are implementing in Okhaldhunga, Ramechhap, Rasuwa, Nuwakot, Bhaktapur, Kathmandu, Baglung, Dailekh, Bajhang, Achham, Panchthar, Dolkha, Gorkha, Manang, Myagdi, Rolpa, Rukum East, Mustang, Rupandehi, Jumla districts of Nepal. The productivity of potato production area of PMAMP is 23.28 mt/ha. Programs focused to potato are technology transfer – production package (seed, micronutrients, plant protection, technology). To promote seed certification, DAS-ELISA testing protocol for six virus testing, is under implementation; and the minimum infrastructure standard required for the production of foundation/basic seed has been started.

Problems and Challenges

Seed potato

The problems and challenges in seed potato in Nepal are enlisted herewith:

- True Potato Seed (TPS)
 - Quality of parental lines of TPS (parental lines TPS67, TPS7, MF2) has been deteriorated.
 - There is limited market for TPS
 - Production of TPS demands highly technical skill.
- Pre-Basic Seed
 - There is inadequate storage facility for long time
 - Highly technical skill is required to produce PBS
 - There is marketing problem in PBS
 - There is remaining yield gap
 - There is difficulty to maintain the seed cycle of potato seed and which results difficulty in seed certification system potato
 - There is no insurance during cold storage of PBS

Other tuber crops

Similarly, there are problems in seed of other tuber crops which are low quality planting materials; insufficient or poor technology; inadequate or poor post-harvest handling technology; unorganized markets; and cultivation in marginal land

Way Forward

In the present condition, to be self-sufficient in potato, there are two options like productivity enhancement or area expansion. In case of productivity increasement, it is necessary to raise productivity up to 18.53 mt/ha. Or if self-sufficiency will be meet by area expansion, the area of potato has to be raised up to 17,898 Ha.

Focusing either one option productivity or area, the seed cycle maintenance and seed certification, and varietal development are mandatory for achieving self-sufficiency. Similarly, strengthening of the prevailing organizations which have license for producing PBS is necessary. Development of varieties having high productivity, stress resistance, varieties need for industrial sector and biofortified varieties, will be other steps to be done in potato sector. Coordination has to be done with International Potato Center for receiving new parental lines for TPS (TPS67, TPS7, MF2). There is need to develop technical know-how for TPS and PBS production. Farmers have to be encouraged for storing the PBS in cold storage by providing subsidy to the farmers. Nepal is rich in agrobiodiversity, and in potato there are many local germplasms, so the conservation and utilization of local and indigenous germplasm of potato have to be focused by our programs and policies. Branding of potato in producing in specific geographical regimes will be next step to promote our local potato like mude ko alu may one brand and many other brands can be created in potato based on geographical locations.

Conclusion and Recommendation

Potato can be a strategic commodity for food security in Nepal. By using quality seeds, the productivity can be enhanced as well as the program for area expansion can be launched to move to self-sufficiency programs ahead. However, the seed cycle maintenance, certification, varietal development, conservation of local germplasm has to be done by the government of Nepal.

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Seed Management and its Impact on Processing for the Potato Industry

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Abstract

The role of seed potatoes and their management in enhancing productivity and quality is highly significant for both processing and table potatoes. Processing industries require high-quality potatoes, which can only be achieved with the use of high-quality seeds. This paper highlights current practices, challenges, and innovations in seed production, storage, and distribution, evaluating their impact on the potato value chain. The reviews the present status of seed management and its impact on Nepal's potato industry while assessing its future prospects.

Keywords: Potato processing, Seed management, Seed quality, Value chain, Varieties

Introduction

Potato (*Solanum tuberosum*) is one of Nepal's most important cash crops, playing a vital role in food security and income generation. It is cultivated across diverse agro-climatic zones, from the Terai (plains) to the mountainous regions, allowing for year-round production.

Seed management is a pivotal factor influencing potato yield, quality, and resilience to diseases. The use of quality seeds significantly enhances productivity and ensures consistency in final products. However, Nepal's potato industry faces significant challenges, including limited access to disease-free certified seeds, inadequate storage facilities, and fragmented distribution channels. Addressing these issues is critical for the sustainable growth of the processing sector and the overall agricultural economy.

Transforming potatoes into various food products through different manufacturing processes is known as potato processing. The potato processing industry encompasses grading, cleaning, peeling, cutting, blanching, frying, freezing, and packaging. Changing food habits have increased the demand for processed potato products such as French fries, chips, flakes, mashed potatoes, and dehydrated potato products. Processing requires clean seeds of specified variety and specific cultivation practices that meet quality standards for the best final products.

Despite its significance in food security and income generation, the average productivity of potatoes in Nepal remains among the lowest in the world. The major limiting factors include the use of inferior seeds or ware potatoes as seeds by the majority of farmers and the lack of proper production technologies.

Background and Context

Nepal's potato industry has been expanding due to increasing domestic consumption and the growing popularity of processed products like chips and fries. However, the industry faces challenges, including limited access to processing varieties, high-quality seeds, inadequate seed storage facilities, and a lack of coordination between farmers and processing companies. The absence of appropriate processing varieties and the unavailability of quality seeds often lead to lower yields and quality inconsistencies, hindering the development of the processing sector.

With the rising demand for processed potato products, new processing industries are emerging and seeking suitable potato varieties. The National Potato Research Program (NPRP, NARC) has yet to develop many processing varieties, but private sector initiatives, such as First Choice Foods Pvt Ltd (FCF), have introduced some varieties. NPRP and private sectors are now focusing on the development of processing varieties.

Seed System

1. Evolution of the seed system

In 1989, a tissue culture laboratory was established with financial and technical support from the Swiss government. Contract growers were encouraged to form cohesive groups for informal high-quality seed production. Today, source

seed (pre-basic seed) is still supplied by the tissue culture laboratory. Over the past decade, the government has set up one tissue culture lab at the Potato Development Center, Nigale, and supported seven private labs out of eight to meet the national PBS demand of 850,000 PBS per annum. (Table 1).

Table 1: Tissue culture lab and PBS production in Nepal

S.N.	Name	Address	Established	Current status	Capacity	Remarks
Private tissue culture lab						
1	Ficus Bio-Tech Pvt. Ltd.	Budhanilkantha 02, Kathmandu, Gauradaha 02, Jhapa	2075 BS	Working	100 thousand tubers	50% assist by NPDP/GOV.
2	Shreeram Niketan Bio-Tech Pvt. Ltd.	Godawati Mun., Lalitpur	2075 BS	Working	200 thousand tubers	Self-assist
3	Kushal Agriculture Research and Development Center Pvt. Ltd. (KARDC)	Koteswor Kathmandu, Field Side Laxmana Bardiya	2069 BS	Working	100 thousand tubers	50% assist by RISMFP
4	Nepal Krishi Anusandhan Tatha Bikas Kendra	Hetauda 18, Jalari Makawanpur	2075 BS	Partially working	100 thousand tubers	50% assist by NPDP/GOV.
5	One Step Agriculture Solution Pvt. Ltd.	Dhangadi 05, Kailali	2075 BS	Partially working	100 thousand tubers	50% assist by NPDP/GOV.
6	Pragatisil Yuwa Krisak Samuha	Nala, Kavre	2065 BS	Closed	50 thousand tubers	PACT, PMAMP, and District Development Committee
7	Khaddhyanna Biu-aalu, Alaichi Falful Narsari Udyog	Panauti 02, Kushadevi Kavre	2075 BS	Working	100 thousand tubers	50% assist by NPDP/GOV.
8	Nepal Biu Utpadan Kendra	Taukhel, Godawari Lalitpur	2060 BS	Partially working	100 thousand tubers	PACT
Government tissue culture lab						
1	National Potato Research Program	Khumaltar, Lalitpur	1989 AD	Working	200 thousand tubers	
2	Seed Potato Center	Nigale, Sindhupalchok	2075 BS	Working	100 thousand tubers	

Nepal's seed production operates under three systems:

- 1. Traditional System:** Small farmers produce potatoes for self-consumption, using leftover stocks from the local market as "seed potatoes." These are often small-sized whole tubers (10-15 gm).
- 2. Formal System:** Government farms produce seed potatoes under strict technical norms and certification rules. However, limited land availability restricts large-scale seed production.
- 3. Seed Producer Group (SPG) Approach:** Launched in 2010, this government-led initiative trains farmers to produce certified seed potatoes under the Seed Quality Control Centre (SQCC). However, economic constraints and inadequate/improper storage facilities hinder the sustainability of this program.

Seed Management Practices in Nepal

1. Seed production and certification

Seed potato production is challenging due to low multiplication rates, high disease pressure, rapid seed degeneration due to virus infections, damage during transportation, and post-harvest losses in storage.

While seed production involves government agencies, cooperatives, and private entities, certification remains inconsistent. Some seed producer groups and private agencies follow Truthful Labelling, but a standardized certification process is crucial to ensuring disease-free, high-quality seed.

2. Varietal selection

Processing quality depends on the selection of potato varieties. Preferred varieties have high dry matter content, low sugar accumulation, appropriate shape and size, and resistance to pests and diseases. Recent experiments show that:

- **Best varieties for French fries' production:** Innovator, Sagitta, Alverstone Russet, Santana, Frysona and Lady Rosetta were introduced by First choice foods Pvt. Ltd.
- **Best varieties for potato chips:** Khumal White-2, Khumal Ujwal, Khumal White-4 were released and recommended by PRP.

3. Storage and distribution

Poor storage infrastructure leads to post-harvest losses and deterioration of seed quality. There is no distinct storage system for seed, ware, and processing potatoes in Nepal. Recently, FCF has developed a cold storage facility specifically for processing potatoes. Investment in low-cost storage solutions and cold chain logistics is essential to maintaining seed quality throughout the year.

Impact on the potato processing industry

High-quality seed directly increases yields and improves tuber quality, essential for processed products. Consistent access to disease-free seed ensures uniformity in shape, size, and taste critical factors for industrial processing. Conversely, poor seed quality leads to irregularities that impact processing efficiency and final product quality. Availability of high-quality seed varieties can also boost export opportunities by enhancing the competitiveness of Nepalese potato products in international markets.

Major Constraints

Key challenges facing Nepal's potato industry include:

1. Limited availability of processing varieties

To date, the National Potato Research Program (NPRP) has focused exclusively on table varieties. Of the 17 varieties released or registered (12 released and 5 registered), only two are suitable for both table and chip processing. No cultivars have been developed specifically for French fries or other processing purposes. Recently, few varieties introduced by First Choice Foods (FCF), a private sector company, have been tested and three varieties among them were registered for French fry production. This limited availability of processing-specific varieties particularly those with high dry matter and low sugar content constrains the potential for industrial processing and value addition. The absence of such varieties poses a significant barrier to the development of a robust potato processing industry in the country.

2. Inadequate human resources and infrastructure

There is a notable shortage of skilled professionals in key areas such as agronomy, seed science, and plant breeding—particularly those specializing in potatoes. In addition, essential supporting infrastructure, including collection centres, curing houses in production areas, disease indexing facilities, and decentralized seed storage units, is either inadequate or underutilized. This is often due to poor planning and substandard construction, especially in regions designated for seed production.

3. Inefficient seed production approaches

Nepal continues to rely heavily on traditional and informal seed systems. Many farmers save and reuse their own seed tubers year after year, or use leftover tubers after household consumption or market sales. This practice leads to the accumulation of diseases and the progressive degeneration of seed quality. There is a significant disconnect between the National Potato Research Program (NPRP), private tissue culture laboratories producing pre-basic seeds (PBS), and seed producer groups (SPGs). Consequently, the seed production cycle remains incomplete, and

the adoption of modern seed multiplication techniques for producing improved seed potatoes is minimal to non-existent.

4. Lack of a proper seed certification system

In Nepal, the Seed Quality Control Center (SQCC) holds full responsibility for the seed certification process. However, due to inadequate staffing within the SQCC and related institutions, the certification system for potatoes is either weak or inconsistently enforced. The absence of standardized inspection protocols, effective quality control, and traceability systems further hampers the availability of high-quality, certified seed potatoes for farmers. This undermines farmer confidence in the seed supply chain and discourages the growth of commercial seed enterprises.

5. Low technical expertise among farmers

Most seed producer groups (SPGs) and farmers in Nepal lack adequate awareness and training in modern seed production practices, including disease management, grading, and post-harvest handling. Extension services remain limited, and access to information on improved agronomic practices, the use of quality seed, and proper storage techniques is insufficient across all provinces. This knowledge gap hinders productivity and the overall quality of seed potatoes.

6. Limited irrigation facilities

Irrigation remains a major constraint in many potato-growing regions of Nepal. In the mid and high hills, rain-fed farming is the predominant practice, making potato production highly vulnerable to climate variability. The lack of reliable irrigation infrastructure limits the ability to expand seed potato production across multiple seasons and regions, thereby restricting productivity and resilience.

7. Poor cold storage infrastructure

Potatoes require controlled storage conditions to maintain quality. However, Nepal faces a significant shortage of well-distributed, energy-efficient cold storage facilities. There is no specialized storage system in place; seed, ware, and processing potatoes are typically stored under the same conditions. Existing facilities are often concentrated in urban areas, making them inaccessible to farmers in higher hills, lower mid-hills and remote areas. This lack of appropriate storage leads to high post-harvest losses and premature or over sprouting, ultimately compromising in quality and market value.

8. Insufficient incentives for industries and farmers

The government provides limited financial support for seed production, particularly for purchasing pre-basic seeds (PBS), irrigation, and mechanization. This support is insufficient, and as a result, seed producer groups (SPGs) and farmers often cannot afford to retain seed tubers through the necessary 34 production cycles required to produce improved seeds. Economic constraints hinder their ability to invest in quality seed production. There is a clear need for targeted subsidies at each stage of the seed production cycle, along with improved access to credit and crop insurance, to encourage greater investment in seed production and supporting infrastructure.

9. Weak coordination between production, marketing, and processing sectors

Currently there is lack of seed booking system in Nepal, which creates uncertainty in seed production and weakens coordination across the potato value chain. Seed producers, ware potato growers, traders, processors, and policymakers often operate in isolation, resulting in fragmented efforts. This disconnection leads to mismatches between supply and demand, price volatility, and the underutilization of both production and processing capacities.

Future prospects

With urbanization, population growth, and changing food habits, the demand for processed potatoes is increasing. Potatoes' high productivity per unit area makes them crucial for food security and poverty alleviation. Clean seed availability could boost production by up to 49%. Improved seed production, disease control, varietal enhancement, and efficient processing can unlock significant potential for Nepal's potato industry.

Import analysis

Nepal's import of processed potato products has consistently increased over the past five years. Nearly all processing potatoes are imported from India, along with about 10% of the country's table potato consumption (350,000–400,000 tons annually). Despite Nepal's ecological suitability for year-round fresh potato production, inadequate seed management forces heavy reliance on imports.

Nepal's ecological conditions are highly suitable for year-round fresh potato production, making it well-positioned to meet both internal and export market demands. There is active willingness and participation from farmers and cooperatives in seed and ware potato production. The government committed to support essential machinery such as planters, ridgers, and harvesters, facilitating agricultural productivity. Additionally, there are abundant storage facilities in both cold storages and rustic storages, though they are currently utilized at only 50–60% of their capacity. Furthermore, Nepal has sufficient laboratories for quality PBS production.

Despite these resources, a critical question arises: Why does Nepal still need to import table potatoes, processed potatoes, and potato-based products?

Conclusion

Nepal possesses significant potential for potato production, yet the country continues to rely heavily on imports. One of the key challenges is the quality of seed potatoes, which must be addressed to boost domestic productivity. To establish a sustainable seed management system, government policies should prioritize support for seed potato production, storage, processing, and distribution. This includes providing targeted subsidies for seed producers and related industries, enforcing stricter seed certification standards, and revising existing regulations to ensure quality and sustainability across the value chain.

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Current Status of Research on Vegetable Seed, Varietal Development, and Future Perspectives in Nepal

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Abstract

The horticultural sector in Nepal significantly contributes to the national economy, food security, and rural livelihoods. It has been notable progress in vegetable seed research and varietal development during last decade. The National Horticulture Research Centre including other horticultural research stations have been involved in the varietal research and development. The current breeder and foundation seed production of major vegetable crops under NARC is about 1,900 kg (2080/81). The breeding programs are focused on the development of hybrid and stress-tolerant varieties. Currently, the NHRC has been doing hybridization of tomato, chili pepper and cucumber, and has identified promising pipeline tomato and cucumber hybrids having disease resistance, high yield, and climate resilience traits. Introduction of superior exotic germplasms with the collaboration of international organizations and exploitation of elite local landraces are the important strategies for the varietal development of vegetable crops in the future. Moreover, the prioritized areas of horticultural research include demand-driven varietal development, strengthening source seed production, and conserving local landraces. The strategic directions aim to reduce dependence on imported seeds, promote sustainable vegetable production, and address climate challenges. Overall, Nepal's vegetable seed research and varietal development efforts are pivotal in ensuring food security, improving farmer incomes, and fostering resilient agricultural systems capable of adapting to evolving environmental conditions.

Key Words: Horticulture, Hybrid varieties, Open-pollinated varieties, Seed research

Introduction

Horticultural crops play a significant role in Nepal's agricultural economy, contributing substantially to the livelihoods of farmers, enhancing food security, and providing essential nutrition. The diversity of Nepal's agroecological zones allows for the cultivation of a wide variety of horticultural crops, ranging from temperate vegetables to tropical spices and medicinal plants. The contribution of the agricultural sector to the gross domestic product (GDP) was approximately 24.12% (MoALD, 2023), while the contribution of the vegetable subsector was 5.99% (MoALD, 2022).

Realizing the importance of vegetable sector in Nepal, research studies on vegetable seed and varietal development of major vegetable species have been carried out for last few decades. National Horticulture Research Center (NHRC) carries out problem-based research, develops modern technologies, and transfers them to the farmers. Moreover, germplasm collection and conservation, varietal introduction, varietal development, source seed, and mother stock production, and hybrid breeding, and postharvest management in horticulture crops are some major thrust areas of research in the NHRC. NHRC is also responsible for planning, developing, and releasing/registering improved varieties of vegetables, fruits, spices, and other horticultural crops according to the National Seed Vision, 2015. NHRC has released and registered some varieties of vegetable crops during recent years (NHRC, 2021). NARC is steadily advancing its efforts in seed research as part of its broader mandate to generate demand-driven technologies for vegetable crop production. The Centre has been also focusing on the varietal development, seed quality enhancement, and the adaptability of vegetable crops to diverse agro-ecological zones.

Methodology

This paper provides a concise comprehensive overview of vegetable crop research conducted within the NARC's research stations over the past two to three years. The information in this research paper has been included from a variety of published scientific literatures, NARC station's annual reports, and technical papers. The report highlights key research achievements on the varietal development and release and breeder and foundation seed production.

Results and Discussion

1. Existing Stations and Centers for horticulture research and seed production under NARC

Among the 63 research Stations established by the Nepal Agricultural Research Council (NARC) across Nepal's diverse agro-ecological zones, 19 research stations are devoted exclusively to horticulture. There is NARC's strategic commitment to advancing horticultural science, particularly in the field of vegetable research. These stations are instrumental not only in developing improved technologies on horticultural crops including varietal development and seed research.

Vegetable seed research in Nepal has become a focused area of NARC's that high-quality of improved varieties of vegetable species are crucial for enhancing productivity, reducing dependency on imports, and supporting food security. The major research programs at the NARC's horticultural stations include varietal development, testing, multiplication, and dissemination of superior varieties. The horticultural research carried out in different Stations and Centre includes national centers, provincial directorates, and commodity programs. The research emphasis is given on the development of appropriate agro-technologies based on the farmers' needs and problems, development of disease-resistant, high-yielding, and climate-resilient vegetable varieties.

2. Annual Vegetable Breeder and Foundation Seed Production by NARC Research Stations

In the fiscal year 2080/81, a total of **1,896.35 kg of vegetable seeds**, comprising **188.92 kg of breeder seed** and **1,707.43 kg of foundation seed** was produced by different NARC's Research Stations nationwide. The crops that the source seeds are being grown, are comprised of cauliflower, tomato, broad leaf mustard, radish, French bean, cowpea, turnip, cucumber, okra, brinjal, spinach, garden pea, carrot, Swiss chard, sweet pepper, onion, and lablab bean. The objective of the source seed production from the NARC is to support to the Private Seed Companies for the quality seed production.

Table 1: Status of Source Seed Production by NARC Research Stations in 2080/81

S.N.	Crop	Station	Breeder seed (kg)	Foundation seed (kg)	Total (kg)
1	Cauliflower				
	i. Kathmandu Local	NHRC, Khumaltar	0.7		0.7
		DoAR, Lumle		1.05	1.05
	ii. Khumal Jyapu-1	NHRC, Khumaltar	2.8	14	16.8
		ARS, Pakhribas		2.3	2.3
	Sub Total		3.5	17.35	20.85
2	Tomato				
	i. Srijana Parent Line	NHRC, Khumaltar	0.3		0.3
	ii. Khumal Golbheda Hybrid-2, Parent line	NHRC, Khumaltar	0.015		0.015
	iii. Khumal Golbheda Hybrid-3, Parent line	NHRC, Khumaltar	0.015		0.015
	iv. Pusa Ruby	DoAR, Khajura		1	1
		DoAR, Parwanipur		0.5	
	Sub Total		0.33	1.5	1.33
3	Broad Leaf Mustard				
	i. Khumal Ratopat	NHRC, Khumaltar	1		1
	ii. Khumal Chaudapat	NHRC, Khumaltar	1		1
		DoAR, Parwanipur		0.55	0.55
		HRS, Dailekh	3.75	65.01	68.76
	iii. Manakamana Rayo	HRS, Malepatan	1	20	21
		DoAR, Lumle		1	1
	iv. Marpha Chaudapat	HRS, Jumla	0.5	41.5	42
		DoAR, Lumle		2	
	v. Tangkhuwa Rayo	ARS, Pakhribas		10.3	10.3
	vi. Belachapi Chaudapat	ARS, Belachapi	10		10
	vii. Red Giant	DoAR, Lumle		0.7	0.7
	Sub Total		17.25	141.06	156.31
4	Radish				
	i. Mino Early	NHRC, Khumaltar	1		1

S.N.	Crop	Station	Breeder seed (kg)	Foundation seed (kg)	Total (kg)
		ARS, Pakhribas		88	88
		DoAR, Lumle		6	6
		HRS, Dailekh	3	54.82	57.82
	ii. 40 Days				
	HRS, Malepatan	1	20	21	
		DOAR, Tarahara		11	11
		DoAR, Khajura		0.5	0.5
		NHRC, Khumaltar	0.34		0.34
		DoAR, Lumle		6	6
		HRS, Dailekh	1		1
	iii. Pyuthane Rato	NHRC, Khumaltar	0.5		0.5
		DoAR, Lumle		1	1
	iv. Pusa Chetki	DoAR, Parwanipur		1	1
	v. Tokinashi	HRS, Jumla	0.5	9.5	10
	vi. Lumle Red	DoAR, Lumle		2	2
	vii. Sakurijima	DoAR, Lumle		0.7	0.7
	Sub Total		7.34	200.52	207.86
5	Bean				
	i. Trishuli	HRS, Malepatan	2	10	12
		ARS, Pakhribas		173	173
		NHRC, Khumaltar	24		24
		HRS, Dailekh	9	16.7	25.7
	ii. Four Season	HRS, Malepatan	5	40	45
		HRS, Dailekh	18.7	45	63.7
		NHRC, Khumaltar	8		8
	iii. Semi Light Long	NHRC, Khumaltar	8.8		8.8
	iv. Long Green Bean	NHRC, Khumaltar	6		6
	Sub Total		81.5	284.7	366.2
6	Cowpea				
	i. Khumal Tane	NHRC, Khumaltar	3		3
	ii. Meter Long	DOAR, Tarahara		13	13
	iii. Sarlahi Tane	DOAR, Tarahara		29	29
	iv. Great Wall-2	NHRC, Khumaltar	1.4		1.4
	v. Great Wall-3	NHRC, Khumaltar	1.6		1.6
	vi. Prakash				
	vii. Surya				
	viii. Malepatan-1	HRS, Malepatan	10	300	310
		DOAR, Tarahara		2	2
	Sub total		16	344	360
7	Turnip				
	i. Kathmandu Red	NHRC, Khumaltar	5		5
	Sub total		5		5
8	Cucumber				
	i. Bhaktapur Local	NHRC, Khumaltar	4.6		4.6
		DoAR, Lumle		2.6	2.6
	Sub Total		4.6	2.6	7.2
9	Okra				
	Parwani Kranti	DoAR, Parwanipur		4	4
	Arka Anamika	HRS, Malepatan	5	50	55
		DoAR, Khajura		7	7

S.N.	Crop	Station	Breeder seed (kg)	Foundation seed (kg)	Total (kg)
	iii. Parvati	HRS, Malepatan	5	50	55
		DOAR, Tarahara		18	18
		DoAR, Parwanipur		3	3
	Sub Total		10	132	142
10	Brinjal				
	Pusa Purple Long	DoAR, Khajura		2	2
	PS-1	DoAR, Parwanipur		15	15
	iii. Pokhara Lurkee-1	HRS, Malepatan		3	3
	Sub Total			20	20
11	Spinach				
	i. All Green	HRS, Malepatan	5	50	55
	Sub Total		5	50	55
12	Garden Pea				
	i. Sikkime Local				
	ARS, Pakhribas		26	26	
		DoAR, Lumle		11	11
		HRS, Dailekh	15.5	63	78.5
	ii. Arkel				
	ARS, Pakhribas		32	32	
		DoAR, Khajura		29	29
		HRS, Jumla	5	100	105
		HRS, Dailekh	7.4	90	97.4
	Sub Total		27.9	351	378.9
13	Cress				
	i. Chamsur Sthaniya	ARS, Pakhribas		13.5	13.5
	Sub Total			13.5	13.5
14	Broccoli				
	i. Green Sprouting	ARS, Pakhribas		17.2	17.2
	Sub Total			17.2	17.2
15	Carrot				
	i. New Kuroda	HRS, Jumla	0.5	25.5	26
	Sub Total		0.5	25.5	26
16	Swiss Chard				
	i. Susag	HRS, Jumla	0.5	17	17.5
	Sub Total		0.5	17	17.5
17	Sweet pepper				
	i. California Wonder	DoAR, Khajura		2	2
	Sub Total			2	2
18	Onion				
	1.1 Red Creole				
	HRS, Jumla	0.5	4.5	5	
		HRS, Dailekh	3	86.5	89.5
	Sub Total		3.5	91	94.5
19	Lablab bean				
	Malepatan Hiunde Simi-1	HRS, Malepatan	3		3
	Malepatan Hiunde Simi-2	HRS, Malepatan	3		3
	Sub Total		6		6
	Total		188.92	1707.43	1896.35

Table 2: F1 tomato hybrid seed production by Private Sectors in 2078/79**F1 tomato hybrid seed production by private sector and farms in 2078/079**

S. N.	Name of organization	Inbred seed provided (g)	Estimate Hybrid seed produced (kg)
1.	Anmol Seeds Pvt.Ltd	20	3.5
2.	Kathmandu Agro Concern, Lalitpur	55	6
3.	CEAPRED, Lalitpur	28	30
4.	Sarba Shrestha Seed Pvt. Ltd. Bhaktapur	35	45
5.	Himalayan Seeds Research & Training Center, Dolakha	20	13
6.	Raina Seed International, Kathmandu	13	10
7.	Pramila Krishi Farm, Kathmandu	13	10
8.	Gorkha Seed Pvt. Ltd. Kathmandu	70	42
9.	Dibya Seed Pvt. Ltd. Kathmandu	5	0
10.	Namuna pryabarniya krishi farm, Dang	50	9
11.	Sivasakti Agro& Seed center Pvt. Ltd. Lalitpur	7	3
12.	SEAN Seeds and Service Centre	3	27
13.	Bimal agro farm and research centre, Bharatpur	11	5
14.	Crimson Integrated Farm, Godawari	7	2.5
15.	Nirjala Seeds and Agro Pvt.Ltd	7	2
16.	Barahi Mauri tatha Ghaar Nirman Udhhyog, bajrabarahi	3	0.5
17.	Urja Agro Pvt.Ltd	6	4
18.	Vegetable Crop Development Centre, Lalitpur	21	12
19.	Vegetable Seed Production Centre, Rukum	8	3
20.	Horticulture Development Resource Centre, Malepatan	5	0.4
21.	Spices Crop Development Center, Panchkaha	10	1
22.	Horticulture Research Station, Malepatan	7	0.2
23.	Horticulture Research Station, Dailekh	4	0.5
	Total	408	229.6

3. Varietal Improvement in Vegetable Crops

NARC has significant achievements on the varietal development of vegetable crops. As of now, a total of **281 varieties** have been released and or registered. Of the total, **94 are open-pollinated (OP) and 187 are hybrids**. The **National Horticulture Research Centre (NHRC)** has played a pivotal role on the varietal development including hybrids. Notably, the Centre has recently released two tomato hybrids: namely **Khumal Golbhenda Hybrid-2** and **Khumal Golbhenda Hybrid-3**. in order to meet the diverse needs of growers and the market. In **2080/81**, five varieties: **Pokhara Lurki-1**, a variety of brinjal developed by the **Horticulture Research Station (HRS), Malepatan**, **Kalo Bhanji** and **Jimpakha Rayo**, broad leaf mustard varieties, **Tistung Akbare**, a **chili variety**, and **Madale Kakro**, a variety of cucumber have been registered. The inclusion of farmer-developed varieties reflects a growing emphasis on the local adaptation and more resilient varieties in the climate change context.

4. Registered/released varieties during 2021 to 2024**Cucumber**

- **Madhu F1:** A hybrid variety known for its attractive appearance and superior taste. It exhibits a vigorous branching habit with multiple branches. The first fruit sets at around **58 days after transplanting**. Fruits weigh approximately **550–565 g.**, with an average yield of **70–75 tons per hectare**. The predominant fruit skin color is **white** and it is recommended for cultivation in the **mid-hill regions** (600–1600 m asl). The variety was released by NHRC in 2022.
- **Krishna F1:** This hybrid cucumber also features attractive color and excellent taste. It has a similar branching

habit as of Madhu and sets fruit **55 days after transplanting**. Average fruit weight ranges from **530 to 535 g**, with an yield of **60–65 tons per hectare**. The fruit skin is green and it is suited for the eastern hill regions (**600 -1600 masl**). The variety was also released by NHRC in 2022.

Tomato

- **Khumal Golbhenda Hybrid-2:** An indeterminate hybrid tomato, has average fruit weigh **70–80 g**. It yields **60 - 70 tons per ha**, with first harvest at **70 days in mid-hills** and **80 days in the Terai**. It is **tolerant to late blight** and produces red fruits. The variety is recommended for **mid-hills and Terai**, and it was released by NHRC in 2021.
- **Khumal Golbhenda Hybrid-3:** This hybrid is also an indeterminate type, having average yield of **60 - 65 tons per ha**, with an average fruit weight of **70-75 g**. First harvest occurs at **65 days (mid-hills)** and **75 days (Terai)**. It is **late maturity, blight tolerant**, with **red-colored fruits** and recommended for the **Terai and mid-hills**. The variety was also released by NHRC in 2021.

Onion

- **Khumal Pyaj-1:** Yield **40–45 t/ha**, with green leaves 40–45 cm long and **10.2 mm wide**. Bulb weigh **160–180 g** and are **light yellow** in color. The variety was registered by NHRC in 2024.
- **Khumal Pyaj-2:** Yield **35–40 t/ha**, with green leaves 37–40 cm long and **8–9 mm wide**. Bulb weight **120–130 g**, with a **dark violet** color. The variety was registered by NHRC in 2022.

Lablab Bean

- **Malepatan Hiudesimi-1:** Light green pods, sowing time: **Asar–Shrawan**, first picking at **140-150 days after sowing**, with a yield of **25-30 t/ha** and recommended for **300-1250 m asl**. The variety was registered by HRS, Malepatan in 2022.
- **Malepatan Hiudesimi-2:** Pod color: light violet, first harvest at **135-145 days after sowing**, yield: **15-20 t/ha**, and recommended for **300-1250 m asl**. The variety was registered by HRS, Malepatan in 2022.

Broad Leaf Mustard

- **Manakamana Rayo:** It is ideal for planting between **Asoj-Kartik in 800–1600 m asl**. The variety was registered by HRS, Malepatan in 2021.
- **Belachapi Chaudapat:** Features **soft leaves** and **late bolting**, recommended for the **Terai and inner Terai** regions. The variety was registered by ARS, Belachapi in 2024.

Garlic

- **Rajikot Lasun-1:** An open-pollinated variety with a **maturity period of 250-260 days** and a yield of **17.26 t/ha**, suitable altitude for **2000–3000 m asl in Karnali Province**. The variety was registered by HRS, Rajikot in 2024.
- **Rajikot Lasun-2:** Matures in **230-240 days**, with a higher yield of **21.8 t/ha**, recommended for the same elevation range. The variety was registered by HRS, Rajikot in 2024.

Brinjal

- **Pokhara Lurki-1:** Fruit yield 25-30 t/ha with **15–26 cm** fruit length. First picking at **70–75 DAT**. The variety was registered by HRS, Malepatan in 2024.
- **Parwanipur Selection:** Grows to a height of **65-75 cm**, has a **crop duration of 170-180 days**, and yield of **25-26 t/ha**. The variety was registered by DoAR, Parwanipur in 2021.

French Bean

- **Chaumase Simi:** This variety begins pod picking at **55–60 DAS**, with yield of **18-20 t/ha**. It is well-suited for cultivation in the **Terai, mid-hill, and high hill regions** up to an elevation of **2200 m asl**. The variety was registered by NHRC in 2022.

5. Promising/Pipeline Varieties

The NHRC in collaboration of Horticultural Research Stations and Directorate of Agricultural Research has made significant progress in developing promising varieties of vegetable crops. The evaluation and verification of promising cultivars of various vegetable species are underway. These pipeline varieties are as following:

Table 3: Promising genotypes of vegetable crops

S.N.	Crop	Variety	Characteristics	Recommended Domain	Office
1	Cauliflower	Terai-1	Harvesting period 63 DAS, average curd weight 248 g, relatively heat tolerant, and yield 20.89 t/ha	Mid-hills	NHRC
2	Cauliflower	Terai-2	Harvesting period 58 DAS, average curd weight 193 g, relatively heat tolerant, and yield 14.67 t/ha	Mid-hills	NHRC
3	Taro	HRMCO001	Corm diameter: 17.2 cm, corm weight: 1.5-3.5 kg, and yield: 40-50 t/ha	Terai and mid-hills	HRS, Malepatan
4	Radish	HRDRAD002 (Okura)	Mid-season variety, short and thick white root, serrated green leaves, and yield 63.20 t/ha	Terai and mid-hills	NHRC
5	Radish	HRDRAD005 (Miyasige)	Mid-season variety, oblong thick and white root with green top, serrated green leaves, and yield 63.90 t/ha	Terai and mid-hills	NHRC
6	Tomato	AVTO 0301	Indeterminate, late blight resistant, oval fruits (45-50 g), and yield: 45-50 t/ha	Terai, inner Terai, mid-hills	NHRC
7	Tomato	AVTO 1705	Semi-determinate, oval fruits (50-60 g), and yield 35-40 t/ha	Terai and inner Terai	NHRC
8	Potato	CIP 392025.7	Suitable for chips, late blight tolerant, and yield 20-28 t/ha	Terai, mid, and high hills	NPRP, Khumaltar
9	Capsicum	HRDCAP001	Determinate, fruit weight 69.9 g, yellow fruit color, and 37.8 t/ha	Mid-hills	NHRC
10	Pea	HRSDGP11-13	Flowering within 58 DAS, green pod yield 12.9 t/ha, seed yield 1.30 t/ha, powdery mildew tolerant	Mid-hills	HRS, Dailekh

6. Progress in the development of hybrids and stress-tolerant varieties at NHRC

The **NHRC, Khumaltar** has been focused on the hybrid development including biotic and abiotic stresses tolerant varieties of major vegetables. It has been significant progress in **tomato hybrid development**. Currently, multi-location evaluation of **35 F1 single-cross tomato hybrids has been underway for last three years**. The precious traits including bacterial wilt and late blight resistant, fruit characteristics and yield of exotic germplasms are considered for developing hybrids. Most of the genotypes introduced from **the World Vegetable Centre, Taiwan** have been included in the hybridization. From these F1 hybrids, some promising hybrids have been screened and are kept in pipeline for the release in coming season.

Besides tomato hybrid development, hybridization programs in cucumber, **bitter gourd, sweet pepper, and brinjal have been progressed in NHRC**. Currently, evaluation of the developed F1 hybrids for their specific traits under different agro-climates are going on in collaboration with NARC Horticultural and Provincial Directorates. Likewise, screening of tomato genotypes against two diseases: late blight and bacterial wilt have been conducted for last six years in NHRC. Among the lines, **AVTO 1915** and **AVTO 1705** were identified as resistant to late blight, while **AVTO 1314**, **AVTO 1718**, and **AVTO 9802** showed moderate resistance. For bacterial wilt, **AVTO 0301** demonstrated strong resistance, and both **AVTO 0301** and **AVTO 1718** were found moderately resistant. Notably, **AVTO 1718** showed dual tolerance to both diseases, making it a valuable genetic resource for developing resilient tomato hybrids.

Moreover, NHRC has introduced several genotypes of tomato, sweet pepper, brinjal, bitter gourd, and cucumber from international research institutions, with a strategic focus on enhancing crop resilience to various biotic and abiotic stresses. These genotypes have been specifically evaluating for their **tolerance to biological challenges** including various **diseases, heat stress, drought, and soil** factors.

7. Future Strategies to Strengthen Vegetable Research

Prioritize Demand-Driven Varietal Development: NARC should focus on the varietal development, addressing the farmers' needs, market demand, and climate challenges. Incorporating participatory breeding approaches will

ensure greater relevance, adoption, and impact of research outputs.

Strengthen Breeder Seed Production and Maintenance Breeding: Enhance the capacity of NARC's Stations to produce and maintain high-quality nucleus and breeder seeds of the released and or registered varieties.

Enhance Research Infrastructure and Human Resources: Invest in modern research infrastructure, laboratories, and equipment, particularly for seed physiology, biotechnology, and genetic analysis, including capacity-building programs for the human resources.

Promote Conservation and Use of Indigenous Genetic Resources: Priority should be given on the collection, conservation, and utilization of indigenous landraces and varieties, which are crucial for developing climate-resilient and high-yielding varieties.

Expand Public-Private and Institutional Partnerships: NARC should collaborate research programs with universities, private seed companies, NGOs, and international organizations to leverage resources, access global germplasm, and develop varieties of consumer's preference and market trend.

Coordination with Extension and Seed Production Agencies: Foster coordination among NARC, DoA, NCPVC, and Private Seed Companies and Cooperatives to ensure wide delivery of improved varieties and seeds through national seed systems, and feedback from the stakeholders.

Enhance Data Management and Research Planning Systems: Develop a central seed research database and monitoring system to track breeding progress, varietal performance, and their dissemination.

Conclusion

Nepal's horticultural sector, particularly vegetable seed research and varietal development, has made significant achievements during last decade. NHRC and other NARC's Stations have released and registered open-pollinated as well as hybrids of major vegetables, which are high yield potential including disease resistant. Further efforts on the hybrid development, stress tolerance, and disease resistance have been continued with the objectives of enhancing productivity, climate resilience, and farmer's livelihoods. For future strategies to cope up the future challenges of climate changes and farmer's demand, there must focus on demand-driven breeding, conserving indigenous genetic resources, and fostering hybrids development.

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Present Status of Seed (Potato and Tuber Crops) Research, Varietal Development and Future Perspective in Nepal

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Abstract

Potato (*Solanum tuberosum* L.) is an important vegetable crops of Nepal. It is the major component of vegetables of Nepalese people. The crop is being cultivated in the country throughout the year. Significant increase (from 20 kg to > 100 kg/person/year) in Per capita consumption of potato in Nepal shows the growing demand of potato within country. Besides, country has opportunity to get advantage from this crop by exporting to giant markets in neighboring countries. Major areas to be improved in the potato sector development is to strengthen its seed production system along with development of market preference variety. Research and development activities in potato was started since 1960s. Major seed sector research in tuber crops has been confined to potato though in beginning stage. Research to increase the quality, size and number of Pre-Basic-Seed (PBS) was initiated since the establishment of Nepal Agricultural Research Council (NARC). Similarly, varietal effect on the seed multiplication ratio, number of seed potato and their storability have been studied. Study on the effect of plant density, PBS generation and pruning in seed potato production have been done and recommended for seed production. Since the establishment of formal research and development program by then Government of Nepal, many genotypes of potato have been brought in the country and evaluated for the suitability in different agroecological regions. In later years, research on varietal development activities have been focused on disease and insect resistance, early maturing, good storability, suitability for processing, climate resilient and high yielding qualities. So, far thirteen varieties of potato released, and five varieties registered. Research on sweet potato varieties has been initiated. As a result of evaluation of exotic and local germplasms of sweet potato, two varieties have been released and few are in pipelines. Different research stations are involved in Collection and evaluation of germplasm of ole, yam and Colocasia. Ever increasing internal demand, and scope of marketing in neighboring countries are the big opportunities to increase the production and productivity of potato and other tuber crops in Nepal. This can be achieved by making strong seed system, utilizing the potentiality of agrodiversity, speed breeding using new breeding tools and product diversification.

Keynotes: Basic seed, Constraints, Generation, Seed replacement ratio.

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important crops of Nepal used in every kitchen of Nepalese family and consumed as both stable food and vegetable. It ranks first in terms of productivity, and second in area of cultivation and production after rice. The present productivity of potato in Nepal is 17.23 ton/hectare which is mainly due to the use of new varieties, improved cultivation technologies and clean seed potato (though not sufficient). In Nepal, potato can be produced throughout the year by utilizing the genetic and agroecological variation which ranges from 100 to more than 3000 masl. The area coverage of potato cultivation in high hills and mountain, Mid-hills and Terai is estimated as 18%, 42% and 40% respectively. Per capita consumption of potato in Nepal was estimated as <20 kg/person/year during 1990s which has been significantly increased to 90-95 kg/person/year in 2022.

The total production of potato is 3410829 MT from 198256 hectare of land with the productivity of 17.23 mt/ha. The seed replacement ratio (SRR) of potato in Nepal is 15% where the contribution of improved varieties in Nepal's total potato production is 51%. Formal research and development in Potato in Nepal was initiated during 1962 by establishing the potato farm in Nigale and Jaubari and formal official attempt was done by establishing the National Potato Development Program (NPDP) in 1972. After the establishment of Nepal Agricultural Research Council (NARC) as an autonomous body to conduct the higher study and research in agriculture, wings for potato research was put under NARC as National Potato Research Program (NPRP) in 1991. Since the establishment NPRP is involving in different research activities in potato and sweet potato, production, and distribution of pre-basic and basic seed of different varieties of potato.

Major Constraints of Potato Production in Nepal

The national average yield of potato in Nepal is low (17.23 mt/ha) as compared to other countries like USA (51.45 mt/ha), Sweden (36 mt/ha), India (25.79 mt/ha), Pakistan (24.43 mt/ha) and China (20.45 mt/ha) (FAO, 2023). A significant sum of national currency has been expensed to import large amount of ware potato, seed potato and potato products. The import can be reduced if the productivity of potato is increased. The major constraints which should be managed to increase the production and productivity of potato in the country.

Lack of early maturing and high yielding varieties

The varieties/genotypes of potato which are grown in Nepal are of long or medium maturing types. Nepalese farmers are demanding early maturing varieties (70-90 days) to fit this crop for their cropping system. Majority of cropping systems in Nepal are Maize or rice-wheat (high hills), Maize or rice-Wheat/or mustard (mid hills) and Rice-Wheat or legumes/mustard (in Terai). Farmers do not want to sacrifice the main crops which previously established in their cropping system that's why the area expansion under potato is not so rapid. They have preferred to incorporate the potato during the gap period between two major crops. Since the gap period is short, early maturing potato with higher yield could be the best option. And soil moisture management for potato will be easy because of the higher residual soil moisture after rainy season crops.

Inadequate availability of quality planting materials

Most of the farmers in Nepal are cultivating the potato using degenerated seed potato causing significant yield reduction. Almost 50% of total potato production area is covered by improved varieties. Majority of potato growers use the potato tubers saved for seed from generations or purchase the seed from market with no certification. More than 400 thousand metric tons of seed potato is required in Nepal. The productivity of potato can be increased by at least 25% using quality seed potato.

Informal seed production and limited distribution system

The demand of seed potato of different varieties is estimated as around 4 lakhs metric tons (as calculated with the total production 3.4 million tons with the seed multiplication ratio of potato as 8.5). The supply of seed potato to the farmer is very limited. Seed potato is produced through community-based seed producer group in few districts and distributed locally. The quantity of seed produced by farmers and farmers group is not sufficient even for district. Pre basic seed (PBS) has been produced by government laboratories (NPRP and PDC, Nigale) as well as few private laboratories after getting the license from Seed Quality Control Center (SQCC). Adoption of seed cycle through PBS to different generations of basic seeds (Basic seed 1 to Basic seed 4) is very weak. Seed cycle maintenance and seed distribution system has not been well established. Most of the potato seeds in mid hills and terai are sold in market without seed certification.

Limited nutrient, disease, pest management and mechanization practices

Potato is heavy feeder crop and demands higher nutrients. The availability of chemical fertilizers during potato cultivation is limited and on the other hand farmers are using very fewer chemical fertilizers than recommended dose. Many fungal, bacterial, and viral disease attack the potato crops and significantly reduce the yield. Because of the use of degenerated seeds, poor management practices, the yield of potato at farmers field is very low. Late blight is one of the major diseases causing the losses in farmer's field. Similarly, plants with viral infection have very less yield. Among major insect pest, aphid is one of the dominant insects helping the transfer of the viral disease from diseased to healthy plants. Due the land fragmentation and small land holding size of Nepalese farmers, mechanization in potato farming is quite difficult. Majority of potato growers in Nepal are using manual labor in almost all the activities in potato cultivation which have led to higher cost of production.

Limited seed storage facilities in the country

The availability of cold storage for fruits and vegetables are limited in the country. Potato needs special temperatures for different purpose of utilization. Seed potato, ware potato and potato for processing purposes need 2-4°C, 4-7°C and 7-12°C of storage temperatures, respectively. The quality of potato is highly influenced with the storage temperatures and duration. Many of the storage facilities in Nepal store the potato along with other commodities. Seed potato storage needs special environment and separate structures to maintain the seed quality which is not available in the country.

Lack of processing varieties

Significant quantities of potato and its products have been imported in the country. Most of the products are starch, frozen potatoes, and processed foods. Recently few potato-based industries have been established in the country. These industries have utilized the potato from abroad because of the no or very low production of potato with

processing qualities. NPRP has recently been started to develop the variety for processing qualities. Availability of quality seeds of potato varieties with processing qualities (Chips, French fries etc.) should be increased in the country to supply the raw materials to the industries.

Status of Seed Potato Research in Nepal

Majority of research on potato and tuber crops are focused on potato crop variety and its crop husbandry. Limited research has been conducted in postharvest handling, storage, and processing. There are very limited researches conducted on seed potato production.

An experiment was conducted to study the losses in seed potato under different storage conditions. The results showed that the shrinkage loss in seed potato was highest (in all tested varieties) under Diffused light storage condition. Rate of sprouting varied according to variety and field performance was recorded better in the variety with longer dormancy period (Dhital et al, 1996). Similarly research was conducted (Dhital and Ghimire, 1998) to study the effectiveness of different storage methods for seed potato. Three storage methods viz cold store, diffused light storage under room conditions and under ground pit storage were used to store the seed potato. The result showed that cold storage (at 3-7°C) was superior to other two methods in terms of plant vigor and yield irrespective of varieties. Dhital and Wilcockson, 2004 reported that yield potential of seed potato stored under Diffused light storage was reduced to a large extent than cold stored seed tuber because of advanced physiological aging of seed potatoes.

Research on Pre-Basis Seed (PBS)

Performance of *in vitro* plantlets and their yield performance in glasshouse was studied to produce *in vitro* plantlets using 3% sucrose and sugar in different MS media. The results showed that the performance of plantlets in *In vitro* as well as in glasshouse was found indifferent when sucrose is replaced by sugar (Sakha et al, 2008).

To identify the low-cost technology in production of *In vitro* plantlets, an experiment was conducted to produce the increased number of plantlets in a single bottle. The result showed that higher useable nodal explants were produced when 10 plantlets/bottle (in 400 ml capacity bottle) were cultured as compared to 12 and 15 plantlets/bottle (Sakha et al, 2008).

A comparative study to produce pre-basic seeds of potato was conducted at the Khumaltar, Lalitpur. The Yield of PBS by using *in vitro* plantlets and stem cuttings under different crop geometry in glasshouse showed that the *In vitro* plantlets gave 5 mini tubers/plant while it was only 2 per plant in cutting plants. But the average weight of mini tubers was 2.8 g and 8.7 g respectively in the tubers produced from *in vitro* plants and cuttings. Similarly, the effect of different crop geometry to plant the plantlets were studied. This study revealed that the number of tubers per square meter were higher (294/m²) in 10x10 cm spacing (Sakha and Rai, 2004).

Table 1. Effect of Season on Rapid multiplication of Virus Free Plantlets under Glass house and Screenhouse conditions for Spring and Autumn Production in Khumaltar, Lalitpur (Dhital et al, 2010)

Parameters	Spring		Autumn	
	Glasshouse	Screen house	Glasshouse	Screen house
Contamination of subculture (%)	6.2		9.2	
Rate of regeneration (%)	89.2		95.2	
Mortality of transplanted <i>In vitro</i> plantlet (%)	8.7	9.4	7.0	6.2

Study on Crop geometry for Basic Seed Production

A study to identify the suitable crop geometry for basic seed potato production was conducted in Jumla (2250-2300 masl) using different spacing. The result of the experiment showed that potato tuber planted at 50 x 20-25 cm gave the higher number of seed size tubers (44/m²) as compared to recommended spacing (60 x 25 cm) (31/m²) (HRS, 2021).

Status of varietal research in potato and tuber crops

Potato is one of the most important crops of Nepal after Rice, Wheat, Maize, and Millet. It ranks first in Productivity, second in production and fifth in area under cultivation among the cultivated crops in Nepal. Although potato was introduced in Nepal almost 300 years ago, the formal program for its development was initiated during 1960s. For the concentrated effort in Potato development in Nepal, National Potato Development Program (NPDP) was established under ministry of Agriculture in 1972. Through this program, Swiss Development Cooperation, and

International Potato Center (CIP), Peru, many activities in varietal introduction, seed tuber production, evaluation of True Potato Seed (TPS) families were conducted which gave the opportunity to introduce many potato varieties in Nepal. With the establishment of Nepal Agricultural Research Council (NARC) as an autonomous research organization in 1991, NPDP was divided as Potato Research Program (PRP) and Potato Development Program (PDP). With the continuous effort, till now 13 varieties of Potato have been released and recommended for the cultivation in different agroecological regions.

In initial years, effort in variety selections were given for higher yield and disease resistance. Later added efforts have been given as drought tolerant, higher storability, short maturity, longer dormancy and processing qualities. Recently in 2081, two processing varieties viz. Khumal Seto-3 and Khumal Rato-4 have been released which are also suitable for processing (Making potato Chips).

Besides, five varieties, which are very popular among farmers as well as consumers have been registered and recommended for the cultivation in different agroecological regions.

Table 2: Released and Registered varieties of Potato in Nepal

Varieties	Year	Source	Domin	Remarks
Kufri Sindhuri	2049	India	Terai	Released
Kufri Jyoti	2049	India	Mid and High hills	Released
Desire	2049	Netherland	Terai-High hills	Released
Khumal Seto 1	2055	CIP	Mid and High hills	Released
Khumal Rato 2	2055	CIP	Terai	Released
Janak Dev	2055	CIP	Terai- Hills	Released
Khumal Laxmi	2065	CIP	Mid Hills	Released
IPY 8	2065	CIP	Terai and Inner Terai	Released
Khumal Upahar	2070	CIP	Terai	Released
Khumal Ujwal	2070	CIP	Mid hills	Released
Khumal Bikas	2075	NPRP	Mid and High Hills	Released
Khumal Rato-4	2081	CIP	Mid and High Hills	Released
Khumal Seto-3	2081	CIP	Terai and Mid Hills	Released
Cardinal	2076	Netherland	Terai-High Hills	Registered
Rosita	2076	Switzerland	High Hills	Registered
MS. 42-3	2076	CIP	Terai and Mid Hills	Registered
TPS 1	2070	CIP	Hills	Registered
TPS 2	2070	CIP	Hills	Registered

(Source: NPRP 2023)

In Recent years, three varieties of Potato suitable for French Fry production have been registered with the combined effort of National Potato Research Program (NPRP) and First Food Choice (a private potato processing company).

Table 3: Registered Potato Varieties suitable for French Fry Production with their postharvest quality

Varieties	Specific gravity	Dry matter content	PWL % @90 DAS	reducing sugar (mg/100gm)
Alverstone Russette	1.08	22.53	7.85	10.444
Innovator	1.09	24.54	9.31	10.418
Sagitta	1.08	22.49	9.60	3.662

(Source: NPRP, 2023)

Varietal Development in Sweet Potato for Food and Nutrition Security

Sweet Potato (*Ipomoea batatas* L) is one of the high energies containing food. Although, this crop has very potential for reducing food and nutritional security in Nepal, this crop has not got very focused program. This crop has been cultivated in marginalized and neglected field in Nepal. Realizing the importance of this crops as a climate resilient, high yielding as well as high energy food, NPRP has initiated the research work in variety development of sweet potato. As a part of variety development collection of locally adopted germplasms, their evaluation and utilization are going on. Besides, different genotypes from International Potato Center (CIP), Lima Peru were brought at the Program. With the continuous evaluation of sweet potato genotypes, two varieties (Suntale Sakharkhanda-1 and Suntale Sakharkhanda-2) have been released for cultivation. Overall, 38 different sweet potato genotypes have been conserved under field conditions in NPRP, Khumaltar in 2023/24. The important characters of released sweet potato varieties is given below.

Suntale Sakharkhanda -1

- High yielding (13-15 t/ha) than check varieties
- Semi compact plant type (vine length)
- Higher farmer's preference
- Beta carotene and other mineral content: high (40.95mg/100gm), (Japanese red low(3.57mg/100gm), local check- 2.24mg/100gm)
- Total mineral content high (3.62%)
- Low tuber damage by insect pest
- Attractive root shape, size, skin and flesh color
- Good for Salad purpose and practiced for preparing pickles, juices, bread and biscuit

Suntale Sakharkhanda-2

- High yielding (18-25 t/ha) than check varieties
- Higher farmer's preference
- Beta carotene and other mineral content: high, Carotene-17.58mg/100gm, total minerals-(3.87%)
- High protein content-3.14%
- Low tuber damage by insect pest
- Attractive root shape, size, skin and flesh color
- Good for Salad purpose and practiced for preparing pickles, juices, bread, and biscuit

The varietal evaluation in different stages of experimentation is going throughout the country. Some of the major varieties with their characteristics in Coordinated Varietal Trial have been given as:

Table 4: Morphological Characteristics of Sweet Potato Genotypes under Coordinated Varietal Trial (CVT)

Genotypes	Plant type	Vine color	Mature Leaf color	Shape of central lobe
Benshisahar White	spreading	green	green with purple edge	semi-elliptic
CIP 105085.2	semi-compact	green	slightly purple	elliptic
CIP 105086.1	semi-compact	green	green	lanceolate
CIP 106861.3	spreading	totally dark purple	yellow-green	teeth
CIP 106906.1	semi-compact	green	slightly purple	linear (narrow)
CIP 187020.1	spreading	totally dark purple	green with purple edge	semi-elliptic
CIP 194540.5	spreading	green	green with purple edge	traingular
CIP 199062.1	semi-compact	green	slightly purple	linear (narrow)

CIP 440132	spreading	green with many purple stripes	greyish (due to heavy pubescence)	triangular
CIP 440293	extremely spreading	green	green	teeth
Kimichaur Seto	spreading	mostly purple	slightly purple	teeth
Suntale Sakharkhand-1	erect	green	slightly purple	elliptic

Status of varietal research in colocasia and yam

Different types of Colocasia and Yam have been cultivated throughout the country with their local name. The same landrace has different name in different location. Variations among the landraces have been observed. Locally cultivated landraces of Colocasia in Gandaki Province were collected and evaluated at Horticulture Research Station, Malepatan, Pokhara. With the continuous evaluation (performance, phenotypes, genotypes), one landrace is going to be registered. There are 16 landraces of Colocasia collected at the station. The major characteristics of corms and cormels of collected landraces is given in Table 5.

Table 5: Corms and Cormels characteristics of Colocasia landraces collected from the different districts of Gandaki Provinces at Horticulture Research Station (HRS).

Sl. No	Land races	Major corm /cormel characteristics
1	Hatti Paun (Elephant foot)	Brown color, Multi-faced (Many Eye bud in a corm), Round shaped corm, fewr cormel numbers.
2	Bhainsi Khutte (Buffalo foot)	Flattish round brown corm, medium number of cormlets, and medium sized corm.
3	Bermeli Pidalu	Red and round shaped medium sized corm, cormlet Number medium
4	Chhattare Pidalu	Brown medium size corm, more corm let number with longshaped
5	Dudhe Pidalu	Round and brown corm, corm let number more
6	Thado Mukhe (Errecta)	Long shaped corm, number of cormlet, brown in color
7	Khujure	Oval type brown corm, corm let number more
8	Rato Bhale (Red cock)	Red in color, small size corm, corm let number more and longin shape
9	Sat Mukhe Pidalu (Seven faced)	Multi faced (Many eyed bud in a corm), less corm lets, c Shape flatish round
10	Rato Mukhe (Red faced)	Red and round shaped corm, corm let number medium
11	Pancha Mukhe Pidalu (five)	Flattish round brown corm, no corm lets
12	Lahure Pidalu	More corm let number, small size corm, brown colored round corm
13	Gante Pidalu	Round and medium sized corm, higher number of corml
14	Chhaure Pidalu	Brown and small corm, maximum numbers of cormlets
15	Khujure Rato Pidalu	Medium Brown oval shape corm, corm let number more
16	Thaune Pidalu	Big oval shaped corm, fewer number of cormlet, brown i color

(Source: HRS, 2019)

Very little works have been done in Yam. Few landraces collected from the vicinity of Pokhara have been maintained and evaluated at the HRS, Malepatan. Few landraces were also brought from Horticulture Development Center (HDC), Sindhuli. HDC has also collected and evaluated the land races of Colocasia and Yam. The center is also involved in the promotion of their cultivation through technology transfer and seed distribution.

Strategy to Promote Variety Development and Seed Production

- Strengthen the breeding programs in the country through personnel capacity building and infrastructure improvement
- Develop models for private investors to adopt public varieties/ advanced breeding lines on short term exclusive rights basis to allow for cost sharing in the variety testing and registration process
- Support import of early generation starting material and/or tubers to boost seed volumes.

- Research options for government to subsidize private seed growers in the production of certified seed
- Develop/introduce climate resilient varieties for production in the hot lowland under rain fed and irrigated conditions
- Promote officially released potato varieties that are high yielding, resistant to diseases and suitable for various utilization demands
- Develop models for PPP to strengthen seed potato production, certification, storage and sale with county governments, donors, and seed companies
- Promote adoption of digital seed inspection and certification schemes
- Establish aggregation and logistics platforms to reach farmers with seed at the farm gate at lower costs

Way Forward

- Low-cost technology development for rapid production of quality planting materials
- Tissue Culture based seed potato Production (Meristem culture, single node cuttings, soil less culture and apical rooted cuttings)
- Domain base/low cost seed potato technology development (From PBS to BS3)
- Enthusiastic involvement of cooperatives, community and private sector in seed potato Production and distribution.
- Development of variety for short maturity (70-90 days), Longer dormancy, processing quality, disease resistance, resilient to climate change effects etc
- Utilization of biotechnological tools for crop improvement (molecular characterization, DNA finger printing, protoplast culture, anther culture, mutation Breeding and genetic transformation, etc.)
- Collection, characterization, evaluation, and maintenance of germplasm of underutilized tuber crops (Yam, Taro, Githa, Cassava, etc.)

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Vegetable Seed Production in Nepal: Status, Issues and Challenges

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Abstract

To meet the need of ever-increasing population, the breeders are continuously making the efforts by developing new varieties. High-quality seeds alone can improve crop yield by 20–25%, contributing to better water and nutrient use, disease resistance, and climate resilience. Despite being in a prime geographic location, Nepal lacks sufficient domestic capacity to meet seed demands, relying heavily on imports. By registering varieties, the national catalogues of commercial varieties can be diversified, and varieties which are better adopted to particular local environments can be promoted and commercialized by a wider range of actors. The process involves applications, review by technical committees, release/registration decisions, and notification in the Nepal Gazette or website of Ministry of Agriculture and Livestock Development. All the imported varieties of vegetables will be registered by one season trail in farmer's field by importers themselves.

Keywords: National Seed board, Notification, Registration, Release

Introduction

High-quality seeds alone can improve crop yield by 20–25%, contributing to better water and nutrient use, disease resistance, and climate resilience. This is essential given global pressures such as climate change, urbanization, and food security demands. Population growth rate high in developing and least developed countries whereas rural population is stagnant and rapid growth of urban population is about 50-70% (Sun et al., 2017). World depends on agriculture for food, feed and fiber. Must need to increase productivity and further, challenged by climate change, increasing demand of feed and fodder as well as increased used of biofuel.

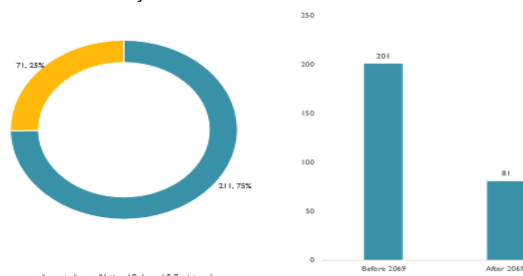
Global and National Seed Market

The global seed market reached \$53.95 billion in 2022, expected to rise to \$82.04 billion by 2031. Vegetables account for \$12.80 billion. Despite being in a prime geographic location, Nepal lacks sufficient domestic capacity to meet seed demands, relying heavily on imports. Nepal is in fastest growing region and sandwiched between second and fifth largest seed market in world, but neither have the domestic capacity to produce quality vegetable seed nor facilitate to avail the global competitive variety without compromising the quarantine system.

Status of Vegetable's Variety Notification till Date

Till now 282 vegetables varieties have been notified. However 201 varieties have been registered before 2069 B.S. and only 81 varieties have been notified after 2069 B.S. Out of total varieties, only 25% of National varieties have been notified and remaining 75% varieties of imported ones. (SQCC, 2024).

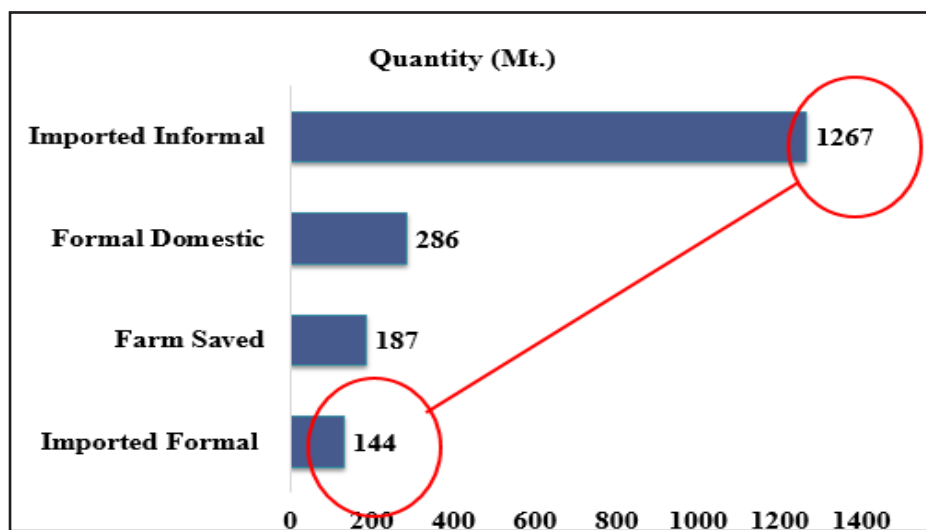
Total no of variety notified : 282



Seed Import Status

In recent years, Nepal has become heavily reliant on imported vegetable seeds, particularly hybrid varieties, due to inadequate domestic production and increasing demand for high-quality, high-yielding seeds. During the fiscal year 2080/81, the country formally imported 569 metric tons (MT) of vegetable seeds, valued at approximately NPR 90 crore. The imports were dominated by different crop categories, with legume crops accounting for the highest volume of open-pollinated (OP) seeds at 337.2 MT. Meanwhile, crucifer crops contributed 33.53 MT of hybrid seeds, cucurbitaceae crops made up 93.81 MT of hybrid seeds, and solanaceous crops accounted for 17.6 MT of hybrid seeds. This dependence on imports highlights the

need for strengthening domestic seed production to meet the growing agricultural demands of the country. Nepal's seed sector must strengthen **local production, quality control, and research** to reduce this dependency and support sustainable agricultural growth.



Informal Seed trade of vegetable seed

Illegal import of vegetable seeds into Nepal is a **significant challenge** to national seed policy enforcement and agricultural sustainability. The informal vegetable seed trade in Nepal has significant implications, undermining both the agricultural sector and governance. One major concern is the loss of government revenue and critical data, as informal transactions escape taxation and prevent institutions from tracking seed usage and distribution. This unregulated trade also distorts market dynamics, often leading to price hikes due to a lack of oversight. Additionally, the formal seed import sector is dominated by a few players, fostering monopolistic practices that stifle competition and transparency. High-tech producers face technical constraints, as they struggle to access reliable, certified seeds through informal channels. Farmers relying on uncertified seeds are further disadvantaged, as they are often ineligible for crop insurance or soft loans. Bureaucratic obstacles, such as cumbersome No Objection Letter (NOL) requirements, discourage legal seed trade while failing to curb informal flows. Moreover, informal seed distribution bypasses certified varieties, preventing farmers from benefiting from improved plant breeding advancements. Compounding these issues is the disconnect between existing laws and their enforcement, which weakens the overall integrity of Nepal's seed system and hampers agricultural development.

Problems of Vegetable Seed Production in Nepal

Vegetable seed production in Nepal faces multiple challenges that hinder its growth and sustainability. One major issue is the limited access to elite germplasm and weak institutional support for seed research and development. The absence of certified breeder seeds and the deterioration of source seed quality—due to a lack of maintenance breeding and proper seed cycles—further compromise production. There is also a significant gap between demand and supply, with the market largely requiring hybrid seeds while domestic production remains dominated by open-pollinated varieties. The absence of a structured variety deployment plan exacerbates this mismatch. Additionally, seed production is scattered across small-scale operations, leading to high costs and inefficiencies. Stringent policies, regulations, and bureaucratic directives create further obstacles for producers. While improved road access has enhanced enterprise profitability, the lack of incentives for domestic seed producers discourages investment in the sector. Informal seed trade across porous borders, along with unreliable contracts and frequent contract breaches, undermines formal seed systems. Finally, limited technical expertise and inconsistent seed quality restrict the sector's potential, leaving Nepal heavily dependent on imported seeds despite its agricultural potential.

Legal provision of variety notification or registration in Nepal

Seed Act, 2045 (Second Amendment, 2079)

Structural arrangements for release and registration of different varieties

- National Seed Board (NSB)
- Secretariat: Seed Quality Control Center

- Provincial Seed Board (PSB): Gandaki and Bagmati province already form the Provincial Seed Board

Legal provisions for notification of varieties

Arrangements for Notification by Federal:

Release variety: Ministry can notified variety by publishing a notice in Nepal Gazette after consultation with National Seed Board.

Local and Imported variety

- Registered after decision from National Seed Board
- No need to published in Nepal Gazette
- Published in Ministry website or other medium

Arrangements for Notification by Province

- Notify within the domain of province except imported varieties
- Provincial Ministry can notified variety by publishing a notice in Province Gazette after consultation with PSB.
- Provincial Ministry should consult with NSB before variety notification or registration

Section 11.6 of the Seed Act, 2045

The process of notifying or registering the variety of seeds shall be as prescribed and the process accordingly. According to the nature of certain crops, process of registering variety can be specified in different ways.

In Section 15(d) of the Seed Act, 2045

License Provision for Variety Development and Maintenance

- National Seed Board can issue license but Nepal government should approve for variety development and maintenance license
- Permits can be given to individuals or organizations by making provincial laws in accordance with the quality and standards set by National Seed Board

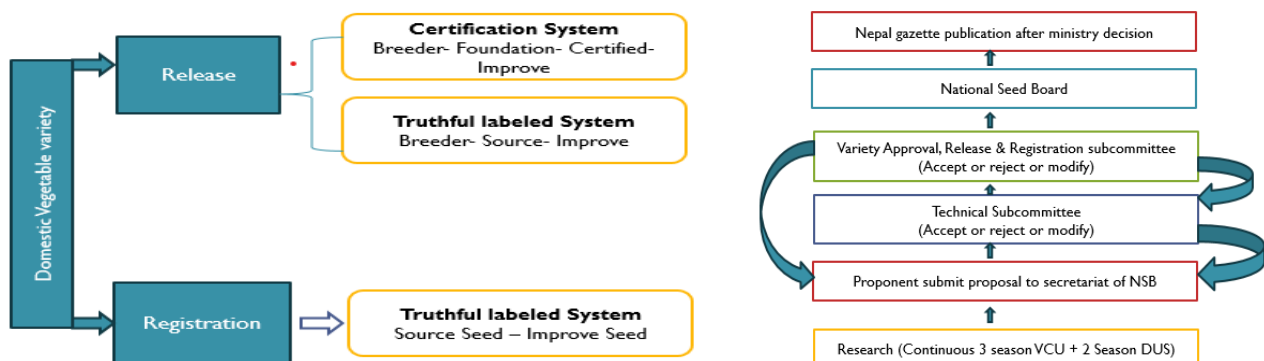
Seed Regulation, 2069

National Seed Board (NSB) has three sub-committee to assist National Seed Board for variety notification and registration. Out of three, one is Variety approval, release and registration sub-committee (VARRSC) under the chairmanship of Director General of Department of Agriculture.

Variety can be notified and there are four ways which are listed here under:

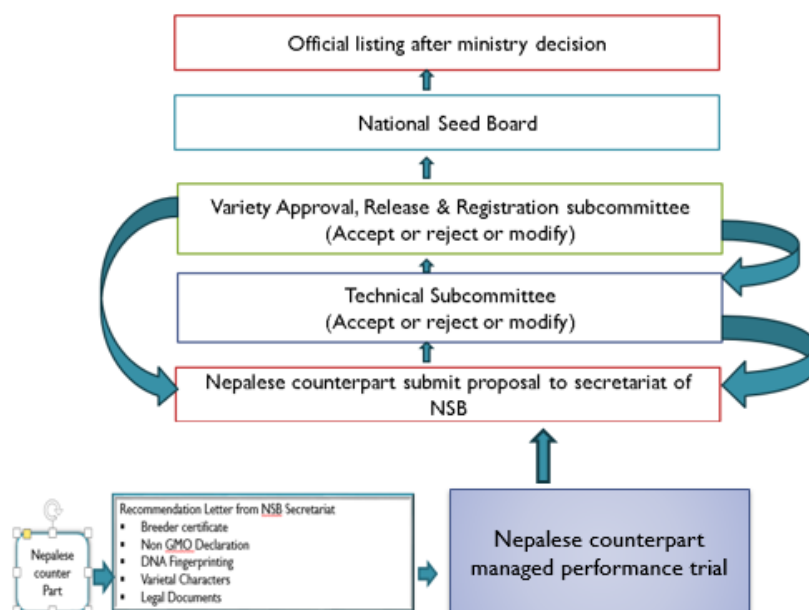
- Schedule A: Release of National variety
- Schedule B: Registration of National variety
- Schedule C: Registration of imported variety
- Schedule D: Registration of Land race and Local crop

Notification of Domestic Vegetable Varieties and Quality Control System



Notification of Domestic Vegetable Varieties and Quality Control System

Procedure of Notification of Exotic Vegetable Varieties



New Opportunity to Produce Vegetable Seed: Custom Seed Production

Custom seed production presents a promising new opportunity for Nepal to enhance its vegetable seed sector, offering a pathway to reduce dependency on imports while catering to the growing demand for high-quality seeds. The country's favorable agro-climatic conditions, long winter seasons (ideal for seed storage and crop cycles), and availability of affordable labor create a strong foundation for this venture. Additionally, the high market demand for seeds and farmers' willingness to pay for quality varieties further strengthen the case for custom seed production. This model could also streamline the seed registration process, making it more efficient and farmer-friendly.

However, several challenges must be addressed to realize this potential. Ensuring the safety and security of parent seed material is critical, as is the need for accredited laboratory services to maintain quality standards. Strict pest risk assessments and quarantine measures are necessary to prevent disease outbreaks, along with clear regulations for production zones. Investment in seed production research is essential to develop locally adapted, high-yielding varieties. Another major hurdle is the risk of contract breaching, which can undermine trust between seed producers and buyers. Addressing these challenges through policy support, institutional strengthening, and private-sector engagement will be key to unlocking the full benefits of custom seed production in Nepal.

Horticultural Crops Registration System in Neighboring Countries

Horticultural Crops Variety Registration in India

The National Seed Policy, 2002 of India, regulate the sale, import and export of seeds and planting materials of agriculture crops including fodder, green manure and horticulture and supply of quality seeds and planting materials to farmers throughout the country.

All varieties, both domestic and imported varieties that are placed on the market for sale and distribution of seeds and planting materials will be registered under the Seeds Act. However, for vegetable and ornamental crops a simple system of varietal registration based on "breeder's declaration" is adopted in India. Registration of varieties will be granted for a fixed period on the basis of multi-locational trials to determine Value for Cultivation and Use (VCU) over minimum period of three seasons, or as otherwise prescribed as in the case of long duration crops and horticultural crops. Samples of the material for registration will be sent to the NBPGR for retention in the National Gene Bank.

Horticultural Crops Variety Registration in Bangladesh

In the National Seed Policy, 1993 of Bangladesh, for new varieties of wheat, rice, jute, potato and sugarcane developed by private or public agencies will be subject to notification by the National Seed Board of Bangladesh. Varieties of all other crops developed by public research agencies will be subject to an internal review and approval by each respective agency and must be registered with NSB before being released. Varieties of crops, other than

rice, wheat, jute, potato and sugarcane that are imported or locally developed by a private person, company or agency must be registered with the NSB giving prescribed cultivar descriptions, but will not be subject to any other restrictions.

The crops and notification procedure for controlled crops before commercial purpose in Bangladesh:

- The National Seed Board (NSB) shall designate kinds and varieties of crops that are to be notified. Initially, rice, wheat, jute, potato and sugarcane will be the only notified crops.
- Release of the varieties of notified crops will be subject to evaluation and testing by the Technical Committee on Seeds.
- Varieties of all other crops will have to be registered prior to being sold, but there will be no requirement for prior testing and approval.
- Any variety, whether imported or developed in Bangladesh, must registered with the National Seed Board. Except for controlled or notified crops, registration will not involve testing or any other procedure.

Requirements in Bangladesh for non controlled crops

- Proposed Name – Scientific, English, Bangla
- Company and Dealer Profile
- Ecological demand
- Breeder details
- Agronomical demands (seed rate, PoPs,)
- Disease and Insect trial and reaction details.
- Description of variety – Identification and other special features
- Description of Initial Yield Trial (IYT), Multi Location Trials (MLT), Yield Trial on Farmers Field and Agronomic Trial

Data to be Recorded for Release and Registration of Varieties in Nepal

The crop, botanical name, old name before registration, new name after registration, parents of the new variety, country of origin, source and accession number should include in the proposal. Agronomical characters like days to 50% flowering, days to maturity from seeding, plant height, fruit weight, yield and multi-location data of initial evaluation trial (IET) and coordinated varietal trial (CVT) data should be taken from at least three location. Morphological traits like seed shape, seed color, seed size, flower color, leaf shape, petiole wing, growth habits, branching, foliage color and plant height etc should be measured and incorporate in proposal.

Response of Stress like as biotic, abiotic and nutritional quality such as protein %, carbohydrate %, minerals, and vitamins should be included in proposal. Beside that recommendation domain, time of planting, seed rate and sowing distance, reasons for recommendation, distinctness of variety, disease scoring (at least 2 consecutive year), insect scoring (at least 2 consecutive year), stability test, testing location at least 3 location and picture and video clips of farmers response should be submitted during submission of proposal in National Seed Board Secretariat

Key Challenges in Domestic Seed Production and Registration

The seed production and distribution sector faces several critical challenges that hinder its effectiveness and growth. One major issue is the **low access to elite germplasm and inadequate institutional support**, which limits the development of high-yielding and resilient crop varieties. This problem is further exacerbated by the **lack of certified breeder seeds and the poor quality of source seeds**, leading to inconsistencies in crop performance and farmer dissatisfaction. Moreover, there is a significant **gap in the supply-demand chain, particularly concerning hybrid seeds**, which are often in high demand but not readily available due to inefficiencies in production and distribution systems. Another pressing concern is the **absence of a coherent variety deployment plan**. Without a strategic approach to introducing and promoting specific crop varieties in suitable agro-ecological zones, farmers are left with mismatched or underperforming options. In addition, **seed production practices are scattered and often come with high costs**, making it difficult for smallholder farmers and seed producers to scale up operations sustainably. Compounding these challenges are **porous borders and frequent violations of seed production contracts**, which undermine the integrity of seed systems and open the door to counterfeit or substandard seeds

entering the market. Finally, **weak policy enforcement and a lack of technical know-how** across the seed value chain limit the implementation of best practices and regulatory compliance, further stalling progress in improving seed quality and availability. Addressing these interconnected issues requires coordinated efforts from both public and private stakeholders, alongside robust policies, capacity building, and investment in research and infrastructure.

Nepalese variety notification and registration process of vegetable crops by one season farmers trail by importers whereas in the neighboring countries where direct registration of horticultural crops was already started is another challenge for our country. Characterization of genotypes, spot examination and development and approval of Plant Variety Protection and Farmers Right (PVPFR), incentives to breeder involved in variety development and strengthen to private sector Research and Development are issues in variety registration of vegetable registration in Nepal.

Conclusion

The vegetable seed sector in Nepal holds strong potential for rural economic growth, yet faces structural challenges in terms of production, distribution, and policy alignment. For the registration of vegetable seeds. The government has developed official guidelines for the registration process, which include documentation of varietal traits and performance, and field trials to ensure genetic purity and identity.

Despite these efforts, coordination issues, weak enforcement, and lack of awareness among farmers and seed producers slow down effective implementation. Overall, while Nepal has laid the groundwork for a functional seed registration system, improving institutional support, training, and streamlined procedures is critical for maximizing the potential of its vegetable seed sector.

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Horticulture in Vedic Civilization: A Perspective on Vegetable Seed Conservation

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Abstract

It has been universally acknowledged that the Veda is the earliest available literature of human civilization meaning to knowledge. Vedic agricultural production system works in harmony with nature, sustains the health of soils, ecosystems and people. This paper simply tries to present the agricultural wisdom expressed in different Vedic literatures and its relevancy in the present context with reference to vegetable seed conservation. The importance of seed in crop production is known to human being from the very beginning of Vedic civilization (युनक्त सीरा वि युगा तनुध्वं कृते योनौ वपतेह वीजम् । गिरा च श्रुष्टिः सभरा असन् नो तेदीय इत् सृण्यः पक्वमेयात् ॥ (ऋग्वेद) (Vaidik Sukta Sangraha, 2020). Vedic civilization inspires to use local knowledge and skills derived from experienced practices from generation to generation seed system management. Over thousands of years of Vedic civilization, farmers have developed a variety of seed management practices that continue to exist in Nepal currently. Due attention needs to be given to value and respect the Vedic wisdom of vegetable seed conservation practices supported by further research and development.

Keywords: Conservation, Horticulture, Vedic, Vegetable seed

Introduction

Going by the Vedic literature, it is quite evident that agriculture sector was the key source for livelihoods of the people (कृषिमूलं हि जीवनम् । ऋग्वेद). Vedic civilization has been contributing in the field of agriculture biodiversity conservation since ancient times. The agriculture awareness of Vedic seers, right from the Vedic periods, was remarkable and praiseworthy as Agriculture has been treated as source of prosperity and sustenance (कृषिमित्कृषस्वा वित्ते रमस्व बहु मान्यमानः ॥ ऋग्वेद) (Vaidik Sukta Sangraha, 2020). Vedic wisdom continued from the time immemorial which arose in the course of many centuries and has been extended and handed over one generation to another by verbal communication initially.

Vedic civilization inspires to use local knowledge and skills derived from experienced practices from generation to generation such as maintenance of home garden in their yard having different fruits, vegetables and medicinal plants with watershed management practices. Nepal is considered one of the most biologically diverse and culturally rich countries in the world. Many Vedic literatures have well mentioned the importance of agricultural practices in Nepal.

(काश्मीरदेशके वज्रदेश्ये नेपाल देशके । पञ्चाल कोसलकुरु विराटान्वय भूमिके ॥
मालवे शकदेश्ये वा सिन्धु सौविर भूमिषु । शुरसेना वान्ति चेदिकोङ्कणान्धादि भूमिषु ॥
यदा यदा वृष्टिपात स्तदा शस्ता कृषि क्रिया । (काश्यपीयकृषिपद्धति)

Almost all Nepalese cultures have something to offer to conserve bio-diversity including seed conservation and utilization. Vedic culture has respect for vegetable seed conservation which is reflected in several of its scriptures, texts and followed through rituals and practices.

Methodology

This paper is based on review of Vedic literatures. The information for this study is derived from the review of seed conservation related Vedic literatures supplemented by the experiences of authors working in Nepal as a follower of Vedic civilization.

Result and Discussion

1. Vedic farming system and culture of vegetable seed conservation

Agriculture, animal husbandry and fruit based agroforestry are the major components of integrated farming system in Vedic civilization as mentioned in the different literatures. Vedic culture has attached great respect to natural elements including earth. Integrated farming system with due respect of ecology and ecological balance is the major approach of agriculture.

All ancient knowledge and wisdom related to development of Vedic science of vegetables is well described in Vedas (Rigveda, Yajurveda, Atharvaveda) and other Vedic literatures specially in KrishiParashar, Sathapath Brahmana, Kashyapiyakrishipaddati and Vrikshayurveda

Vedic literatures clearly mention that agriculture was considered prestigious among all occupations (कृषेऽन्यत्र नो धर्मो न लाभः कृषितोऽन्यतः । न सुखं कृषितोऽन्यत्र यदि धर्मेण कर्षति ॥) (Shastri, 2017). Different dimensions of agriculture are expressed in Vedic literature very strongly. As food is the basic need of human being and for which a developed agricultural system is most essential (अन्नो वै प्राण । वेद) (Juganu, 2013). Vedic seers have also given top priority of food crops production= All creatures -life_ come into being from Anna -food_, and this food arises with the help of rain= Through yagyas we get rain, thus yagya gives rise to activity or karma (अन्नाद्भवन्ति भूतानि पर्जन्यादन्नसंभवः । यज्ञाद्भवति पर्जन्यो यज्ञः कर्मसमुद्भवः) ॥ (Ramsukhadas, 2022).

Kashyapiyakrishipaddati is an excellent text on vedic agriculture covering various aspects of vegetable specially brinjal (वार्तक), pointed gourd (पटालिका), pumpkin (कुष्माण्डक), coriander -धान्याकम्), cucumber (उर्वारिकम्), chilli (मरिचिका), Black pepper (मरिच), ginger (अदरक कन्द) and turmeric (पीतबालुका) and Leafy vegetables (शाक) (Juganu, 2013).

Over thousands of years of Vedic civilization, farmers have developed a variety of seed management practices that continue to exist in Nepal currently. Seed supply system has been maintained by farmers producing and conserving their own seeds for subsequent planting and exchanging with other farmers and relatives. The Vedic literatures mention that farmers plant, select, maintain purity, store, use and exchange seed of farmer-preferred cultivars over generations for their livelihoods (बीजस्य पुटिकां कृत्वा विधान्यं तत्र शोधयत् । बीजं विधान्यसमिश्रं फलहानिकरं परम् ॥ एकरूपं तु यद्बीजं फलं फलती निर्भरम् । एकरूपं प्रयत्नेन तस्माद्बीजं समाचरेत् ॥ (कृषिपराशर) (Shastri, 2017).

From the very beginning of Vedic civilization, human societies developed various institutional mechanisms, customs and religious beliefs to conserve, protect and promote their natural resources including vegetable seed. Farming communities have also identified, protect and managed seeds through selection and cross breeding as described in literatures time (बीजसंरक्षणं कार्यं कृषि कर्म विशारदैः ।) Over thousands of years of Vedic civilization, the government used to support the farmers for seed supply management. Conservation for seed sovereignty followed by food sovereignty and national sovereignty is considered very important. Support for conservation and seed system management is the duty of King÷government as mentioned in Kashyapiyakrishipaddati (Juganu, 2013)

भूपाल रथवा रक्ष्यं काले देयं प्रकृतिर्तितम् । बीजराशीः परश्रेयः कृषेस्तु प्रथमं धनम्

तदादिलोके सर्वत्र बीजानि विविधानि तु । रक्ष्यन्ते कृषिकर्मज्ञैः मानवैः सूक्ष्मबुद्धिभिः ॥ (कश्यपीयकृषिपद्धति)

The rituals and spiritual ceremonies of Vedic civilization play vital role for conservation of plant species including vegetable seed. We can take the example of the Bala Chaturdashi festival, generally lies on the month of Mangsir i.e., the starting of the winter season in Nepal. In the Nepalese term, it is pronounced as Satbij chharne din, where the hundred kinds of cereals, vegetable and fruit seed are mixed and sowed to the jungles and field nearby different Shiva temples. It has a great message that the ancient people developed many effective measures to safeguard our seed systems which reflect sustainable agriculture biodiversity conservation (Kaphle, 2023 et.al.,)

Ecology is mainly concerned with the interrelation of living organism with their environment. Bhumishukta of Atharvaveda is one of the important source of ancient wisdom on the relation of human being to his environment and his duty is to conserve it= Some mantras illustrate the importance of Yajnas for rain, agriculture, air, environment, all living creatures and their interrelationship (कृषिश् च मे वृष्टिश् च मे... औद्भिष्टं च मे यज्ञेन कल्पन्ताम् ॥ (Vaidik Sukta Sangraha, २०२०).

The major agricultural practices described in Vedic literatures are soil and land management with village settlement, integrated farming system with due consideration of ecology, crop cultivation inclusive of plant protection measures and agricultural technology, irrigation system management, animal husbandry, agroforestry management and meteorological observation in relation to farming system.

Methods of farming have also been discussed in Vedic literatures. There is some sort of similarity between method of farming mentioned in Atharvaveda and modern method. In sathapatha brahmana, a vedic texts, the whole process of farming has been described in four word-Karsana (preparation of the field), Vapana (Sowing seeds), Lavana (Reaping the harvest) and Mardan (Threshing). Ploughing was regarded as an important process in cultivation. Prayers were offered for the ploughshare to plough the field properly and for tillers to practice properly (शुनं सुफला वि तुदन्तु भूमिं शुनं कीनाशा अनु यन्तु वाहान् ।) (Vaidik Sukta Sangraha, 2020). Cultivation of a wide range of cereals, vegetables, and fruits was common, and animal husbandry was the important means for their livelihoods.

Nepal is rich in religious, cultural, ethnic and biological diversity. Even now, in Nepal these components are well integrated in the farming system in Nepal. The farming system of Nepalese agriculture varies according to the agro ecological zones. However, integrated farming system, having agriculture, animal husbandry and agroforestry are the major components, is prevalent even now.

As we find in Vedic literatures, cultivation of a wide range of cereals, vegetables, and fruits was common, and animal husbandry was the important means for their livelihood. There was belief that those farmers who are near to nature they must be remarkably close to God= The importance of seeds was emphasized and a certain sequence of cropping was recommended and the practice of preparation of manure by the cow dung for irrigation was common during this time (भूपालैरथवा रक्ष्यं काले देयं प्रकीर्तितम् । वीजराशिः परश्रेयः कृषेस्तु प्रथमं धनम् ॥) (Juganu, 2013)

From the very beginning of Vedic civilization, human societies developed various institutional mechanisms, customs and religious beliefs to conserve, protect and promote their natural resources including biodiversity. Currently these knowledge is called indigenous knowledge. Farming communities have also identified and managed a series of genes through selection and cross breeding as described in literatures (बीजनामपि चैनेषामातपे शोषितात्मानाम् । रक्षणं चैव मादिष्टमुत्तमैस्तु कृषीवलैः) ॥ (Juganu, 2013)

2. Vegetable seed conservation through karmakanda and rituals

The ancient wisdom, based on experiences and knowledge, recorded in Vedic literatures have been transferred to us over several thousand years in the form of karmakanda and rituals. Karmakanda expressed in the Vedic texts relate directly to the day-to-day life of the people, governing the social, religious, and spiritual rituals performed by people. It is believed that karmakanda includes rituals, ceremonies and actions, which, when performed, lead to bring prosperity in human life. Vedic pandits and priests were most informative and played the key role for extension of knowledge and experiences through karmakanda. For this, ancient education institutions especially Gurukul also played important role for dissemination of ancient wisdom of karmakanda to the students practically. Farmers are suggested to follow rituals to be performed as per suggestion of Vedic texts from preparing land for sowing to the ritual for storing the harvest (Kaphle *et al.*, 2023)

The relationship between Vedic culture and ecology is the integral part of ancient Nepalese societies too. Diversified community in Nepal used many local knowledge and skills derived from experienced practices from generation to generation such as maintenance of home garden in their yard having different fruits and medicinal plants, watershed management practices having a belief that they should not cut plants surrounding the source of water, water harvesting and conservation making groundwater recharge pond and grazing land (Gaucharan) protection specially for cow. Besides, use of cow dung and urine-based fertilizer to enhance microorganism diversity in soil for healthy food production. Therefore, Vedic culture can be understood as a holistic model that inspires a reconnection of humans with nature and provides one of the best models for agricultural biodiversity conservation (Kaphle *et al.*, 2022)

Relations with diverse biological entities and concern for their conservation remained important components in the structure of ancient civilizations of Nepal which is still followed. We can take the example of the Bala Chaturdashi festival, generally lies on the month of Mangsir i.e. the starting of the winter season in Nepal. It is also called the day of sowing different grain seeds. In the Nepalese term, it is pronounced as Satbij chharne din, where the hundred kinds of cereals, vegetable and fruit seed are mixed and sowed to the jungles and field nearby different Shiva temples. It has a great message that the ancient people developed many effective measures to safeguard our seed systems which reflect sustainable agriculture biodiversity conservation. Thus, Karmakanda and rituals have a great role in agriculture seed conservation as these inspire people to follow the agricultural conservation activities in sequence creating awareness (Kaphle *et al.*, 2023).

Conclusion

Overall study revealed that Vedic civilization has been contributing in the field of vegetable seed conservation since ancient times. This paper has just presented the agricultural wisdom expressed in different Vedic literatures with

reference to vegetable seed conservation. It has a deep respect for biodiversity which is reflected in several Vedic literatures and followed through daily rituals and practices. The Vedic knowledge could form the very potential basis for modern agricultural science. Finally, it can be concluded that Vedic traditions and wisdom have often paved the way for further research in the field of vegetable seed conservation.

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Production Technology of Hybrid Tomato Seed Srijana, Khumal Hybrid-2 and Khumal Hybrid-3

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Abstract

Tomato ranks as the third most important vegetable crop in Nepal based on area and productivity. Tomatoes are cultivated both seasonally and off-season. The cultivation of tomatoes, both in open fields and plastic houses, is in increasing trend. Hybrid varieties are widely used, and almost 100% of the tomatoes grown in plastic tunnels are hybrids. Nepal Agriculture Research Council (NARC) has released three hybrid tomato varieties; Srijana at 2010 and two new hybrid tomato varieties; Khumal Hybrid-2 and Khumal Hybrid-3 recently. These hybrids are resistant to diseases like blight and suitable for cultivation in both open fields and tunnels. These are also highly favored by farmers and consumers alike, and about 80% of the tomatoes grown in plastic tunnels in Nepal are Nepali hybrid varieties. Hybrids have the major advantage of high productivity, earliness, uniformity, better transport quality, and abiotic and biotic stress resistance. This paper provides a comprehensive overview of the seed production and management techniques for the hybrid tomato varieties; Srijana, Khumal Hybrid-2 and Khumal Hybrid-3. These hybrid varieties, with their enhanced disease resistance and adaptability to different climatic conditions, hold great potential for tomato farmers in Nepal. As demand of these hybrid seed is higher, majority of seeds are produced through private partnership program.

Keywords: Hybrid seed, Plastic tunnel, Seed production, Tomato, Varieties

Introduction

Tomato ranks as the third most important vegetable crop in Nepal based on area and productivity. It contains essential nutrients like vitamins A, B, C, E, calcium, and phosphorus, and can be consumed both raw and cooked. Tomato farming is increasingly expanding in Nepal. In the fiscal year 2066/67 B.S. (2009/10 A.D.), tomato cultivation covered 15,609 hectares with a total production of 242,018 metric tons, whereas, by the fiscal year 2078/79 B.S. (2021/22 A.D.), it had increased to 22,911 hectares with a production of 422,703 metric tons (MoALD, 2022) indicating a 46% increase in cultivation area. Both seasonal and off-season tomatoes are cultivated in Nepal. Off-season cultivation is done from Ashad to Mansir (mid-June to mid-December) and seasonal cultivation from Poush to Jestha (mid-December to mid-June). Off-season tomatoes fetch a better market price and are easier to sell (Shrestha and Gautam, 2076). There are many hybrid varieties in the market which are being grown by the farmers.

Hybrid (F1) cultivar is the F1 progenies crosses of two inbred lines. Inbred lines are used to develop population of single crosses, 3-way crosses, double crosses, back crosses and complex crosses (Walter, 1986). Selection of parents for a population may involve consideration of the heterotic relationships among available genotypes. The restoration of phenotypic performance by crossing inbred lines to produce a hybrid is called heterosis where the increase in size, vigor or productivity of a hybrid plant over the average or means of its parent. The hybrid cultivars cannot be reproduced from seed of the hybrid generation (Anonymous, 1980). Hybrid seed is used for the commercial production of number of crops. Each of these crops must meet four requirements for the successful production and use of hybrid seed;

- a) Heterosis is exhibited by the F1 progenies of crosses between the parents
- b) Fertile pollen can be eliminated from the female parent
- c) Pollen from the male parent is effectively transported to the female parent
- d) Hybrid seed can be produced reliably and economically (Wright, 1980).

In 2067 B.S. (2010 A.D.), the Nepal Agricultural Research Council registered 'Srijana' hybrid tomato cultivar. The cultivation of tomatoes, both in open fields and plastic houses, is increasing daily. Nowadays, tomato cultivation using plastic tunnels, particularly for farmers living in areas 800 to 2,200 meters above sea level, has become a popular method. Hybrid varieties are widely used, and almost 100% of the tomatoes grown in plastic tunnels are hybrids. These hybrid varieties are highly favored by farmers and consumers alike, and about 80% of the tomatoes

grown in plastic tunnels in Nepal are Nepali hybrid varieties. To meet the rising demand, the National Horticulture Research Center has partnered with private seed producers to produce hybrid tomato seeds for several years. In the fiscal year 2078/79 B.S. (2021/22 A.D.), 151 kilograms of hybrid seeds (valued at approximately 15 million NPR) were produced through the Private Partnership Program (PPP). The production and supply of seeds is increasing in formal sector in Nepal with a surge of community based and contract seed production led by community groups and private seed companies respectively (Gaire et al. 2016). This initiative has created job opportunities and prevented a large outflow of funds. The center has also released two new tomato hybrid cultivars, Khumal Hybrid-2 and Khumal Hybrid-3, which are resistant to diseases like blight and suitable for cultivation in both open fields and tunnels from Terai to hills. This article provides technical knowledge on producing seeds for these tomato hybrid cultivars.

Climatic Requirement

Warm and sunny weather is ideal for growing tomatoes. Temperature plays a crucial role in the success of tomato cultivation, with an optimal range of 20–30°C for general growth and 28–30°C for fruit development. At temperatures above 35°C, fruiting does not occur, and below 18°C, pollination is impaired. The optimal night temperature for tomatoes is between 13°C and 21°C. If night temperatures drop below or rise above these levels, it can halt the fertilization process, causing fruit drop and preventing fruit formation.

Temperature also affects the coloration of tomatoes. When temperatures fall below 10°C, Lycopene and Yellow carotenoid, which give tomatoes their red and yellow colors, respectively, do not develop, causing the fruit to remain green. The optimal temperature range for Lycopene and Carotenoid development is 20–25°C. However, temperatures below 10°C or above 40°C hinder color development in tomatoes.

Tomato Varieties

Tomato varieties can be categorized into self-pollinated and hybrid varieties based on their genetic source.

Hybrid tomatoes have become increasingly significant in recent years. The production of hybrid seeds requires two self-pollinated pure lines (parental lines). Srijana is produced using the female parent (HRD1) and male parent (HRD17) Khumal Hybrid-2 is produced using the female parent (HRA14) and the male parent (HRD7), while Khumal Hybrid-3 is produced using the female parent (HRA20) and the male parent (HRD2).

Srijana

Srijana is the first hybrid variety of tomato developed in Nepal. It is characterized by tall plants, and the fruit ripens 75–80 days after transplanting. The fruits are red and heart-shaped, with a thick skin (4–4.8 mm) and a mildly sour taste. The average fruit weighs 50–60g. The plant height can reach 4.5 to 5m. The average yield in open fields is 2.0–2.5 MT. while in plastic houses, it can reach 4.0 to 5.0 MT. per hectare. This variety is resistant to bacterial wilt and less prone to blight but can be affected by fusarium wilt and nematodes. Registered in 2067 BS (2010), it is recommended for cultivation in the Terai, mid-hills, and high-hills.

Khumal hybrid-2

This hybrid variety has tall plants, and fruits are ready for harvest 70–80 days after transplanting. The fruit is red and slightly flattened, weighing an average of 70–80g. The variety has an average yield of 60–70 MT. per hectare. It shows moderate resistance to blight and is recommended for cultivation in areas from the lowlands to the high hills. The characteristics of the parent line of Khumal hybrid-2 is briefly described below:

Female Parent: Semi determinate (HRA14): The plant is of medium height, and its growth stops at certain nodes. As the plant continues to grow, flowers form at each node along the main stem, limiting its height.

Male Parent: Indeterminate (HRD7): The plant continues to grow, with flowers developing every third node. The indeterminate growth pattern requires staking for support.



Figure 1: Khumal Tomato Hybrid-2 plant and fruit

Khumal hybrid-3

This hybrid variety has tall plants, and fruits are ready for harvest 65–75 days after transplanting. The fruit is red and round, weighing an average of 65–75g. The variety has an average yield of 55–60 MT. per hectare. It shows moderate resistance to blight and is recommended for cultivation in areas from the lowlands to the high hills. The characteristics of the parent line of Khumal hybrid-3 is briefly described below:

Female Parent: Semi determinate (HRA20): The plant is of medium height, and its growth stops at certain nodes. As the plant grows, flowers form at each node along the main stem, limiting its height.

Male Parent: Indeterminate (HRD2): The plant continues to grow, with flowers developing every third node. This indeterminate variety requires staking for support.



Figure 2: Khumal Tomato hybrid-3 plant and fruit

Table 1: Morphological characteristics of three Nepali tomato hybrid varieties

Characteristics	Srijana	Khumal hybrid tomato -2	Khumal hybrid tomato -3
Growth type	Indeterminate	Indeterminate	Indeterminate
Plant height (cm)	145 ±19	143±13	136±12
Days to flowering from transplanting	30±3	24±4	22±4
Flowers/cluster (no.)	6±1.5	6±1.2	6±0.9
Fruits/cluster (no.)	6	5	5
Days to fruit maturity	68±6	66±6	65±5
Yield (MT/ha)	68±7.7	74.5±8.5	62.4±7.7
Average yield per plant	2996±162	2856±348	2852±254
Fruit size	Medium	Medium	Medium
Fruit color	Red	Deep red	Deep red
Average fruit wt.(g)	58±7	80±11	76±8
Fruit shoulder shape	Slightly depressed	Slightly depressed	Feebly depressed
Fruit end shape	Flat	Flat	Flat
Locule number	5	5	4
Average fruit length (mm)	40.5±3.3	44.5±3.9	45±4.2
Average fruit width (mm)	42.6±2.9	50.8±7.1	49.6±4.7
Seeds per fruit (no.)	130±12	104±9	120±8
Insect pest (1-9)	3.5	2.3	3.0
Late blight (1-9)	4.7 (MR)	3 (MR)	3 (MR)

Nursery preparation

The ideal temperature for seed germination is between 20°C and 30°C. Tomato seedlings should be grown in plastic plug trays filled with a mixture of one-part compost and two parts coco peat. To protect the seedlings from frost and low temperatures, they should be kept in plastic domes or warm places. Seedlings are ready for transplanting 25–30 days after sowing. Healthy and virus-free seedlings are crucial for successful tomato farming.

Seedlings are often destroyed by green grasshoppers during the rainy season and brown grasshoppers during the winter and dry season. To protect the nursery, insecticides should be applied. Sometimes, in the early morning, cutworms can be found cutting the seedlings at the soil surface, causing them to collapse. If this problem is

observed, Malathion powder should be spread on the soil, followed by irrigation. In case of an attack by aphids, Rogor or Imidacloprid (1 ml per liter of water) should be mixed and sprayed.

1. Seedling rot disease

Seedlings can rot at various stages, such as Seeds rotting in the soil before sprouting, Seedlings rotting at the base (the stem appears to be constricted as if tied by a wire, causing death). This disease primarily occurs under conditions of high temperature, excessive moisture, waterlogged soil, or high seedling density. To prevent this, treat the soil with Bavistin, disinfect the seeds, and maintain proper hygiene in the nursery. The disease tends to thrive in conditions where there is a lack of proper air and water drainage. For grown seedlings, use fungicides such as Dithane M-45 (2 grams per liter of water) or Bavistin (1.5 grams per liter of water).

2. Soil requirements

Tomatoes can be grown in all types of soil, but the ideal soil should have a pH of 6–7, should be well-drained, and should be rich in organic matter. Loamy and sandy clay soils are most suitable for tomato cultivation.

3. Soil preparation and fertilizer use

For growing hybrid tomato seeds, small pits should be prepared, and for each plant, apply 2–3 kg of compost, 5g of urea, 15g of DAP (diammonium phosphate), 5g of potash, 2g of biozyme, 1g of zinc, and 1g of borax before planting. After 20–25 days, top-dress with 5g of urea per plant. After harvesting the second fruit, apply 5g of urea, 7g of DAP, and 3g of potash per plant, and carry out weeding and hoeing. After every 2 or 3 harvests, apply 5g of urea for continuous fruit production and maintaining size.

4. Micronutrient requirements

Micronutrients play an essential role in the growth and development of tomatoes. Among the 16 required micronutrients, boron, zinc, iron, and copper (copper sulfate) are the most critical for tomatoes. These nutrients are required in small amounts, but their deficiency can severely affect the growth and development of the plants. The lack of these nutrients results in stunted plant growth, reduced flowering and fruiting, and other issues. Therefore, during planting, nutrients such as biozyme, zinc, and borax are applied.

Planting time

Tomato seedlings are typically transplanted from Chaitra to Ashad (mid-March to mid-July) in the hills at elevations of 800 to 2,200 m. For mid-hill regions (1,000 to 1,600 m), seeds are sown from Falgun to Baisakh (mid-February to mid-May).

1. Transplanting seedlings in a plastic tunnel or greenhouse

Seedlings should be transplanted when they are 15 to 20 days old, or when they have 4 to 5 leaves. In open-field tomato crops, diseases and pests are more common, and the plants often suffer from various stresses. Additionally, pollen placed on the female part can be washed away by rain, and there can be disorganized pollination by flying insects like bumblebees and bees. Therefore, seed production should be carried out inside a plastic-covered greenhouse. Ideally, the greenhouse should be built with plastic roofing and mesh surrounding it.

In the crossing block, the male variety seedlings should be planted separately. Typically, 10% of the plants should be male and should be transplanted 10 days before transplanting the female variety seedlings. Since the male plants have indeterminate growth, they do not need to be replanted if insect pest and disease management is done properly. The male flowers continue to provide pollen for the female plants.

2. Planting distance

For seed production of Srijana, female line HRD1 is indeterminate type and these new hybrid varieties, female varieties like HRA14 or HRA20 are medium height, and require regular movement during pollination. The distance between rows should be 90 cm, and between plants should be 50 cm. Male varieties like HRD17, HRD7 or HRD2 should be planted at a distance of 75 x 60 cm.

Weeding and irrigation

Weeding should be done for the first time 20–25 days after transplanting. Depending on soil moisture, irrigation should be done every 7–10 days, and the lower branches emerging from the stem should be removed. Watering should be done daily until the seedlings are well-established. After transplanting, water should be applied every 2–3 days, ensuring the water reaches only the roots. Wetting the entire plant and leaves can increase the incidence of

diseases like blight. In a plastic greenhouse, more water is required, so drip irrigation is recommended.

Pruning and Staking

For female plants, 2 to 3 branches should be allowed to grow per plant in Srijana, whereas 3 to 4 branches in Khumal hybrid 2 and Khumal hybrid 3, and other shoots emerging from the axils should be pruned. Unnecessary branches touching the soil should also be removed. This allows good air circulation, reducing pest and disease incidence, and helps the plants utilize nutrients more efficiently, improving fruit and seed quality. Lower yellow and old leaves should be removed from the stem, making pollination easier. Tools used for pruning should be cleaned with ethyl alcohol or dipped in a solution of 1-part cow's milk to 3 parts water to prevent disease transmission.

Since both male and female plants are medium to tall in height, staking is essential to prevent fruit rot and disease. There are various methods of staking tomatoes. For female plants, place bamboo stakes between every 4 plants, with a height of 150 cm for HRA14 and HRA20 and 175 cm for HRD1 plants. Tie the first tie at 30 cm from the ground, with subsequent ties spaced 30–40 cm apart. For semi determinate plants require 3 to 4 layers of tying, while indeterminate plants require 4 to 5 layers. In both male (HRD17, HRD2, HRD7) and female plants (HRA14, HRA20), allow 3 to 4 branches per plant and remove the rest.

After a month or four weeks of transplanting, two branches will emerge on the tomato plant. Branches below this level should be removed. You can also one branch be left at each higher node, allowing up to 4 branches per plant. Branches or leaves touching the soil should also be removed. Bamboo stakes should be placed to support the plants to prevent them from collapsing. If bamboo is not available in sufficient quantity, soft plastic or nylon ropes can be used to provide support from above. This improves air circulation within the plant, prevents fruits from dragging on the ground, ensures even sunlight exposure, and makes pruning, pollination, pest control, and spraying easier. All these practices contribute to producing high-quality fruit and seeds.

Rouging

The process of removing undesirable, weak, and disease-infected plants is called rouging. Even with careful attention, sometimes suspicious unwanted plants can be found. For instance, if there are clear differences in the leaves, flower color, and fruit size, plants infected with bacterial blight or viral diseases must be removed.

Seed production

To produce hybrid seeds for these varieties, 6 g of female seeds (HRD1/HRA14/HRA20) and 2 g of male seeds (HRD17/HRD7/HRD2) per ropani of land is needed.

1. Emasculation

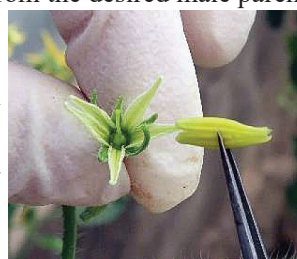
In the process of emasculation, the flower's male parts (the anthers) are removed before the flower matures to prevent self-pollination. This ensures that the flower can only receive pollen from another plant (usually from the selected male parent), allowing for controlled cross-pollination. The emasculation is done carefully to ensure the female parts (stigma and ovary) remain undamaged.

2. Collecting Male Flowers

Male varieties (HRD17, HRD 7, HRD 2) should be harvested when the flowers are fully open, but before the pollen falls, either in the evening or in the morning. This allows for the collection of pollen in various ways. The harvested flowers should be kept in a room overnight, and the next morning, pollen can be collected by sieving through a 1 mm mesh. For collecting pollen from many flowers, a vibrator can also be used. For a few flowers, the tip of the anther can be lightly cut and squeezed with forceps to drop pollen onto a Petri dish.

3. Dusting of pollen

After emasculation, pollen from the desired male parent is collected and dusted onto the stigma of the emasculated flower. This leads to fertilization and the production of hybrid seeds. The dusting is done manually, often using a brush or other small tool to ensure precise application.



Emasculated flower



Dusting of pollen

Figure 3: Emasculation and pollination

4. Pollination and Fruit Care

For female varieties (HRA 14, HRA 20), the male parts should be removed (emasculation) from flowers that have not opened their petals yet but are ready to bloom from 6 AM to before 11 AM. The stigma of these emasculated flowers should be touched with pollen to perform the pollination process. If pollination is done at the right time, the fruits formed from flowers with abundant pollen will have a higher seed count. Care must be taken not to damage the female part (pistil) during pollination. If there is a chance of pollen shortage, flowers should be collected while they are blooming abundantly, and the pollen should be stored in a vial that prevents air from escaping in a desiccator in the refrigerator for up to a week. Only 3–4 fruits should be allowed to grow per cluster. During pollination, care must be taken not to injure the female parts; otherwise, the flowers may fall off. Similarly, a pest attack can prevent the proper development of pollen. If fruit is attacked by worms, it will not be useful for production. Fruits can be harvested 40–45 days after pollination.

These steps are crucial in producing **hybrid tomato seeds**, where controlled pollination leads to the development of plants with desired traits from both parent plants.

Pest and disease management

1. Pests and their control

1. **White Fly:** The white fly, which appears in plastic houses during warm weather, sucks the sap from tender leaves from underneath, weakening the plant and transmitting viral diseases. To control this pest, yellow sticky traps should be hung, and a solution of 1 gram of Acetamiprid or 1 milliliter of Imidacloprid should be mixed with 1 liter of water and sprayed.
2. **Aphids:** During cooler weather, aphids suck sap from the soft parts of the plant, weakening it and transmitting viral diseases. To control these pests, a solution of 1 milliliter of a systemic insecticide should be mixed with 1 liter of water and sprayed.
3. **Leaf Miner:** The larvae of this pest are very small and burrow inside the leaves, causing white trails to appear on the leaves. To control this pest, a systemic insecticide like Rogor should be sprayed at a rate of 1 milliliter per liter of water.
4. **Fruit Borer (*Helicoverpa armigera*):** This pest attacks fruits during dry weather, rendering them useless. All affected fruits should be removed and destroyed. Use pheromone traps or spray a systemic insecticide like Rogor at a rate of 1 milliliter per liter of water.
5. **Mites:** Mite infestations can occur during hot and dry weather, hindering plant growth. Fine webs may also appear on the leaves. To control mites, spray a solution of 1 milliliter of Karathane per liter of water.

2. Diseases and their control

Whether seed-borne or non-seed-borne, all diseases weaken plants and can lead to complete crop failure if not managed in time. Commonly observed diseases and their control methods are as follows:

1. **Late Blight:** Caused by the fungus *Phytophthora infestans*, this disease affects both surfaces of the leaves in conditions of high humidity and cool nights. If symptoms appear, spray a solution of 1.5 grams of Krilaxyl per liter of water.
2. **Early Blight:** This disease, caused by the fungus *Alternaria solani*, presents as circular black spots on the upper surface of leaves and spreads quickly in warm, moist weather. To control this disease, spray a solution of 2 grams of Dithane M-45 per liter of water.
3. **Septoria Leaf Spot:** Caused by the fungus *Septoria lycopersici*, this disease shows spots surrounded by a black ring with ash-colored centers on the leaves and spreads in warm, moist conditions. To control this disease, spray a solution of 2 grams of Dithane M-45 or 1.5 grams of Krilaxyl per liter of water, or use a solution of Trichoderma.
4. **Fusarium Wilt:** The fungus *Fusarium oxysporum* attacks, causing yellowing on one side of the plant and gradually spreading upward. For disease control, mix 2 grams of Bavistin with 1 liter of water and water the soil around the roots.
5. **Bacterial Wilt:** Caused by the bacterium *Pseudomonas solanacearum*, this disease can cause sudden wilting of the plant when it is fruiting. After infection, the plant should be uprooted and buried, ensuring no water accumulates in the planting area. The soil should be treated with a 2% formalin solution, and

proper crop rotation should be implemented.

6. Powdery Mildew: Caused by the fungus *Oidium neolycopersici*, this disease appears as a white powdery substance on the upper surface of the leaves, which eventually leads to leaf drop. To control this disease, prune the plant for better air circulation and spray with a solution of 2 milliliters of Karathane per liter of water.
7. Blossom End Rot: This is especially caused by a calcium deficiency, resulting in a dark, sunken spot (0.5–1 inch wide) at the blossom end of the fruit during warm, dry weather. To control this, remove affected fruits and raise the soil pH above 6. Calcium should be applied to the soil and sprayed on the plants.

Harvesting and Processing Fruits

Fruits should be harvested when they change color to red and kept in a room for 1–2 days. The middle thorn should be pressed to extract the seeds and jelly-like substance into a plastic container, leaving it for fermentation for 24 hours. Afterward, wash with water. The tiny seeds that float on the water should be removed, as they are light. The cleaned seeds should be placed in a fine cloth bag and hung to drain excess water. Then, the seeds should be spread on a thin cloth and covered lightly with another cloth to dry in the sun. Once dry, remove inert materials and store the seeds in an airtight container or desiccator for preservation. This method produces high-quality seeds.

Way Forward

- Collection and utilization of genetic resources from local and exotic sources should be done.
- Expand collaboration with international organizations (CG centers, WorldVeg etc) for germplasm exchange
- Collaboration with private seed companies/cooperatives and agro-vets should be done.
- Improvement of technical capacity of researchers should be done.
- Training to technician cooperatives and farmers on hybrid seed production should be done.
- Establishment of molecular breeding facility should be done.

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Hybridization Techniques and Hybrid Seed Production Methods in Cucumber

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Abstract

Cucumber (*Cucumis sativus* L.) is a very popular and remunerative vegetable crop among the farmers of Nepal and its area in cultivation is increasing year after year. Demand of hybrid variety of cucumber is increasing and 78% of hybrid seed of cucumber seeds used in the production system are imported from abroad. Realizing this fact National Horticulture Research Centre (NHRC), under the Nepal Agricultural Research Council (NARC), has taken an initiative in developing hybrid varieties of various vegetable crops including cucumber. This paper mostly covers theoretical concepts of cucumber hybridization. It also guides through practical approaches, experience and evidence of hybridization activities conducted at the NHRC, Khumaltar. It is partly a literature review and partly based on the experience of the NHRC. Among the various systems of hybridization the Gynoecious × Monoecious and Gynoecious × Gynoecious are most common practices and the Gynoecious × Monoecious system for hybrid seed production has been used in the NHRC, Khumaltar. In Cucumber, gynoecious lines are used as female parents for hybrid seed production, which does not require modification. However, in gynoecious lines, male flowers need to be developed to maintain these lines. In some cases, to increase seed yield or if used as female parents, may need hormones to induce more female flowers in monoecious line. Among the several growth regulators available for sex modification, application of Ethrel (200 ppm) at 2nd and 5th true leaf stage for the promotion of female flowers (pistillate) and for the promotion of male flower (staminate), Maleic Hydrazide (25-100ppm) at 2-4 true leaf stage are being used. The NHRC successfully has registered Madhu-F1 (HRDCUC004 × Bhaktapur local) and Krishna-F1 (HRDCUC009 × Dhankuta local) under the National Seed Board in 2078.

Key words: Gynoecious, Hybridization, Monoecious, Registered

Introduction

Hybridization has been considered the most effective practical approach for increasing productivity and developing desired traits in crop varieties. This approach is used to develop F1 hybrids, which are superior to their parental lines in terms of productivity, quality, and adaptability in diverse situations (Chakrabarty et al., 2023). As the hybrid is a product developed by crossing two genetically distinct parents, its production is determined by the various systems. It employs various methods, combining pollination control mechanisms, to govern the activities that determine the isolation distance, planting ratio, synchronization of flowering, rouging, and supplementary pollination. In Nepal, the National Horticulture Research Centre, under the Nepal Agricultural Research Council, has taken the initiative in developing hybrid varieties of various vegetable crops. The NHRC has already registered two cucumber hybrids that utilize local genotypes as one of their parents.

Hybrid seed production in Cucumber is a technical process that requires controlled pollination to maintain superior characteristics, such as increased yield, disease resistance, and uniformity in offspring. This process relies on strategically combining desirable traits from carefully selected inbred parental lines. The gynoecious and monoecious parents are used to develop the hybrids. We use this method to develop cucumber hybrid varieties at the NHRC. In Nepal, out of 38 registered and recommended varieties, seed production is possible for only two open-pollinated varieties: Kusle and Bhaktapur Local (OP). Cucumber growers used only 19% of open-pollinated seeds, and 78% of hybrid seeds used in the production system were imported from abroad (Kafle and Joshi, 2018). Therefore, seed production and marketing of the Nepalese cucumber hybrids through private sector is utmost important. Some studies suggested that the key components for successful cucumber production included quality seed production and distribution, introduction of improved varieties, disease and pest management, post-harvest management, and access to finance (Khanal et al., 2020).

Cucumber (*Cucumis sativus* L., 2n=2x=14) is the member of the economically important family of cucurbitaceae. It is warm-season crops mainly grown in the tropical and sub-tropical regions of the world. Most farmers began growing hybrid cucumbers under plastic houses in accessible areas during the off-season to earn remunerative

returns due to their adaptability and high yields under these conditions (Gautam et al., 2021). Results revealed that the benefit-cost ratio was 3.22 in the study area (Khanal et al., 2020). The productivity of cucumber is very low in Nepal (15.21 mt/ha) (MoALD, 2079/80) compared to Asia (49.61 mt/ha) and world average productivity (39.34 mt/ha) (FAO Stat, 2021). This could be due to the use of local and open-pollinated varieties, which are grown in open fields. Most farmers used their local varieties for normal-season production in open fields (Gautam et al., 2021).

Methodology

This paper mostly covers theoretical concepts of cucumber hybridization. It also guides through practical approaches, experience and evidence of hybridization activities conducted at the NHRC, Khumaltar. Therefore, it is partly a literature review and partly based on the experience of the NHRC.

Conceptual Framework of Cucumber Hybridization

1. Floral biology and sex expression

Hybrid seed production of Cucumber is relatively easy because we need not to emasculate the perfect flower. It's a monoecious species having staminate (male) and pistillate (female) flowers borne on the same plant in different position and rarely bisexual. We can easily distinguish pistillate flowers by the presence of a visible inferior ovary behind the corolla, which requires pollen deposition onto their three-lobed stigma for fertilization. For hybrid seed production, we prefer the gynoeceous sex form which is commercially viable. These plants develop only female flowers, and we do not need to emasculate male flowers. The proportion of female and male lines in cucumber hybrids has been found to have been adopted from 3:1 to 5:1. In Northern India, the female and male rows are planted in a specific row ratio of 4:1 (Chakrabarty et al., 2023). At NHRC, we usually practice 5:1 ration because our male parents profusely develop male flowers.

In general, four systems of hybrid cucumber seed production has been proposed using a gynoeceous line (Robinson, 2000). They differ in the type of flower used as the pollen donor.

1. Gynoeceous × Monoecious
2. Gynoeceous × Gynoeceous
3. Gynoeceous × Hermaphroditic
4. Gynoeceous × Andromonoecious

Among these systems, the Gynoeceous × Monoecious and Gynoeceous × Gynoeceous hybrids are most commonly in practice and the NHRC use Gynoeceous × Monoecious system for hybrid seed production. This system became popular for the development of stable inbred lines for the gynoecey trait during the late 1950s. The hybrids produced by the cross of a gynoeceous and monoecious line resulted in hybrid vigor and a high degree of female sex expression, with uniform and concentrated fruit formation, which was especially advantageous for mechanical harvest (Robinson, 2000). Because it tends to produce mostly female flowers, seed from this type of hybrid is usually blended with seed from a monoecious cultivar, added in a proportion of about 10%. This practice improves pollination, which is required for fruit set in genotypes that are not parthenocarpic. However, it has the disadvantage of affecting uniformity, which is one of the principal advantages of hybrid cultivar production (Robinson, 2000). When the hybrid is parthenocarpic, blending is not required because fruits can develop without pollination. Parthenocarpic is the case for many cucumber hybrids used in greenhouse production.

2. Sex form modification

In general, the objective of sex form modification is to increase femaleness and subsequently increasing the seed yield. In Cucumber, gynoeceous lines are used as female parents for hybrid seed production, which does not require modification. However, in gynoeceous lines, we must develop male flowers to maintain these lines. In some cases, to increase seed yield or if used as female parents, we may use hormones to induce more female flowers in monoecious line. Several growth regulators available for sex modification can be classified into two groups

For promotion of male flowers (staminate)

- AgNO₃ (250 ppm) start from 2-3 leaf stage to 5-6 leaf stage for 3 times

For promotion of female flowers (pistillate)

- Application of Ethrel (200 ppm) at 2nd and 5th true leaf stage
- Maleic Hydrazide (25-100ppm) at 2-4 true leaf stage

3. Flower receptivity and effective pollination

Female cucumber flowers are receptive to pollen only on the day they open, and they begin to lose receptivity rapidly after that. If pollination does not occur within that window, the flower will wither and die, and fruit development will not take place. An earlier study in rainy season under naturally ventilated polyhouse showed that the pollination carried out at 9.00 AM increased the percentage (96.97%) of fruit setting in gynoeceious Cucumber (Nagar and Maurya 2015). In Khumaltar condition, we also prefer pollination around this time. Pollination (natural or manual) should ideally happen in the morning, when flowers are fully open and pollen is most viable.

4. Flower selection and cotton covering

Female flower from female line and male flower from male line that is supposed to be open on next day must be covered with cotton. The next day, the male flower from the male line should be picked up, and its petals should be removed. The cotton that is covering female flower in female line should also be removed and the anther of male flower should be rubbed in the stigma of female flower to transfer pollen. Pollination is conducted manually and should be done in the morning, from 7:00 a.m. to 11:00 a.m. The female flower should be immediately covered with cotton after completing pollination to prevent from crossing. In the female line, we should remove all female flowers appearing below the 8th node. Female flower in alternate node from 8th node onward should be selected for crossing. A total of nine fruits should be pollinated per plant i.e 3 flowers in each branch.

Crop Management Techniques

1. Climatic and soil requirement

Hybrid cucumber production, essential for high yields and disease resistance, is significantly influenced by climatic factors. It is a warm season crop; long period of warm, dry weather and abundant sunshine is needed. Optimum temperature for growth and development is 18-30°C. If growing temperature is less than 15°C at night there will be no growth and when temperature is above 30°C, there is adverse effect on female flower production and produce less number of female flower. Long day conditions and intense sun produce more male flower while short day conditions and mild sun produce more female flower. Consistent and adequate moisture is crucial. Relative humidity levels of 60-80% are generally preferred. Well-drained, fertile soil with a slightly acidic to neutral pH, ideally between 6.0 and 7.0 is ideal for cucumber cultivation. This pH range facilitates efficient nutrient uptake. Excellent drainage is paramount to prevent root rot. Sandy loam or loam soils amended with organic matter, such as compost or well-rotted manure, are preferred.

2. Planting Time

In the mid-hills, for seed production, Chaitra-Baisakh transplanting is preferred inside a plastic house. Generally, this transplant provides harvestable fruits in Asar-Shrawan. The seed requirement for the female line is 20g/ropani, and for the male line, it is 5g/ropani. Seed of male line must be sown in nursery 20 days before sowing of female line.

3. Crossing Block

Crossing block is the land/field where female and male line is planted. At the NHRC, we maintain a 5:1 male-to-female ratio. We recommend planting the male line 20 days before planting the female line to have sufficient pollen for pollination and crossing, as well as fertilization. Male and female lines are planted in separate rows in a crossing block. The crop geometry for female line is 1 m x 1 m and male line (generally monoecious) is 1.2 m x 1.2 m.

4. Manures and fertilizers.

Manures and fertilizers are applied in pits at final land preparation before transplanting. Well decomposed FYM or compost 5 kg, mustard cake 100 gm, bone meal 100gm, poultry manure 100, MoP 40gm, DAP 40 gm biozyme 3 gm, zinc 3 gm and borex 3 gm should be applied in the pits 2-3 days before transplanting. The first top dressing should be applied 10-15 days after transplanting, using 10 grams of urea, by creating a ring around the root zone. We should repeat this process three times at 15-20 day intervals. Since Cucumber is a heavy feeder, foliar application of multiplex @ 2 ml/litre or vegimax @ 1 ml/litre of water at 15 days intervals found effective.

5. Training and pruning

Cucumber is grown in stakes to improve fruit quality, yield and pest management. One main stem and two primary branches should allow to grow and others branches should be remove. After reaching to the height of 5-6 feet mesh is made from GI wire and branches are spread on the GI wire mesh. Pruning should be done frequently to disease and older leaf.

6. Irrigation

Cucumber has high water requirements and sensitive to water stress. The frequency of irrigation depends on soil type and weather conditions. First irrigation should be given immediately after transplanting. Flowering and fruit setting are the critical stages for irrigation. Irrigation should be done by making furrow or ring or drip system and avoid direct contact of leaves with water.

7. Roguing and field inspection

Off type plant from both male and female parents should be removed before flowering. If female flower does not appear upto 5th node, those plant should also be removed.

At least 3 field inspections should be done

1st: Before flowering- check plant and leaf characters (vegetative growth stage)

2nd: At the time of flowering-check flower, spine color

3rd: At fruit maturity- check the fruit characters, shape, size and color

8. Fruit Harvesting

In Khumaltar condition, the fruits become ready for harvesting 40 days after pollination and harvesting is done manually when seeds reach their maximum physiological maturity. Maturity indices indicate that the outer skin of the green variety turns yellow, while the white variety turns brown. We keep harvested fruits in a shed for 1-2 days to ensure they are well-matured. Then, the fruits should be cut longitudinally; the seed, along with the juice, is scraped out and allowed to ferment in a plastic bucket for 1-2 days to remove the gelatinous pulp from the seed. The pulp should be frequently stirred to prevent the growth of mold. Then the seeds should be washed repeatedly by rubbing with hands until the mucilage is completely removed from seed. After repeated washing the non-viable seed will float while viable seed remain in the bottom of container. The pure seeds are then dried in shade for 3-4 days. The seed should be dried until it has a moisture content of 10%.

The NHRC Product: Madhu and Krishna

The National Horticulture Research Center has been developing cucumber hybrids utilizing exotic and local germplasms. Its efforts have paid off, and the NHRC successfully registered Madhu-F1 (HRDCUC004 × Bhaktapur local) and Krishna-F1 (HRDCUC009 × Dhankuta local) under the National Seed Board in 2078 (HRD, 2022).

Table 1: Characteristics of the NHRC developed cucumber hybrids

Characters	Madhu - F1	Krishna-F1
Branching habit	Multiple	Multiple
Vine length (m)	4.6	4.43
Leaf blade size (cm)	31.2	32.88
Intensity of leaf color (green)	Dark	Dark
Sex type	Gynomonoceious	Gynomonoceious
Fruit shape at stem end	Obtuse	Obtuse but tapering
Fruit type	Slicer	Slicer, pickle
Fruit spine color	Black	Black
Spine size	Smooth	Smooth
Fruit shape	Elongated	Elongated
Predominant skin color	Light green with white stripe	Dark green
Secondary skin color	Dark green	White stripe
Skin texture	Netted	Clean
Flesh color	White	Cream with light color
Fruit length (cm)	25.83	27.77
Fruit girth (mm)	59.6	59.31
Fruit wt (gm)	522	519.64
Male: Female ratio	1:14	2:1
Pistillate in node no	6	7
Organoleptic taste	Very good	Very good

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Status and Issues of Pre- Basic Seed (PBS) and True Potato Seed (TPS) Production in Potato Crop Development Center, Nigale, Sindhupalchok

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Abstract

Potato (*Solanum tuberosum* L.) is a critical crop for food security and income generation in Nepal, ranking fifth in cultivation area and fourth in production. Despite its agro-economic significance, productivity remains constrained by the limited availability of quality seeds. This paper explores two advanced seed production technologies - **Pre-Basic Seed (PBS)** through tissue culture and **True Potato Seed (TPS)** via hybridization. **PBS production** involves meristem culture under sterile laboratory conditions, virus testing (DAS-ELISA), and mini-tuber production in aphid-proof screen houses. PBS seeds, graded by weight (A: >5g, B: 1–5g, C: <1g), enhance yield by 49.8% but face challenges like high infrastructure costs, skilled manpower shortages, and inconsistent demand. **TPS technology**, an alternative to costly seed tubers, relies on hybrid progeny HPS 7/67) and offers advantages such as disease resistance and suitability for remote areas. However, TPS adoption is hindered by labor intensity, genetic variability, and climate sensitivity. Nepal's institutional framework NPRP, PCDC-Nigale) and private labs produce 990,000 PBS tubers annually, yet supply falls short of the national demand. TPS production, though limited (9.5-32 kg/year), shows promise for resource-constrained farmers. Key recommendations include strengthening tissue culture infrastructure, scaling up certified seed programs, fostering public-private partnerships, and promoting climate-resilient TPS hybrids. These strategies aim to bridge the seed deficit, boost productivity, and support sustainable potato farming in Nepal.

Keywords: Hybridization, Potato, Pre-basic seed, Tissue culture, True potato seed

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important crops in Nepal, playing a vital role in both food security and income generation. In the Terai and mid-hill regions, it is widely consumed as a vegetable, while in the high-hill areas; it serves as a major staple food crop. Among the major food crops rice, maize, wheat, and millet, potato ranks fifth in terms of area coverage, fourth in total production, and first in productivity (MoALD, 2022/23). Potato cultivation is particularly well-suited for smallholder farmers due to its short growing period (3–4 months), high nutritional value, and relatively low water requirements. It also fits well into various cropping systems and is a key ingredient in almost all vegetable-based diets across Nepal. In addition to its importance at the household level, potato holds significant commercial and industrial value. It serves as a raw material for potato-based processing industries, adding further economic potential through value addition and employment generation.

The country has witnessed significant growth in potato production over the years, with the area under cultivation expanding from approximately 198,256 hectares to about 203,812 hectares and the productivity is approximately 17.11 ton per hectare in recent years (MoALD, 2022/23). In the year 2022/23, Nepal produced around 3.41 million metric tons of potatoes, reflecting an increase in both production and cultivated area due to adoption of new technology and the use of improved potato varieties. The productivity of potato is still lower than neighboring countries as well as its production potential. There are several factors which are responsible for lower production of potato among them loss of PBS seed cycle, insufficient supply of source seed and use of informal source for potato seed are most important factors (Potato seed system in Nepal by S.Gairhe, 2021).

In the fiscal year 2022/23, Nepal saw a significant expansion in potato cultivation, with the total area increasing to approximately 203,812 hectares (MoALD, 2022/23). Given the standard seed rate of 2.5 tons per hectare, the estimated national seed potato requirement stands at around 509,530 metric tons. This substantial demand highlights the critical importance of a reliable and sustainable seed supply system. Despite the increasing area under cultivation and improved yields through new technologies and better varieties, seed availability-particularly quality seed-remains a major bottleneck. Addressing this gap is essential for enhancing productivity, ensuring food security, and improving the livelihoods of smallholder farmers who depend on potato as a key crop.

The availability of quality potato seed is one of the most critical factors influencing potato productivity in Nepal. High-quality seed ensures healthy plant growth, better resistance to diseases, and higher yields, which are essential for both household food security and commercial farming. Poor seed quality, often resulting from the use of informal seeds, leads to lower yields, increased vulnerability to pests and diseases, and reduced income for farmers. Therefore, strengthening the potato seed system through advanced technologies like Pre-Basic Seed (PBS) and True Potato Seed (TPS) production is vital for improving productivity, supporting smallholder farmers, and ensuring the sustainable growth of Nepal's potato sector.

Institutional Framework for Potato Seed Production in Nepal

To address the seed quality issue, Nepal has established two major governmental institutions for potato seed production and distribution:

National Potato Research Program (NPRP), Khumaltar – operating under the Nepal Agricultural Research Council (NARC), focuses on varietal development, breeder seed production, and research on potato agronomy and seed health.

Potato Crop Development Center, Nigale, under the Department of Agriculture (DoA) – responsible for the multiplication and distribution of certified seed potatoes to regional and local extension offices and farmers.

In addition to these, private sector organizations and cooperatives have increasingly participated in the production and multiplication of quality seed potatoes, especially at the pre-basic and basic seed levels. Despite these efforts, the current supply is not sufficient to meet the growing demand, especially with the expansion of commercial farming.

For production and distribution of quality potato seed, there are mainly two governmental organizations which are National Potato Research Program (NPRP), Khumaltar, under Nepal Agriculture Research Council and Potato Crop Development Center, Nigale under Department of Agriculture and various private entities are responsible for producing pre-basic seeds; however, the current output remains insufficient to meet the growing demand for quality seed potatoes. The importance of quality potato seeds cannot be overstated. High-quality seeds are critical for ensuring robust plant health and maximizing yield. Poor seed quality can lead to suboptimal plant stands, increased vulnerability to pests and diseases, and ultimately lower yields. For quality seed potato production there are mainly two methods. One is Pre basic Seed (PBS) production through tissue culture and second is true potato seed (TPS) production through hybridization.

Methods of Quality Seed Production

There are two primary methods used for producing quality seed potato in Potato Crop Development Center, Nigale, Nepal:

1. Pre-Basic Seed (PBS) Production via tissue culture
2. True Potato Seed (TPS) production through hybridization.

1. Potato Pre-Basic Seeds (PBS)

Virus and disease free In-vitro plantlets are produced using tissue culture technology and these In-vitro plantlets are transferred into the Aphids/insects proof screen/glass house and 1-25 gram of small potato Mini tubers are produced called (PBS) Pre-Basic seeds. Double antibody sandwich - enzyme linked immuno-sorbant assay is used to test six major potato viruses, namely PLRV, PVS, PVX, PVY, PVA and PVM. PBS was produced for the first time in Nepal during 1989/90 at NPRP, Khumaltar. As per the study of NPRP, Khumaltar the productivity of potato has been increased by 49.8% due to utilization of pre-basic seed potatoes.

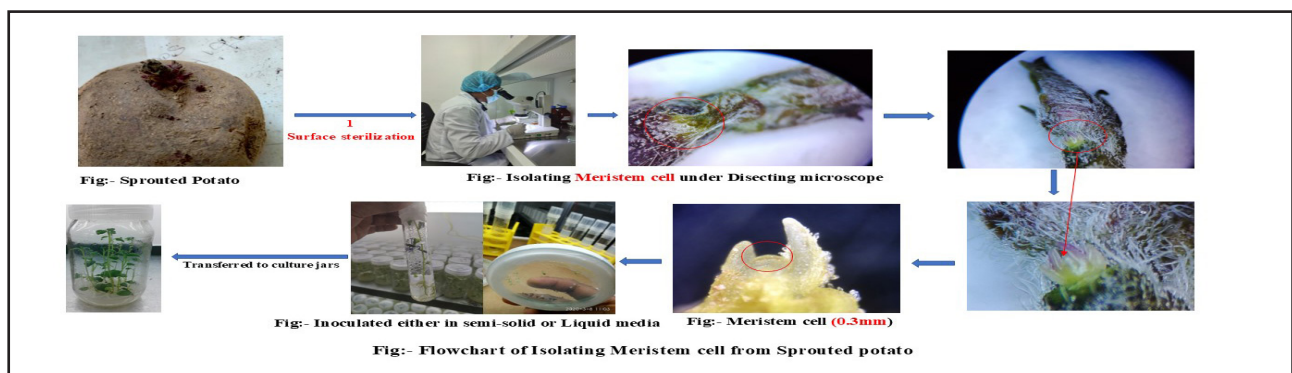
In the process of potato pre-basic seed production there are two important steps, first step is conducted inside the tissue culture laboratory and the second step is conducted inside insect proof screen house.

1.1 Inside tissue culture laboratory

In-vitro cultivation of plantlets and its parts on nutrient medium under aseptic artificial environmental condition is called plant tissue culture. It allows the production of large number of genetically identical plants from single mother stock. Inside tissue culture laboratory following steps are followed to produce virus free potato in-vitro plantlets.

- Firstly, potato tubers are kept in semi dark room/area at 25-30 °C for 2-3 weeks and let them sprout.
- When the potato tubers are sprouted the fresh sprouts from potato tubers are taken and they are surfacely sterilized with tap water for 7-10 minutes and washed with mixed solution of detergent and Tween-twenty for 15 minutes and again they are washed with distilled water with continuous shaking for 10 minutes.

- Then sprouts are taken into Laminar Air Flow (LAF) and they are washed with 70% ethanol for 30 second and then with 2% sodium hypochlorite solution for 5-7 minutes.
- Then finally sprouts are washed with double distilled water for 3 times 5 minutes each.
- Then with the help of dissecting microscope, sterilized forceps and scalpel 0.2-0.3 mm size of meristem cell is isolated and inoculated in either liquid MS media or semi-solid MS media prepared with 0.25mg/l GA3 (Gibberellic acid) hormone.
- And these media containing meristem cells are incubated in sterilized incubation room in which room temperature is $23\pm 2^{\circ}\text{C}$, light intensity of 3500 lux and photoperiod of 16 hours' light and 8 hours' dark.
- After 45-60 days' whole plant with 6-8 node, leaves and roots is developed.
- This whole plant is sub-cultured in fresh MS-media containing 0.15m/l GA3 through single nodal cutting method.
- Then virus testing is done using DAS-ELISA method to diagnose six different types of viruses i.e. PLRV, PVA, PVX, PVM, PVS, PVY.
- When the plants are found virus free they are considered as mother plant and as per Seed Quality Control Centre (SQCC) PBS seed certification policy, NPRP, Khumaltar is responsible to produced mother plant and these mother plants are given to SQCC certified tissue cultured laboratory for the multiplication and PBS production. Then these mother plants are multiplied (sub-culture) using single nodal cutting technique inside tissue cultured laboratory.
- Once the sub-culture is done after about 25-30 days' plantlets are transferred into screen house.



Source: PCDC, Nigale

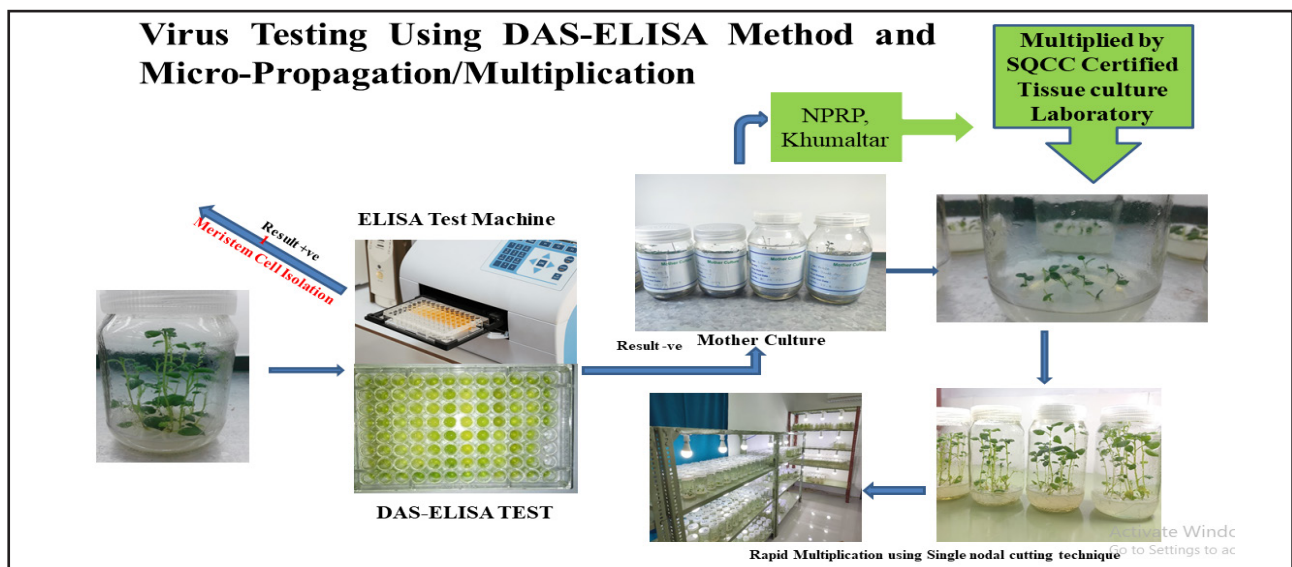


Fig: Virus testing and Rapid Multiplication using Single nodal cutting technique

1.2 Inside aphid proof screen/glass house

Before transferring of in-vitro plants in the bed of screen house we should prepare the bed (sand and soil mixture of 75:25 ratios) and sterilized the bed. To sterilize the soil bed we can use either formalin or Silvox.

- Before soil treatment chemical fertilizer i.e. N: P: K with dose of 200:200:120 kg per ha is mixed in the soil and irrigated with UV treated water, and nitrogen should be used in at least 2 split doses.
- 25-30 days old in-vitro plants are taken into the screen house and they are kept for 3-4 days for acclimatization, during these 3-4 days we should prepare and sterilize the soil bed.
- If we use formalin for soil treatment then formalin (6-10% of formaldehyde) is used, whole soil bed is treated with formalin and covered with plastic for 2-3 weeks. But use of formalin for soil treatment is risky for the person who regularly work in screen house as formalin is health hazardous chemical and can cause cancer in long run.
- Now days instead of formalin Silvox (Nano silver hydrogen peroxide) is being used for soil treatment, and Silvox is safe to use for human health and we don't need to wait for 2-3 weeks as we can plant in-vitro plants after 12 hours of soil treatment by Silvox. Normally Silvox dose at 35ml/3ltr/m² of water is applied uniformly over soil bed and it doesn't require plastic covering, after 12 hours we can transfer the in-vitro plants in the bed.
- After 3-4 days of acclimatization, we start planting of In-vitro plants
- Before planting roots of these in-vitro plants are treated with 1-2 % of fungicide (Bavistin) for few seconds.
- The distance between plant to plant should be 10cm and the distance between row to row should be 25cm.
- After planting, irrigation is done with UV treated water and 1-2% Bavistin (fungicide) is sprayed over the plants
- Regular irrigation and monitoring should be done for plants.
- Normally after 3-4 months of planting of In-vitro plants PBS is ready to harvest.
- Irrigation should be stopped 15-20 days before harvesting.
- Haulm pulling is done 7-10 days before harvesting.
- Finally, after harvesting Grading is done on the basis of its weight

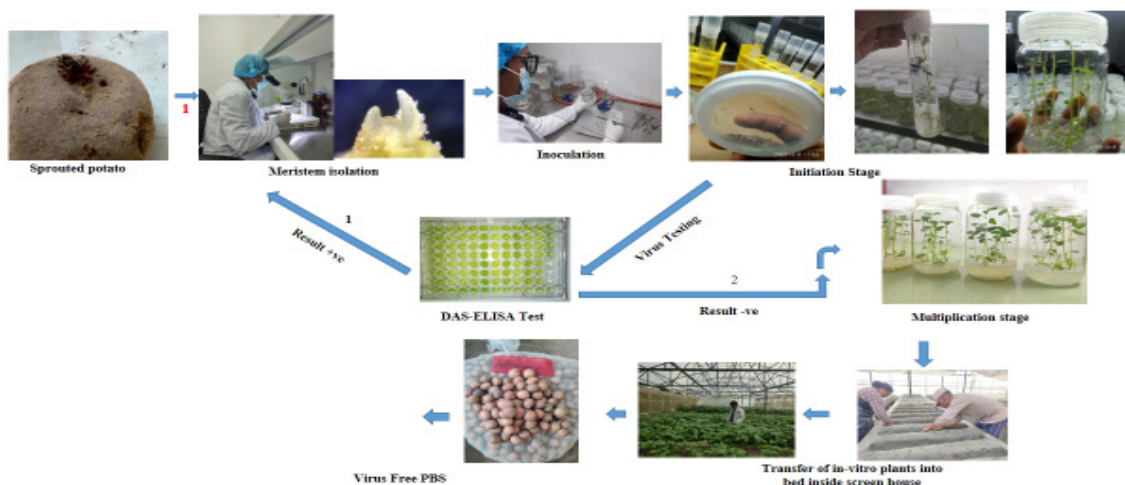


Fig: Flowchart of Virus free Potato PBS Production

Source: PCDC, Nigale

1.3 PBS seed grading



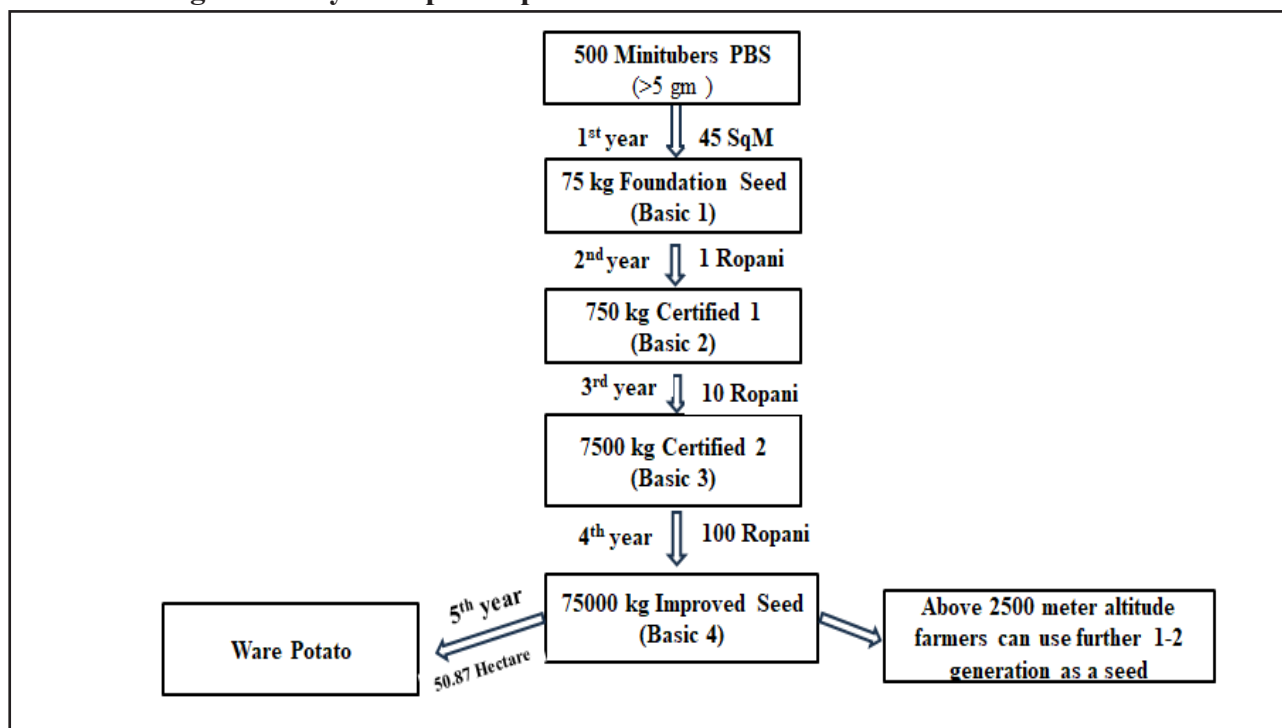
Fig: Virus free PBS tuber

Source: PCDC, Nigale

S.N.	Wt. of PBS Seed	Planting Distance	Area covered by 500 PBS Seed tuber
1.	>5 gm (up to 20 gm) (A grade)	60*15 cm	45 Sq.m

2.	1-5 gm (B grade)	60×7 cm	25 Sq.m
3.	Up to 1 gm (C grade)	60×5 cm	15 Sq.m

1.4 Planning of seed cycle of potato pre-basic seed



Source: PCDC, Nigale

1.5 PBS production, demand and Supply of as per fiscal year 2080/081

S.N.	Certified PBS Producer	Annual Production as Per 2080 B.S.	Annual Demand and Supply	Remarks
1.	National Potato Research Program (NARC), Khumaltar	1.50 Lakh Tuber	Around 80% are sold	20% is used for Basic seed production Untimely and Demand/order of Seeds Variety is changeable every year.
2.	Potato Crop Development Centre, Nigale, Sindhupalchok	95 Thousand Tuber	Around 90% are sold Demand is higher than Production	10% is used for Basic Seed Production
3.	Ficus Biotech Pvt.Ltd, Budanilkantha, Kathmandu	1 .00 Lakh Tuber	Around 60% are sold	40% is used for Basic Seed Production
4.	Shree Ram Niketan Biotech Pvt.Ltd, Godavari	3 .00 Lakh Tuber	Around 75% are sold	25% is used for Basic Seed Production. Untimely and Demand/order of Seeds variety is changeable every year.
5.	Khaddyenna Tatha Biu Aalu, Alaichi Tatha Falful Nursery Uddhyog, Kushadevi	1.50 Lakh Tuber	Around 20% are sold	80% is used for Basic Seed Production

6.	Kushal Agriculture Research and Development centre, Bardiya	1.50 Lakh Tuber	80% are sold	20% is used for Basic Seed Production
7.	Apex Biotech and agri-forestry Research centre Pvt.Ltd, Jhapa	45 Thousand Tuber	50% are sold	50% is used for Basic Seed Production
	Total PBS Production	9.90 Lakh Tuber		

Source: Annual reports of PCDC 2080-081 BS

1.6 Data of pre-basic seed production in different fiscal year at PCDC

S.N.	Fiscal Year	Number of In-vitro Jars	Pre-basic Seed (No. of tuber)
1.	2080/081	6500	95,240
2.	2079/080	4220	56,850
3.	2078/079	1800	45,000
4.	2077/078	60	28,180
5.	2076/077	0	12,500

Source: Annual reports of PCDC

2. Seed production technology of True Potato Seed (TPS)

In Nepal, the traditional method of using seed tubers is common but costly and prone to diseases. TPS technology was introduced to overcome these challenges and improve productivity in remote areas where access to quality seed tubers is limited. True potato seeds, or “botanical potato seed” differentiates from “seed potatoes”, which are genetically identical clones produced in large numbers by planting pieces of a potato stem or tuber or through tissue culture.

2.1 Parent lines for planting

Conventional varieties in the mid-hill region in Nepal have been found to be vulnerable to foggy weather, cold waves and late blight disease. Hence, farmers have been producing potatoes from TPS seeds from hybrid potato varieties, like HPS 7/67 and HPS 1/13, obtaining yields of about 35 tons per ha.



Fig: TPS Berry and Seed

Source: PCDC, Nigale

Any successful true potato seed program must guarantee a reliable supply. Fortunately, TPS can be produced following steps similar to those used to produce many other vegetable crops.

2.2 Pollination or crossing of parent line

Pollination can occur either naturally, or under controlled conditions. If plants are left in the field to set fruits naturally, much of the seed will result from self-pollination

The proportion of out-crossing that occurs is caused primarily by insects. The resulting TPS is termed “open pollinated seed” as only the female parent is known. Seed also can be produced from controlled pollination done by hand. In this case, the TPS is termed “hybrid progeny”. With controlled pollination, pollen from the male parent is placed on the stigma of the flower. This can be done in the field or in the greenhouse under controlled conditions.

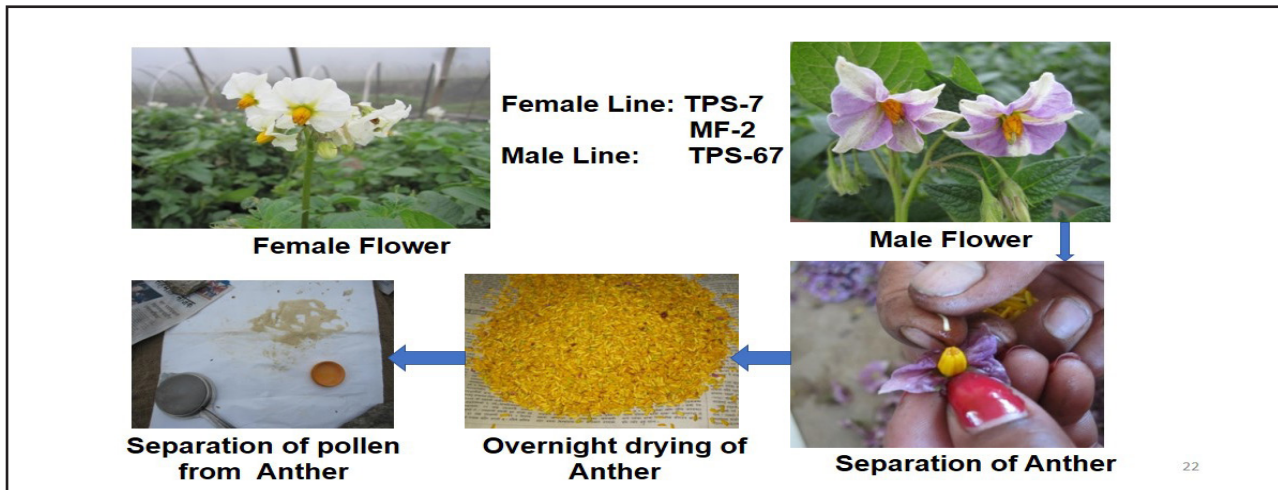


Fig: True Potato Seed (TPS) Production Steps

Source: PCDC, Nigale

2.3 Berry harvest

A few days after pollination, berries will start to develop on the plants. In about 40 days, these berries will be ready for harvesting. Under field conditions, a flowering plant will produce an average of 20 berries. When berries are mature, they are harvested and kept at room temperature until they are soft enough to easily extract the seed. The number of TPS per berry can range from 50 to 500, though the average usually is about 200. One gram contains approximately 1000-1500 TPS.

2.4 TPS Seed storage

TPS extracted from the berries is then dried at room temperature in low relative humidity. When kept at room temperature, seed can remain viable for several months up to approximately two years. At 4° C, TPS can be stored for several years without losing germinability. In both cases, however, low relative humidity during storage is essential. TPS also has a longer dormancy period than tubers. Although it lasts from four to nine months, it can be broken by a simple treatment with Gibberellic acid.

TPS Production Con..

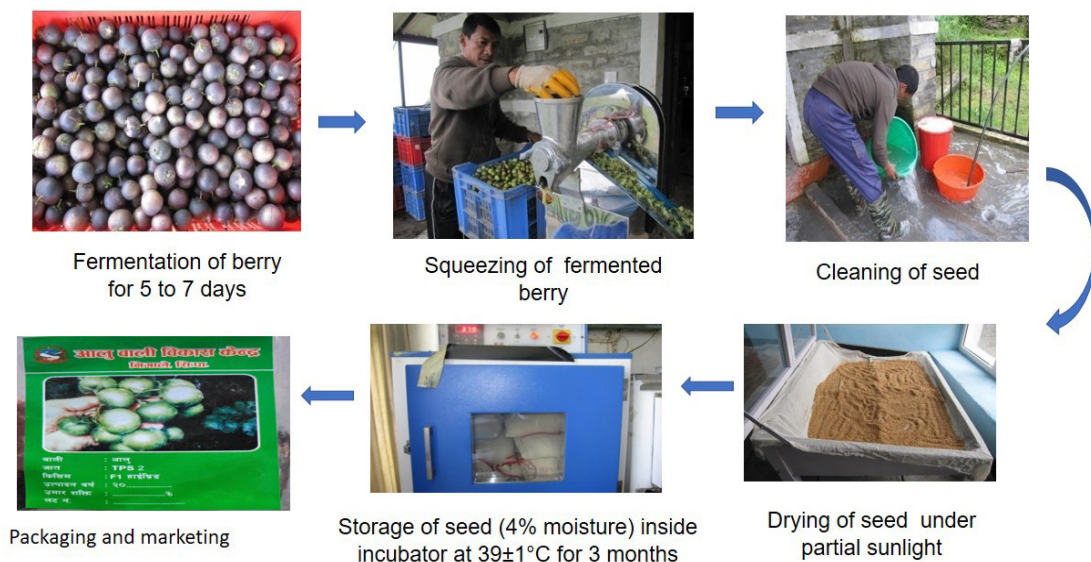


Fig: Berry harvest, seed processing and storage

Source: PCDC, Nigale

2.5 TPS Seedling tuber production through TPS Seed

The first generation of tubers produced from seedlings grown from TPS is referred to as “seedling tubers”. This production method combines the advantages of TPC with those of planting seed tubers.

- Depending upon environmental conditions, seedling tubers will grow in densely sown ground beds or in rows in the field.

- When properly managed, a nursery bed will yield as many as 800 clean seedling tubers per square meter.

Seedling tubers can be used to increase seed tuber quality, Furthermore, tubers can be multiplied to produce additional potatoes for consumption. In production seedling tuber can be grown by:

2.5.1 Seed sowing

Field sowing TPS has potential in areas with mild temperatures, where rainfall is light and evenly distributed during the first five to six weeks after sowing. This permits good germination and seedling establishment in the field. Sowing directly to the furrow often produces inconsistent results. There are ways to facilitate field sowing, such as the use of pelleted seed, fluid drilling and the “plug mix” methods. With “plug mix”, seed is pre-germinated in a prepared soil mix and sown. Under favorable conditions, good plant emergence from direct sowing of TPS can be achieved.

TPS to seedling tuber production



Cleaning of seed

- HCL 10-11% (3:1 water and HCL)
- NAOCL (10:1 water and NAOCL)

5 gm seed=25-30m.square area



Seedling tuber 100-120 kg



TPS nursery (P/P and L/L distance 5×25cm)



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Figure: Seed sowing and seedling tuber harvesting

Source: PCDC, Nigale

2.5.2 Transplanting seedlings to the field

Transplanting TPS seedlings to the field has several advantages over direct sowing. First, plants are in the field less time, freeing the land for other uses. Weed competition is also reduced and agronomic practices are simplified.

- TPS can be sown in trays or ground beds in a nursery. In warm climates, use of shade in nurseries for 15 to 20 days after sowing helps achieve more uniform emergence and vigorous seedling growth.
- Seedling emergence normally occurs between eight to ten days after sowing. Seedlings are thinned a week to ten days after emergence.
- Approximately 35 days after sowing, the seedlings are ready for transplanting.
- To reduce shock at transplanting due to adverse conditions, seedlings can be transplanted with soil-covered roots using containers such as compost cubes, banana leaf cups, or thin, plastic trays.
- This system has promising applications, especially in areas where vegetation production by transplanting is a common practice.
- When adequate management practices are followed, adapted progenies can yield more than 30 tons per hectare.

2.5.3 Har vesting and storage

2.6 TPS Production trend in PCDC over 5 Years

Data of True Potato Seed (TPS) Production in Different Fiscal Year at PCDC

S.N.	Fiscal Year	TPS Seeds (kg)
1.	2080/081	19.50
2.	2079/080	32.00
3.	2078/079	9.80
4.	2077/078	8.30
5.	2076/077	9.50

Source: Annual reports of PCDC, 2081-082 BS

True Potato Seed (TPS) is utilized in both the Terai and hill regions of Nepal. However, its adoption is significantly higher in the Terai, particularly in the eastern districts such as Jhapa, Morang, and Sunsari, as well as in the western Terai districts including Bardiya, Dang, Rupandehi, and Nawalparasi. The favorable climatic conditions, better access to irrigation, cold storage facility and established seed networks in these areas have contributed to the greater popularity and success of TPS technology in the Terai compared to the hill regions.

Key Challenges in Pre-Basic Seed Potato and True Potato Seed Production in Nepal

Pre-basic seed production, primarily carried out through tissue culture and greenhouse multiplication, is essential for supplying clean and disease-free planting material. However, several constraints limit its effectiveness in Nepal:

a) Limited Infrastructure and Facilities

- Inadequate number of well-equipped tissue culture labs, screen houses, and controlled-environment greenhouses.
- Poor maintenance and outdated equipment reduce efficiency and seed quality.

b) Skilled Manpower Shortage

- Limited availability of trained personnel in tissue culture, greenhouse management, and seed health monitoring.
- High turnover of skilled staff in government labs and lack of training programs.

c) High Initial Investment

- Infrastructure setup and maintenance costs are high, making it less feasible for small or private operators without financial support.

d) Quality Control and Certification Gaps

- Weak enforcement of quality assurance and certification protocols for pre-basic and basic seed production.
- Lack of standardized monitoring systems and seed traceability.

e) Limited Public-Private Collaboration

Weak coordination between government agencies and private sector stakeholders involved in seed multiplication and dissemination.

With increasing demand for potatoes and the need for sustainable farming practices, TPS technology has great potential to enhance potato production in Nepal. Efforts to improve farmer training, develop climate-resilient TPS varieties, and integrate TPS into mainstream farming systems can contribute significantly to food security and rural livelihoods.

Recommendations to Overcome Challenges

1. Strengthen infrastructure and facilities

Upgrade Existing Laboratories and Screen Houses: Invest in modernizing tissue culture labs, screen houses, and greenhouses with reliable power and water supply to ensure consistent and high-quality PBS and TPS production.

2. Build technical and human resource capacity

Training Programs: Organize regular training for technical staff of three levels of government on tissue culture, disease indexing, greenhouse management, and TPS hybridization techniques.

3. Enhance quality assurance and certification

Strengthen Seed Certification: Enforce strict quality control and certification protocols for PBS and TPS to ensure only disease-free, high-quality seeds.

4. Promote research and innovation

Develop Climate-Resilient Varieties: Support research on TPS hybrids lines that are tolerant to local climatic stresses and diseases and farmers' choice.

5. Strengthen public-private partnerships

Collaborate with Private Sector: Encourage private biotech labs and seed companies to participate in PBS production.

6. Increase farmer awareness and adoption

Establish model farms and demonstration plots to showcase the benefits of PBS and TPS technologies. Extension Services: Strengthen agricultural extension programs to educate farmers on the advantages, handling, and management of PBS and TPS.

7. Ensure policy and financial support

Subsidies and Grants: Provide targeted subsidies for infrastructure development, input costs, and certification fees for PBS and TPS production.

Seed Policy Reform: Update national seed policies to prioritize PBS and TPS in the formal seed system and ensure sustained government support.

8. Maintain seed cycle and parent line

Preserve Parent Lines: Regularly rejuvenate and maintain parental lines for TPS and PBS to prevent genetic degeneration.

Seed Cycle Management: Implement a strong seed cycle plan to ensure timely multiplication and supply of quality seeds.

9. Promoting community-level seed production: A sustainable way forward

Community-level seed production is a vital component for strengthening Nepal's potato seed system. The large-scale multiplication and dissemination of quality seed to farmers across the country can be effectively achieved through active community participation.

- Strengthen infrastructure for tissue culture and screen house seed production.
- Enhance training programs for technicians and farmers. capacity building program
- Develop and enforce robust seed certification and traceability systems.
- Promote research on locally adapted TPS hybrids with uniform tuber traits.
- Facilitate public-private partnerships to scale up quality seed production and distribution.
- Seed cycle maintain of all providence, federal and local governments

Conclusion

The Potato Crop Development Center, Nigale, and other organizations are working to produce and supply better seeds, but current efforts are not enough to meet the country's needs. To solve these problems, it is important to improve infrastructure, train more people, compulsory seed certification and seed cycle maintain, support community seed production. The government and private sector should work together to make sure farmers can easily access quality seed. By focusing on these areas, Nepal can boost potato production, help farmers earn more, and strengthen food security for the whole country.

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Vegetables Genetic Resources, Conservation and Challenges

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Abstract

Nepal harbors a rich diversity of vegetable genetic resources, with 435 species across 15 agroecosystems, constituting 6.6% of the country's agricultural genetic resources. This includes 7,500 landraces and 334 wild vegetable species. Despite the release and registration of 344 varieties from 39 vegetable crops, 95% of these are exotic, leading to a loss of 40% of the country's vegetable biodiversity. The National Genebank has adopted four major conservation strategies: Ex-situ, On-farm, In-situ conservation, and Conservation breeding. A range of conservation approaches, including seed banks, field genebanks, agro gene sanctuaries, DNA and tissue banks, community genebanks, and crop-specific parks, have been deployed. Additionally, associated banks like agro-insect field genebanks and herbal conservation gardens have been initiated. Currently, 952 accessions of 46 vegetable crops are conserved within the National Genebank, while 257 accessions are stored in foreign genebanks, 926 in the World Vegetable Center, and 25 accessions of 9 vegetable crops in USDA genebanks. Nepal has also included 7 accessions of 4 vegetable crops under the Multilateral System of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The main challenge is to enhance the competitiveness of site-specific native vegetable crops by promoting their cultivation through ecological agriculture, as foreign varieties undergo extensive testing and dominate the market. To address this, native landraces, which are climate-resilient, nutrient-dense, and culturally significant, need greater focus in research, education, extension, and marketing. Linking native vegetables to geographical indications and declaring broad leaf mustard as the national vegetable could support the preservation and promotion of Nepal's vegetable biodiversity. Expanding ecological agriculture that enhances the competitiveness of native crops is critical for long-term sustainability.

Keywords: Accessions, Climate resilient, Conservation banks, Genetic erosion, Vegetable crop diversity

Introduction

Vegetable genetic resources (VGRs) play a crucial role in food security, nutrition, health, environmental sustainability, and business. Due to the diverse cultivation practices of farmers over centuries, Nepal has maintained a wealth of unique, site-specific landraces across its varied agroecological zones (Upadhyay and Joshi 2003, Budathoki et al., 1993, Joshi et al., 2017, Joshi and Shrestha 2019, KC et al., 2021, Poudel and Joshi 2020). These native landraces are not only climate-resilient but are also rich in nutrients, healthy, and flavorful. However, despite their potential, native vegetables are often overlooked in research, education, and extension programs, with a greater focus placed on exotic and hybrid varieties (Budathoki et al., 1993, Joshi et al., 2020). The main challenge lies in making these site-specific native vegetable crops more competitive by adopting ecological agriculture practices (Pandey 1993). Chemical-based farming and protected agriculture have contributed significantly to the loss of genetic diversity, with native vegetables largely neglected in formal agricultural sectors. Moreover, under the guise of crop protection, many beneficial insects and organisms have been eradicated. To address this, it is recommended to shift the focus of crop protection offices toward "Crops, Agro-insects, and Microbes Conservation" and create environments that are friendly to insects, microbes, and birds. Adopting ecological pest management and creating habitats for beneficial organisms would help sustain biodiversity.

Following the establishment of Nepal Genebank, numerous approaches have been introduced to conserve and promote the sustainable use of vegetable genetic resources. These include seed banks, field genebanks, crop-specific parks, school field genebanks, agro-gene sanctuaries, community genebanks, and conservation vegetable breeding. These initiatives aim to make landraces more competitive while promoting site-specific varieties and expanding

conservation efforts through fairs and diversity blocks. Associated conservation banks, such as agro insect field genebanks, aqua pond genebanks, and herbal conservation gardens, have also contributed to the preservation and enhancement of crop diversity.

To further advance conservation, the documentation and profiling of vegetable diversity at various levels (households, villages, districts) is necessary, along with the generation of passport data. A vegetable diversity index should be developed to identify centers of diversity and estimate regional diversity. Additionally, linking these efforts to geographical indication (GI) can help promote native crops like broadleaf mustard, which is grown in nearly every household and originated in Nepal. Declaring it as the national vegetable would symbolize the country's commitment to its agricultural heritage. To ensure the success of native vegetables in the market, local seed cycles should be encouraged, and product cycles should be globalized. This can be supported by providing farmers with market and irrigation guarantees, such as the establishment of collection centers in each municipality. Native vegetables tend to have fewer pest and disease issues compared to exotic varieties, offering significant advantages for both farmers and consumers. Therefore, increasing research, promoting ecological farming practices, and securing market access are essential for safeguarding Nepal's rich vegetable genetic resources.

Groups of Horticultural Genetic Resources

Horticultural genetic resources (HGRs) are one of three groups within agricultural plant genetic resources (APGRs), alongside agronomic plants and forages (Figure 1). Vegetables fall under the horticultural category and can be classified into domesticated, semi-domesticated, wild edible species, and wild relatives (Joshi et al 2023). Based on the parts used, vegetables are further categorized into leafy and stem vegetables, flowers, fruits, roots and tubers, and seeds and pods (Joshi 2022). These include both lower and higher plant species. Mushrooms are also considered important vegetables, though they are not discussed in this paper.

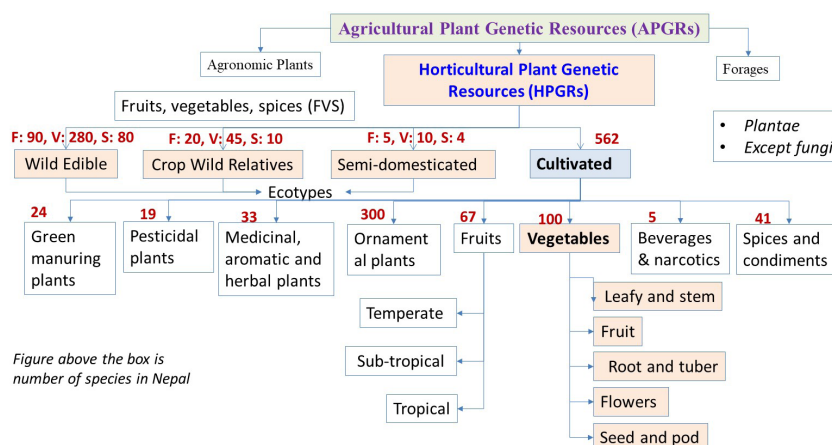


Figure 1: Classification of horticultural plant genetic resources based on economical values

Source: Joshi et al., 2020, 2022, 2023

1. Vegetable genetic resources

Vegetables play an integral role in the Nepali diet, often consumed as side dishes along with staple foods. This diverse consumption pattern is reflective of the country's rich biodiversity, which is driven by its varied climate and ethnic diversity (Budathoki et al., 1993, Joshi and Shrestha 2019, Joshi et al., 2019). As a result, Nepal is home to a large number of vegetable species, making vegetable cultivation a significant aspect of the agricultural landscape. Out of Nepal's 24,300 identified biological species, 28% are categorized as agricultural genetic resources (AGRs). Within this group, vegetables account for 6.6%, reflecting the importance of this crop group to the country's agrobiodiversity. Vegetables in Nepal are grown across a wide range of altitudes, from as low as 60 meters to as high as 4,700 meters above sea level, and are distributed across 15 different agroecosystems. The country harvest 435 species of vegetables, showcasing a remarkable variety (Joshi et al., 2022, Joshi et al., 2017). Among these, 100 species are domesticated, while 280 are wild (Figure 2) but edible, offering a vast pool of genetic diversity for research, conservation, and utilization.

This diversity exists at multiple levels: from the agroecosystem level to vegetable crop groups, species, cultivars (landraces and modern varieties), genotypes, and alleles. Both genotypic and phenotypic variations are observed, allowing for adaptation to Nepal's diverse ecological zones. This broad genetic base is crucial for maintaining resilience in agricultural systems, especially in the face of challenges like climate change and market demands. Prior to the Convention on Biological Diversity (CBD), there was a free exchange of germplasm, leading to the

widespread availability of exotic varieties in Nepal. Today, the country's vegetable genetic resources comprise a mix of exotic, native, local, hybrid, open-pollinated, inbred varieties, as well as breeding lines, cultivars, and traditional landraces. These varieties serve multiple purposes, such as being used fresh, dried, in salads, pickles, soups, and even as staple foods. This diversity of uses adds to the cultural significance of vegetables in Nepalese cuisine and underscores the importance of conserving and utilizing these resources for future food security and agricultural innovation.

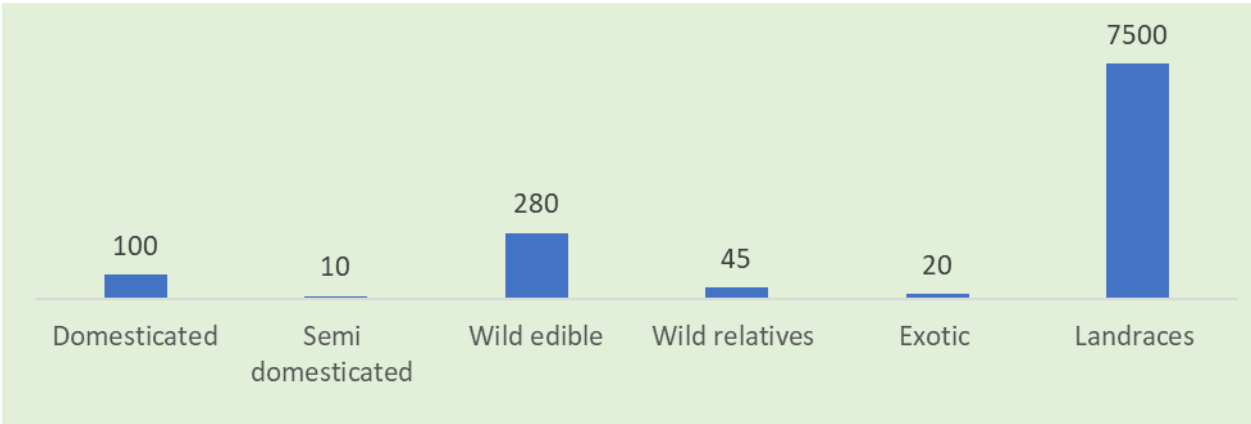


Figure 2: Number of vegetables species and total landraces in Nepal

Source: Joshi et al., 2017, 2020, 2022

2. Classification of vegetable crops

Vegetable crops can be classified based on various criteria, which aids in their effective conservation strategies (Figure 3). For instance, one important distinction is between orthodox and non-orthodox seeds. Orthodox seeds can be stored for long periods under low-moisture and cold conditions, making them suitable for storage in seed banks. However, non-orthodox seeds, which do not survive drying or freezing well, require different approaches, such as conservation in field genebanks or tissue banks. These methods ensure that non-orthodox varieties, which might be more vulnerable to environmental changes, are preserved outside their natural growing environments. In addition to the technical classification of seeds, conservation efforts also prioritize certain types of vegetables. Native and local vegetable landraces are given higher priority because they are well adapted to local conditions, offer greater genetic diversity, and often have traits like climate resilience and nutritional richness.

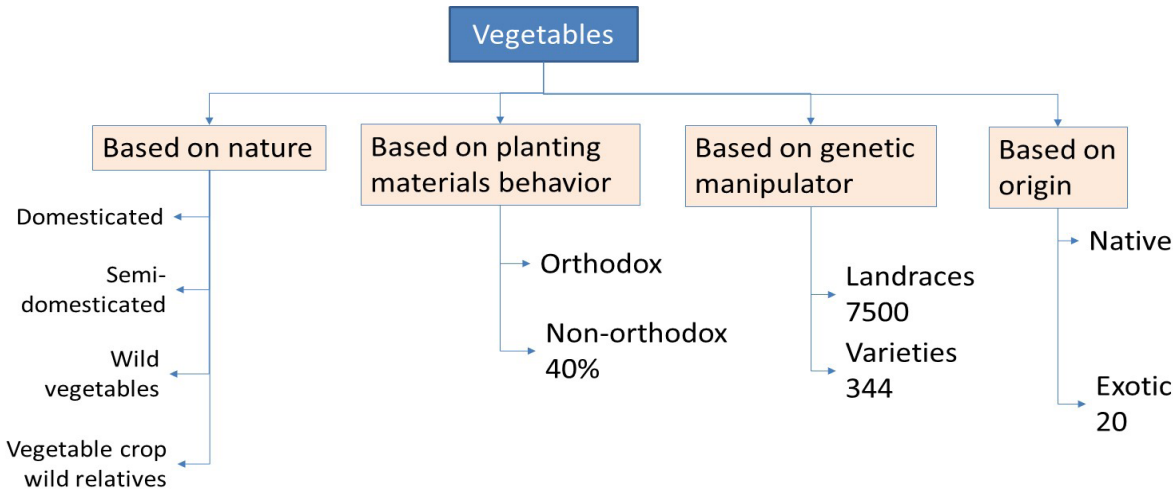


Figure 3: Classification of vegetable crops based on conservation perspective

Source: Joshi et al., 2017, 2020, Joshi 2022

3. Landraces

Landraces refer to the genotypes that have been cultivated by farmers over generations without formal breeding intervention. These varieties have naturally adapted to their local environments, making them uniquely suited to specific regions. In Nepal, it is estimated that there are around 7,500 landraces of vegetables, which play a crucial role in the country's agricultural biodiversity. Most farmers in Nepal rely on these landraces, grow organically and

follow an informal seed system, where seeds are saved and exchanged within farming communities rather than purchased from commercial seed suppliers. Many of these landraces have evolved in specific sites, becoming well-adapted to local climatic and soil conditions. They are often preferred by farmers for their resilience, flavor, and nutritional value, despite the increasing pressure from hybrid and exotic varieties. By maintaining these traditional varieties, farmers contribute to the conservation of genetic diversity, which is essential for long-term sustainability and adaptability to changing environmental conditions. However, the shift towards formal breeding and the promotion of exotic varieties threatens the survival of these valuable local landraces.

4. Released and Registered (RandR) vegetable varieties

In Nepal, Released and Registered (RandR) vegetable varieties refer to any varieties officially listed under the National Seed Board. These varieties are recognized for commercial cultivation and distribution. A significant portion of RandR varieties in Nepal is dedicated to vegetables, accounting for 56% of the total. Currently, there are 409 RandR varieties across 40 vegetable crops, although 114 varieties have been denotified over time, possibly due to obsolescence or poor performance (SQCC 2024). A detailed analysis of 344 RandR vegetable varieties from 39 crops revealed that 95% of these varieties originated outside Nepal, according to a study by Joshi et al. (2017). This heavy reliance on exotic varieties reflects a trend in Nepal's agricultural sector where foreign vegetable strains, especially hybrids, are prioritized. This trend is further evidenced by the lack of data on the origin of recently registered varieties, suggesting a shift towards adopting hybrid varieties without transparent records of their genetic sources.

Despite the availability of native landraces that are climate-resilient, nutrient-rich, and flavorful, there is less focus on promoting these local varieties. Native vegetables have the potential to withstand Nepal's diverse climate challenges while offering higher nutritional and health benefits. However, the agricultural market and policies continue to favor exotic and hybrid varieties, often sidelining the ecological and cultural benefits of traditional crops. This shift towards hybrids could further erode the genetic diversity of Nepal's vegetable species, posing risks to food security and sustainability in the long term.

5. Wild vegetables

In Nepal, the number of wild vegetable species far exceeds that of domesticated vegetables, with over 334 wild species, including spices, reported across the country (KC et al., 2021). These wild vegetables are found in diverse regions, thriving naturally from as low as 60 meters to over 3,500 meters above sea level, and are available throughout the year. The majority of these species grow in the mid-hill regions of Nepal, where they are harvested by local communities. Their natural growth and unique qualities make them highly prized in the market, often fetching higher prices than cultivated vegetables (Pandey, 1999).

These wild vegetables are renowned not only for their delicious taste but also for their high nutritional value and health benefits (KC et al., 2021, Pandey, 1999). Some of them even possess nutraceutical properties, meaning they can contribute to both nutrition and medicinal benefits. For many farmers, the harvesting and selling of these vegetables play a crucial role in sustaining their livelihoods and local economies. This informal trade is essential for their income, as these vegetables are often sold in small quantities, with vendors sitting by the roadsides to offer them to passersby. The practice of gathering and selling wild vegetables connects these communities with nature while providing an important economic lifeline.

Practices Leading to Genetic Erosion

Nepal has lost 50% of its vegetable biodiversity, a stark indicator of genetic erosion (Joshi et al., 2020). This loss is a result of the cumulative impact of following agricultural practices, reducing the country's ability to sustain a diverse agricultural ecosystem and leaving it vulnerable to the challenges posed by climate change, pests, and diseases (Joshi et al., 2019, 2023).

Genetic erosion, the loss of genetic diversity, has been exacerbated in Nepal due to several agricultural practices. One significant factor is the widespread cultivation of uniform, homogenous, and exotic varieties. These varieties are often chosen for their high yield or marketability but displace native, genetically diverse varieties. This shift reduces the genetic pool of indigenous species, which are often more resilient to local environmental conditions. The practice of monoculture-growing a single variety over large areas-further amplifies genetic erosion. By focusing on one crop type, especially in large-scale farming, farmers inadvertently limit the diversity of plants in their fields. This uniformity not only makes the crops more vulnerable to pests and diseases but also reduces the natural selection processes that contribute to genetic diversity.

Additionally, the use of the same rootstock for many varieties and species contributes to this issue. While rootstock

compatibility is essential for certain plants, relying on a limited number of rootstocks reduces genetic variability within crops. This can affect the plant's ability to adapt to environmental changes, further increasing the risk of genetic erosion. Another contributing factor is the practice of asexual propagation, which halts the natural process of meiotic variation. Unlike sexual reproduction, which encourages genetic diversity through recombination, asexual propagation maintains genetic uniformity. While this method can be beneficial for ensuring uniformity and specific traits, it limits evolutionary potential and prevents the introduction of new genetic traits that could help species adapt to changing environments. Protected agriculture, which often involves controlled environments like greenhouses, can also lead to a loss of associated biodiversity. By creating conditions that favor specific crops and varieties, these systems can exclude the many organisms that naturally interact with plants in an open ecosystem, thus diminishing the broader genetic diversity of the agricultural landscape.

Efforts to conserve genetic diversity through gene banks and field genebanks have been put in place, but these collections are limited to certain areas and buildings. While these repositories serve as valuable resources for preserving biodiversity, they cannot fully replace the diversity that exists in natural environments. Additionally, this method of conservation often focuses on a limited range of species, neglecting the broader spectrum of plant varieties. Legal frameworks also play a role in genetic erosion. In Nepal, the legal provision for selling and buying registered and released (RandR) varieties, along with economic incentives, often favors commercial and exotic varieties over indigenous ones. This focus on registered varieties discourages farmers from maintaining and cultivating traditional varieties, further diminishing genetic diversity in crops. Another challenge is that the seed cycle has moved outside farming communities, breaking traditional systems where farmers would save and exchange seeds within their communities. This shift to external seed sources has reduced the circulation of local varieties, limiting the diversity of plants grown and threatening the survival of lesser-known or underutilized species.

Conservation Strategies and Components

To conserve Nepal's rich vegetable genetic resources (VGRs), the National Genebank has adopted four key strategies based on the action site: Ex-situ conservation, On-farm conservation, In-situ conservation, and Conservation breeding (Joshi et al., 2020).

Ex-situ conservation involves storing and preserving VGRs outside their natural habitats, typically in seed banks, field genebanks, or other conservation facilities. This method ensures that genetic material is safely stored for future use and research. On-farm conservation focuses on preserving genetic diversity within local farming systems. This approach supports farmers in cultivating and maintaining native landraces in their fields, helping to conserve site-specific varieties in their natural agroecosystems. In-situ conservation entails protecting VGRs in their natural environments, allowing the plants to evolve and adapt to changing conditions. This strategy is essential for maintaining the dynamic nature of genetic diversity in wild and semi-domesticated vegetable species. Conservation breeding involves the deliberate breeding of native vegetables to enhance their genetic traits, making them more resilient, productive, and marketable. This strategy helps to improve site-specific varieties while ensuring their conservation.

In addition to these site-based strategies, Nepal's conservation efforts are also guided by four levels of governance: Local level, Province level, National level, and International level. These levels ensure that conservation activities are coordinated and supported from grassroots communities to global initiatives, with appropriate policies and resources allocated at each stage. Furthermore, five key conservation components have been identified and practiced to ensure the sustainable conservation of agrobiodiversity. These components, illustrated in Figure 4, provide a comprehensive framework for maintaining and utilizing VGRs, ensuring that Nepal's rich vegetable diversity is preserved for future generations.

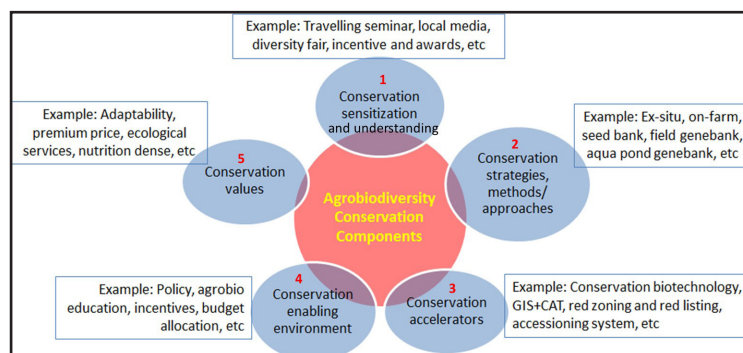


Figure 4: Components of conservation of agrobiodiversity

Conservation Approaches and Status

Nepal employs a variety of innovative conservation approaches to safeguard its vegetable genetic resources (VGRs), implemented within the framework of four key conservation strategies: **Ex-situ**, **On-farm**, **In-situ**, and **Conservation breeding**. These approaches include seed banks, field genebanks, agro-gene sanctuaries, DNA banks, tissue banks, community genebanks, school field genebanks, crop-specific parks, and aqua pond genebanks (NAGRC, 2022, Joshi et al., 2020). These diverse strategies ensure that VGRs are conserved across different contexts, from controlled environments to local farming systems (Figure 5). In addition to these, associated conservation initiatives such as agro-insect field genebanks, herbal conservation gardens, and indigenous plant nurseries (Raithane nurseries) have been established. These facilities promote not only the conservation of vegetable crops but also the broader biodiversity of insects, herbs, and other organisms that contribute to agricultural ecosystems. Together, these approaches create a dynamic system for preserving and promoting genetic diversity in Nepal's agricultural landscapes.

The first Community Genebank was established in Gaver Valley, Banke, in 2022, and there are now three such genebanks operating in Nepal, all focused on conserving vegetable genetic resources (VGRs) through active utilization. While similar to community seed banks, these Community Genebanks encompass all six components of agrobiodiversity, including crops, forages, livestock, agro-insects, agro-microbes, and aquatic agricultural genetic resources (AGRs). Community Genebanks can be operated through two primary models. The first model is village-level, where each household maintains different landraces of various species. Collectively, these households form a robust community genebank, promoting local biodiversity and knowledge sharing. The second model involves maintaining AGRs in specific areas, complemented by the construction of storage facilities and other structures to support conservation efforts. Through these innovative approaches, Community Genebanks enhance on-farm conservation, empower local communities, and contribute to sustainable agricultural practices.

The **National Genebank of Nepal** has made significant progress in conserving VGRs. It currently holds 952 accessions from 46 different vegetable crops (Figure 6). Additionally, Nepalese vegetable crops are conserved internationally, with 257 accessions stored in foreign genebanks, 926 accessions at the World Vegetable Center, and 25 accessions of nine vegetable crops maintained by the USDA. Furthermore, seven accessions from four vegetable crops have been included under the **Multilateral System (MLS)** of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which facilitates the sharing of genetic resources globally.

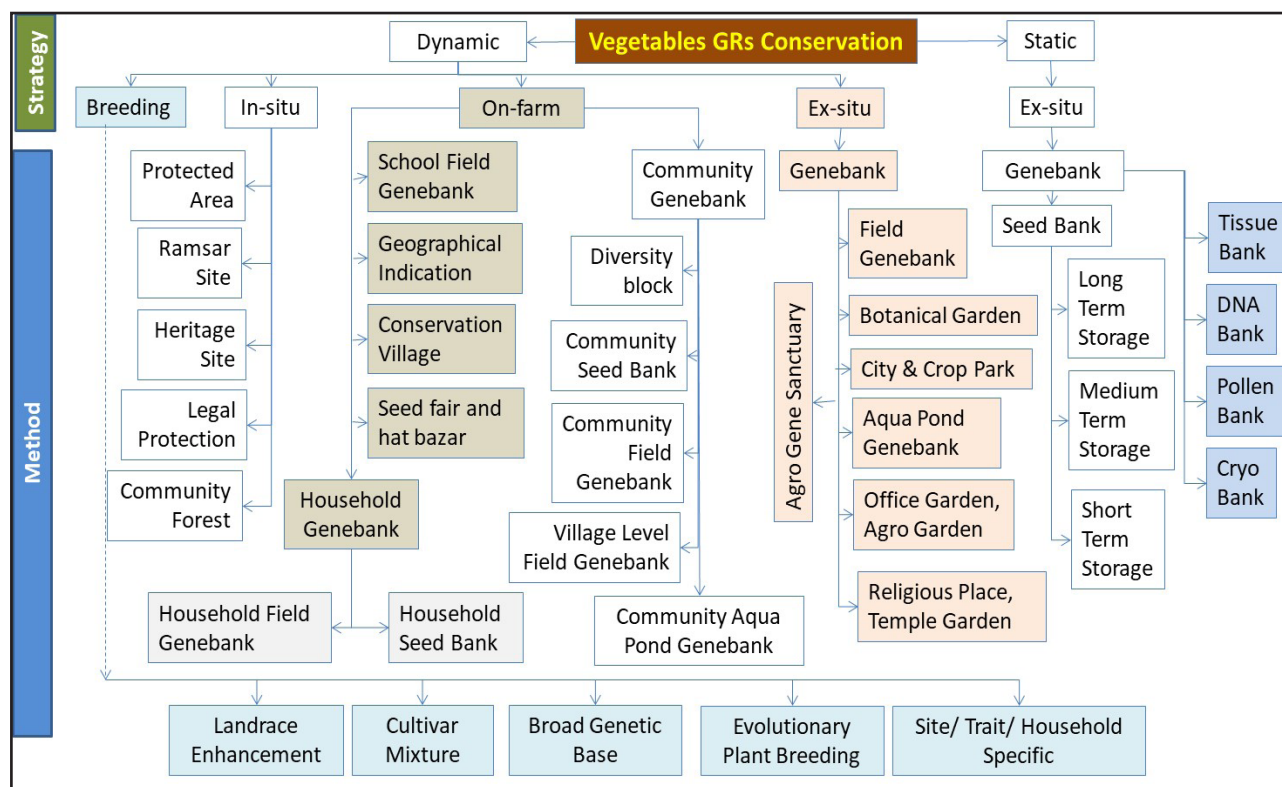


Figure 5: Action site-based conservation strategies, methods and approaches for VGRs

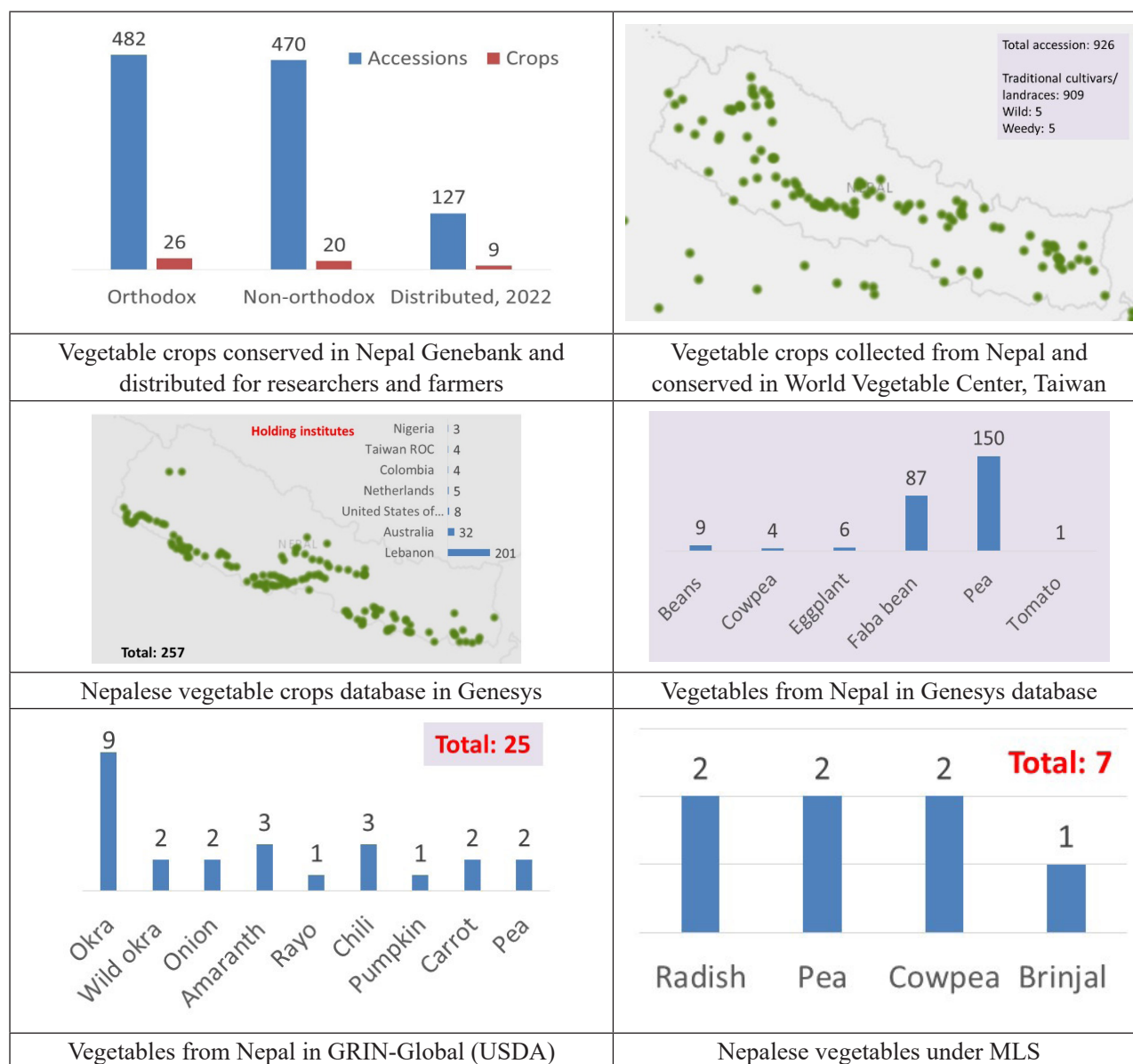


Figure 6: Conserved Nepalese vegetable accessions in different banks

Conservation Accelerators

Conservation requires multifaceted approaches and tools to be truly effective. Among these tools, **conservation accelerators** play a crucial role in enhancing the preservation of genetic diversity (Joshi et al 2020). Defined as actions that directly or indirectly promote the continued existence of existing genetic diversity, conservation accelerators are essential components of any conservation strategy. These accelerators can encompass a wide range of practices, including the development of community engagement initiatives, the establishment of policy frameworks that support biodiversity, and the implementation of sustainable agricultural practices. Some such accelerators are described below. By leveraging these action tracks, stakeholders can create an environment conducive to the preservation and enhancement of genetic resources, ensuring that both current and future generations benefit from the rich biodiversity available in ecosystems.

1. Agrobiodiversity Impact Assessment (AIA), Red zoning and red listing

Before implementing any projects or activities in specific agricultural areas, conducting an **Agrobiodiversity Impact Assessment (AIA)** is essential. This assessment aims to identify and protect endangered and rare genotypes by facilitating their rescue, relocation, and conservation in genebanks. The Genebank has actively employed AIA in its initiatives and has advocated for relevant stakeholders to mainstream it alongside Environmental Impact Assessments (EIA) to ensure a comprehensive approach to conservation. In addition to AIA, **red zoning** and **red listing** are crucial tools for prioritizing conservation efforts (Joshi et al., 2017). Red zoning involves identifying areas where landraces are at risk, while red listing establishes a catalog of these vulnerable species. By employing

these methods, conservation targets can be identified and prioritized, allowing for focused efforts to protect the most threatened genetic resources. Together, AIA, red zoning, and red listing provide a robust framework for conserving agrobiodiversity and ensuring the sustainability of agricultural ecosystems.

2. Agroecology based practices

To preserve site-specific vegetable and agricultural diversity, the Nepal Genebank has championed ecological agriculture through the development of **10 key principles of agroecology** (Figure 7). These principles aim to enhance sustainability, resilience, and productivity within local farming systems. By promoting these agroecological practices, the Genebank encourages farmers to adopt methods that align with the natural ecosystem, thereby supporting biodiversity while improving soil health and crop yields. The implementation of these 10 keys serves as a framework for farmers to cultivate a diverse range of crops and maintain their agricultural heritage. These practices not only contribute to ecological balance but also empower communities by fostering a deeper understanding of the interconnectedness of agriculture, environment, and health. For a detailed overview of these principles.

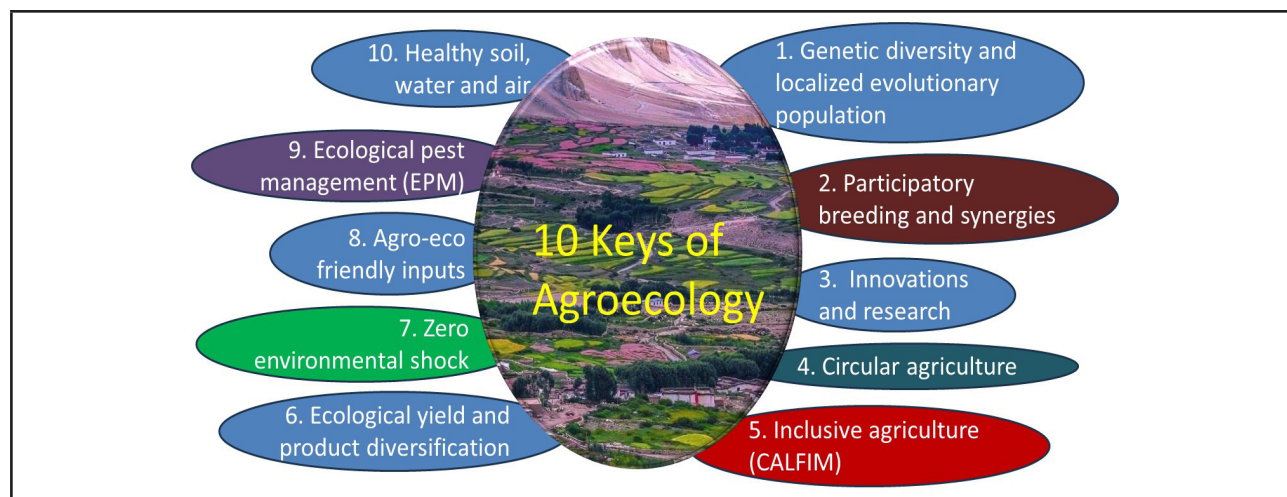


Figure 7: 10 keys of agroecology for promoting genetic diversity

3. Promoting eco-friends' cultivation practices

Focusing solely on single yields for promoting any crop variety is neither sustainable nor beneficial for health, as monoculture practices can deplete ecosystems. In response, the Nepal Genebank has initiated efforts to promote varieties that offer high ecological yields (Figure 8), emphasizing their contributions not only to human nutrition but also to the environment, animals, water, air, soil, and overall ecosystem health. By cultivating crops alongside their eco-friendly companions, farmers can enhance biodiversity and support the fertility of the soil while ensuring a healthier environment. Eco-friends of crops are companion species that help improve overall performance; these can include various combinations, such as rice grown with fish, black gram, azolla, ducks, and beneficial agro-insects. Additionally, the Genebank has begun estimating the **Food Health Index** for each food item, akin to a nutritional profile for agricultural products. This index provides a score or composition that highlights the healing properties, benefits, and potential drawbacks of different foods, particularly for individuals with health concerns. By promoting these eco-friendly practices and assessing food health, the Genebank aims to foster sustainable agriculture that supports both human health and environmental integrity.

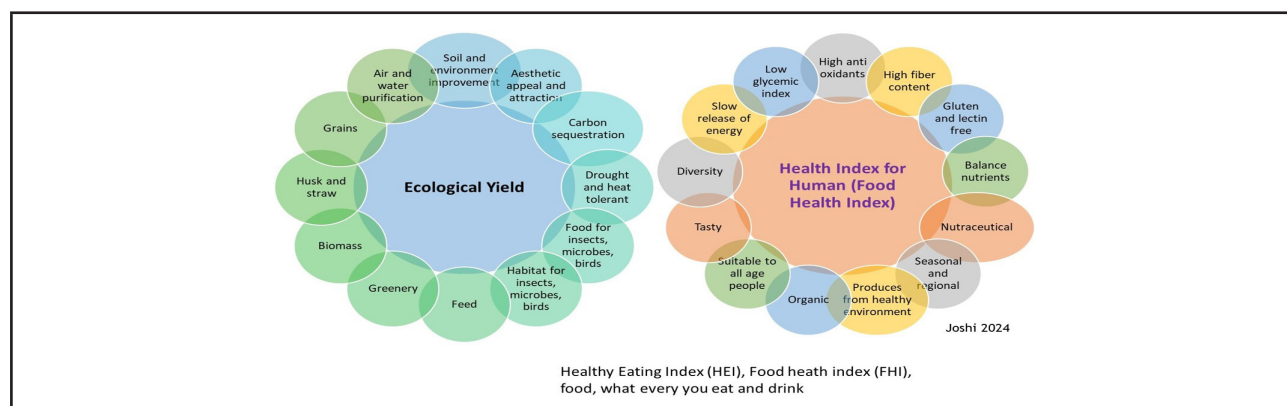


Figure 8: Contributing factors in ecological yield and food health index

4. Cultivating diversity for climate resilient and other stresses

To address the challenges posed by climate change and other environmental stresses, cultivating a higher degree of genetic diversity—both intra and inter-varietal—is essential. This approach fosters a site-specific evolving system that can better withstand unpredictable climatic conditions. Implementing strategies such as **cultivar mixtures** and **evolutionary plant breeding** allows for the enhancement of resilience in crop systems. In addition, adopting **polyculture** practices can significantly contribute to biodiversity and soil health while reducing the risks associated with monoculture farming. The integration of **climate-smart germplasm** and **climate-smart plant breeding** techniques further supports the development of varieties specifically tailored to thrive in changing environments. By focusing on these diverse cultivation strategies, farmers can create robust agricultural systems capable of adapting to climate-related challenges while ensuring sustainable food production.

5. Landrace enhancement and registration (conservation through use)

To improve the viability and attractiveness of landraces for farmers, the Nepal Genebank has implemented a participatory landrace enhancement program. This initiative has successfully led to the genetic enhancement of numerous landraces, making them more competitive in agricultural production. As a result of these efforts, communities have taken the initiative to register these enhanced landraces with the National Seed Board. So far, ten landraces from six different vegetable crops have been officially registered (Figure 9). Previously, there were no provisions for the registration of landraces; however, the persistent efforts of the Genebank have prompted a policy revision that now allows for the registration of landraces with a broad genetic base. This development not only supports the conservation of traditional varieties but also empowers local communities by recognizing their contributions to agricultural biodiversity and enabling them to access markets more effectively.

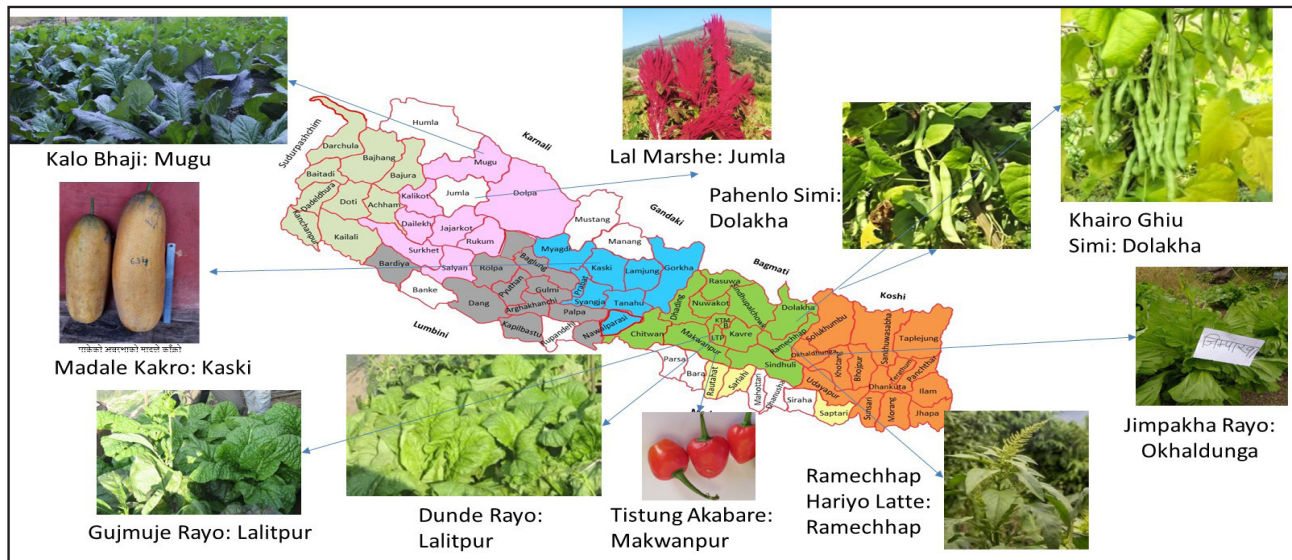


Figure 9: Registered vegetable landraces by communities

Source: SQCC 2024

6. Domesticating wild vegetables

In many forest areas of Nepal, farmers commonly collect various wild vegetables for consumption. To enhance the utility of these species, the domestication of wild vegetables is deemed essential. This practice not only promotes better utilization of these resources but also helps maintain undisturbed forest ecology by shifting cultivation efforts to private lands. In support of this initiative, the Nepal Genebank has established a wild vegetable garden focused on the domestication of several species, including **Chuke palunge**, **Niuro**, **Jaluko**, **Tree fern**, **Bethe**, and **Kause/Chhaaki Simi**. By cultivating these wild vegetables, the Genebank aims to foster biodiversity, improve food security, and encourage sustainable agricultural practices among local communities (NAGRC, 2022).

7. Pre breeding vegetable crops

To accelerate the breeding process for vegetable crops, the Nepal Genebank has implemented regular pre-breeding activities. These efforts have led to the identification of more than 100 elite lines across various vegetable species (NAGRC, 2022), which have been shared with farmers and breeders. Pre-breeding plays a crucial role in developing high-yielding varieties by focusing on identifying site-specific broad genetic base varieties. This approach not only enhances the genetic diversity available for breeding programs but also helps ensure that the resulting varieties are well-adapted to local growing conditions.

8. Application of biotechnology, GIS and CAT

The Nepal Genebank has effectively integrated biotechnological tools into its conservation strategies for vegetable genetic resources (VGRs). These tools include the establishment of a **DNA bank** and a **tissue bank**, which facilitate the long-term preservation of genetic material. Additionally, the Genebank employs techniques such as **genetic diversity assessment** and **DNA fingerprinting** to evaluate and characterize the genetic variability within its collections. Geographic Information Systems (**GIS**) have also played a critical role in the Genebank's efforts (Joshi et al., 2017). Collection mapping and gap analysis conducted through GIS enable the identification of areas where specific VGRs are underrepresented, facilitating targeted conservation efforts. Furthermore, the **Climate Analog Tool (CAT)** is utilized to identify potential analog sites, allowing for the repatriation of germplasm and the exploration of new areas for potential germplasm collection. By leveraging these advanced technologies, the Nepal Genebank enhances its capacity to conserve and utilize the rich diversity of vegetable genetic resources effectively.

9. Farmers' market and home stay

In Nepal, it is common for farming households to waste a significant amount of native vegetable produce, such as chayote, sponge gourd, and pumpkin. However, if these products could be sold, farmers would be incentivized to grow them more actively. Establishing farmers' markets, or open markets, is an effective approach to ensure the availability of a diverse range of agricultural products and create a direct link between primary producers and consumers. Previously, "haat bazar" (weekly markets) were a common practice throughout the country, but they declined over time. Now, these markets are re-emerging, providing a platform for households to operate as local shops and sell their produce directly. In addition to farmers' markets, home or farm stays have gained popularity as a successful agro-tourism initiative. By showcasing native and local germplasm, traditional farming practices, and local foods, these stays allow visitors to experience authentic rural life while providing farmers with additional income. This dual approach not only helps farmers maximize profits from their vegetable production but also fosters a deeper connection between consumers and the rich agricultural heritage of Nepal.

10. Geo-localized famous vegetable crops

Nepal is home to many famous vegetable landraces that are closely linked to specific geographic regions, such as Jumli simi, Akabare khursani, Kuvinde Farsi, Mude Salu, Bhaktapure Kakro, Terhathume Bose Aduwa, Gujmujje Rayo, Bajhange Aalu, and Pyuthane Mula. The Nepal Genebank is actively working on documenting and gathering evidence to grant Geographical Indication (GI) tags to these products. This recognition will help farmers gain higher market benefits while promoting the continued cultivation of these landraces, ultimately contributing to their conservation.

11. Collaboration for conservation of all VGRs across the Country

Nepal Genebank collaborates with a wide range of stakeholders to ensure the conservation and availability of vegetable genetic resources (VGRs) throughout the country. Key partners include government bodies such as the **CDABCC**, **Department of Agriculture (DoA)**, **NC-PVS-CD**, and the **Ministry of Agriculture and Livestock Development (MoALD)**, along with **government farms** and **NARC research stations**. Academic institutions, including **IAAS** and **NAIAS**, as well as international organizations like **ICIMOD**, play a crucial role in research and conservation. The **Botanical Garden in Godawari**, **LIBIRD**, schools, and local communities are also involved in grassroots conservation efforts. Collaboration extends to **Raithane agro products**, municipalities, and conservation-focused organizations like **WWF** and the **Department of Plant Resources (DPR)**.

12. Digital/ Virtual Genebank and Database

Nepal Genebank has embraced digital tools to enhance the accessibility and visibility of its conservation efforts. A video documentary showcasing the Genebank's work has been developed and made available online, allowing a broader audience to understand its importance. In addition, the Genebank actively shares updates and features through social media platforms such as Facebook, Twitter, TikTok, and YouTube, making information readily accessible to the public (NAGRC, 2022).

To streamline data management, the Passport app has been developed, helping to track and document plant genetic resources. The Genebank's database is also available through the Genesys web portal, (<https://www.genesys-pgr.org/a/map/v2LYApy1qK7/@28.278205,84.123929,7z>) providing global access to its extensive collection of genetic resources. The Genebank's own website (<https://genebank.narc.gov.np/>) offers additional information, and its data is linked with the **FAO-WIEWS** platform (https://www.fao.org/wiews/data/ex-situ-sdg-251/search/en/?no_cache=1andfbclid=IwAR2I8xSwLSgZN_NTG-x_yzUn2nMK8KOFkMyXeH7Hpdp5mCbMPh-7hSQd9w#results), contributing to international conservation efforts. These digital resources ensure that information

on Nepal's valuable plant genetic resources is easily accessible for research, conservation, and utilization.

Challenges

The management and utilization of vegetable genetic resources (VGRs) in Nepal face several significant challenges that hinder the preservation and promotion of native biodiversity. These challenges stem from a variety of factors, including the prioritization of foreign varieties, genetic erosion, and the marginalization of traditional farming practices. One major issue is the priority placed on testing and marketing foreign vegetable varieties by institutions like NARC, the Seed Quality Control Center (SQCC), and the Department of Agriculture (DoA). This focus has led to the underutilization of native vegetable crops in research, education, and extension programs. Indigenous landraces are often perceived as inferior, limiting their use despite their potential for resilience and adaptability in local conditions. This bias further discourages the integration of native crops into mainstream agricultural development.

Additionally, the replacement of site-specific landraces with single varieties grown over large areas contributes to genetic erosion. Instead of promoting the diversity of locally adapted varieties, wide cultivation of uniform crops leads to a loss of site-specific traits and biodiversity. Monogenotypic fields, kitchens, and markets—where a single variety dominates—are increasingly common, undermining the broad genetic base necessary for a resilient agricultural system. Genetic erosion is occurring at a rapid pace, driven by several factors. The preference for exotic vegetable varieties, especially those suited for controlled environments, has led to the displacement of traditional landraces. The narrowing of genetic diversity is especially pronounced in vegetatively propagated vegetable crops, where farmers often rely on a limited number of varieties.

Furthermore, the increasing use of chemical inputs and protected farming practices has exacerbated the destruction of agrobiodiversity. These practices, while promoting short-term yields, threaten the long-term survival of diverse plant species by creating environments that favor a narrow range of crops. Climate change, with its new stresses and unpredictable weather patterns, is accelerating the pace of genetic erosion by introducing challenges that many traditional varieties cannot withstand.

The transfer of farmers' seed rights to seed companies and the promotion of linear, industrialized vegetable farming have further complicated the situation. The emphasis on formal agricultural systems, which often rely on external inputs and commercial seed cycles, reduces farmers' ability to maintain localized, self-sustaining seed cycles. There is also a debate surrounding whether landraces, traditionally considered public goods, should be treated as private goods in modern agricultural markets. Genetic diversity, which evolves naturally within local populations, is often left unrecognized in agricultural policy. Additionally, associated biodiversity, such as pollinators and soil microbes, is largely ignored, further diminishing the ecological balance essential for sustainable agriculture. The lack of policy recognition for genetic diversity poses a significant barrier to conserving VGRs. While evolving populations in local systems continue to adapt and change, many agricultural policies favor static, non-evolving populations in commercial farming, limiting the potential for innovation and resilience in the face of environmental change.

Way Forward

Agrobiodiversity forms the foundation of life and the advancement of agricultural sciences. To address agricultural problems effectively, one must give due attention on agricultural biodiversity. The focus should be on preserving, utilizing, and advancing the rich diversity of vegetable genetic resources (VGRs) that the country possesses, as these hold the potential for sustainable development. A key strategy moving forward is to "go for local, work on local, respect local, and globalize local." This approach calls for the promotion of indigenous vegetables and technologies, ensuring they are globally competitive. Developing site-specific varieties with broad genetic bases, adapted to local conditions, is crucial for increasing the global market value of native crops. Additionally, ecological agriculture, which emphasizes the cultivation of diverse crops, should be a priority. This helps maintain the ecological balance, improves soil health, and reduces reliance on external inputs.

Protecting local landraces by granting them geographical indication (GI) tags and securing farmers' rights is essential. Farmers must be empowered to complete seed cycles themselves, ensuring that traditional knowledge and practices are preserved. Establishing banking systems for vegetable genetic resources (VGRs) is also critical. Agro-gene sanctuaries, field genebanks, crop-specific parks, and school field genebanks can serve as conservation hubs. The creation of specialized conservation banks, such as agro-insect, aqua pond, and mushroom field genebanks, along with herbal conservation gardens, will safeguard diverse species. A Himalayan seed bank should be established as a safety backup for Nepal's invaluable genetic resources.

Mainstreaming approaches like Agrobiodiversity Impact Assessment (AIA), red zoning, and red listing—together

with rescuing germplasm and planting materials—will help in conserving native varieties. Passport data for germplasm should also be integrated into the National Genebank. Guaranteeing market access and irrigation for farmers is equally important to ensure the continued cultivation of native vegetable diversity. Native vegetable crops must be embedded into research, education, extension programs, and the marketplace to fully unlock their potential. Finally, to signify the importance of native vegetables, broad leaf mustard should be declared the national vegetable of Nepal.

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Diversification, Propagation and Value Chain Issues in Underutilized Root and Tuber Crops

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Abstract

Different ecological belts of Nepal are endowed with different types of climates due to its geographical locations and physiography which is favourable for agricultural production, especially vegetable crops including root and tuber (RandT) crops. Most of the important RandT crops of the world can be grown in Nepal and are the engine of growth for rural economy and poverty alleviation. RandT crops possess a huge genetic diversity at variety and landrace levels in Nepal. There are more than 30 edible and non-edible underutilized RandT crops reported in the world and among them, taro, yam, cassava, elephant foot yam, ground apple and sweet potato are the major cultivated RandT crops in Nepal. Despite the suitable climate, comparative advantages and great contribution in food security the growth of domestic production and its value chain development has remained slow in the past. Research work on root and tuber crop is inadequate and extension programme is almost lacking. RandT crops are mostly perennial crops but they are also cultivated as an annual crop as they become ready to harvest in 8-10 months. Suitable and productive varieties can be developed and expanded through the propagation of these crops by collection, conservation and promotion of RandT crops which ultimately help to improve the food security and nutrition.

Keywords: Climate, Conservation, Food security, Nutrition, Varieties

Introduction

Nepal has favourable agro ecological diversity for agricultural production, especially in the vegetable sector including Root and Tuber Vegetable Crops. Different ecological belts are endowed with different types of climates due to its geographical locations and physiography. Most of the important Root and Tuber Vegetable Crops of the world can be grown in Nepal. The Agriculture Development Strategy (ADS, 2015) has recognized high value horticultural crops including Root and Tuber Vegetable Crops as engine of growth for rural economy and poverty alleviation. Plants yielding starchy roots, tubers, rhizomes, corms and stems are defined as Root and Tuber (RandT) crops (Scott *et al.*, 2000). Root crops should not be confused with root vegetables like radish, turnip, carrot and beetroot. Major Root and Tuber Crops including yams are categorized as tuber crops, taro and cocoyam are derived from corms/underground stems and swollen hypocotyls, and cassava and sweet potatoes are storage roots. RandT crops in Nepal are mainly used for human food but very little in processed form either for human consumption or animal feed. Since industries for manufacturing starch, alcohol and fermented beverages from RandT crops are still in very infant stage, RandT crops have not gained the industrial importance in production at national level yet. Taro, yam, cassava and ground apple also serve as supplementary food sources for the farmers at different communities. In the past, almost all of the RandT crops were the food of cultural occasions and too some extent regular food for marginalized poor, however, with the increased awareness towards the value of these crops, rapidly urbanized population in recent years and their changed food habits have started to diversify their food intake from normal cereal-based diets to greater consumption of root and tuber crops. Besides the food and nutritional importance, some RandT crops are very important for celebrating religious festival such as '*Maghe Sankranti*', the first day of the month '*Magh*' (mid-January). Taro and sweet potatoes are used as pure and holy food during fasting especially in *Thulo Ekadashi* during *Kartik*. There is year-round availability of these tuber crops in local markets which signifies the increasing importance of RandT crops in Nepal. Despite their importance in income generation, food and nutritional security and to some cultural context, little research and development attention have so far been given to these crops.

Major Root And Tuber Crops Varieties in Cultivation Practices

Root and Tuber crops contribute as source of food and nutrition as they produce large quantities of dietary energy

and have stable yields under conditions in which other crops may fail. Though, further investigation might be necessary to find out the centre of origin of these crops, most of RandT crops possess a huge genetic diversity at variety and landrace levels in Nepal. This diversity can be found in almost all of the agro-ecologies. RandT crops contain mainly carbohydrates (16-24% of their total weight) with some protein and fat (0-2% each). There are more than 30 edible and non-edible RandT crops reported in the world and among them, taro (*Colocasia esculenta* L.) Schott), Yam (*Dioscorea alata* L.), Cassava (*Manihot esculenta* Crantz), Elephant Foot Yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson), Yacon (Peruvian Ground Apple) (*Smallanthus sonchifolius* (Poepp.) H. Rob.) and Sweet Potato (*Ipomoea sp.*) are the major cultivated RandT crops in Nepal (Table 1.). A total of 77 sweet potato germplasm consisting of 22 exotics and 55 locals are maintained under field condition. The variety of sweet potato released by Seed Quality Control Center (SQCC) and the variety of sweet potato and taro maintained at Nepal Agriculture Research Council (NARC) in Nepal is mentioned hereunder (Table 2 and 3).

Table 1: Major R andT Crops Seed Varieties in Cultivation Practices

S.N.	Root and Tuber Crops	Local cultivars/Germplasms
1.	Yam	Sarlahi Red, Pangnang (Yellow and White), Jante (Hatti Paile), Hatti Dare, Patale, Ban Panang, Ban Tarul
2.	Taro (Colocacia/Arum)	Panchamukhi, Dudhe, Hatti Pau, Khari, Chiple (Singane), Okhale (Pong), Hatti Sunde
3.	Elephant Foot Yam (Ole)	Gajendra, Local
4.	Sweet Potato	CIP 440099, CIP 440020, CIP 440015, CIP 4400513, Local White, Local Brown, Local Red, Japanese Red, White Round, Helen Yellow
5.	Cassava/Tapioca	Red, White
6.	Yam Bean	Rajendra Misrikand-1, Mexican, Indian Local
7.	Bhyakur	Rani Bhyakur, Chuiyan Bhyakur
8.	Gittha	Local Bitter, Local Sweet
9.	Suthuni	Local

Table 2: Variety of Sweet Potato released by SQCC in Nepal

S.N.	Crops	Variety	Released year	Remaks
1.	Sweet Potato	Suntale Sakharkhand 1	2076	High beta-carotene content
2.	Sweet Potato	Suntale Sakharkhand 2	2076	

Table 3: Variety/germplasm maintained at NARC in Nepal

S.N.	Crops	Number of Variety/Germplasm	Remaks
1.	Sweet Potato	20	Local collection
2.	Sweet Potato (OF)	11	CIP, Peru
3.	Taro	54	Field Gene bank, Khumaltar

Root and tuber crops are very much adaptive in low input agricultural systems and important for food and nutritional security. Rural people mostly involved in utilizing root and tuber crops and they maintain the traditional knowledge regarding their location, season, preservation, processing and culinary uses. Nepal has diverse agro-ecological and climatic conditions favourable for the production of RandT crops but are considered as underutilized crop species. RandT crops particularly sweet potato, taro and yam contribute a major share in the traditional food systems of many people in Nepal and these crops play a major role in the food security of the people especially in mid and High Hills of Nepal. The production of yam, taro and sweet potato still depend on local varieties.

Propagation Techniques of Root and Tuber Crops

Root and tuber (RandT) crops are perennial crops but are also cultivated as an annual crop as they are ready to harvest in 8-10 months. Suitable and productive varieties can be developed and expanded through the propagation of these crops by collection, conservation and promotion of RandT crops. Propagation of a crop is a technique that helps to increase the number of plants which ultimately help to coverage the land under improved cultivars and can get the desired properties such as higher yield, bigger fruit, sweeter, tastier to eat and better price in the market.

This article mentions about propagation techniques of some major RandT crops cultivated in Nepal.

1. Propagation technology in yam

Propagation in yam is done from tuber. Planting tuber is called Sett (Fig. 01). The size of the sett has a big impact on the production. It has been found that small size tubers produce less while large size tubers produce more. Similarly, the planting part of the sett also seems to affect the yield.

Planting the upper part of yam i.e. head (Crown) yields more, while planting the lower part i.e. tail (Tail) yields less. So, when cutting the seed, remove the bottom half of the yam and slice the upper half in to sett pieces with transverse cuts (cross-sections).

It should be planted only after keeping it immersed in Dithane M-45 pesticide at the rate of 1 gm per liter of water for 5-10 minutes.

Propagation method

Step 1: Choosing the mother seed yam

- The weight of mother seed yam should be between 500 grams to 1 kg.
- Tuber should be sprouted, healthy and not rotten.
- Must be free from diseases, insect-pests and nematode.



Fig 1: Planting tuber of Yam

Step 2: Make pieces of mother seed yam

- Materials needed to slice the seed yam: sharp knife, pesticides, and tuber.
- Seed yams should be cut rounded.
- The size of each cut piece should be 6 cm. X 6 cm.
- Then each piece should be cut into strips and each piece should be of uniform size.
- Each set should weigh between 25 to 50 grams.

Step 3: Treatment and planting of the cut set

- Materials needed during treatment: cutting set, ash, chemicals, water, basket, gloves.
- The cut set should be treated with fungicide. Ash can also be used instead of pesticides.
- Then the set should be placed in a basket and immersed in the pesticide solution for 5-10 minutes.
- Now after draining the water from the basket and the treated sett should be dried by keeping it in the shade then only planted.

2. Propagation technology in cassava

- Propagation in cassava (Fig. 02) is done by cuttings of branch called sets.
- Disease free, 8-12 months matured, 2-3 cm. thick stemmed sets are considered suitable for planting.
- The lower or upper soft part of the branch is not suitable. Therefore, if you plant the middle part, there is more chance of survival.
- The 1/3 part of stem from uppermost area of branch and 5 cm from lower region should be cut and removed.
- It is best to plant middle part of the stem (Fig. 03).
- When cutting the set, the lower part should be rounded and the upper part should be cut slanting so that it is easy to identify when planting.
- Set should be of 25 - 30 cm. in length. There is a lot of reduction in the production when planting set length is of 10 cm.
- Storing the sets in shade for 15 days gives good sprout.



Fig 2: Cassava Plant

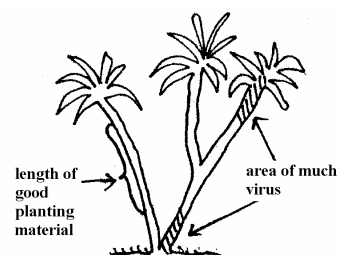


Fig 3: Planting material of Cassava

3. Propagation technology in taro

- Propagation of taro is done by large and small corms as well (Fig. 04).
- Propagation should be done with healthy corms of uniform size weighing 20-25 gm free from diseases.
- It has been found that planting seeds of small weight results in less production, while planting seeds of heavier weight produces more.
- At present, to reduce the seed rate, small corms are kept separately from the fruit and at the time of planting, cutting it into two pieces from the head and then cutting it horizontally into two pieces from the middle, it is also a practice to plant a mini set of 10 grams.
- When planting, cut corms should be treated with Indophil-45 fungicide at the rate of 1 gm per liter of water for 20 minutes and dried in a shaded place.

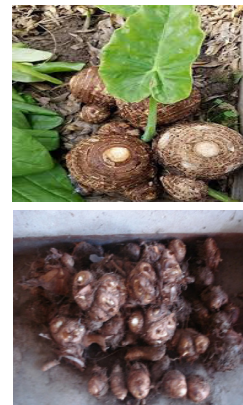


Fig. 4: Corms of Taro

4. Propagation technology in sweet potato

- Propagation of sweet potato can be done by planting whole sweet potato tuber or cuttings of stalks (Fig. 05).
- But if cuttings are taken from the same stalk and applied again and again, there is a possibility of mite attack.



Fig 05: Planting material of Sweet Potato

- Therefore, it is better to plant sweet potatoes in the bed and prepare a new stalk.
- Stalks of mature sweet potato are the best to use as planting material for propagation.
- The upper part of the stalk i.e. towards the tip should be used for propagation. It has been proved from various trials that more growth and larger size tubers are obtained.
- There should be 25 cm long stalk from tip with 3-4 nodes.
- Before planting, overnight soaking of stalk in a solution of fungicide like Carbendazim at the rate of 2 ml per liter of water will improve germination and prevent seed borne diseases.
- Planting of stalk should be maintained at a distance of 60 cm. x 25 cm

5. Propagation technology in elephant foot yam (ole)

- Propagation of elephant foot yam can be done either by Sett or Corm (Fig. 06).
- It is customary to plant Mini Sett weighing up to 100 grams for seed production.
- 15 Mini Setts are produced from 1.5 kilogram of ole.
- Planting of Mini Sett at 45 cm. X 30 cm spacing yields up to 1 kg in 6-7 months which is good for seed next year.
- Planting Setts or corms of 750 gm to 1000 gm is recommended for higher yield.
- If cut parts of a large seed are to be sown, it should be treated with Trichoderma mixture in cow dung solution and sown.
- At the time of planting (March-April), large seeds are cut into pieces of 750-1000 grams, mixed with cow dung or wood dust and dried in a shady place for a few hours and sown.



Fig. 06: Sett of Ole

6. Propagation technology in yam bean (Mishrikanda) Pachyrrhizys erosus

- It is propagated by seeds which are contained in pods (Fig. 07).
- A pod length is up to 7 to 15 cm. and contains up to 8-10 seeds.
- Seeds are brown or red.
- Seed is flat rather than round.
- Seed rate: It usually takes 20-60 kg / hectare. The seed rate depends on the distance of planting, the time of

planting and the purpose for which it is planted.

- Generally, it is sown in the month of June-July (*Jeshta-Ashadha*) and harvested in December-January (*Mangsir-Poush*)
- Its sowing time is from June to September (*Jeshta-Ashwin*) according to its purpose:
 - For seed production it is planted in early June at the distance of 30 cm x 30 cm.
 - For tuber production it is planted in August-September (*Bhadra-Ashwin*) at a distance of 30 cm x 15 cm. or 15 cm x 15 cm for small tuber and 60 cm x 45 cm or 60 cm x 60 cm for large size tuber.
 - When planted late, the tuber is small, so there is no problem of tuber cracking, but the yield is low.
- Mexican and Indian local varieties are in cultivation. The Mexican variety has a large size tuber and its weight is up to 1.52 kg. but it is less sweet in taste and tuber cracking is often observed.
- Indian local variety is of 200-300 grams but it is softer, the fiber is less, the shape of the tuber is conical, the pulp is white, the bark is soft and cream in color and tuber cracking is less.
- Rajendra Misrikand-1 variety of India is an improved variety. The production of this variety is 40-55 tons per ha. and the tuber crop is ready in 110 to 140 days. One tuber weighs up to 600-700 grams. It is very soft, sweet and the tuber does not crack.



Fig 07: Pods of Yam Bean

Diversification of Root and Tuber Crops

Root and tuber (RandT) crops are of diverse uses. On a global basis, approximately 45% of root and tuber crop production is consumed as food and in the form of various delicious dishes as well (Fig. 08), with the remainder used as animal feed or for industrial processing for products such as starch, distilled spirits, and a range of minor products.

		
Pudding (Philippines)	Doughnut (Philippines)	Cake (Philippines)
		
Haluwa (India)	Pudding (USA)	Pieces of Cake

Fig. 08: Various food dishes of R and T Crops (Yam)

Root and tuber crops are indispensable in the field of agriculture. These crops provide essential nutrients, income opportunities, and resilience for farming systems worldwide. Their adaptability and ability to grow in diverse environments make them a cornerstone of food security, particularly in regions vulnerable to climate change. As the global population grows, root and tuber crops will remain essential to feeding communities and supporting sustainable, diverse agricultural practices.

They are important food crops that have gained increased importance due to their role in food security, their ability to withstand drought as well as their potential for commercial processing. It can be processed into flour, animal feed, or even biofuel. Sweet potato leaves are also edible and nutritious, adding more versatility to the crop. There's a growing demand for both cassava and sweet potatoes in various industries, from food processing to starch production. Cassava and sweet potatoes are a step towards a sustainable future for agriculture and food security.

The main nutritional value of roots and tubers lies in their potential ability to provide one of the cheapest sources of dietary energy, in the form of carbohydrates, in developing countries. They provide a substantial part of the world's food supply and are also an important source of animal feed and processed products for human consumption and industrial use.

Growing root and tuber crops contribute to agricultural biodiversity, reducing dependency on cereal grains and increasing dietary options/choices. This crop diversity makes farming systems more resilient to pests, diseases, and climate fluctuations. For instance, rotating root and tuber crops with other crops can break pest cycles and improve soil health.

Value Chain Issues in Root and Tuber Crops Seed

The major value chain actors include Input Suppliers, Farmers, Farmers Groups, Cooperatives, Traders (collectors, wholesalers, retailers), and Service Providers. There are 18 major markets for root and tuber crops along with other vegetables located at Birtamod, Biratnagar, Dharan, Dhankuta, Golbazaar, Dhalkebar, Bardibas, Lalbandi, Kalimati, Benighat, Bharatpur, Pokhara, Butwal, Tulsipur, Birendranagar, Kohalpur, Attariya and Kanchanpur and cooperatives and farmers of some production pocket areas.

1. Actors and functions

Key actors identified included individual farmers, farmers' groups, cooperatives and traders at different stages (collectors, wholesalers, retailers). Input suppliers and service providers were also among the key actors in the chain. Fig. 09 presents the key actors in root and tuber crops value chain in Nepal.

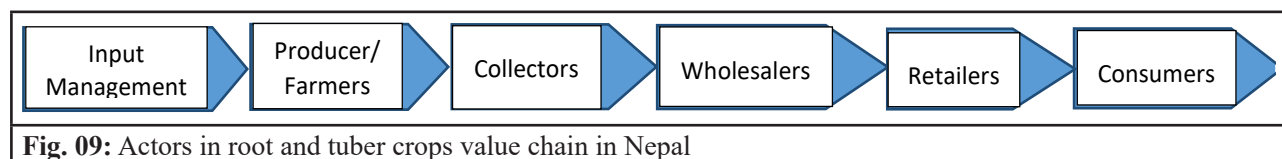


Fig. 09: Actors in root and tuber crops value chain in Nepal

1.1 Input Management

Agricultural inputs, primarily planting materials in root and tuber crops are mostly managed by farmers themselves. In case of yam, the upper crown is used as seed which is kept intact in the soil and also the arial fruits of yam called mirek are also used as planting material and mostly managed by farmers themselves. Mostly organic manure and some quantities of chemical fertilizers are used buying it from local agro-vets and cooperatives.

1.2 Producer

There are basically two categories of producers in production areas i.e. subsistence and commercial producers. Subsistence farmers generally produce some of the root and tuber crops depending on family need and family interest for home consumption and for festival use. Some surplus produce is sold to local *haat bazaar* and local shops. Commercial farmers cultivate root and tuber crops and sell their produce to known collectors or cooperatives. There are no any set arrangements to make the marketing based on contract. Farmers have no technology of creating price advantage over time.

1.3 Collectors

Collectors are the key actors of the root and tuber crops value chains who are involved in collecting from production pocket to the wholesale markets. Their trading activities include: buying and assembling, repacking, sorting, selling to middlemen/or, transporting and selling at market centers in cart or pick up and sell to the wholesalers or wholesale markets. Both collectors and growers make a kind of mutual agreement for price negotiation.

1.4 Wholesaler

Wholesalers are mainly involved in buying root and tuber crops from the collector and supplying them to the retailers. They also store products, usually for a maximum of one to two week. They are mainly located in major markets of Birtamod, Biratnagar, Dharan, Dhalkebar, Lalbandi, Kalimati, Narayanghat, Pokhara, Butawal, Birendranagar, Kohalpur, Dhangadhi and Kanchanpur where there are market hubs with some infrastructure such as office buildings, open stores, transaction sheds, and shop sheds. These market hubs are usually established with

government support and operated by local market management committee.

1.5 Retailers/vendors

Retailers and vendors are the other important actors with close linkages with the wholesalers and the consumers. Their involvement in the chain includes buying of root and tuber crops, transporting to their retail shops, grading, displaying and selling to the consumers.

1.6 Consumers

Consumers are the individual households, hotels, army camps and police quarters who buy and consume root and tuber crops occasionally during some festivals and also a little quantity as regular items during the season.

2. Enablers and facilitators

In a value chain, the enablers provide regular support services or represent the common interest of the value chain actors. Functions at the enabler level include public research and technology development, promotional services, marketing or advocacy and other support service providers. These enablers and facilitators are public actors, private actors and NGOs.

2.1 Public actors

Public actors at higher level, business enablers are Ministry of Agriculture and Livestock Development (MoALD), Department of Agriculture (DoA), Ministry of Industry, Commerce and Supply (MoICS). These institutions facilitate policy formulation and bilateral trade agreements with other countries. Nepal Agricultural Research Council (NARC) and National Center for Potato, Vegetable and Spice Crops Development (NCPVSCD) and Tuber Vegetable Development Center (TVDC), Sindhuli are working to develop new varieties and disseminate different technologies in root and tuber crops. Gene Bank /NARC is involved in collection, evaluation and variety development. Agriculture Knowledge Centers works as technical supporters to the producing farmers. Provincial ministries and local government facilitate policy and program support.

2.2 Private actors

Federation of Nepalese Chamber of Commerce and Industries (FNCCI) and Agro Enterprise Centre (AEC) is working in the area of market development by providing market information and facilitating for market linkages, etc. At traders' level, major market centers are supporting for business successes by providing market information. Some NGOs such as Local Initiative for Biodiversity Research and Development (LI-BIRD) and cooperatives and farmers' groups are also maintaining the local land races at community level.

3. Value chain governance

The value chain governance of root and tuber crops in Nepal is heavily dependent on occasional demand during festivals and rituals. Therefore, the value chains are highly influenced by the particular demand time and supply from local producers and import from India. In most cases, the business relations between the various operational actors are of both special contract and free market exchange. Due to the lack of a proper contractual market system and minimal bargaining power, farmers are forced to sell their product at the price offered by the traders. Traders usually refer to Indian markets for price fixation. In some cases, there are conflicts among the traders and farmers regarding payment and failure to keep their commitment. Overall, the governance of the root and tuber vegetables value chain is buyer driven with minimum trust between various actors. Traders are always complaining that the farmers are not providing quality product while farmers are blaming the traders for offering low prices.

Conclusion

Root and tuber crops are the significant component of the Nepalese food system. Due to their high starch content and calorie, these crops play a major role in food security of small and marginal farmers and the ethnic people. Local landraces of RandT crops are tolerant to biotic and abiotic stresses and have wide adaptability to diverse agro-climatic conditions. Nepal has suitable climate and comparative advantages for the production of different kinds of root and tuber crops. Farmers are looking for high quality planting materials. The cultivation techniques (agronomy, tuber physiology, propagation, storage and postharvest, etc.) of RandT crops must be studied for enhancing the production and overall utilization should be promoted to improve the variety as well as livelihood of rural people. Indigenous knowledge residing in farm communities about RandT crops must be explored and documented. The industrial usages of RandT crops should also be explored and disseminated to rural communities. Government policies should give high priority in plans and policies for conservation and promotion of RandT crops thereby; public institutions mandated to RandT crops prioritize the research activities (exploration, collection, and multiplication, characterization at morphological, molecular and functional compound levels) and their maintenance

at field, in-vitro and Community Field Gene bank. Nepal needs to study province wise internal demand and in country production status, balance sheet status; study external demands for raw root and tuber crops to produce, flour and powder products, encourage private sectors for opening industries along with commercialization of the produces. The government should encourage farmers for increased production by providing some incentives or subsidy in some inputs for few years.

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Management of Major Diseases of Vegetable Seed Crops Identified in NPPRC Laboratory

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Abstract

Area under vegetable cultivation is increasing in Nepal; however, the farmers are unable to meet the demand of vegetables particularly in urban areas. With the increasing market demand even seed production has become increasingly challenging for farmers. Vegetable seed production is critical to agricultural sustainability and food security. Nevertheless, seed crops are highly susceptible to several diseases that threaten seed quality and yield. The area under vegetable seed crops, along with overall production and productivity, has been increasing steadily. Based on received and identified samples at the National Plant Pathology Research Centre (NPPRC), laboratory diagnostics have identified key pathogens affecting disease caused by fungus, bacteria, viruses and nematode. The identified samples in vegetables consisting fungal diseases with 70% were root rot, alternaria leaf spot, downy and powdery mildew, early and late blight, and anthracnose. Similarly, with 8% were bacterial wilt, bacterial stem rot, bacterial canker, black rot, and pith necrosis. In viral diseases with 16% were cucumber mosaic virus, tomato mosaic virus, tomato leaf curl virus, potyvirus zucchini yellow mosaic virus and 6% by nematodes. So, early detection with an effective management practice is most necessary to ensure the production of high-quality, disease-free vegetable seeds.

Keywords: Diagnosis, Disease, Horticultural crops, Identification, Vegetable seed

Introduction

Ensuring the availability of high-quality vegetables seed however; seed-borne and seed-transmitted diseases pose a significant threat to both seed quality and crop productivity caused by fungi, bacteria, viruses, and nematodes. The National Plant Pathology Research Centre (NPPRC) plays a vital role in identifying and diagnosing major diseases affecting vegetable seed crops through laboratory-based investigations. It not only ensures a good yield of healthy seeds but also contributes to sustainable agricultural practices by preventing the spread of diseases. It has a significant impact on seeds, often exhibiting poor germination rates, weak seedlings, and reduced vigour, all of which can affect crop performance and overall productivity. The economic impact of vegetables diseases leads to significant economic losses by reducing both seed yield and quality, leading to higher production costs and lower marketability and environmental health. This can be managed by using disease free seeds and seed treatments. In order to combat these challenges, integrated disease management is essential. This includes practices like using resistant varieties bred to tolerate or resist specific pathogens, crop rotation of vegetable seed crops with non-host plants to reduce the build-up of soil-borne diseases, and field sanitation practices. Cultural practices such as removing infected plant debris, proper spacing, timely planting, appropriate fertilization, cleaning tools, and avoiding excessive irrigation can also prevent the spread of diseases. The application of proper chemical and biological fungicides and pesticides within an integrated pest management framework, along with seed treatments using fungicides, bactericides, and other biological agents before planting, can reduce the risk of seed-borne diseases and improve germination and seedling establishment. Regular monitoring of fields by surveillance for early disease symptoms can help identify and control outbreaks before they spread significantly. A combination of these all strategies can significantly reduce disease incidence and enhance the resilience of seed crops. By implementing integrated disease management strategies, farmers can ensure healthy crops, quality seeds, and long-term agricultural success. Effective disease management practices can reduce reliance on chemical treatments, maintain high-quality seed production, optimize yields, minimize their impact on the environment and human health, and ensure the sustainability of farming practices. Diagnosis is one of the most important aspects for the proper identification of the disease and its causal agents to apply any measures for disease management. Proper disease diagnosis is therefore vital.

Materials and Methods

National Plant Pathology Research Centre (NPPRC) laboratory identify major diseases affecting vegetable seed crops and evaluate effective management practices through sample collection seed health testing by blotter, agar plate, growing seed for 3-4 weeks, pathogen identification morphological and molecular, and assessment of integrated disease management techniques. The samples of different vegetables such as; tomato, potato, chilly, capsicum, pumpkin, chayote, gourds, cauliflower, cabbage, broccoli, radish, carrot, mustard, ginger, garlic, and onion from various locations were received from surveys, field visits, and stakeholders for diagnosis and advisory services. The main objectives of this center are accurately identifying diseases, determining causative agents, assessing disease severity, and understanding the spread of diseases under conducive environmental factors. By contributing to scientific research on new diseases, their causes, and their impact, NPPRC provides good recommendations with education and awareness about the diseases, their symptoms, causes, and management strategies. For accurate disease diagnosis and proper identification, various activities were carried out. This included gathering information about the crop's history regarding field distribution, year of cultivation, variety, previous crop, weather conditions, time of disease appearance, soil type, and use of organic and inorganic manures and pesticides. The samples were labeled with the crop name, location, and date of collection, handled gently, and kept out of the sun, preferably in a cooler area. With the signs and symptoms of the collected samples were studied along with the incidence and severity levels of diseases. Visual inspection was conducted initially, followed by incubation in a moist chamber, agar plate tests using selective media, and molecular testing. Consultations with literature, internet searches, and images were used to finalize proper management practices. Suspected disease samples were checked for their distribution pattern, i.e., localized or systemic. The samples were categorized as fungal, bacterial, viral, nematode, or others based on visual signs and symptoms. The ooze test is one common practice for bacterial disease testing. Common symptoms include leaf blight, wilt, anthracnose, scab, mosaic, and leaf curl, while mildew, mold, smut, rust, and sclerotonia are common signs for diagnosing diseases (Manandhar and Amatya, 1992). For fungal diseases, methods like direct inspection, washing tests, blotter tests, agar and selective media plate tests, and seedling tests were used. For bacterial diseases, morphological, biochemical, pathogenicity, hypersensitive, and serological tests were applied (Manandhar and Amatya, 1992). Viral diseases were identified using dry seed inspection, seedling growing tests, indicator plant tests, and serological tests. Plant parasitic nematodes were characterized using extraction and morphological identification methods.

Observations were compared with visual color pictures from the internet and crop compendiums for diagnosis (Barnett and Hunter, 1972). The first step upon returning to the laboratory was to keep diseased tissue in a moist chamber to induce sporulation. This could involve placing the sample in a sterile petri dish with wet filter paper and a glass tubing triangle to expose it to humid conditions (Mathur and Kongsdal, 2003). Methods like washing tests in Tween 20, sodium hydroxide soaking, and blotter methods were employed for detecting seed-borne fungi. Laboratory equipment such as sterile petri dishes, incubators, autoclaves, laminar flow hoods, microscopes, seed germination trays, biosafety cabinets, and refrigerators/freezers was essential for pathogen analysis and seed testing done for disease identification.

Results

National Plant Pathology Research Centre (NPPRC) laboratory identify plant disease every fiscal year. 50 % are vegetables. Among them, 70% of samples were infected by fungus, 8% bacterial, 16% viral and 6% by nematodes. Those samples were either collected during surveys and field visits or received from different stakeholders for diagnosis and advisory services with detailed information for accurate disease diagnosis and proper identification in figure 1.

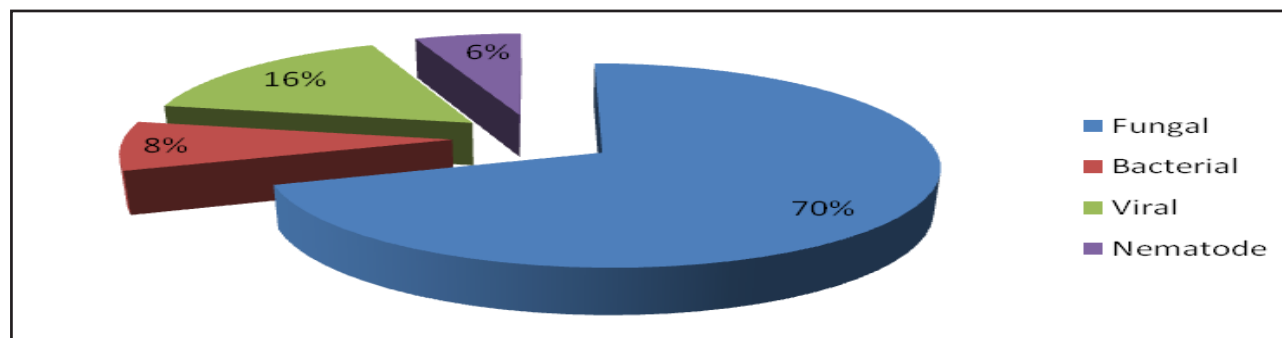


Figure 1: Frequency of major diseases identified every fiscal year

The major diseases identified from different vegetables that NPPRC laboratory received regularly. Vegetable diseases sample having the potential to infect germinating seedlings, leading to disease outbreaks in plant populations under suitable moisture and temperature conditions. Out of received and identified diseases sample 48% solanaceous crop with the pathogen *Fusarium* sp., *Alternaria solani*, *Phytophthora infestans*, *Leveillula taurice*, *Collectotrichum* sp., *Spongospora subterranean*, *Erwinia carotovora*, *Ralstonia solanacearum*. 16% of cucurbits crop with the pathogen *Pseudoperonospora cubensis*, *Colletotrichum* spp, *Didymella bryoniae* 14% of crucifers crop with the pathogen *Alternaria brassicicola*, *Peronospora parasitica*, *Xanthomonas compestris* pv *campestris*, 18% of cole crops with the pathogen *Botrytis* sp., *Phoma* sp., *Alternaria* sp., *Stemphylium* sp. and rest were other crops received from different locations of Lalitpur, Bhaktapur, Dolakha, Kanchanpur, Siraha, Banke, Kavrepalanchowk, Sarlahi, Kaski, Kathmandu, Kavre palanchowk, Gulmi, Panchthar, Dhading, Rautahat, Gorkha, Sindhupalchowk, Jhapa, Chitwan, Bara, and Nuwakot districts for accurate disease diagnosis and proper identification shown in figure 2.

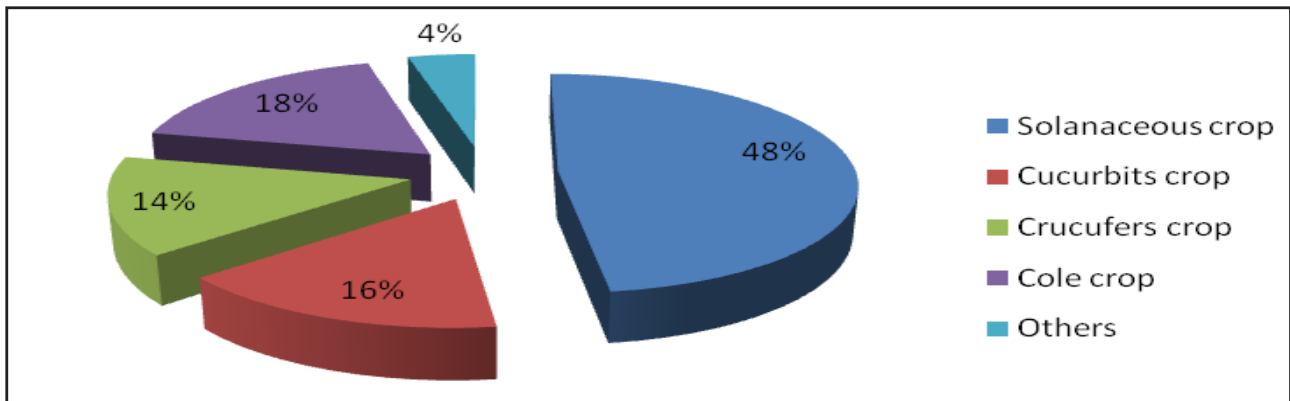


Figure 2: Frequency of major crop identified every fiscal year

Discussion

The results of this study highlight the significant threat posed by seed-borne pathogens to vegetable seed quality and viability. Vegetable seed crops are vulnerable to a wide range of diseases caused by fungi, bacteria, viruses, and nematodes. Disease management strategies are crucial since the health and quality of seeds directly impact the next generation of crops. Seed-borne diseases can spread quickly, affecting entire growing seasons and leading to significant yield and economic losses. The production of vegetable seed crops requires specialized measures, ensuring disease-free seed production is therefore a priority for farmers, seed companies, and regulatory agencies. Fungi, being the predominant group, constitute the largest number of plant pathogens and are responsible for a range of serious plant diseases. Similarly, viral, bacterial, and nematode diseases are also responsible so far. Nematodes, though constituting a smaller proportion, can inflict substantial damage through their feeding activities on plant roots, leading to reduced nutrient uptake and compromised yield (Hansen and Wick, 1993). The importance of managing seed-borne diseases lies in their transmission, the demand for healthy seeds in the market, and their impact on yield and quality. Phytosanitary regulations to prevent the import and export of infected seeds should impose strict measures to ensure sustainable production, reduce yield losses, and maintain crop quality. Based on our findings, recommendations for disease management strategies should therefore be provided, making the management of these diseases an essential task for all producers.

In terms of percentage, 70% of samples were infected by fungi, 8% by bacteria, 16% by viruses, and 6% by nematodes. It shows that vegetable disease crops are on an increasing trend. Based on the identification in the NPPRC laboratory, solanaceous crops, followed by cucurbits and cruciferous crops, were found to be the major problems in vegetable. The identification of some fungal diseases occur on a wide range of vegetables, which include anthracnose, botrytis rots, downy and powdery mildews, fusarium, rhizoctonia, sclerotium rots, and rust. Though fungal diseases are predominant, the viruses, while less prevalent, can have significant economic impacts due to their ability to spread rapidly and cause severe symptoms such as leaf curl and roll, mosaic patterns, and stunted growth. Bacterial pathogens, though less common, are notorious for causing diseases like bacterial wilt, stem rot, pith necrosis, and leaf spot, often necessitating integrated control measures. These predominant pathogens align with findings from similar agro-climatic regions, indicating a widespread prevalence of these organisms in vegetable seed systems. Accurate diagnosis is crucial to the development of an effective control program encompassing a wide array of species causing various plant diseases, ranging from root rots and fruit rots to foliar blights. This category encompasses a diverse range of hosts not included in the specified categories, indicating that diseases are prevalent across various agricultural sectors (Riley et al., 2002). They cause both qualitative and quantitative losses of crop

yield every year. Direct losses are caused by both quantitative and qualitative yield reductions, while indirect losses result from control measures and quarantine status. Diagnosis activities were carried out with the objectives of determining the distribution of diseases in the country, exploring new disease outbreaks and their epidemiology, and providing information for disease management and research area prioritization. These activities help in understanding the distribution of diseases in the country, exploring new disease outbreaks and their epidemiology, and providing valuable information for disease management. Discussing the potential impact of these diseases on plant health and agricultural practices is vital. Additionally, it is important to discuss the strengths and limitations of each diagnostic technique used. These efforts will help farmers detecting diseases early and managing them properly. Identifying specific pathogens and understanding how they relate to the observed symptoms in plants is significant, as major vegetable seed crop diseases can develop quickly and cause losses if not managed.

Conclusion

Continued survey should be done due to change in pathogen diversity which may be caused by selection pressure due to changes in the cropping system introducing new genotypes, and climate change. The findings emphasize the coordination and collaboration with national and international organizations is must for the early detection, regular seed health monitoring, and the adoption of integrated, crop-specific disease management approaches to ensure the production and distribution of high-quality, disease-free vegetable seeds for addressing the challenges of pathogen persistence.

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Insect Pests Management of Vegetable Seed Crops

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Abstract

Vegetable seed production is a complex among the entrepreneurships warranting the attack of an array of insect pests including the most primitive one Lucerne flea *Sminthurus viridis* (Collembola: Sminthuridae) to the most evolved hymenopteran pest, the mustard saw fly *Athalia lugens* (Hymenoptera: Tenthredinidae). Much homogeneous crops required for vegetable seed production along with an intensive use of agro-chemicals and the compounding effects of global climate change have accelerated the resistance, resurgence, outbreaks and trans-boundary invasions of insect pests. Yet, the option is an integrated pest management (IPM) to settle the pest population below economic threshold. This article reviews the major field and storage pest insects associated with vegetable seed production in Nepal.

Keywords: Insect pests, Pest invasion, Pest management, Vegetable seeds

Background Information

Fresh vegetable production has boomed as an economically viable enterprise in Nepal as illustrated by its leading contribution of 13.44% to Agricultural Gross Domestic Production (MoALD, 2023). Though the area under vegetable production has slightly increased, production per acreage has continuously increased pertaining to the availability of high yielding varieties and the technical know-how among the entrepreneurs (Fig. 1).

The national seed production system, despite a tremendous increment in productivity of fresh vegetables, is not sufficient to satisfy the national seed demand as illustrated in Fig. 2 (Source: SQCC, 2024). Accordingly, the major vegetable seed market is dominated by the imported and registered hybrid varieties. The proportion of the imported open pollinated varieties is also comparable to those of domestic seed production (Fig. 2) leaving a crystal-clear message to all players; especially the research, education, and extension systems, of agricultural innovation systems of Nepal to facilitate the seed production entrepreneurships.

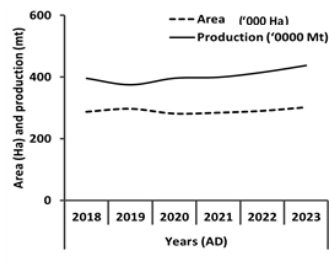


Figure 1. Area and production of fresh vegetable in Nepal (Source: Krishi Diary (2023), MoALD, Nepal)

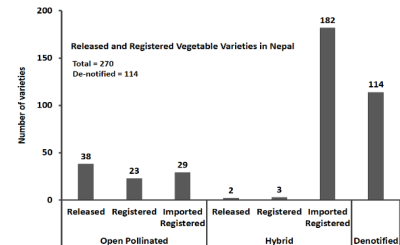


Figure 2. Released and registered vegetable varieties in Nepal (Source: SQCC, retrieved on 2024 October 22)

Vegetable seed production is a much sophisticated enterprise as it requires more time to reach maturity, has to face natural calamities like irregular rains, hailstorms, insect and non-insect pest problems. Additionally, vegetable seeds require extra time and cost compared to fresh vegetables. Amongst the bottlenecks of vegetable seed production, insect pest problem is a major one. In addition to causing direct damage to the vegetable seed crops, many insect pests vector the devastating plant diseases both persistently and non-persistently aggravating the problem much further. Insect pest management recommendations both for commercial vegetable and their seed production are primarily based upon the calendar sprays of chemical insecticides.

In recent years, owing to the shift in cropping pattern from hetero to homogeneity, ecosystem and habitat manipulation, global climate change, global trade liberalization and because of the heavy reliance on agro-chemical based intensive farming, many insect pests have switched their hosts, have developed mutagenic resistance to broad-spectrum insecticides and the minor pests have changed into the major ones. Despite all these, integrated management of the insect pest menace in vegetable seed production system is a sole alternative. This paper has highlighted the scientific evidence for the insect pest management of vegetable seed production in Nepal there by suggesting a policy-support for the vegetable seed producers.

Management of Major Insect Pests of Vegetable Seed Production

1. Tomato pin worm

Tomato pinworm (TPW) *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) is a serious oligophagous holometabolous (Fig. 3) pests of solanaceous vegetable crops in many countries.

It is among the highly invasive ones and colonizing the world very fast. It has been reported that TPW alone can threaten 87% of the world tomato production and has already colonized majority of tomato pockets of Asia, Africa and America (Santana Junior et al., 2019). Since its invasion report in Nepal in 2016, it has colonized almost all the East-West tomato belt (Bhat and Bajracharya, 2024).



Figure 3. The developmental stages of the tomato pin worm *Tuta absoluta*: (a) egg, (b) larva, (c) pupae, and (d) adult [Source: Uygun & Ozguven (2024)]

Larvae are the mesophyll feeding agents making irregular mines which negatively affect the photosynthesis and can cause a total tomato yield loss (Shiberu and Getu, 2017). It is expected to permanently infest major tomato growing world including Nepal as depicted by Ecoclimatic Index (EI) > 50 in Fig. 4 (Santana Junior et al., 2019). Similarly, it poses a high degree of Establishment Risk Index (ERI) (Azrag et al., 2023). Accordingly, ERI will increase by 0.05 points by 2050 and by 0.1 points by 2070. Both EI and ERI indices point out that the TPW is permanently establishing in Nepal warranting an integrated approach of management.

Following could be the IPM approach for TPW management.

- Collection and composting of TPW-infested leaves, growing tips and fruits to check the next-crop population hike
- Application of balanced fertilizers. Tomato and other host plants grown with dose of N-fertilizers become much susceptible to the pests.
- Plastic mulching both in open and protected cultivation of tomato and alike crops to block the underground pupation of TPW.
- Crop rotation with non-solanaceous crops and removal of alternate solanaceous hosts/ weeds help to dampen the next season TPW population down
- A hectare of land is monitored either with 4-5 yellow delta traps or with Wota-T traps baited with female-produced pheromone lures. Major TPW-activity could be observed in March-April in mid-hilly Nepal condition (Bhat and Bajracharya, 2024).
- Combining two eco-friendly tactics; bio-control with ethological control is more effective. In a review report of Colmenárez et al., (2022), larval parasitoid *Apanteles gelechiivoris* Marsh (Hymenoptera: Braconidae) when combined with ethological approach of using sex pheromone traps results into larval parasitism rate of 68.75%. Similarly *Trichogramma brassicae* Bezdenko (Hymenoptera: Trichogrammatidae) has been found an effective bio-control to suppress PTW population (Sadidi and Raeesi, 2021).
- Chemical control trail conducted by NERC identified chlorantraniliprole (an anthranilic diamide insecticide), and spinosad (a macrolide insecticide) most effective against PTW. NERC suggests to use these insecticides in rotation to avoid resistance development (Bajracharya et al., 2017).
- An IPM package of using microbial insecticides (*B. thuringiensis* var *kurstaki*, *B. bassiana*), Azadirachtin-based neem insecticides and safer chemical chlorantraniliprole significantly reduces the TPW population even reducing the crop protection cost by 50% (Buragohain et al., 2021).

2. Cabbage butterfly

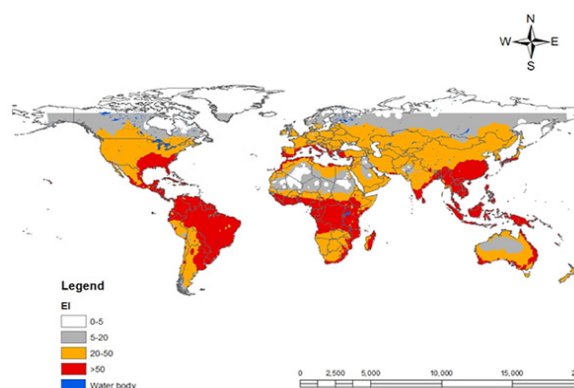


Figure 4. The Ecoclimatic Index (EI) for Tomato Pin Worm (0-5 = unsuitable, 5-20 = less suitable, 20-50 = moderately suitable and >50 = highly suitable) [Source: Santana Junior et al., (2019)]

Cabbage butterflies *Pieris brassicae* (L.) (Lepidoptera: Pieridae) and *Pieris rapae* (L.) (Lepidoptera: Pieridae) are the major constraints of vegetable seed production in Nepal hills. It may cause up to 40% yield loss of cruciferous vegetables (Hasan et al. 2008). *Pieris* larvae can feed up on all the plant parts of glucosinolate-releasing brassicas (Hopkins et al., 2009), especially cabbage, cauliflower, mustard and radish, and can attack both vegetative and reproductive parts eventually leading into a total kill of the host plants (Hasan and Ansari, 2010). Scanning of crucifer field just above crop canopies for the fluttering flight of the butterfly during onset of spring (after completion of pupal-overwinter) when flowering season of the brassicas starts, is key to know its existence and call for its management practices. Another method of scouting is sample search of ventral leaf surface of crucifers for the presence of light-yellowish cluster of 50-70 eggs in batch. Like other pests, the following integrated approach could be adopted for the management of cabbage butterfly:

- In small scale vegetable seed production field, aerial sweeping and catching of fluttering adults and smashing of the egg clusters is possible. However, for larger fields, it demands the use of repeated sprays.
- Predators like mantis, birds and others do not perform well because of the glucosinolate-sequestration by the larvae
- Pakistani strain of *Heterorhabditis* nematode exhibited increased compatibility when tested in combination with Azadirachtin-based formulation in opposite to the chemical combination (Askary and Ahmad, 2020).
- Bhandari et al., (2019) in a field trial proved spinosad as the most effective insecticide followed by emamectin benzoate. Biopesticides *Btk* and *B. bassiana* and other botanicals performed much better compared to control.
- Giri et al., (2020), among the tested soft chemical insecticides, identified spinosad and cypermethrin as the most effective among others suggesting them as the last resort to protect cabbage cauliflower crops from cabbage butterfly.

3. Tomato fruit borer (*Helicoverpa armigera*)

Tomato fruit borer *Helicoverpa armigera* (Hubner), corn earworm *Helicoverpa zea* (Boddie) and tobacco budworm *Heliothis virescens* (Fabricius) are major global challenges of heliothine noctuid pest complex. Among these, *H. armigera* is the most dominating one (Fig. 5, Kriticos et al., 2021) and can complete its life cycle in more than 180 plant species (Tay et al., 2013). Accordingly, Nepal is *H. armigera*'s country. It also inflicts potential damage to vegetable crops like tomatoes, beans, peas and other legume crops, if unattained, total collapse of the crop with no seed production possibilities. Diverse host range (Tay et al., 2013), high rate of reproduction (per female 773 eggs on chickpea and 557 eggs on tomato) (Fitt, 1989; Kumar et al., 2017), capability of long distance migration (Jones et al., 2019; Feng et al., 2004) and hybridization possibility with *H. zea* (Corderio et al., 2020) developing a newer mega-pest (Anderson et al., 2018) are some biological characters for which *H. armigera* are taken difficult to deal pest. Integrated control is thus should be a part of husbandry and the following management practices are recommended.

- Monitoring is the foremost step towards IPM of any pest. *H. armigera* is also monitored with traps baited with synthetic analogs of female-produced sex pheromone lures (Loganatham and Uthamasamy, 1998). Since the Heliothines are noctuid moths, they can also be monitored with light traps.
- Cultural methods like deeper summer plowing to expose out the pupae to prey and predators, application of balanced fertilizers with ample amendment of organic sources of fertilizers like farmyard manure and compost, inter- and mix-cropping with non-preferred crops like onion and garlics, removal of crop residues
- Pest exclusion netting of tomato polyhouses in Kavre and Lalitpur assisted in significantly reducing *H. armigera* population (Singh et al., 2018).
- Development of Bt crops has been a major host plant resistance (HPR) strategy in many developed countries. However, it is regulated on its use in Nepal. HPR is yet to be an explored field of research in Nepal.
- Egg parasitoid *Trichogramma* has been identified as a successful bio-control agent against many noctuid

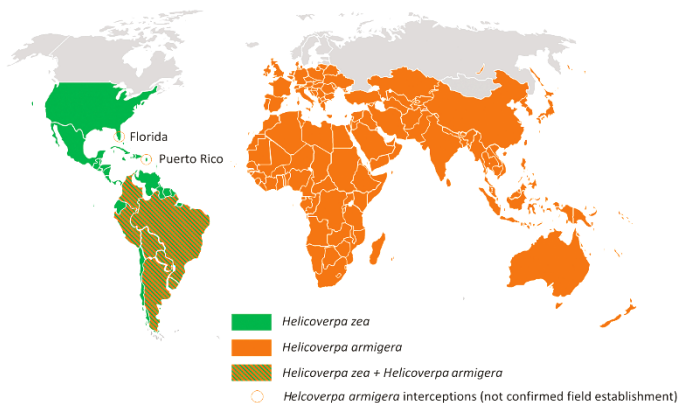


Figure 5. Global distribution of *H. armigera* and *H. zea* as economically important pests (source: Kriticos et al., 2021)

moths including *H. armigera*. National Maize Research Program (HMRP), Rampur, NERC, Khumaltar and other NARC stations across the country are rearing, testing and releasing locally available highly effective *Trichogramma*.

- The most infective viral strain HaNPV is also successfully used against *H. armigera* in many parts of the world (Luo et al., 2014).
- The lowest number of fruit damage (8.41%) in a flubendiamide followed by cocktail of chlorpyrifos + cypermethrin (15.70%) and emamectin benzoate (20.82%) was reported by Regmi et al. (2018). Ghimire et al. (2022) very recently reported the reduction of *H. armigera* larvae population on tomato by 66.52 and 68.85% after the 1st and 2nd spray of spinosad. Carneiro et al. (2014) while testing with different groups of insecticides observed the acute contact and ingestion toxicities of spinosad and chlorpyrifos followed by acephate, Bt, dimethoate, flubendiamide. Abamectin, chlorantraniliprole and methomyl also acted satisfactorily. Similar efficacy of spinosad and methomyl was also reported by Badshah et al. (2011). High degree of efficacy of spinetoram against this pest was reported by Hanafy and El-Sayed (2013). However, the pest has already developed resistance to synthetic insecticides and Bt-based HPR (as reviewed by Haile et al., 2021). For responsible product stewardship, deploying alternate use of different groups of insecticides against *H. armigera* thereby to block and break resistance development is equally important.

4. Cut worms

Holometabolous noctuid moths' caterpillars, the cut worms' cut-off vegetable seedlings of tomato, pepper, cabbage, peas, beans, squash and others, and so are regarded as polyphagous. They are problematic during hot and dry summers (recited after Bowden et al., 1983) and can increase by 10-folds of their general equilibrium population during havoc. Larvae are also night dwellers and are the only destructive stage especially to vegetable seedlings of early season plantings mainly because of a strong migration habit of adult moths (Sindhu et al., 2019). Paneru and Giri, (2011) highlighted on the two major cutworm species; greasy cutworm *Agrotis ipsilon* (Hufnagel) and *Agrotis segetum* (Dennis and Schiffermuller). The eco-climatic zones of Nepal are highly favorable for the cutworms as illustrated from CLIMEX model by Hayat et al. (2021).

Cutworms are difficult to deal with pests. However, these can be managed with the integrated management approach as follows.

- Monitoring with light and pheromone traps are successful (Raina and Khan, 2007; Sachan and Gangwar, 1990). Blue green lights are found more attractive to the cut worms (Veda and Vaishampayan, 1993). Buleza et al. (1988) found that 80 ug of 1:3:4 of female sex pheromone components [(z)-5-decen-1-ol acetate, (z)-7-decen-1-ol acetate and (z)-9-tetradecenyl acetate] per trap is the most appropriate proportion and dose. Monitoring data could be summarized to set economic thresholds and to follow the management options.
- The pest shelters and breeds on refuge crops and on the early season weeds. So, their removal along with the mulching of the main crop to provide shelter for natural enemies is beneficial.
- Plowing at least or half months ahead of plantation exposes hiding larvae and pupae to the generalist's predators like birds
- Higher seed rate in endemic areas to compensate for the crop losses can be practiced.
- Collection and mechanical disruption of the curled-up larvae near the base of young plants
- Irrigating the field very frequently to force the hidden larvae to come out to be exposed to the predators and scorching sunlight
- Shelter-baits with weed trashes or crop remnants attract the caterpillars to hide from day light which could be killed manually. Similarly, Bt- and other synthetic chemical admixed baits can be deployed in varying mode of applications like spot application to attract and kill, broadcasting before planting vegetable seedlings, and also after presence of the caterpillars (Bhattacharya et al., 2014).
- Egg parasitoids like *Trichogramma* spp and *Telenomus* spp (Pal and Katiyar, 2010), and endo-larval parasitoid like *Cotesia* spp are effective bio-control agents of the cutworms (Patil et al., 2016).
- Micro-insecticides containing NPV, Bt, granulosis virus, entomopathogenic nematodes (*Steinernema*, *Heterorhabditis*), fungi (*M. anisopliae* and *B. bassiana*) are found plenty effective to suppress the pest below economic level (Yuksel and Canhilal, 2018; Wennmann et al., 2015; Pandey, 2013; Chandel et al., 2009; Prater et al., 2006; Boughton et al., 2001). Spray or bait-broadcasting after admixing the commercial/ locally manufactured formula with grain brans could be much more effective.

- Vegetable seed crops could be protected from the cut-worms with a precise selection and timely application of chemical insecticides. Chlorpyrifos, cypermethrin, triazophos, imidachlopid, emamectin benzoate and thiamethoxam are popular both for foliage spray and for bait-broadcasting with grain substrates (Chandel et al., 2022; Joshi et al., 2020). However, alternate application of insecticides with different modes of actions are imperative for the no and delay resistance development among the worms.

5. Brinjal fruit and shoot borer

Brinjal fruit and shoot borer (BFSB), *Leucinodes orbonalis* (Guenee) (Lepidoptera: Pyralidae) is widely distributed across Asian countries (Fig. 6, Bragard et al., 2023) and is one of the major impediments to brinjal fruit and seed production in Nepal. Expert knowledge elicitation and pathway modeling by the European Food Safety Authority (EFSA) panel confirmed 3-670 (with 90% CR, certainty range) BFSB infested brinjal enter Europe with a possible impact of 0.67-13% on brinjal production if no specific action taken (Bragard et al., 2023). This holometabolous and monophagous pest can inflict a total crop failure if left unmanaged. Nursery seedlings, growing tips of the field crops and the brinjal fruits are attacked by the borer rendering the fresh vegetable unsuitable for market and further impairing the seed production processes.

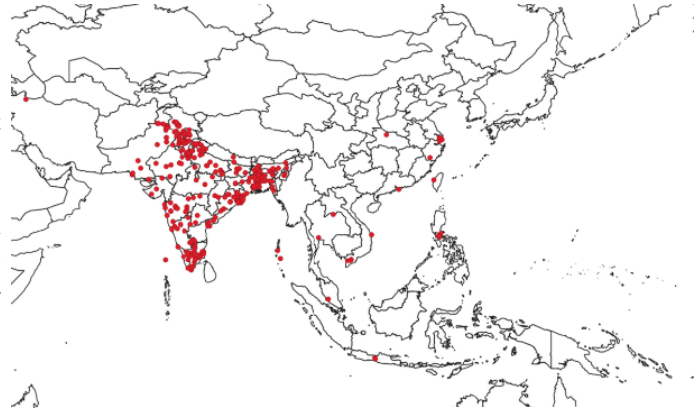


Figure 6. Point distribution of *Leucinodes orbonalis* in Asian countries based on systematic literature search [Source: Bragard et al., 2023]

Mainly the ventral surface of flush leaves and the floral parts are the preferred oviposition sites for a very high fecund female (80-260 eggs) (Alpuerto, 1994) singly or in a batch of 6-7. Initially creamy eggs turn reddish during hatching releasing whitish

larvae in an incubation period of a week (as reviewed by Mainali, 2014). After completing 5 (sometimes 6) larval instars in different parts (newly hatched on tender floral parts, mid-staged larvae on shoot tips and matured ones on the brinjal fruits), they drop on the ground and go for pupation in a grey boat-shaped cocoon (Pannusamy et al., 2021). Under harsh winter, pupae go for overwinter rest. However, under favorable seasonal conditions, it lasts for 8-9 d (Van Hung et al., 2020). Adults live for <7 d and oviposition period is also very short (<3 d) (Laichattiwat et al., 2017). So, short life and high fecundity are the major reasons behind its havoc in brinjal farms. It thus demands an integrated and area-wide approach for management.

- Some cultural practices like early planting, plucking the infested shoot tips, flowers and fruits, and collection of remnants of the preceding brinjal crop and destruction help to check the population buildup of BFSB.
- Captive growing of brinjal nursery checks the migration of BFSB to the main vegetable and seed growing field. Similarly, barrier crops like maize around the brinjal field, clean cultivation and crop rotation with non-preferred crops are advantageous to limit BFSB population.
- Growing resistant varieties is the most compatible IPM approach against the pests. However, Nepalese brinjal varieties are not absolutely tolerant to the BFSB infestation. Only moderately tolerant varieties (oblong-long in shape like Pusa Long, Pusa Kranti, Lurki, Pokhara Nurki, etc.) are available. Roundish varieties are much susceptible to the borer (recited from Paneru and Giri, 2011).
- Like in other moth pests, BFSB eggs are also well parasitized by *T. chilonis*. Saleh et al. (2024), out of 60 identified hymenopteran parasitoids of BFSB in brinjal field, identified *Apanteles hemara* (N.) (Hymenoptera: Braconidae) as the most potential one. The parasitoid *A. hemara* has also been reported to work efficiently against amaranth leaf webbers; *Spoladea recurvalis* and *Udea ferrugalis* (Lepidoptera: Crambidae) (Othim et al., 2017). So, in Nepalese conditions too, they could be tested to identify the best one for which further research initiatives are required.
- Pheromone traps impregnated with leucine lure are widely used both for monitoring, and mass trapping and disruption of male BFSB moths. Cork et al., (2001) confirmed E11-16: Ac as the major female sex pheromone component of BFSB. Addition of 1% of its related compound, E11-16: OH improved the trap efficacy compared to E11-16: Ac alone. Loading 3mg of the 100:1 of E11-16: Ac + E11-16: OH in a rubber septum (black or white) and deploying in a funnel trap resulted into a significantly higher BFSB attraction than those deploying E11-16: Ac alone. Delta, water pan and funnel traps can effectively be used. Denser installation of the traps (100/ ha) with leucine lures can achieve a significant control over the pest (Cork et al., 2007).

- Bt brinjal varieties are also available in the international market. Nepal has imposed regulation on those varieties. However, Bt-based insecticidal formulations are available which can be incorporated in IPM against BFSB.
- Botanical-based insecticides like neem oil and azadirachtin are effective against early larval instars and also act as antifeedant and oviposition deterrence against the foliage pests like BFSB.
- Chemical control has been widely practiced among the brinjal growers. Spinosad followed by emamectin benzoate, thiacloprid, chlorantraniliprole and flubendiamide performed well to control the field brinjal infestation (Jat and Shrivastava, 2022). Almost similar efficacy of the chemical insecticides was reported by Sowmya and Rajnikant, (2023). Percent field damage of brinjal by the BFSB was markedly lower when spinosad, flubendiamide, chlorantraniliprole, and emamectin benzoate were tested against the pest. Neem oil and *B. bassiana* also acted significantly compared to control. So, these insecticides with different mode of actions could be suggested to incorporate in IPM against BFSB in rotational basis so as to weaken the chances of resistance development.

6. Diamond back moth

Billions of dollars are annually invested for the management of global diamond back moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) management programs in cruciferous vegetables (Zalucki et al., 2012). Though Kfir (1998) believed that DBM originated either in the Mediterranean region or in the Southern Africa, mtDNA based study by Juric et al. (2016) also could not absolutely prove their claim. Later You et al. in 2020 by evaluating (nuclear and mitochondrial genomes, and *COI* sequencing) 532 DBM genomes representing 114 populations across the world confirmed that South America as the place of origin of DBM from where it expanded via three distinct directions; towards North America, Europe and Africa. European expansion further expanded to Asiana countries and to Australia too (Fig. 7). Now, DBM is considered as the most widely distributed amongst the butterfly and moth species on the Earth (Furlong et al., 2013).

The DBM is multivoltine (4-20 generations a year) pest. Highly fecund female (~200 eggs/ female) prefers to oviposit on dorsal leaf surface (Justus et al., 2000). Tiny light yellow to pale green neonate larvae mine through the spongy mesophyll from ventral leaf surface. Remaining three instars are voracious feeders and become darker as they mature. Larval period lasts for 2-3 wk. Second-fourth instars feed on green layers of leaves, floral parts, siliques and growing grains. When disturbed, larvae exhibit a backward wriggle moves and spin down on a silken thread. Pre-pupal larvae go for pupation under a silken cocoon formed on the leaves of host plant and emerge as adults after 5-15 d (Capinera, 2001). The insect is named DBM for its light colored diamond-marks with a creamy or light-colored band at the back when at rest, which is much clearer in males. As reviewed by Philips et al. (2014), adults live long (up to 8 wk and 2 wk in an average) and reproductively active at least for 10 d.

- Crucifer seed production demands a heavy invest on inputs and time. So, insect pest menace is anticipated.

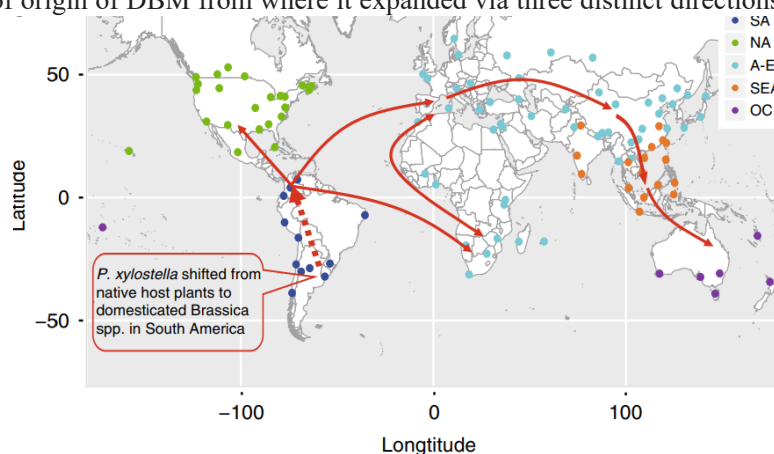


Figure 7. A proposed route of global colonization of the DBM populations [Source: You et al., 2020] SA - South America, NA - North America, A-E - Africa-Europe, SEA - South and East Asia, OC - Oceania.



Figure 8. Biological stages of DBM (Upper left -Eggs, right - Larva, Lower right - Pupa and left- Adult) [source: different web materials]

Though Bt-crops, resistant to many herbivore insects are developed, our regulation on their use and recent resistance development by the pests have challenged their cultivation. HPR with other morpho-physiological features are not sought feasible.

- Crop rotation with non-crucifer crops and clean cultivation dampen the DBM population down for the next season crop (Talekar and Shelton, 1993).
- Overhead irrigation like sprinkler irrigation dislodge the DBM early instar larvae from plant surface or drown them to die there by reducing the DBM injury to the crops (Talekar et al., 1986).
- Intercropping with non-hosts reduces the DBM attack on cabbage. Asare-Bediako et al., (2010) when evaluating intercropping cabbage with non-hosts (tomato, pepper and onion), the least damage holes on cabbage heads and average yields were obtained in cabbage+tomato intercrop. Onion and pepper intercropping were also at par with chlorpyrifos sprays.
- Trap cropping is practiced in many developed countries. Collards and Indian mustard are popularly used for trap cropping of DBM (Shelton and Nault, 2004). Badenes-Perez et al., (2004) demonstrated a 300 times greater oviposition by DBM in collard trap crops than in cabbage crop.
- Mating disruption using female sex pheromone component's lures has been sought as an effective IPM tool, both for monitoring and mass disruption. However, due attention to be paid on the geographic variation on the pheromone blends of DBM strains (Miluch et al, 2014). Altogether four components of the blends are identified; Z11-16: Ac, Z11-16:Ald, Z11-16: OH and Z9-14: Ac. Variation in amount (ug) ratio (or proportion) of 3:7:1:0 in Chinese, 1:3:2 in American, 50:50:1 in Indian and 30:70:1:0.1 in Canadian and 6:4 in Japanese strains suggests for the prior information on the local blends to assure the higher efficacy of the lures and traps. Addition of green leaf volatile (Z-3-hexenyl acetate) significantly increases the attractiveness of lures to the male moths (Miulch et al., 2014). Though non-significant, higher number of moths were captured when pan traps were not painted except dull white and were installed at a plant height (Miulch et al., 2014).
- As in the cases of other pest insects, bio-control of DBM is also a first line tactic of IPM (Fig. 9). In a review paper by Sarfraz et al., (2005), almost 130 parasitoid species are identified to attack biological stages of DBM. Amongst all, ichneumonids (genus *Diadegma* and *Diadromus*), braconids (genus *Microplitis* and *Cotesia*) and the eulophid (genus *Oomyzus*) are the most effective larval parasitoids. *Cotesia plutellae* shows a preference for non-parasitized DBM larvae over parasitized one. Moreover, *C. plutellae* is also champion in developing resistance to pyrethroids. Liu et al., (2003) recorded resistance to pyrethroids by resistance factor 13.6 after 13 selections of highly resistant DBM host showing good prospect of using it as a bio-control agent. This is also supported by the report of abundance of *C. plutellae* in a South African field which was repeatedly treated with pyrethroids (as reviewed by Sarfraz et al., 2005). The generalist egg parasitoid *Trichogramma brassicae* Bezdenko is also popularly used, but with a high risk of non-target parasitism (Babendreier, et al., 2003).
- Bt-based formulations characterized by species-specific toxicity, compatible to the genetic engineering technique and little or no harm to non-target organisms including humans (Bauer, 1995). However, Tabashnik et al., (1990, 1993) and Tabashnik (1994) evaluated the resistance of DBM to a number of insecticidal crystal proteins like Cry1A series (Cry1Aa, Cry1Ab, Cry1Ac) and so newer protein crystals are added in the list which show greater efficacies during initially and subsequently the pests develop resistance mainly due to the interference with any of the steps in mode of action of Bt Cry proteins (Tabashnik, 1994).
- Vandenberg et al., (1998) screened 54 entomopathogenic fungi (EPF) including the most popular and effective *B. bassiana* and *M. anisopliae*. Works on EPFs are regular in NERC, Khumaltar. However, commercialization is yet to be a part of research in Nepal.
- Granuloviruses (PxGV), nucleopolyhedrovirus (PxMNPV) and cypovirus (PxCPV) strains infecting different strains of DBM from different parts of the world are found to have differences in LC₅₀ and LC₉₉ values (Cherry et al., 2004; Grzywacz et al., 2004; Lu et al., 2004; Woodward et al., 2004; Kariuki and McIntosh, 1999) thereby providing an opportunity to select the most virulent one.
- Though chemical measures are sought as an easy and effective options to size DBM population down to the economic level, instant resistance development by the DBM strains from across the world is a serious concern. The 2020 Arthropod Pesticide Resistance Database documented 877 global cases of DBM resistance to all major classes of insecticides, outnumbering to all the pests in the world. Wang et al. (2021) demonstrated the resistance level of different Chinese population of DBM to spinetoram, beta-cypermethrin, indoxacarb, chlorantraniliprole, abamectin, chlorfenapyr, chlorflazuron, and even to the Bt-pesticides suggesting for

the wise selection of an IPM tactic against the pest. Opoloioiu et al., (2023) demonstrated that the resistance of DBM to emamectin benzoate is inherited as an autosomal, recessive trait conferred by a single or few closely linked loci. Surprisingly, emamectin benzoate resistant strain also exhibited multi-resistance profile to popular insecticides (chlorantraniliprole, lambda-cyhalothrin, fipronil, indoxacarb, spinetoram, abamectin, and others).

- To effectively circumvent the global DBM problem, recent molecular advances can be a newer avenue. Philips et al., (2014) summarizes that the informations achieved so far, especially in the part of insecticide-resistance in DBM (by chemosensory proteins, proteinase activities in the mid-gut, sodium channel genes, cytochrome P450 gene and bacterial symbionts, and molecular mechanisms related to detoxification of glucosinolates and insecticides) for the further improvement necessities. RNAi technology has been proved to knock out the cytochrome P450 gene, target acetylcholine esterase genes successfully and to target the suppression of the receptor gene of pheromone biosynthesis (Plx-PBANr) on female DBMs resulting in reduced male attractiveness. Dead-end trap crops as above could be another technology to tackle DBM havoc. DNA-based prey-detection approach has provided an excellent option to understand the specific and generalist predators' role in DBM control (as reviewed by Schmidt et al., 2021). The basic idea is to field collect predators and conduct PCR to identify pest's DNA in their stomach.
- To sum up, development of new insecticidal formulas with novel modes of action aided with the RNAi technology to suppress the resistance genes and mechanisms, trap cropping and crop resistance breeding, regular monitoring of insecticide resistance, improvement of current bi-control and cultural practices, pheromone-based behavioral management including suppression of receptor genes are some newer interventions to be commercialized for successful global DBM control program.

7. Fruit flies

Fruit flies are a complex of cucurbit cropping system in Nepal. So far, 27 tephritid species are reported in Nepal (Sapkota et al., 2024). However, only a couple of the flies are posing serious threat to the cucurbit industry in Nepal. Notably, *Bactrocera tau* Walker, *Bactrocera dorsalis* (Hendel) and *Bactrocera cucurbitae* (Coquillett) are among the most destructive ones. *Bactrocera scutellaris* (Bezzi) and *Bactrocera diversa* (Coquillett) are also frequently encountered, their level is not crossing the economic level. These authors have recently reported eight fruit fly species [*B. tau*, *B. cucurbitae*, *B. dorsalis*, *B. diversus*, *B. scutellaris* Wiedemann, *Bactrocera. correcta* (Bezzi), *Bactrocera zonata* (Saunders) and *Dacus longicornis* Wiedemann) in cucurbit cropping system in Gandaki Province (Chiluwal et al., 2022). It was also declared from the trap (baited either with cue lure, or methyl eugenol or their mixtures) collection of fruit flies from nine cucurbit pockets of seven districts of Gandaki and Bagmati province that the most dominant was *B. tau* with a dominance index of 0.55 (Chiluwal et al., 2024). Interestingly, the fruit flies, one at the least are pest of concern in every nation in the world. So, possibility of invasion and pattern of dominance seems to be changed periodically. Probably, the dominance of *B. tau* as reported by Chiluwal et al., (2024) could be of the reasons. Interspecific competition (as reported by Ma et al.,

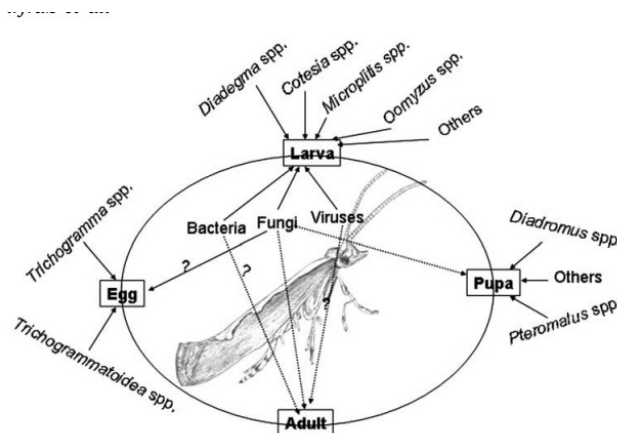


Figure 9. Principal bio-control agents of *Plutella xylostella* (L.) [Source: Sarfraz et al., 2005).

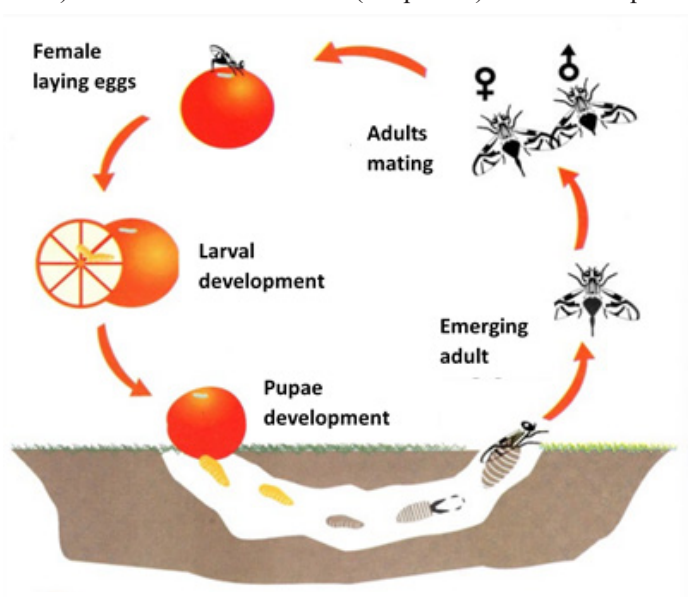


Figure 10. Typical fruit fly life-cycle [Source: FAO/IAEA, 2023].

2009) between previously assumed dominant *B. cucurbitae* and currently dominating *B. tau*, probably after its invasion in Nepal could be the reason behind the interspecific substitution. However, it would be too early to declare before nation-wide cue-mediated survey and surveillance. Furthermore, invasion possibility of highly aggressive tephritid fruit flies like *Anastrepha grandis* (Diptera: Tephritidae) in Nepal is very high as reported by Teixeira et al., 2021) using Maxent algorithm.

These holometabolous cucurbit pests with their biological stages having different nutritional guilds and habitat; eggs and larvae inside fruits, pupation under soil and aerial adults (Fig. 10) are also difficult to deal pest enforcing farmers to replace cucurbits from their farming system. Many seed producing farms are unable to produce enough seeds of cucumbers to meet national demand. So, a systematic approach of fruit fly management involving multiple tactics should be adopted to safe-gourd the cucurbit vegetable crops and their seed production program. Monitoring, identification and behavioral control: In the cucurbit ecosystem in Nepal, both cue lure-sensitive (like *B. cucurbitae*, *B. scutellaris*, *B. tau*, *B. diversus*) and methyl eugenol - sensitive species (*B. dorsalis*, *B. zonata*) are much encountered. *Bactrocera cucurbitae* and *B. tau* are much devastative to cucurbits causing fruit damage before maturity. So, monitoring and identification are must important. Cue-baited trapping and mass disruption is the widely used fruit fly control measures. Ahmad et al. (2023) found the most appropriate methyl eugenol: cue lure 60: 40 for *B. dorsalis* and 10:90 for *B. cucurbitae*. We also found an appropriate trapping height of the traps baited with cues (cue-lure or methyl eugenol) and found that “lower the trap height, higher the trap catches” in the case of fruit flies (Fig. 11). This happened mainly due to the energy saving strategy in the flies to approach to the shortest distance of the cues.

- Food baits attract both male and female flies in the principle that flies need sugar and protein for growth and development of eggs and sex organs. Protein baits such as hydrolyzed protein or bacterial fermentation broth are found effective (as reviewed by He et al., 2023).

- Mulching (especially with black plastic) of the open field cucurbit crops and at protected structures are popular and are beneficial in reducing the fruit fly population as they disrupt the lifecycle by not allowing the proper pupation of the dropped fruits/larvae to the soil.

- Bagging and netting is considered the safest idea to produce cucurbit seeds effectively with a healthy crop stand. Paper/ plastic/ cloth bagging or netting the production area or use of insect exclusion net in plastic houses are widely practiced to safe-gourd the crops.

- Natural enemies like *Fopius arisanus* and *Diachasmimorpha longicaudata* (Hymenoptera: Braconidae) are popularly used parasitoid wasps (Ndlela et al., 2020; Rousse et al., 2006) to control different tephritid species across the world. In Nepal, studies related to parasitism of the fly biological stages are not conducted yet. However, we can have benefit of adaptation research from those reported in other countries.

- Instead of adopting curative approach, sanitation of the cucurbit farms is an effective measure to reduce the fruit fly population. Addition on sanitation could be an augmentorium (Jang et al., 2007; Klungers et al., 2005) based on a principle of “pests in parasitoids out”. Augmentorium is simply a tent like structure where in fruit fly infested fruits are piled up facilitating the easy escape of parasitoids out to the field and containing the emerged flies in (Fig. 12). Collection and composting of the fallen infested mandarin fruits in the case of closely related *Bactrocera minax* caused >70% reduction in pupal density per unit area (Chiluwal et al., 2023) supporting the importance of sanitation and augmentorium method of pest management.

- Irradiation-mediated sterile insect technique (SIT) has become the choice of fruit fly control tactics, especially for quarantine purpose and for the area-wide control programs in the field. Generic doses of irradiation (mainly gamma- and X- ray) are proposed for many fruit fly species (Barnes, 2016; Shelly and McInnis, 2016) with an ease of pupal-irradiation. Male pupae reared under laboratory condition are irradiated with the proposed generic doses and released to compete with the wild ones. The male and sperm-competitiveness in many irradiation male insects are already proven and applied in many parts of the world.

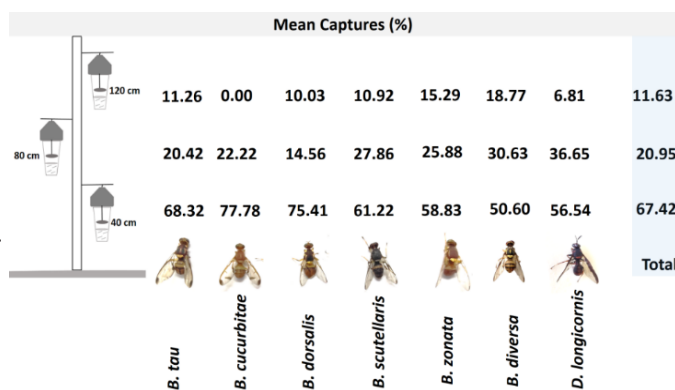


Figure 11. Effect of trap-installation height on the attractiveness of male fruit flies to cue-lure or methyl eugenol baited transparent bucket traps at cucumber field of DoAR, Lumle during 2021-2022.



Figure 12. Different augmentorium structures used widely across the world to enhance augmentorium-based biological control of fruit flies. [Source: Klungness et al. (2005)]

- Though less priorities are given to insecticidal fruit fly management, a few are evaluated for their efficacies (Lekha and Swami, 2007). Azadirachtin for its repelling action and spinosad for interfering the acetylcholinesterase activity. The differential efficacies of imidacloprid, chlorpyrifos, thiacloprid, beta-cypermethrin, fipronil, malathion, spinosad and others are reported (Arouri et al., 2015; Harter et al., 2015; Yee and Alston, 2006). Similarly, bio-insecticides containing fungus (*leucanicillium*, *Beauverria*, *Metarrhizium*) bacteria (*Bti*) and nematodes (*Steinernema* and *Heterorhabditis*) are also practiced in some parts of the world (as reviewed by Dias et al., 2018).
- Strict quarantine to block the introduction of highly invasive quarantine flies like *A. grandis* and *C. capitata* should be in practice as Nepal stands third for the likelihood of invasion of globally invasive pests.
- The area-wide multi-year control program could be the major tactic to size the fruit fly population down the economic level. However, priorities could be given for the pheromone-mediated behavioral, augmentorial sanitation and physical (bagging, netting) methods of management. To adopt an effective management strategy, components of agricultural innovation systems; research, education and advisory services should have a good knowledge of the fruit fly species and their species- and site-specific management strategies.

8. Leaf miner fly

A pest native to South America, the leaf miner fly [*Liriomyza huidobrensis* (Blanchard) (Diptera: Agromyzidae)] has now become the economic pest both in native and invaded regions of the world. Chavez and Raman (1987) reported it to be the classical example of secondary pest outbreak, as a result of the selection pressure after heavy insecticide use against the regular pest (*Tuta absoluta*) in 1970s in South America. The polyphagous pest resistant to many conventional insecticides was then carried to other parts of the globe with an ever-increasing trend of global trades and movements (Meyerson and Mooney, 2007). Scheffer et al. (2024) used phylogeographic analysis of >2 kb of mitochondrial cytochrome oxidase I and II sequence data from >400 field-collected *L. huidobrensis* specimens from both native and invaded populations and confirmed that it has spread to at least 30 countries on five continents (Fig. 13). Chiluwal et al. (2012) assessed foliage damage by *L. huidobrensis* on potato and concluded that the lower geographical altitudes and the lower plant canopy face much damage by the pest. Weintraub et al. (2017) recorded 365 host plant species from 49 plant families for *L. huidobrensis*. Seed production of many vegetable crops like tomato, pea, broad bean, four-season beans, bell pepper and other in both field and protected structures are constrained by this pest in Nepal. The adults of this holometabolous (Fig. 14.) dipterous pest are blackish with yellow spots on the head and thorax. Females puncture the leaf tissues both for feeding (by both adults) and oviposition. The translucent eggs then hatch into maggots and tunnel through the parenchymatous leaf tissue. After completing three instars, the pupation takes place in the ground and emerge as adults for repeating the regeneration (Pirtle and Severi, 2020). High intrinsic rate of increase with several generations a season are the reasons for their rapid growth, crop losses and the insecticide resistance. Based on control costs and tomato production value as a function of *L. huidobrensis* density, Lopes et al. (2019) calculated economic injury level (EIL) when 3.24 maggots exist per tomato leaf. Based on $EIL = 3.24$, the sequential sampling plan for *L. huidobrensis* has been developed (Fig. 15). In Fig. 16,

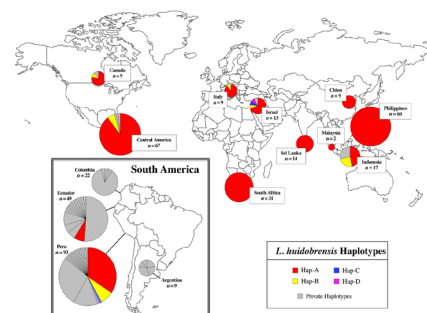


Figure 13. Global distribution of collection sites and haplotype composition of populations of *Liriomyza huidobrensis*. Each circle represents pooled samples for each country. Sample sizes are shown within boxes; in addition, circles are approximately scaled for population size. Slices within each circle represent haplotypes present in that particular location and indicate relative abundance. All private haplotypes (those found only in a single country) are shown in grey. Haplotypes shared between two or more countries are indicated in color. [Source: Scheffer et al. (2024)]

the three maggots per leaf (a) and more than three per leaf (b) are shown showing for the importance of EIL and sequential sampling plan. Accordingly, the action to limit the *L. huidobrensis* population to reach EIL should be started well ahead of the situation Fig. 16 (a) and we may incur a huge loss when we reach situation at Fig. 16 (b).

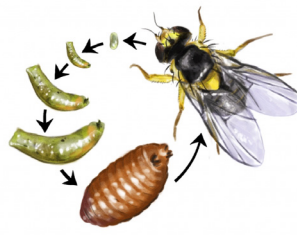


Figure 14. Life cycle of leaf miner fly [Source: Pirtle & Severi (2020)]

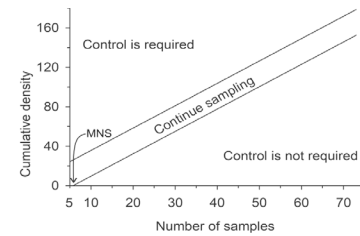


Figure 15. Decision-making limits of the sequential sampling plan for *Liriomyza huidobrensis* in tomato fields [Source: Lopes et al. (2019)]

Since the pest has acquired a global status, an IPM approach is only a relevant idea to suppress its population below economic level. Monitoring and management with yellow sticky traps in small scale tomato seed producing farms is feasible. For a larger area, movable yellow sticky boards could be beneficial by not-spraying insecticides and by reducing related expenses, and reduce killing natural enemies (Chavez and Raman, 1987). Preference to yellow color traps were also illustrated by Hamza et al., (2023).

- Defoliation and composting of the lower leaves of tomatoes could be an another cultural practice to check the population build-up of the fly as Chilawal et al. (2012) reported the lower leaves are preferred to be attacked by the flies compared to leaves of upper canopy.
- Reducing dampness and more spacious planting of the crops (like tomato, peas, beans, etc.) for penetration of sunlight to the crop canopy would certainly reduce the crop infestation.
- Since the pest shows positively geotactic pupation, mulching would reduce the pupation rate resulting into a reduced subsequent generation.
- A considerable cohort of biological control agents (>80) of leaf miner species are reported (Liu et al., 2009).
- Though the exploring and using bio-control agents against leafminer flies in Nepal is not practiced, there are many entomopathogens tested globally and found effective. Among all, parasitoid *Diglyphus isaea* is found effective to control agromyzid leaf miner populations in both their native and invaded areas (Rauf et al., 2000; Chen et al., 2003). *Dacnusa sibirica* is the widely used parasitoid of leafminer under glasshouse (Leuprecht, 1992). Pathogenicity tests of entomopathogenic fungi (*Beauveria bassiana* and *Metarrhizium anisopliae*) against the leaf mining flies are carried out with pronounced efficacies (Migiro et al., 2011).
- Baker et al. (2012) suggested the phytosanitary measures to block the further introductions of *L. huidobrensis* to other potato belts of the world. However, wider host range and loopholes in the phytosanitary legislations have led the accidental introductions of the flies.
- Though we have witnessed a manifolds of resistance to conventional insecticides by *L. huidobrensis* adults, chemical measures to control are still practice across the world to size the fly population down the EIL. Botanical insecticides extracted from Neem tree *Azadirachta indica* and Bakaino *Melia azedarach* are proved to have extraordinary feeding and oviposition deterrence activity, and translaminar effects increasing pupal mortality without negatively affecting the parasitism (Bahchio et al., 2003; Weintraub and Horowitz, 1997). Similarly, systemic effect of spiosad on the larvae of *L. huidobrensis* was reported by Weintraub and Mujica (2006) where the treated larvae could not advance to next life stages. Recently, another insecticide, spinetoram has been reported to significantly reduce the fly population after sprays (Hamza et al., 2023). Yadav et al. (2024) demonstrated that the chlorantraniliprole

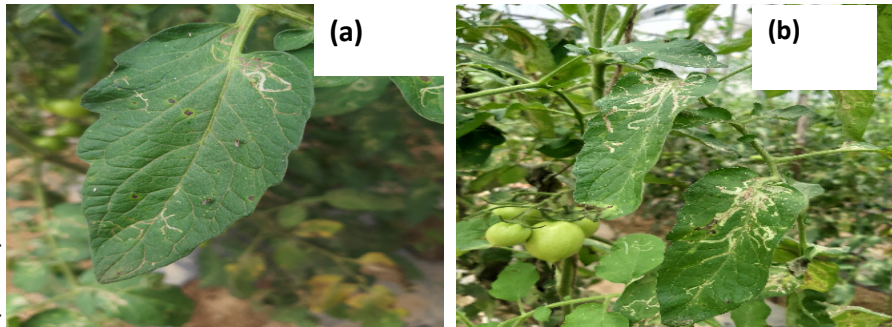


Figure 16. Situation of EIL = 3.24 maggots/tomato leaf (a) and >3.24 maggots/leaf (b) at tomato seed production block at Lumle, Kaski in 2022 (Photo by: Dr. K Chilawal).



Figure 17. A crab spider (Tomisidae) catching and feeding on a *Liriomyza huidobrensis* adult (Source: Weintraub et al., 2017).

and emamectin benzoate were equally and highly effective against another agromyzid fly, *L. sativae*. So, we have a few insecticides in hand that are effective against the fly. However, care should be given to apply in appropriate dose, volume and frequency to mitigate the possible resistance development in the insects.

9. Aphids

Aphids, trans-literally plant lice, are pests of nearly every plant species and are also most common in Nepalese farming systems. Vegetable seed producing farms suffer more from the pest as they interfere the seed production process, especially during flowering, pod formation and maturity stages when the temperature starts to rise favoring the aphid colonization.

Table 1. Major aphid pests of vegetable seed production in Nepal, their host plants and transmitted plant diseases

Aphids	Vegetable host plants	Transmitted viral diseases
Cowpea aphid, <i>Aphis craccivora</i> Koch	Beans and peas	Leaf curl virus, bean mosaic virus, cucumber mosaic virus, rosette virus
Cabbage aphid, <i>Brevicoryne brassicae</i> L.	Brassicas like cauliflower, cabbage, broccoli and others	Cauliflower mosaic virus, Turnip mosaic virus, Cabbage black ring spot virus, beet yellow virus
Mustard aphid, <i>Lipaphis erysimi</i> (Kaltenbach)	Cauliflower, cabbage, broccoli, radish, turnip, broad-leaf mustard	Cauliflower mosaic virus, Cucumber mosaic virus, Potato Virus Y, turnip mosaic virus, bean yellow mosaic
Black bean aphid, <i>Aphis fabae</i> Scopoli	broad beans, French beans, carrots, tomatoes, sugar beet, spinach, cucurbits	Bean mosaic, bean necrosis, potato leaf roll, bean yellows, etc.
Green peach aphid, <i>Myzus persicae</i> (Sulzer)	Tomato, brassicas, cucurbits, brinjal,	Potato leaf roll, tomato mottling, beet yellow, turnip yellow, lettuce mosaic, bean leaf roll, bean mosaic, cucumber mosaic, cauliflower mosaic
Cotton aphid, <i>Aphis gossypii</i> Glover	Pumpkin, cucumber, pepper, brinjal, okra, squash	Closterovirus, mosaic virus, rosette virus

- Integrated management tactics focusing on prevention, detection and control are suggested to keep aphid population below threshold. Paneru and Giri (2011) in their intensive review based book proposed good to follow steps
- Reflective mulch in vegetable seed producing farms has been found effective to repel aphids. Stapleton and Summers (2002) demonstrated the consistently low aphid population with delayed (by 3-6 weeks) landing of aphids on the *Cucumis melo* L. var. *cantalupensis* escaping the flowering and fruit setting stage which is considered crucial for viral diseases (cucumber mosaic cucumovirus and watermelon mosaic and zucchini yellow mosaic potyvirus).
- Scouting and identification is the foremost step of any IPM programs. Aphids are also identified by scouting and survey. Visual survey with some standard transect walks along the vegetable seed producing fields are recommended for aphid monitoring and identification.
- Washing off of the aphids from vegetable crops with pressure spray of water is also effective as the aphids once lodged down cannot climb again up the plants.
- Excessive use of nitrogenous fertilizers and dense planting make plant succulent and more susceptible to the aphids. So, application of balanced fertilizer and planting in a good spacing, especially for the seed production purpose are recommended.
- Conservation of insect predators like lady beetles (*Adalia bipunctata*, *Coccinella septempunctata*), green lace wings (*Chrysoperla carnea*) and syrphid flies. NERC has developed rearing protocol for *C. carnea*.
- Yellow sticky traps are much attractive to the winged aphids. Monitoring and mass attraction both can be performed using traps fitted at the crop height.
- Dusting plant ashes or soap solution on the vegetable crops is helpful to reduce aphid infestation. Spray of cattle urine diluted @ 1:4 with water is also beneficial.
- Neem extracts, tobacco + soap water decoction, and neem-based soft insecticide sprays are also proven effective against the aphids.

- Extraction of some pesticidal plants like; *Justicia adhatoda*, *Melia azedarach*, *Artemisia vulgaris*, and others and spraying after water solution @ 1:4 has been found effective against the pest.
- Different insecticides are found to work differently on different aphid species. However, dimethoate, imidacloprid, thiomethoxam are found having lower LC₅₀ values (Halder et al., 2011). Similarly, spinosad and *Beauveria* formulations are also found effective (Basnet et al., 2018).

10. White fly

White flies are polyphagous pests and are among the major problems in vegetable production across the world. Among the three popular white fly species (Fig. 18; Skaljic et al., 2012), *Bemisia tabaci* (Gennadius) and *Trialeurodes vaporariorum* (Westwood) are commonly found in Nepal (Paneru and Giri, 2011). *B. tabaci* is commonly a field pest and *T. vaporariorum* is destructive in poly- or green- or glass-house crops. Importantly, tomato seed production under plastic house condition is severely affected by this pest in Nepal.

These homopteran aleyrodids suck cell sap from ventral leaf surfaces and cause direct damage by turning leaves yellow, withering soft plant parts resulting into obstacles in flowering and fruiting for the seed production purpose of the crops. Most importantly, whiteflies are serious vectors of many plant diseases; yellow mosaic and leaf curl diseases. *B. tabaci* is slightly smaller than *T. vaporariorum*, and are distinctly differentiated with their wing postures at rest; *B. tabaci* wings look tent-like tilting gently either sides while in *T. vaporariorum*, they are roof like flat. Nymphal stages are more distinct than the adults (see Fig. 18). The pest with highly fecund females (~320 eggs) can achieve exceptionally the boomed population within a few generations. These factors are equally contributive to the resistance development in whitefly against any kinds of insecticidal molecules. So, whiteflies are also difficult to deal pests.

- Cultural practices like regulating fertilizer and irrigation can be modified to make the crop environment unfriendly for whiteflies.
- Yellow sticky traps installed at crop height for monitoring and mass trapping. Planting at proper crop geometry to avoid dampness and dark in the crop growing environment and thereby reducing the whitefly infestation.
- Drip irrigation is preferred over furrow and sprinkler irrigation to keep crop canopy dry and non-dampened (Abd-Rabou and Simmons, 2012).
- Sulfurous fertilizers are helpful to reduce whitefly infestation (Simmons and Abd-Rabou, 2008).
- UV reflective silver or aluminum coated plastic mulches reduces the severity of white flies in cucurbits, tomato, beans and in chilly (Simmons and Abd-Rabou, 2008;)
- Spray of sour buttermilk help to reduce infestation of sucking pests as milk has a good spreading characteristics and so wings of whiteflies due to casein protein and wetting nature of it causes them to die. Fermented cow milk also can lower whitefly population down by 60% and if sprayed in combination with chili extract, provides a systemic protection (Karthikeyan et al., 2006).
- Some botanical extracts like neem, garlic and some essential oils prevent settling and oviposition by whiteflies on tomato and other plants (Fanela et al., 2016; Castillo-Sanchez et al., 2015; Diabate et al., 2014; Barati, et al., 2013; El Shafie et al., 2012; Nzanza and Mashela, 2012).
- Lady beetles, lace wings and phytoseiid beetles, mirid bugs and predatory mites are popular bio-control agents of whiteflies in green-, glass-house condition.
- Foliar spray of dsRNA to regulate pest population exogenously without genetic alternation is popularly applied to control whitefly too (Cagliari et al., 2019; Dubrovina et al., 2019; Dalakouras et al., 2020; Gogoi et al., 2017), often aided with nanotechnologies, which is yet to be an addressed issue in Nepal.
- Management of whitefly in our condition relies highly on synthetic chemical insecticides. The most commonly used insecticides in Nepal are spiromesifen, spirotetramat, chlorantraniliprole, imidacloprid, flonicamid, nitenpyram along with the *Verticillium lecanii* and *Beauveria*-based formulations are quiet effective. However,

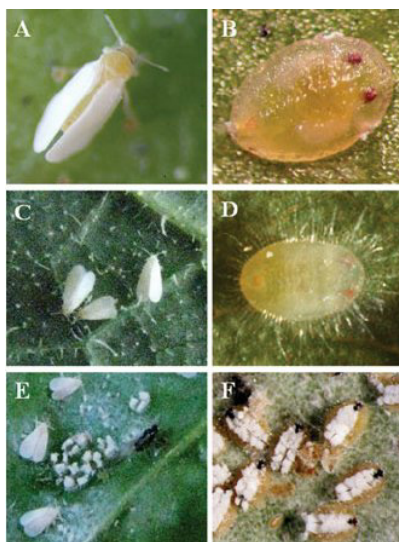


Figure 18. Phenotypical differences between three whitefly species: adults of (A) *B. tabaci*, (C) *T. vaporariorum* and (E) *S. phillyreae*; pupal stages of (B) *B. tabaci*, (D) *T. vaporariorum* and (F) *S. phillyreae* [Source: Skaljic et al., 2012].

whiteflies are also champion of resistance development against these insecticides. So, alternate use of the different groups of insecticides can be practiced.

11. Thrips

Cowpea flower thrips, *Megalurothrips sjostedti* trybom; Melon thrips, *Thrips palmi* Karny; *Frankliniella occidentalis* Pergande; onion thrips, *Thrips tabaci* Lindeman are the major global thrips infesting many crops including vegetable crops. Scarring spots in leaves, growing buds/ flush and in fruits are the major symptom of direct damage. However, they are much popular for their vectoring efficiency for major viral diseases of crops. Besides these, two more thrips' species [bell pepper thrips, *Thrips parvispinus* Karny (Joshi et al., 2024) and chili thrips, *Scirtothrips dorsalis* Hood (Devkota and Shrestha, 2024)] are recently reported infesting vegetable crops in Nepal.

Thrips are minute and slender thysanopteran insects with fringed wings. They feed on the plant surface tissue contents causing them to die resulting silver-grey patches on the leaves and black dots for their excreta. These are the powerful vectors of many plant diseases like tomato spotted wilt virus, necrotic virus in a range of plants. Scarring on cucumber may result in the "pig-tail" like deformities. To know them, field scouting is required. Direct observation for their presence, for their signs like scarring, can be evaluated and score their presence. Secondly, tapping method can also be used. Finally, and the most conveniently sticky traps are appropriate. Blue traps are the most preferred over yellow and red sticky cards by the thrips.

- Cultural practices like avoiding dampness and dark, proper spacing, balanced soil fertilization and irrigation help to reduce thrips population.
- UV-reflective metalized mulches are efficient to repel thrips' infestation (Razzak et al., 2019)
- As in other sap-feeders like aphids and whiteflies, thrips are also controlled by proper cropping methods, physical and mechanical means.
- Chemical means are the stand-alone methods adopted by many vegetable seed growers. Popular thripicides like azadirachtin, spinosad, emamectin benzoate, thiamethoxam and others are used (Gholami and Sadeghi, 2016). Since the thrips easily develop resistance to many groups of insecticides, rotational use of the insecticides is crucial to slow or break the resistance development.

12. Pulse beetle

Pulse beetles or cow pea weevil or bruchids are oligophagous field-to-storage (and vice versa) pests of legumes including peas and beans in the tropics and sub-tropics (Tuda et al., 2005) inflicting considerable nutritional and germination deterioration (de Sa et al., 2014). It is estimated that the third world countries suffer 12-30% storage loss of the legume seeds to this pest (Proctor, 1994). In Nepal, it is the major stored product insect pest of legumes including leguminous vegetable seeds like cow pea, faba bean, broad beans, French beans, four season bean and others. Two species are globally and in Nepal also; *Callosobruchus chinensis* (L.) and *Callosobruchus maculatus* (Fabricius) are competing the similar ecological and nutritional guilds, probably creating an interspecific competition. The identical difference between two species is antennal type. *C. chinensis* is dimorphic; males have pectinate and females have serrate antennae. But, *C. maculatus* males and females both have serrate antennae. The beetles start to glue their eggs on the seed surface of stored vegetable legume seeds which is the very first indication of pest attack. Larvae, the most destructive stage, tunnel and reside in the grains (Credland and Wright, 1990). Since the pest is field-to-storage, it certainly imposes troubles in its management.

- Monitoring with female sex pheromone traps or with sweep netting can be the options to detect the pest in field. Much attractive pheromone components and synthesis methods are developed (Chiluwal et al., 2017; Shimomura et al., 2008).
- Paneru and Giri (2011) suggests to admix sweet flat (*Acorus calamus*) stolen powder or basil leaf powder @ 5 g/ Kg seeds of peas, beans or cow peas; or admixing gains with mustard oil (10mL/ kg of seeds) in storage.
- Essential oils from some pesticidal plants like star anise, wintergreen, croton and other common spices are strong repellents and oviposition deterrents against the bruchids (Chiluwal et al., 2017; Chaubey, 2013; Chaubey, 2008).
- Recent regulation on the celphos (aluminium phosphide) 3 g tablets, popular for storage safe-gourd of many post-harvest commodities, has triggered the search for safer alternatives. Ethyl formate alone and in combination with others have been sought an alternative (Chiluwal et al., 2023, 2020).
- Storage surface treatment, sun-drying of seeds before storage and metal bin or storage in super grain bags are common practice among the farmers.

- Recent experiments in NERC, Khumaltar have found plant essential oils of timur (*Zanthoxylum armatum*), clove (*Syzygium aromaticum*) and others are potential against the bruchid pests.

Keep an Eye on Invasive and Trans-Boundary Insect Pests

Though the global likelihood (0.001) of invasion is very unlikely (Williamson and Fitter, 1996), if it happens, exhibits a catastrophic situation (Venette and Hutchison, 2021). Most importantly, Nepal stands globally the third in terms of overall threat of pest invasion in contrast to its 109th position as an invasion source country (Paini et al., 2016). Every nation, especially Nepal for its invasion-prone geographical location, should keep an eye to the future possible threats of the pests. Immediate control over the pests faces challenges as the invasions are new to our ecosystem, have no natural enemies to naturally suppress their population, lack research results and the extension materials. In those instances, Venette and Hutchison (2021) suggest for prediction and prevention, early detection and rapid response, and management and mitigation. Here, some insect pests globally invading at the fastest rate and possibly invading Nepal and posing threat to vegetable seed sector are discussed.

1. Colorado potato beetle

Though name affixed with potato, Colorado Potato Beetle (CPB) *Leptinotarsa decemlineata* (Say) feeds on a range of solanaceous crops like brinjal, tomato, pepper and others causing total destruction of chlorophyllous leaves before florescence and seed set (Carson-Taylor and Tubam, 2024). These chrysomelid leaf beetle adults (Fig. 19 Left) after overwintering emergence from soil forage a week before laying their bright yellowish-orange oval eggs in cluster (10-30 eggs) on ventral of the leaves. If left untreated, both larvae and adults feed on and completely defoliate the crops. Old grubs (4th instars) are reported to cause 75% damage (Hodgson, 2024).

This prolific breeder (350 eggs per female over 3-5 weeks) because of its polygamy nature (Alyokhin et al., 2015) is of serious global quarantine concern and has already colonized global potato belts (Fig. 20) of Andes peripherals, North America, Europe and Northern Africa and Eurasian ranges and even to our northern neighbor, China (Liu et al., 2014). Moreover, the pest is champion in developing resistance and cross resistance against broad range of insecticides from not-in-use DDT to the neonicotinoids like imidacloprid, thiamethoxam (Quinton, 1955; Alyokhin et al., 2007; Mota-Sanchez et al., 2006; Rondon et al., 2021) by deploying DNA methylation, the process of epigenetic changes (= turning certain genes on and off) which is heritable down to the grandkid generations efficient to tolerate a broad range of toxins (Brevik et al., 2021). Huseth et al. (2014) proposed a new tool and strategy to CPB control by using a product rotation model thereby checking the resistance development in CPB which is an essential element of responsible product stewardship as it is increasingly difficult and costly to develop a newer insecticide in place of insect-resistant one. RNAi-based methods of pest control are marked as avenue against the CPB if some challenges; potential off-target effects, development of resistance against RNAi-technology and overall cost associated with its formulation are addressed (Timani et al., 2023). However, following recommendations of professor of Iowa State University, Hodgson (2024) could settle the CPB problems to below economic level;

- Cultural: sanitation and removal of potential food hosts for an effective starvation technique
- Degree days - based scouting and monitoring (i.e. when temperature starts to rise with spring) to detect the emergence of over-wintered adults
- For small scale cultivation, hand removal or lodging of adults, egg batches and larvae into soap-water
- Crop rotation to check population build-up



Figure 19. Colorado potato beetle adult (Left) and grubs (right) (Source: Carson-Taylor & Tubam, 2024)

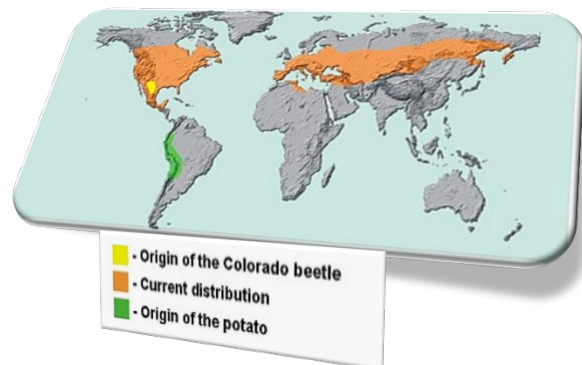


Figure 20. Global spread of Colorado beetle (Source: Venette & Hutchison, 2021)

- Deep plowing to expose over-winter adults up for encouraging predation by birds and other predators
- Early-maturing varieties to escape the CPB attack
- White muscardine fungus *Beauveria bassiana* are effective against adults and grubs
- When crosses the threshold (20-30% at vegetative stage, 5-10% at flowering and 15-20% post-flowering stage) despite above practices, management options should switch to microbials, plant derived and synthetic insecticides
- Neem oil sprays after notifying the maturing CPB eggs and early instar grubs
- Spinosad is also an effective insecticide against the CPB larval stages

2. Japanese beetle

Highly polyphagous and aggressively colonizing Japanese beetle (JB) *Popillia japonica* (Coleoptera: Scarabaeidae) hosts on >300 plants (Fleming 1972) and has attained cosmopolitan distribution (EPPO, 2016). Different feeding guilds of grubs (root zone) and adults (aerial parts) is key to its rise as a destructive pest and so the management is troublesome. In light of ongoing rapid climate change, Rocca and Milanesi (2022) model confirmed the JB colonization across the globe by 2050 (Fig. 21) and intensity of colonization would shift further north with at least 23% range expansion in Europe by this mid-century (Kistner-Thomas, 2019).

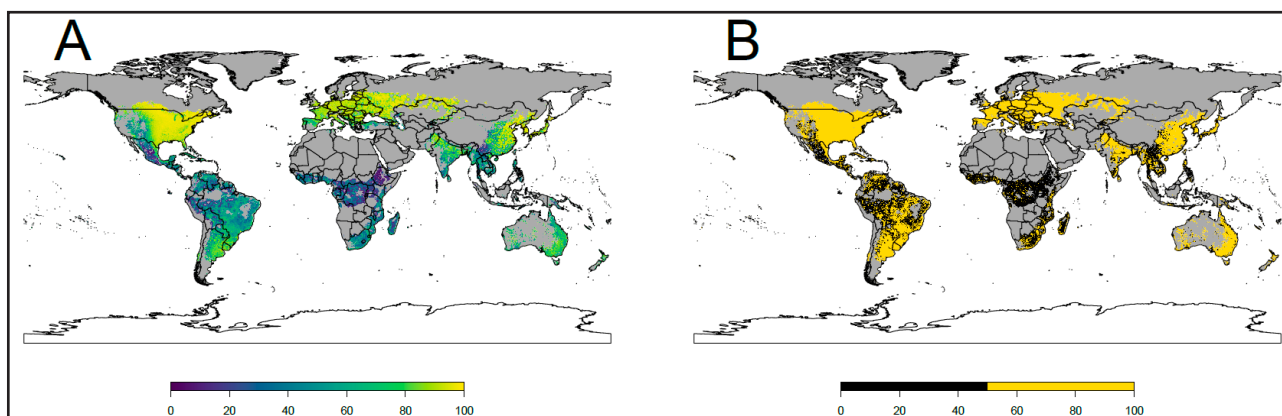


Figure 21: Distribution maps of the JB, estimated under current conditions (A) yellow–blue scale indicates higher–lower occurrence probability values, respectively, (B) areas of predicted species occurrence, presence shown in orange, while absence shown in black and those with below threshold are shown in grey (Source: Rocca and Milanesi, 2022).

Prediction Fig. 21 clearly shows Nepal will face JB problem by this mid-century and so the vegetable seed production industry will face another difficult-to-tackle problem. So, ideal and applicable management practices should at the hand to tackle the JB challenges.

- Strict quarantine and biosecurity checks (Rocca and Milanesi, 2022)
- Scouting and monitoring in much aggregation areas of field like field edges of downwind sides (Sara et al., 2012) and preferably on the most sun-lit plants of the field (Rowe and Potter, 1996; 2000)
- Small scale hand pick is possible. However, vegetable seed production blocks are larger in major. So, further management practices are warranted.
- Monitoring and management with combination of Japonilure and food-type volatile blend (Ladd and MCGovern, 1980)
- Weed management in JB control program is crucial as they shelter in weedy plants during non-host season (Szenderi and Isaacs, 2006; Rodenhouse et al., 1992) and some
- Strip intercropping with antagonist crops (Szenderi and Isaacs, 2006) like wheat/sorghum, reducing soil moisture by irrigation cut off (Potter and Held, 2002; Potter et al., 1996), addition of higher organic matter (Potter and Held, 2002; Dalthorp et al., 2000) and removal of weed shelters (like buckwheat, rye grass and clover) and crop residues (Szenderi and Isaacs, 2006) are some cultural practices to limit oviposition and larval development of JB, especially in vegetable nurseries.
- Early morning or evening drenching of entomopathogenic heterorhabditid nematodes (250,000 infective juniles in a square meter) in fair moist content soil is as efficacious as chlorpyriphos against JB larvae (Klein

and Georgis, 1992; Shapiro-Ilan et al., 2002).

- *Tiphia vernalis* Rohwer wasp externally parasitizes the overwintering grubs following a kairomonal stimuli but, due care should be taken not to spray imidachloprid during seasonal adult flights (Rogers and Potter, 2003).
- Nepal is rich in native generalists and soil-dwelling natural enemies like ground beetles, rove beetles, ants and other carnivorous scarabs, the US and Europeans strains of which are reported to feed on eggs and grubs of scarabaeid pests like JB (Terry et al., 1993). So, the protection of these NEs could be a tactic to defend JB if invaded Nepalese seed producing vegetable farms
- Bacterial insecticide Bt to defend JB (Btj) isolated from Japanese soil has been detected as effective and applicable as soil-applied insecticides (Potter and Held, 2002).
- Though the control efficacy of 90% JB adults by *Istocheta aldrichi*, a pronotom-preferring JB-specific parasitoid fly in Japan dropped down to 20% in US (Shanovich et al., 2019), could be introduced in Nepalese vegetable seed producing farms if found synchronized with the host population in our geo-topo-climatic condition.
- As summarized by Shanovich et al. (2019), diamide insecticide chlorantraniliprole as a seed treatment protects seedlings from the grubs and adults during nursery stage. Pyrethroids popularly used in Nepal (like cyfluthrin, lamda-cyhalothrin, permethrin), neonicotinoids (acetamiprid, imidacloprid, thiamethoxam) and azadirachtin-containing neem products could be deployed against the JB. However, the chemical tactics are to be adopted in rotation to avoid/slow down/ break resistance as JB are reported successful insecticide-resistant.

3. Spider mites

The cosmopolitan two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) family includes ~4000 species (Domingos et al., 2014; Migeon et al., 2007). Intrinsic rate of increase (4-6 generations a season) (Laing, 1969), fastest life-cycle (8 days) in a suitable temperature range (25-30°C) (Jakubowska et al., 2018) facilitated by haplodiploidy (haploid and monogamous male, diploid and polygamous female) (Yoshioka and Yano, 2014) and expansion in territories resulted by the global warming and subsequent climate change (Ximenez-Embun et al., 2017; Meynard et al., 2013; Migeon et al., 2009) are some key facts behind the resistance development to popular miticides (Van Leeuwen et al., 2010; Osakabe et al., 2009) by the mites, their cosmopolitan distribution and their adverse effects on the crop damage, yield losses, quality deterioration and economic damage (Archer and Bynum, 1993; Grbić et al., 2011). The post-winter to full spring season temperature range characterized by the dry weather in Nepal are favorable for the magnificent increase of the mites. Vegetable crops like cucumbers, okra, tomato, eggplant and pepper are mainly attacked and their seed production is hampered in many cases and are in the verge of pandemic attack by these polyphagous, cosmopolitan and hardy to control mites. Mite management options mainly relies on chemical options. In Nepal, components like bifentazate, buprofezin, fenpyroximate, fenazaquin, hexythiazox and propargite are registered as miticides (PQPMC, 2020). However, general insecticides like abamectin, imidacloprid, azadirachtin and others are also used. So, integrated approach should be a deal.

- Foremost tactic of mite control should be scouting field in Z- or W-pattern with a hand-lens observation if suspected specks are noticed. If mites are found scattered in middle and top canopy, starts of the further management tactics are recommended (Dean and Hodgson, 2024)
- Use balanced doses of fertilizers, specially no over-application of nitrogenous fertilizers which favors increased population growth rate (r) and fecundity (Taghizadeh and Chi, 2022)
- -Overhead irrigation like sprinkling reduces mite infestation in vegetable crops (Opit et al., 2006) to facilitate easy florescence initiation and seed set. Overhead irrigation reduces mite population by creating wet surface, by dislodging the mites and by washing the dusts on plants and by creating favorable environments for predators.
- Intercropping vegetables with garlic causes 44-65% reduction in the mobile mite population and egg laying also decreases by 38-65%, the effect could be attributed to the major components (diallyl disulfide or diallyl trisulfide) in garlic (Mohammadi et al., 2021; Hata et al., 2016).
- Fungal and bacteria-based bio-pesticides have proved to be highly acaricidal. Popularly available commercial formulations of *Bacillus thuringiensis*, *Beauveria bassiana* and *Metarrhizium anisopliae* could be successfully used against the mites as many authors have reported >90% efficacy against adult and juvenile mites (Zenkova et al., 2020; Marcic, 2012; Chandler et al., 2005).
- Host plant resistance (HPR) is somehow working in international researches. HPR is mainly attributed to the physical aspects like leaf blade structure, presence of grandular and non-grandular trichomes which secrete

secondary metabolites (such as terpenoids, alkaloids, flavonoids and polyacetylenes), the defense compounds (Rattan, 2010).

- Due to those secondary metabolites, many botanical products like neem oil, extract of pesticidal plants are acaricidal (Dabrowski and Seredynska, 2007; Rattan, 2010; Souto et al., 2021; Ebadollahi et al., 2014; Topuz et al., 2018). Interestingly, aggregation pheromone component of Japanese pine sawyer (monochamol) is also proved to be acaricidal (Chiluwal et al., 2022). However, its commercialization is an awaiting research issue.
- Nepal being rich in acaricidal plants, could be grabbed benefits of using them. Neem based insecticides work greatly in the integrated approach of the mite management. However, Prophylactic treatments before the mites reach EIL are appreciable.
- Though the mites have developed many-fold of resistance against popular miticides across the world, they could be put in rotation for the mite management so as to break or slow down the resistance development. Chemical constituent, propargite is available in Nepalese market (PQPMC, 2020) with some companions like bifenazate, buprofezin, fenpyroximate, hexythiazox. Common insecticides like dimethoate and other organophosphates could also be included in the rotational foliar sprays against the mites.

Suggestions

- Strong research on local, regional, invasive and trans-boundary pest insects
- Molecular-based phylogenesis and geographical distribution identification so as to present scientific evidence in the international communities for right to have compensation for total invasion cost to threatened countries like Nepal.
- Research on newer interventions (like RNAi,) technology in insect pest management.
- Strengthen research, education and agro-advisory systems for the efficient agricultural innovation system in Nepal with special emphasis on insect pest management of vegetable seed production.
- International ties on technology exchange to mitigate the problems of pest insects on vegetable seed production
- Provision of plant protectionists at every local bodies with full authority of pesticide inspection, pest survey-surveillance and focal person to adhere with the research bodies
- Research support from IPPO as Nepal is among the most vulnerable to invasion of pest insects
- Cross cutting issues like host plant resistance to be incorporated for varietal release and registration in Nepal

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Soil Management for Seed Production in Vegetables

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Abstract

Effective soil management is key to high-quality vegetable seed production, especially in Nepal where diverse agro-climatic zones exist. Good soil practices enhance seed viability, vigor, and germination—critical for productive vegetable farming. Essential aspects include managing soil fertility, structure, and moisture, which support seed health. This paper aims to provide a comprehensive overview of soil management practices for vegetable seed production in Nepal, drawing on local research and case studies. We browsed literature from journal articles, working papers, different websites and also did personnel communication with experts and incorporated our experiences as well. For optimal seed growth, well-aerated, nutrient-rich soils are needed. Organic amendments and balanced water management enhance plant strength and seed quality. Fertility management, using organic compost, biofertilizer and balanced fertilizers, keeps nutrient levels favorable for seed development. Proper soil pH and nutrient optimization are also essential, as they support enzyme activity crucial for germination. Practices like crop rotation, organic matter addition, cover crops and mulching help maintain soil health, reduce pathogens, and stabilize moisture. In erosion-prone Nepal, sustainable methods like mulching and terracing protect soil structure. These practices ensure reliable, high-quality seed production, supporting Nepal's agricultural sustainability and food security.

Keywords: Balanced fertilization, Seed production, Soil management, Vegetable crops

Introduction

Vegetable farming has been growing rapidly in recent years (CASA, 2020). Soil management is a critical aspect of seed production in vegetables, as it directly influences plant growth, yield, and the overall health of the agricultural ecosystem. Providing an adequate supply of mineral nutrients to crops is crucial for continued crop growth and productivity (Nair, 2019). Effective soil management practices can enhance soil fertility, optimize nutrient availability, and mitigate environmental impacts associated with agricultural practices. Effective soil management is key to high-quality vegetable seed production, especially in Nepal where diverse agro-climatic zones exist. Effective soil practices improve seed viability, vigor, and germination, which are essential for successful vegetable farming (Nabooji et al., 2022). Good soil practices enhance seed viability, vigor, and germination—critical for productive vegetable farming. Essential aspects include managing soil fertility, structure, and moisture, which support seed health. Organic vegetable growers use a variety of biological inputs, including composts, cover crops, animal and green manures, and animal wastes, to improve fertility and build soil systems (Brust, 2019).

Vegetable seed production is a highly specialized agricultural practice that demands careful soil management. High-input vegetable cropping methods usually require frequent irrigation, an abundance of fertilizer, and repeated tillage procedures (Norris and Congreves, 2018). Therefore, a rise in vegetable production worldwide could have detrimental effects on ecosystem services and soil health. Proper soil management ensures adequate nutrient supply, water availability, and disease-free conditions, which are crucial for producing viable and high-quality seeds. Essential nutrients are vital for plant development and are involved in enzymatic activities and photosynthesis which deficiency can lead to physiological disorders, affecting growth and seed quality (Patel et al., 2022).

Nepal's agricultural sector is predominantly based on smallholder farming, with vegetables being a significant source of income and nutrition for rural households. The production of quality seeds is essential for improving crop yields and ensuring food security. However, soil fertility and health are often compromised due to traditional farming practices, over-reliance on chemical fertilizers, and inadequate soil management strategies. This paper synthesizes current research findings on soil management strategies for vegetable seed production, focusing on the role of

organic and inorganic fertilizers, soil health, and sustainable practices. It also aims to provide a comprehensive overview of soil management practices for vegetable seed production in Nepal, drawing on local research and case studies. We browsed literature from journal articles, working papers, different websites and also did personnel communication with experts and incorporated our experiences as well to develop this paper. This paper explores the current practices, challenges, and recommendations for effective soil management strategies aimed at enhancing vegetable seed production in Nepal. Emphasis is placed on the integration of organic and inorganic fertilizers, sustainable agricultural practices, and the importance of soil health in promoting productivity.

Methodology

We browsed literature from peer reviewed journal articles, working papers, different websites and also did personnel communication with experts. Additionally, we also included our own experiences and ideas to help develop this paper. By using this thorough method, we tried to bring together different views and knowledge, making sure the results are strong and up-to-date with the most recent research and real- practices done across different regions of Nepal.

Interrelation Between Soil Management and Vegetable Seed Production

Ideal soil for seedbed preparation

Neutral to slightly acidic soil with pH between 6.0 to 7.5 is optimal for most of the vegetables which is crucial for nutrient availability and microbial activity. The crumbly soil with easy to work, allowing roots to penetrate easily is desirable. The soil should have a balance of sand, silt, and clay with proper drainage facilities. It should be rich in organic matter. The soil should be moist but not wet, free from weeds and pathogens with adequate nutrient levels. It should also have the quality to regulate temperature. The soil should warm up quickly in the growing season to promote seed germination and early root development. The farmers in hilly region use forest soil for seed bed preparation and this is considered ideal comprising of all the properties suitable for seed bed preparation.

Nutrient management and Seed Yield

Soil nutrient is an important factor, which directly affects the growth, yield and quality of vegetable crops. Soil contains many mineral nutrients, organic materials and water that are absorbed by plant. If any of these nutrients are deficient in the soil it affects crop development and plant shows deficiency symptoms. Therefore, soil nutrient management is necessary for successful vegetable productions. Effective soil management not only benefits crop production but also contributes to long-term soil health and environmental sustainability.

The application of fertilizers is a common practice in vegetable production to enhance soil fertility and crop yield. However, excessive use of nitrogen and phosphorus fertilizers can lead to soil acidification and nutrient imbalances, which may adversely affect plant growth and soil health over time. Liang et al. highlighted that without effective nutrient management, the negative impacts of fertilizer application, such as soil acidification and phosphorus enrichment, are likely to worsen, emphasizing the need for balanced fertilization strategies to maintain soil quality and optimize vegetable production (Liang et al., 2013). In contrast, organic fertilization methods, such as the use of vermicompost, have been shown to improve soil microbial activity and nutrient availability, leading to better plant growth outcomes. Mendoza et al. found that organic fertilization significantly increased the number of leaves per plant compared to mineral fertilizers, indicating a positive effect on vegetable yield (Mendoza et al., 2021). Beside major nutrients, micronutrients like boron, zinc, and iron are critical for flowering, pollination, and seed viability. These micronutrients should be taken into account while considering fertilization program.

Soil Structure and Root Development

Soil structure plays a critical role in determining the growth and development of plants. It affects the ability of roots to grow and supply water and nutrients to the plant. The structure of the soil influences how well the roots can absorb and transport these essential resources, which in turn impacts the overall health and productivity of the plant.

Plant root growth is greatly influenced by soil structure, however in field research it can be challenging to separate it from other soil characteristics. Well-structured soil allows better root penetration, which supports nutrient uptake and water absorption, crucial for seed-setting stages. Soil structure affects the water holding capacity of soil. Soil texture, which refers to the relative proportions of sand, silt, and clay particles, also influences water retention. Compacted soils hinder root growth, reducing plant vigor and seed production. Soil compaction increases mechanical impedance, which adversely affects root length, volume, and surface area, particularly under drought conditions (Zhu et al., 2024). Research indicates that heterogeneous soil structures, characterized by varied pore sizes, promote better root growth compared to homogeneous structures (Giuliani et al., 2024).

Soil Moisture Management and Seed Maturation

Soil properties play a critical role in determining how water is retained, distributed, and made available to plants. Seed maturation depends on the soil's ability to supply consistent water, nutrients, and an aerated environment.

Soil with good water-holding capacity ensures consistent moisture, preventing stress during flowering and seed-setting stages. Overwatering or poor drainage can lead to seed rot or fungal diseases. In order to maintain soil moisture, farmers often go for mulching which is a key for weed control as well as conservation for moisture and temperature regulation. The presence of continuous macropores in the soil provides channels for root growth and water movement. However, if roots are clumped within these macropores, their ability to extract water from the surrounding soil is reduced.

The timing of harvest, influenced by soil moisture, significantly affects seed quality, including germination rates and vigor (Leprince et al., 2016). Research indicates that varying soil moisture levels can lead to significant differences in seed yield (Tamariz et al., 2019). Although optimum soil moisture is necessary for seed development, too much moisture can have negative consequences like fungal infections or seed rot, emphasising the necessity for balanced moisture management techniques.

Insect Pest and Disease Control Through Soil Practices

Nepal is a country characterized by diverse agro-ecological zones and predominantly smallholder farming systems where pest and disease control through soil management is a foundation of sustainable agriculture. Implementing effective soil management practices can significantly suppress pests and diseases by enhancing soil health, promoting beneficial microorganisms and creating conditions unfavorable for harmful organisms. Key soil management practices in Nepal are integrated pest management practices, conservation agriculture, crop rotation, tillage, mulching, soil solarization, application of organic amendment's in soil and including the use of natural predators and botanical extract.

Soil solarization has been identified as a viable technology for killing pathogens. Farmers sometimes go for soil solarization but often they practice mulching for the control of weeds and other pathogens. As soil management techniques improve the natural suppressive properties of soils, this approach is essential for controlling pests and diseases. Beneficial microbial communities that fight pests and diseases can be promoted by effective management of soil, enhancing crop productivity and health. Incorporating organic materials like compost and biochar increases microbial diversity and activity, fostering disease-suppressive soils (DSS) that can inhibit pathogens (Jayaraman et al., 2021; Yadav et al., 2023). In order to decrease pests, it is essential to maintain soil structure and cover crops since they improve microbial ecosystems and water retention. In addition to improving pest and disease control, minimal tillage can maintain soil structure and microbial communities (Hokkanen and Hokkanen, 2024). Reducing the use of agrochemicals encourages the persistence of beneficial species and fosters a more resilient soil ecosystem.

Soil Health and Seed Production

Soil health is another crucial factor influencing seed production. Healthy soils provide essential nutrients, support beneficial microbial activity and optimal physical conditions for plant growth, directly influencing both seed yield and the quality of seeds.

The condition of the soil affects crop development, yield, and sustainability, all of which are crucial variables in seed production. Seed production can be improved by a number of techniques, including correct fertilisation and soil amendments, which can improve the microbial populations and soil characteristics. The management of soil seed banks, which are essential for maintaining plant diversity and resilience, can be affected by various agricultural practices. While Rydgren et al. discuss restoration strategies in alpine environments, their findings do not directly support the claim regarding soil seed banks in vegetable production systems and should be omitted (Rydgren et al., 2012). Furthermore, the nutrient stoichiometry of soils, as discussed by Busch et al., indicates that land use practices and nutrient management are more influential on plant functional diversity than species richness alone, suggesting that tailored soil management can enhance seed production outcomes (Busch et al., 2017).

Sustainable practices in soil management also play a vital role in enhancing seed production. The integration of organic amendments, such as poultry manure and neem leaves, can improve soil fertility and crop yield while minimizing environmental risks associated with chemical fertilizers. In order to provide a favourable environment for vegetable crops, soil amendments such as compost, biochar, and green manures enhance the soil's structure, water retention, and nutrient availability. Furthermore, soil conservation techniques including agroforestry, contour ploughing, and cover crops preserve soil organic matter, reduce erosion, and improve biodiversity (Sinha et al.,

2024). Ekanem and Akpheokhai (2019) found that organic fertilizers could significantly increase vegetable yields, demonstrating their potential as a sustainable alternative to conventional fertilizers (Ekanem and Akpheokhai, 2019). Additionally, the use of cover crops and crop rotations can enhance soil structure and nutrient cycling, further contributing to improved seed production (Shennan et al., 2016). Studies show that micronutrient application can significantly enhance fruit weight, seed count, and overall plant vigor (Soni et al., 2023)

Sustainable Soil Management Practices in vegetable crops in Nepal

For enhancing vegetable crop productivity and maintaining soil health, sustainable soil management practices is essential in Nepal. Application of organic manures and compost is being practiced extensively in smallholder farming systems in Nepal. Green manuring was a traditional practice earlier but has been drastically reduced these days due to commercialization. The use of biofertilizers and conservation tillage for maintaining soil fertility is gaining importance now a days. Terracing and Contour Farming has been a long practice in Nepal and even agroforestry has been an integral part of farming system in hilly and slopy areas. Integration of trees, shrubs, and crops to maintain soil health is being practiced by smallholder farmers. Crop rotation and intercropping is being practiced but the mode of crop rotation and intercrops varies with ecology and domain. Increased nutrient use efficiency and system self-sufficiency are the goals of vegetable rotation design and modelling (Benincasa et al., 2017). Cover crops incorporation have been shown to enhance nitrogen recycling through weed suppression, higher soil carbon levels, and decreased nitrate leaching fears when added to vegetable crop rotations (Norris and Congreves, 2018).

Integrated Nutrient Management (INM) is the prime nutrient management practices as Nepalese farming system integrates livestock farming as well and all the animal dungs are composted to produce farm yard manure and it is being used as soil amending materials in hills and mountains. In terai ecology, inorganic sources of nutrients are mostly dominant and organic manure is used as a supplement whereas in hill and mountain ecology, soil fertility is maintained through organic manure and chemical fertilizers are used as supplement. Soil fertility management practices has been changing over time and there is shortage of FYM in terai and yet, hills and mountains still have it. Legume integration in the cropping system is still in practice but is limited in terai but in hills and mountains, legume integration has remained as tradition. This is one of the reasons of still having good soil fertility in hills and mountains of Nepal. Legumes provide a number of benefits related to sustainability, including carbon sequestration, crop diversity, nitrogen fixation, nitrogen fertiliser reduction, and greenhouse gas emission reduction (Stagnari et al., 2017). The application of green manures additionally helps in controlling agricultural pests and replenishing soil fertility (Kumar et al., 2014). However, only a small percentage of farmers currently use green manures and legumes in Nepal. Therefore, more farmers must be encouraged to include green manures and legumes on sustainable production of vegetable crops. Other organic sources like compost, poultry manure, incorporation of crop residues, cover crops and other organic material is still in practice in all ecological belt but the intensity of incorporation varies.

In addition to providing nutrients, cover crops also help to improve soil structure, inhibit weed growth, and protect the soil from erosion caused by water and wind (Brust, 2019). Most of the crop residues are used as feed of the animals. The system can only be made more productive, economically viable, and environmentally sustainable by combining all of the soil fertility management strategies that are now accessible at the full rotation scale (Benincasa et al., 2017). The findings suggest that in order to preserve or enhance the functioning of soil ecosystems, future sustainable vegetable cropping systems might combine conventional and organic principles (Norris and Congreves, 2018). FYM and legume rotations are crucial methods for re-establishing soil fertility in nations like Nepal, which frequently struggle with scarcity and high prices of chemical fertilizer (Rawal et al., 2023).

Soil Fertility Management and Vegetable Production

The low and declining productivity of soils is one of the primary barriers limiting production of improved potential crops in Nepal (Rawal et al., 2023). Soil fertility is a major determinant of vegetable seed production. Improper or excessive use of fertilizers can lead to nutrient imbalances (Shanmugavel et al., 2023), soil acidification (Ain et al., 2023), and nutrient loss through leaching or runoff (Ain et al., 2023), which can negatively impact soil quality, cause environmental pollution, and also affect seed production. In Nepal, the use of chemical fertilizers has increased over the years; however, their excessive application can lead to soil degradation, nutrient imbalances, and environmental pollution. According to Sharma et al. (2020), the overuse of nitrogen and phosphorus fertilizers has resulted in soil acidification and reduced microbial diversity in many regions of Nepal (Liang et al., 2013). Therefore, it is imperative to adopt balanced fertilization practices that incorporate both organic and inorganic fertilizers. Excessive use of inorganic fertilisers in agriculture can pollute the environment and cause soil acidity and degradation (Roba, 2018).

Organic fertilizers, such as compost, farmyard manure, and green manures, play a vital role in enhancing soil fertility and structure. A study by Adhikari et al. (2019) demonstrated that the application of organic amendments significantly improved soil organic matter content and microbial activity, leading to better vegetable yields (Mendoza et al., 2021). The integration of organic fertilizers not only enhances nutrient availability but also promotes sustainable agricultural practices that are crucial for long-term soil health. Timing of the release of nitrogen to coincide with vegetable crop requirements is the main problem for organic vegetable growers (Brust, 2019).

Soil Health and Management Practices

Establishing appropriate agricultural management techniques that slow down the rate of degradation and increase soil fertility requires immediate action for sustain the soil health (Rawal et al., 2023). Soil health is a multifaceted concept that encompasses physical, chemical, and biological properties of the soil. In Nepal, soil erosion, compaction, and nutrient depletion are prevalent issues that threaten agricultural productivity. Effective soil management practices, such as crop rotation, cover cropping, and reduced tillage, can help mitigate these challenges. For instance, the use of cover crops, such as legumes, can improve soil structure, enhance nitrogen fixation, and reduce erosion (Rydgren et al., 2012). Making the wise utilization of organic resources in combination with nitrogen-fixing legumes that form symbiotic relationships with certain bacteria called rhizobia, which exist in the root nodules is one potential solution to the soil fertility problems for smallholder farmers in Nepal (Rawal et al., 2023). Furthermore, the management of soil seed banks is essential for maintaining biodiversity and resilience in vegetable production systems. Research by Bhattarai et al. (2021) indicates that local seed varieties adapted to specific agro-ecological conditions can significantly enhance crop resilience and yield (Busch et al., 2017). Therefore, promoting the conservation and use of indigenous seed varieties through effective soil management practices is crucial for sustainable vegetable production in Nepal.

Sustainable Practices for Soil Management

Sustainable soil management practices are vital for enhancing the productivity of vegetable seed production while minimizing environmental impacts. Integrated nutrient management (INM) approaches that combine organic and inorganic fertilizers have shown promising results in improving soil fertility and crop yields. A study by Ghimire et al. (2022) found that INM practices led to a significant increase in vegetable yields compared to conventional practices (Ekanem and Akphekhai, 2019). Additionally, agroecological practices, such as agroforestry and intercropping, can enhance soil health and biodiversity. The integration of trees and shrubs into vegetable production systems can improve soil fertility, reduce erosion, and provide additional income sources for farmers (Shennan et al., 2016). These practices not only contribute to soil health but also enhance the resilience of farming systems to climate change. In a study on tomato crops, biofertilizer inoculation paired with green manuring reduced synthetic nitrogen use by 30% without yield loss (Wang et al., 2020). Therefore, promoting the conservation and use of indigenous seed varieties through effective soil management practices is crucial for sustainable vegetable production in Nepal.

Digital Soil Map recently released in Nepal by Nepal Agricultural Research Council would be important tools in sustainable soil management for vegetable crops. It offers detailed information on soil nutrient levels, allowing for targeted fertilization strategies that match the specific needs of different areas within a field. By understanding spatial variability, DSMs help in creating balanced fertility programs that enhance soil health and ensure consistent vegetable crop yields. It can identify areas where practices like reduced tillage or organic amendments will have the greatest impact on increasing soil organic carbon, contributing to climate change mitigation efforts. Vegetable farmers can use sustainable practices that improve soil health, maximise resource use, and ensure long-term agricultural productivity by utilising the comprehensive and geographically accurate data from digital soil maps.

Case Studies in Soil Management in Nepal

There are several case studies and success stories of soil management in Nepal. Some of the prominent case studies includes

Community-Based Seed Production (CBSP) in Dhading: CBSP initiatives in Dhading district have focused on training farmers in sustainable soil management techniques for vegetable seed production. By this study it was revealed that average farm incomes increased by a substantial 57%, elevating numerous households above the poverty line and bolstering food security (Amatya et al., 2018).

Terrace Farming in Mustang: Farmers incorporated green manuring crops (e.g., *Sesbania*) and terrace farming techniques to stabilize soil.

Agroforestry in Syangja: Farmers planted nitrogen-fixing trees like *Alnus nepalensis* alongside vegetable crops (Sharma et al., 2009).

Crop rotation in Kavrepalanchowk: Farmers implemented crop rotation by incorporating nitrogen-fixing crops such as legumes (e.g., peas, beans) alongside the application of the recommended fertilizer rates, achieving favorable outcomes. (Ghimire et al., 2018)

Kattel and Acharya, 2016 reviewed that sustainable soil management practices and technology in Nepal are easily accessible in local conditions, cost effective and help to maintain soil health and fertility as well as increase farm income.

Sherchan and Karki, 2006, reviewed that the integrated nutrient management approach improved the productivity of crops and maintained a sound environment.

Some of the technologies evaluated by National Soil Science Research Centre, NARC showed good results in the field. Vermicomposting, mulching, and the use of biofertilizers like *Rhizobium* for legumes enhanced soil health. The inoculation of *Azotobacter* in sugarcane has also showed encouraging results. Recently, NSSRC initiated a study to see the effect of Phosphate solubilizing bacteria and Mycorrhiza.

Challenges in Soil Fertility Management for Vegetable Production

Soil fertility management for vegetable production in Nepal faces challenges such as **soil erosion**, particularly in hilly regions, which depletes essential nutrients and reduces soil depth. (Chalise et al., 2019). **Nutrient mining** occurs due to over-reliance on chemical fertilizers, leading to imbalanced soil health. **Soil acidity**, caused by excessive nitrogen fertilizer use, further limits nutrient availability. Moreover, Inadequate use of **organic matter** like compost worsens soil structure and microbial activity by upsetting soil well-being because of long time persistence in it. (Pahalvi et al.). **Water management issues**, such as irregular rainfall and improper irrigation, negatively affect soil fertility. Additionally, **climate change** and **limited knowledge** of sustainable practices hinder effective soil fertility management, reducing seed production and vegetable yields.

Conclusion

Effective soil management is essential for optimizing seed production in vegetables. A balanced approach that incorporates both organic and inorganic fertilizers, along with sustainable practices, can enhance soil health, improve nutrient availability, and ultimately lead to higher yields. However, soil erosion, nutrient mining, inadequate use of organic matter, improper water management, climate change, limited knowledge, etc. are some of the pertinent challenges of the vegetable seed production in Nepal. Future research should continue to explore innovative soil management strategies that promote sustainability and resilience in vegetable production systems. Furthermore, future studies should be conducted on developing region-specific soil management strategies that promote sustainability and resilience in vegetable production systems. Policymakers and agricultural extension services should also prioritize the dissemination of knowledge and resources related to soil management to support vegetable growing farmers in adopting best practices.

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An Emerging Pestilence of Solanum Fruit Fly (*Bactrocera latifrons*) (Hendel, 1920) in Akabare Chili Production in Nepal

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Abstract

Solanum fruit fly, *Bactrocera latifrons* (Hendel, 1920) (Diptera: Tephritidae), mostly infests the crops belonging to the Solanaceae family preferably the *Capsicum* Spp. Recently, a recurrence pestilences of *B. latifrons* have been observed in Akabare chili in Nepal. However, its systematic study has not yet been performed. It has been observed that feedings of the solanum fruit fly maggots damage the chili fruits in different parts of the country. The incidences of the solanum fruit fly in Akabare chili have been observed in Kathmandu (mid-hill), Sarlahi (terai) and Sankhuwasabha (mid-hill) districts of Nepal. *B. latifrons* has been identified morphologically and verified by molecular analysis. The accession numbers (PQ108473.1, PP956865.1 and PQ108461.1) are available in the GeneBank.

Keywords: Akabare chili, Fruit fly, Identification, Tephritidae, Threat

Introduction

Akabare chili (*Capsicum* spp.) cultivation is recently taking place a kind of emerging agricultural enterprise to support rural livelihoods in the hilly areas of Nepal (Poudyal et al., 2023). In Nepal, it was grown in 1,481 ha with 9,233 mt fresh fruit production in 2021 (MoALD, 2022). However, various challenges have threatened its yield and fruit quality. Both biotic and abiotic stresses are major contributors to the low productivity of Akabare chili: a very noticeable biotic threat being the fruit fly, particularly *Bactrocera latifrons* (Hendel, 1920) (Diptera: Tephritidae). *B. latifrons*, native to South and Southeast Asia, has recently spread to regions such as Japan, Hawaii, and parts of Africa (CABI, 2024; Liquido et al., 1994), known as the solanum fruit fly, it targets a variety of hosts within the Solanaceae family, including chili, eggplant, and tomato (Mziray et al., 2010).

There are 30 species of fruit flies including *B. latifrons* (solanum fruit fly) in Nepal which are prone to attack on the horticultural crops (Adhikari, 2024 and Adhikari et al., 2022). The solanum fruit fly has caused significant damage to Akabare chili, and is becoming a major biotic challenge to its cultivation in the recent past years in Nepal (Adhikari and Joshi, 2024). The fruit fly deposits eggs inside the chili fruit, where the developing larvae feed resulting severely reducing its quality, yield, and market value (Shimizu et al., 2007). Infested fruits show puncture marks, discoloration, and decay, making them unfit for consumption and sale. Maggot feedings in the fruit's inner tissues also lead to early fruit drops and considerable yield losses, directly impacting farm income. The spread of *B. latifrons* is rapid, as adults can take a long distance flight, and an addition, maggots infested fruits are often transported across districts (Peck and McQuate, 2004).

This pest has already invaded key Akabare chili-growing districts in Nepal, warranting for its regular monitoring and management efforts in fields. As being reasonably a new pest to Akabare chili, a specific management strategy against *B. latifrons* is lacking, and as a repercussion this fruit fly is causing extensive chili fruits damages in Nepal. This study, therefore, provides an initial understanding of *B. latifrons* as a pest to Akabare chili in Nepal with a highlight on the field identification characters of the fruit fly that may be helpful to support its field detection and management initiatives.

Materials and methodology

1. Maggots infested sample collection

This study involved rearing pupae from Akabare Chili fruits infested with fruit fly maggots. Fruits, exhibiting

infestation symptoms, such as surface punctures, discoloration, or early dropping, were collected from Kathmandu, and Sankhuwasabha districts (Table 1, Figure 1). Samples were gathered from selected field areas in each district and taken to the laboratory for study.

2. Rearing maggots and collection of adult flies

In the laboratory, the infested chili fruits were cut open to observe the maggots of the fruit fly. The 3rd instar maggots were reared in 1liter plastic jar each containing 1/3rd volume of sawdust in Kathmandu, and 1/3rd volume of soil in Sankhuwasabha. The containers with the rearing medium were maintained at the moisture level of 20-25% and room temperature of 25±2 °C to allow the fruit fly development from pre-pupae to adult stage. The setup was regularly checked, and once adult flies emerged, they were identified morphologically. The fruit fly specimens from Sarlahi district were also collected during monitoring in para-pheromone trap (Table 1).

Table 1: Locations of the fruit fly maggots infested Akabare Chili field.

S.N.	Location and date of collection	Location and date of rearing
1	Kirtipur-6, Kathmandu on July, 2024	PQPMC laboratory ¹ , Hariharbhawan, Lalitpur on July-August, 2024
2	Tropical Horticulture Centre, Nawalpur, Sarlahi on April, 2023	Trapped in para-pheromone (methyl eugenol) trap in cucurbit field on April, 2023
3	Khandbari-5, Sankhuwasabha on July, 2024	AKC ² Sankhuwasabha, on July-August, 2024
4	2024	2024

¹Plant Quarantine and Pesticide Management Centre

²Agriculture Knowledge Centre



Figure 1: a. Akabare chili plant, b. Fruit fly maggot infested fruit and c. maggot

3. Morphological identification

Adult flies, following established taxonomy guidelines for *Bactrocera* species (Drew and Romig, 2013) were examined under a trinocular stereomicroscope to verify their identity using morphological traits. Key features analyzed included body coloration, distinct markings on the thorax and abdomen, and wing patterning. These characteristics of *B. latifrons* were compared with published descriptions and identification keys specific to fruit flies.

4. Molecular identification

Morphologically identified fruit flies' specimens were sent to the laboratory at Center for Molecular Dynamics Nepal, Thapathali, Kathmandu for molecular identification.

Results and Discussion

1. Solanum fruit fly (*Bactrocera latifrons*)

This fly was first described from Taiwan by Hendel in 1912 as *Dacus parvulus* Hendel, 1912. It is native to Asia (EPPO, 2024). *B. latifrons* belongs to the subgenus *Bactrocera* and may therefore be cited as *B. (B.) latifrons*. (White and Liquido, 1995). *B. latifrons* is primarily distributed across South and Southeast Asia. Waterhouse (1993) noted its presence in Indonesia, though without specifying a particular region. Since this species has been recorded

in Sabah and West Malaysia, it is likely also present in areas like Kalimantan and Sumatra. In Africa, *B. latifrons* has been documented only in Tanzania and Kenya, with its presence in other African regions still unknown (Meyer et al., 2007). This species was also recently introduced to Hawaii, where it was first detected in 1983 (Liquido et al., 1994).

2. Taxonomic classification

Domain: Eukaryota

Kingdom: Metazoa

Phylum: Arthropoda

Subphylum: Uniramia

Class: Insecta

Order: Diptera

Family: Tephritidae

Genus: *Bactrocera*

Species: *Bactrocera latifrons*

Preferred Scientific Name: *Bactrocera latifrons* (Hendel)

Preferred Common Name: Solanum fruit fly

International Common Names: Malaysian fruit fly

Source: CABI, 2024

3. Distribution of solanum fruit fly (*B. latifrons*)

The solanum fruit fly has been described from 28 countries in the world (CABI, 2024) including Nepal. As per the updated report from CABI till 02 April 2024 this pest has been reported from Bangladesh, Brunei, Burundi, Cambodia, China, Congo, France, Hong Kong, India, Indonesia, Italy, Japan, Kenya, Laos, Malaysia, Myanmar, Pakistan, Singapore, South Africa, Sri Lanka, Taiwan, Tanzania, Thailand, Timor- Leste, Uganda, United States and Vietnam (Figure 2).

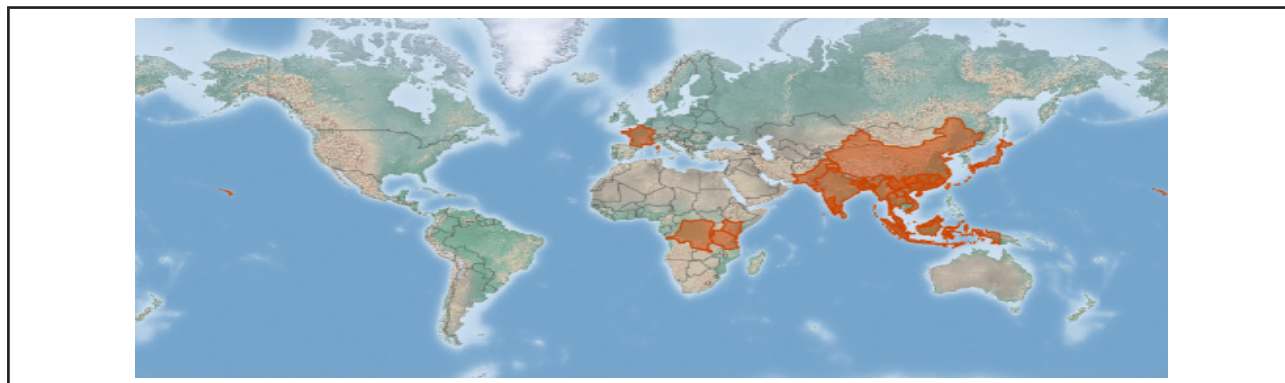


Figure 2: Distribution map of Solanum fruit fly, *Bactrocera latifrons*

Source: CABI, 2024

4. Host plants

It is known that this fruit fly pest species infests fruits in the Solanaceae and Cucurbitaceae families (Drew and Romig, 2013). *Capsicum* species (*C. annuum*, *C. chinensis*, and *C. frutescens*) and *Solanum* species (*S. lycopersicum*, *S. melongena*, and *S. aethiopicum*) are the main host plants in the Solanaceae family. Other families' host plants are regarded as minors. There are 68 host plants solanum fruit fly in 12 families (Combretaceae, Cucurbitaceae, Lamiaceae, Lithomyrtus, Lythraceae, Oleaceae, Passifloraceae, Punicaceae, Rhamnaceae, Rubiaceae, Rutaceae, and Solanaceae) of (CABI, 2024). However, 3 solanum crops are main host plants, namely *Capsicum* (peppers), *Capsicum annuum* (bell pepper) and *Solanum nigrum* (black nightshade) (CABI, 2024). The solanum fruit fly is a significant pest that requires quarantine (PM 7/142, 2020).

5. Morphological description of Solanum fruit fly (*B. latifrons*)

This fruit fly species is medium in size (6-7 mm). Face fulvous with two large oval black spots. **Thorax:** The scutum is mostly black, without medial vitta, 2 lateral vittae; scutellum is completely pale yellow.

Legs: The femora completely pale, can be completely pale to pale with a pre-apical dark spot to darkened (either black or red-brown) throughout the apical region.

Abdomen: Orange-brown to fuscous is the predominant color of the abdomen. Tergites are not fused. The abdomen is not slender-waisted. No distinct T pattern in the dorsal abdomen.

Wing: Expanded into an area at the apex, with a full costal band that does not extend below R2+3. Anal stripe on the wing. Transverse marks are absent (Figures 3 and 4).

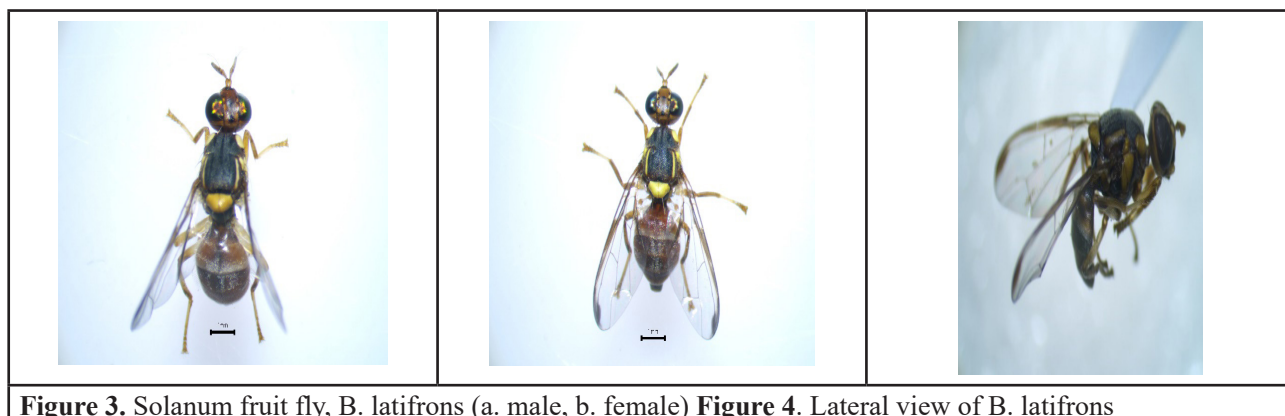


Figure 3. Solanum fruit fly, *B. latifrons* (a. male, b. female) **Figure 4.** Lateral view of *B. latifrons*

6. Molecular identification of solanum fruit fly (*B. latifrons*)

Following the molecular analysis of fruit fly specimens, the Basic Local Alignment Search Tool (BLAST) was employed to conduct a homologous nucleotide search for taxonomic identification. The search for highly similar sequences revealed that the obtained sequence most closely matches *B. latifrons*, as indicated in Table 2.

Table 2: NCBI BLAST result of the sequence with most significant alignment

Location of collection	Query length (bp)	BLAST matched Accession	Scientific name	Common name	Query coverage	Percent identity
Kathmandu	681	MZ621835.1	<i>B. latifrons</i>	Solanum fruit fly	100%	99.12%
Sarlahi	577	ON586734.1	<i>B. latifrons</i>	Solanum fruit fly	100%	99.83%
Sankhuwasabha	675	ON586734.1	<i>B. latifrons</i>	Solanum fruit fly	100%	100%

The fruit fly species *Bactrocera latifrons* was accurately identified through detailed morphological examination and subsequently confirmed using molecular analysis techniques. The genetic data associated with this identification have been submitted to and are accessible in the GeneBank database under the accession numbers PQ108473.1, PP956865.1, and PQ108461.1 for the fruit fly from Kathmandu, Sarlahi and Sankhuwasabha respectively, providing a reliable reference for future research and verification.

The attraction of fruit fly species to methyl eugenol traps in the Sarlahi district has shown inconsistent and contradictory results, as CABI (2024) reported. Notably, this particular species has been observed to exhibit no significant attraction to neither methyl eugenol nor cue lure. In contrast, a study of Kar et al., (2024) documented the collection of the same species from two locations in West Bengal, India. Specimens were retrieved from infested *Capsicum* (Solanaceae) at Chinsurah, Hooghly, and from methyl eugenol traps set up at Ruhia, Murshidabad. The genetic sequences of these specimens have been cataloged and are available in the NCBI GenBank under the accession numbers OL440711 and PP499261, respectively. These findings highlight regional and behavioral variations in fruit fly attraction patterns and offer valuable information for further study.

Conclusion

The solanum fruit fly (*Bactrocera latifrons*) presents a significant pest threat to Akabare Chili production in Nepal, broadly in the solanaceous crops across the Terai and mid-hill regions. This study provides valuable insights into the distribution of *B. latifrons* across Kathmandu, Sarlahi and Sankhuwasabha districts, confirming its presence through both the morphological and molecular identifications. The molecular data have been cataloged in GeneBank, adding to the foundation for future research and pest management strategies. The back-up information on the pest's ability to spread through adult flight and transportation of infested fruits from origin to elsewhere suggest further investigation into sustainable and effective management practices to protect the economic viability of Akabare Chili cultivation.

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Vegetable Seed Production under Precision and Protected Structures

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Abstract

Vegetable seeds are considered as high-value low volume commodities. Quality vegetable seed is vital for increased vegetable productivity. In Nepal vegetable seed production under open field possess challenges like maintaining isolation distances, impacts from biotic and abiotic stress and to avoid this seed production using precise climate and nutrient control under protected structure is the best identified strategy. Precise farming using protected structures allows quality seed production within a definite time and the production of hybrid seed of vegetable is considered profitable ventures in an international context. Among the total of 277 vegetable varieties registered in Nepal 65.7 % are of hybrids. The exact information on seed production amount and area under protected structure is not officially documented but the production of tomato hybrid seeds using Bamboo Plastic Houses (BPH) and Naturally Ventilated Greenhouses (NVGs) is common in Nepalese context. There is a huge scope for producing quality hybrid seeds for import substitution and export promotion for fruit vegetables using precision and protected farming in Nepalese context. Appropriate research, technological support and facilitation from three tiers of government are needed to promote seed production as a profitable enterprise under precision and protected structure.

Keywords: Precision, Protected Structures, Vegetable Seeds

Introduction

Precision and protected farming is a holistic farming system commonly adopted in the world which combines information and communication technology along with crop management practices for maximizing efficiency of production. Precision and protected horticulture is a key for increasing agriculture production and productivity for various types of growing structures in the current world (Atreya et al.,2020). The Distinctness, Uniformity and Stability (DUS) are the major judgment criteria for the quality of any types of seeds to judge this seed should be free from disease, seed vigour and genetic purity (Singh and Tomor,2015). Maintaining DUS quality of the vegetable seed is a key issues globally compared to other ventures like fresh production.

The open field production of vegetable seeds poses several biotic and abiotic challenges like isolation, disease and pest and climatic risks. Compared to open fields, protected cultivation with precise climate and nutrient management delivers high yield and quality attributes. In India, lots of research has been done and this technology is verified for yield and quality attributes (Singh and Tomar,2015), however the protected environment is only limited to the seed production of hybrid tomato in Nepal and around 10 private companies are involved in the hybrid seed production of Srijana tomato variety with limited public institutions involvement (Thapa Magar and Gauchan ,2016). The protected seed production is limited to only hybrid tomato production using BPH and NVGs in most of cases in Nepal.

Each year the demand of quality tomato seed is escalating with limited supply. During the year 2020 the total demand of vegetable seed was 1745 Mt, while production was limited to 475 Mt (Paudel et al.,2020), most of the productions are of open pollinated vegetable seeds. Likewise, the import of vegetable seed is increasing year after year- 160.62 Mt in 2075/76 BS and 218.4 Mt during 2079/80 BS (SQCC,2079/80) and among the total import the share of hybrid variety is around 23%. Among the 277 vegetable varieties registered in Nepal, 182 varieties (65.7%) are of hybrids. The government of Nepal has implemented seed act, seed regulations to facilitate quality seed production and it has also formulated national seed vision for the production of domestic hybrid vegetable seeds (Timsina et al.,2015). Likewise, the national seed policy 2000, national agriculture policy 2004 and other plans and policies along with research and development institutions are in place to promote the production and use of quality seeds in Nepal.

There is a huge potentiality for domestic vegetable seed production using precision farming and protected structures. Seed production under protected structures has been identified as an economical and profitable strategy with the highest possible quality (Singh and Tomar, 2015). Different types of protected structures are highly recommended for the hybrid seed production of vegetables (Srinivasulu et al., 2017). Plastic houses using low-cost frames, like bamboo and net houses, are widely used structures for seed production, followed by NVGs in Nepal. While a few innovative ideas have been adopted for precision farming, the majority of the farmers use drip irrigation, but are limited to the use of water only. There are opportunities to use temperature and humidity control along with precise nutrient application for vegetable seed production in Nepal, as temperature, humidity, and balanced nutrition are the keys to quality vegetable seed production. In tomato seed production, the stigma receptivity, pollen viability, fruit set and yield are limited by temperature and humidity (Singh and Tomar, 2015).

Conceptual Framework of the Study

The main objective of this study is to explore the possibility of seed production using precision and protected farming in Nepal based on the review of a similar scenario that can be applied in our context. This paper is prepared based on the review of available practices for seed production, especially focusing on the Indian context and experiences of seed production activities in Nepal. For reviewing the literature, mostly the literature from the Indian conditions similar to Nepalese agro ecology and socio-economy, taken as the references and conclusions and future courses of actions were prepared based on those reviews and seed production scenarios in Nepal (Figure 1)

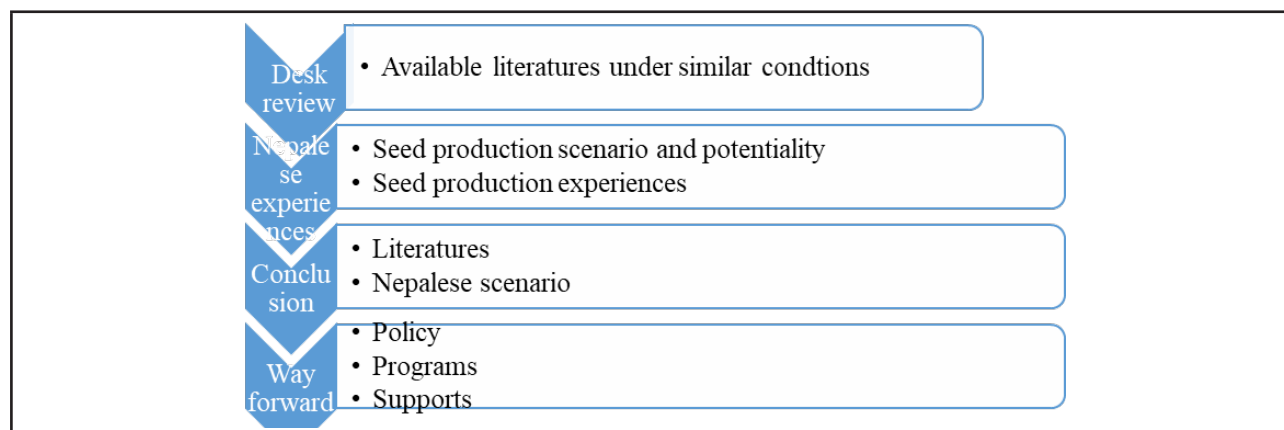


Figure 1: Broad framework for the study

Results

The results in the tabular forms are presented based on the desk review of different studies done in Indian conditions for producing vegetable seeds using different structures and nutrient management practices so that those can be replicated in Nepalese context due to the agro ecological and socioeconomic similarities.

1. Some results of protected seed production from Indian contexts

In India, Net houses and NVGs are common for the seed production practices for the vegetables. The results of vegetable seed production using net house and naturally ventilated plastic house under Indian conditions is presented in Table 1.

Table 1: Results on Protected Vegetable Seed Production

S.N.	Commodities/Conditions	Results	References
1	Pumpkin(<i>Cucurbita moschata</i>) - net house	The fruit set percentage and time doubled than open field	Singh and Tomar, 2015
2	Bitter gourd(<i>Momordica charantina</i>)- net house	High seed yield and no incidence of YMV and fruit fly	Singh and Tomar, 2015
3	Summer squash (<i>Cucurbita pepo</i>)-net house	High seed yield with better quality and no incidence of mosaic virus	Singh and Tomar, 2015
4	Cucumber(<i>Cucumis sativus</i>)- net house and naturally ventilated plastic house(NVPH)	Significantly high seed yield with good germination and vigor with no incidence of disease in autumn season	Singh and Tomar, 2015

5	Bottle gourd (<i>Lagenaria siceraria</i>)- net house	High yield, germination and vigour	Singh and Tomar,2015
6	Tomato (<i>Solanum lycopersicum</i>)- Naturally ventilated green house	Stigma receptivity, pollen viability, fruit set and yield limited by temperature and humidity. Low TYLCV. High yield due to prolonged fruiting time	Singh and Tomar,2015
7	Capsicum (<i>Capsicum annum</i>)- net house and NVPH	High yield and quality	Singh and Tomar,2015
8	Brinjal (<i>Solanum melongena</i>) -Net house	Low incidence of fruit and shoot borer, better seed yield and quality. Longer stigma receptivity and pollen viability	Singh and Tomar,2015

2. Nepalese context

The precision and protected farming for fresh vegetable production has been adopted in Nepal for fresh production since 1.5 decades so there have been limited efforts on protected and precision seed production technologies in Nepal. The research institution- Nepal Agriculture Research Council (NARC) is solely responsible for parental line and breeder seed production and distribution to the seed producers. Some NARC Centers, like Khumaltar, Malepatan and government farms like Vegetable Crops Development Centre Khumaltar, Panchkhal and Rukum are involved in tomato hybrid seed production in Nepal. A case example of vegetable seed production under a protected structure is given in Table 2.

Table 2: Case example of vegetable seed production under protected structures Vegetable Crops Development Centre (VCDC), Nepal

S.N.	Commodities/Crops	Results	References
1	Srjana hybrid tomato under galvanised iron (GI) plastic house	The highest seed recovery (7gram/kg of fresh fruit) was observed during Ashoj to Mangshir (September to December), while low seed recovery (4.5 gram/ Kg of fresh fruit) was observed during Baishakh to Shrawan (April to July)	Field level experiences at Vegetable Crops Development Centre, Khumaltar, Lalitpur
2	Khumal Jyapu variety of cauliflower under net house	The highest test weight of seed was observed, but seed production was reduced due to lack of the pollinizers'	Default-search

Discussion

There are a lot of works done focusing on precision and protected seed production at a global and Indian context but limited evidence was found in the Nepalese contexts. The research and production data/ evidences from the Indian contexts shown in Table 1 justifies the importance of precision and protected structures for high value vegetable seed production. Likewise, the cases from Vegetable Crops Development Center as shown in Table 2 also justifies the importance and potentiality of seed production under precision and protected conditions.

The insect proof net houses are recommended for virus free production, protection from insects/pest, protection from mild frost (Singh et al.,2013). The major advantages of seed production under protected conditions are: 2-4 times more yield than open field; quality, reduced isolation, flowering synchronization, maximum planting population, protection from adverse climate, maintain field standard, judicious use of inputs and ultimately extended seed viability and vigor through nutrient management (Singh and Tomar,2015). There is a clear gap of research activities focusing on seed production under protected structures as this technology is commonly used in offseason vegetable production in Nepal. The BPH along with drip for irrigation and fertigation and plastic mulching are commonly used low cost technology for producing hybrid tomato seeds in Nepal.

In Nepal the government has gave thrust for the precision and protected farming for increasing availability of fresh vegetable through the focused program on potential district by providing 50% subsidy on structures since more than a decade. Now the provincial and local government are promoting those technologies through their regular annual programs. The National Agriculture Policy of Nepal (NAP), 2004, Agriculture Development Strategy (2015-2035) and period plans gave high priority on increasing agriculture production and productivity and for this quality seed

is a vital component. Still there is limited interventions for quality seed production through precision and protected farming but many youth entrepreneurs and private companies are attracted towards this.

Conclusion and Way Forward

In Nepal the number of hybrid vegetable varieties imported over the years are huge compared to other crops as the seed replacement rate (SRR) for the vegetable is almost more than 90%. The research and development activities at a global level as well as some experiences from Nepalese conditions clearly justify the importance of precision and protected seed production in Nepal. Through the adoption of such practices, we can produce quality vegetable seeds for domestic demands as well as export markets.

The federal government i.e. Ministry of Agriculture and Livestock Development, is responsible for the policy support and quality control, likewise, the provincial ministry is mandated for provincial-level policy and program execution along with quality control, and the local level government is responsible for the local level program support based on the current practices.

Though this paper is based on the review and most of the discussion have been done based on the available information from the Indian context which can be replicated in the Nepalese context. To promote this technology, the respective tiers of governments should develop a plan based on the suggested way:

Tiers of government	Responsible organizations	Roles/responsibility
Federal Agriculture Development	Ministry/SQCC and Department of Agriculture	Formulating policies/acts/ guidelines for the promotion and support activities and market intelligence
Federal Agriculture Research	Horticulture Research Division and Provincial research units	Crop and zone specific research on vegetable seed production Development and maintenance of parental lines Development and maintenance of breeder seeds
Provincial Government	Provincial ministries/directorates/ knowledge centers/agriculture development offices/ farm centers	Technology dissemination Farmers support program Market information and networking
Local Government	Agriculture section	Technology extension Farmers support program Market information management

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Online Application Platform for Farmers to Demand Agricultural Programs: A Case of Agriculture Development Office, Kavre, Nepal

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Abstract

The agricultural sector has undergone a massive digital transformation in the last decade. New digital tools are reshaping how farmers grow crops, and consumers buy them. With the use of information and communication technology (ICT), farmers can monitor their crops, respond quickly to threats such as disease or pests, and increase yields. In Nepal, farmers use software packages like Smart Krishi, Hamro Krishi, Digitally Enabled Seed Information System (DESI) software to gain information about crop production technologies and marketing. Additionally, farmers have the opportunity to apply for agricultural programs through online portals. To understand the status of online application platform, use by farmers to demand agricultural programs, a study was done in Kavre district of Nepal in August 2024. The study revealed that after the implementation of online application platform by the Agriculture Development Office (ADO), Kavre coverage of the number of remote farmers increased from 25 percent to 42 percent, and the average number of applications submitted increased from 70 percent to 82 percent. Accessibility and cost efficiency were found to be the major advantages of online application platforms, as farmers can submit their application forms from anywhere using ICT devices. Since online application platform improves application processes' accessibility and efficiency, other ADOs ought to implement it as well.

Keywords: Agricultural Programs, Communication, Information, Online Application Platform

Introduction

Agriculture, serving as the primary livelihood for the majority of Nepalese farmers in Nepal, plays a pivotal role in the nation's economy, contributing 23.4% of the country's Gross Domestic Product (MoALD, 2023). In recent years, there is a remarkable transformation in agricultural practices with the integration of Information and Communication Technology (ICT). ICT has played a significant role in revolutionizing farming practices by bridging information gaps, improving decision-making, and enhancing productivity and profitability (FAO, 2017). Since the 1970s, electronic record-keeping systems and services based on making informed decisions have been offered to producers (Kitchen, 2002). Online platforms can integrate various aspects of farm management such as crop planning, scheduling, resource allocation, and submit application forms to demand the agricultural programs by the farmers.

The software adopted by Seed Quality Control Center, Hariharbawan, Digitally Enabled Seed Information System (DESI) is a very successful software that creates demand, supply, and facilitates the distribution of quality cereal seeds throughout Nepal (SQCC, 2023). Other apps such as Smart Krishi, Geo Kishi, Hamro Krishi, Nepali Krishi, Krishi Guru, etc., also provide information on cultivation technology of different crops and plant protection measures. Similarly, in an online application platform, farmers can submit their application forms through the internet, which does not require visiting the office (Dawadi, 2024). Farmers can apply from their home or from their respective local level, motivating farmers to submit their application forms from their fields. Promoting online applications in agriculture can significantly enhance efficiency. ICT awareness among the farmers provides equal opportunities for applicants to demand agricultural programs of the Agriculture Development Office (ADO) irrespective of their geographical location (Dawadi, 2024). ADO Kavre launched the online application platform for farmers to demand the agricultural program in November 2023.

The traditional application procedure to demand the agricultural programs involves the movement of farmers from their home to the agricultural office, apply forms for different agricultural programs in the agricultural office, and returning home, requiring farmers to spend a day on the application procedure. This costs additional time and money

for farmers in the remote area of Kavre district (Dawadi, 2024). While a lack of training and ICT education is one of the main challenges to the adoption of online platforms (Isitan, 2024), the majority of farmers lack familiarity with computers, smartphones, and other ICT devices, making it difficult to utilize digital information and services effectively (Dutta and Kakoti, 2024). Thus, this paper aims to provide a comprehensive overview of online application platforms to demand an agricultural program in the Kavre district of Nepal.

Objectives

The objective of this study is to understand the status of online application platforms for farmers to demand agricultural programs in Kavre district, Nepal.

Methodology

In August 2024, a comprehensive case study along with a key informant survey was conducted, while secondary data obtained from the ADO, Kavre, served as an important source of information and was systematically organized, processed, and analyzed using Microsoft Excel. The number of applicants and the number of agricultural programs for fiscal years 2079/80 and 2080/81, both before and after the implementation of the online application portal, were obtained from the ADO. Some study parameters were prioritized using the rank index.

Result and Discussion

1. Steps for application

ADO Kavre developed the portal for online application, where farmers can visit this site from ADO, Kavre's official website. In this platform, farmers have the option to choose the different programs and upload the necessary documents as mentioned to apply for a suitable program. Finally, farmers can submit their application forms to the ADO office, Kavre. Figure 1 shows the official page of ADO, Kavre, where farmers can see the program application form, through which farmers can apply their application forms by using the internet.

2. Coverage of farmers through online platform

Agricultural programs are demanded by farmer in every fiscal year and ADO, Kavre launched their annual agricultural program from Bhadra month of every year. Farmers from all geographical regions can submit application forms to apply for their desired agricultural support program. Figure 2 presents the trend of farmers' application before and after the initiation of online application platform. The figure revealed that after the implementation of the online application platform, the coverage of the number of remote farmers increased from 25 percent to 42 percent, whereas application forms of farmers nearer to the ADO office decreased from 75 percent to 58 percent. This indicates that farmers in remote areas showed strong motivation to submit application forms from online platform.



Figure 1: Online application platform

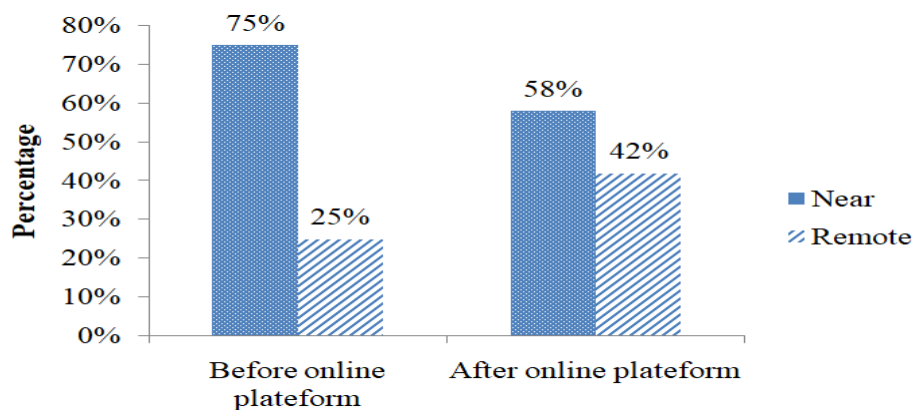


Figure 2: Coverage of farmers through online platform

3. Comparing the number of applications in online platform

Now, most farmers have ICT devices, which can be used to submit the application forms. The annual program of ADO Kavre includes Vegetable promotion program, Small irrigation program, Vegetable promotion in protected structure, Mushroom promotion program, Maize promotion program, Kiwi promotion program, Paddy promotion

program, Machinery distribution program, Spices crop promotion program, and Demand-based livelihood support program. Figure 3 presents the number of applications before and after the online platform, revealing that the average number of applications increased from 70 percent to 82 percent, which discourages the ADO to re-noticing their agricultural programs. This also made clear that most of the farmers are aware of the notice of the agricultural programs issued by ADO, Kavre. The support and promotional activities of the local level, Prime Minister Agriculture Modernization Project, District-based co-operatives, may also be helpful in disseminating information of ADO, Kavre.

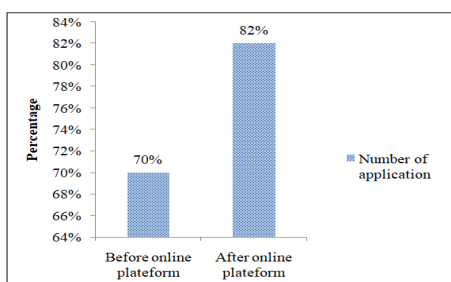


Figure 3: Comparing the number of application in online platform

4. Advantages of online application platform to the farmers

Online applications offer flexibility, convenience, and an easiness of application process that may enhance productivity and efficiency. Table 1 presents the advantages of online application platforms to farmers. The majority of the key informants' ranked accessibility as the first advantage of online platforms, i.e., farmers can submit their application forms from anywhere using ICT devices, which increases the farmers' access to agricultural programs irrespective of their location, followed by cost efficiency. Easier to apply and farmers can save their time are other advantages of the online application platform for farmers.

Table 1: Advantages of online application platforms to the farmers

Advantages	Index	Rank
Accessibility	3.8	I
Cost efficiency	2.6	II
Easier to apply	2.5	III
Farmer can save their time	2.2	IV

Conclusion

ICT has transformed application processes across various sectors, making them more efficient, accessible, and streamlined. In the agricultural domain, an online application platform has proven to be highly beneficial for farmers. After ADO, Kavre introduced such a platform, it experienced a significant increase in applications for its annual support programs, particularly from farmers in remote areas. The Online application platforms were found to increase access, reduce the need for farmers to travel from their fields to the office, and encourage the integration of ICT in agriculture. Given these advantages, other ADOs are encouraged to adopt similar online platforms to enhance service delivery and extend benefits to a broader base of farmers.

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Post-Harvest Management of Vegetable Seed Crops: Practices and Approaches

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Abstract

Healthy seeds are prerequisite for the good yield. Post-harvest management of vegetable seeds is crucial to ensure high-quality seeds for future planting. Proper handling after harvest preserves seed viability, vigor, and reduces the chances of contamination and deterioration of seeds. A number of biological and non-biological processes (improper moisture content, fluctuating temperature, faulty packaging) cause significant losses of seeds during storage. The quality of seeds can be maintained by using careful postharvest handling techniques. The major challenges of post-harvest management of vegetable seeds are inadequate infrastructure and limited access to technology. The ultimate goal of post-harvest management of vegetable seeds is to produce quality seed that meets both national and international standard to fulfill the requirement of the end user and seed related industry. This paper discusses and highlights post-harvest practices and approaches for vegetable seeds at both national and international levels, providing insights that may benefit stakeholders in the country's seed sector.

Keywords: Handling, Moisture, Post-Harvest, Quality, Storage, Vegetable Seeds

Introduction

Seed quality plays a significant role in attaining higher production and productivity in crop plants, including vegetables. Quality seed is a seed which possess all the seed quality attributes, viz. genetic purity, physical purity, germination, vigor, health, moisture, size, weight and color. Seed quality is one of the most demanding parameters within seed enterprises these days. It takes more time and money to grow a vegetable for seed production than it does to grow a crop for fresh consumption. The majority of the seeds especially vegetable seeds are produced by small-scale farmers and stored on the farms.

The major problem in seed enterprise is the damage due to meagre post-harvest management practices resulting from biological factors such as molds, and insects, that is often alleviated by ineffective storage techniques. The quality of the seeds is under strain from the environment. The physical damage caused during postharvest handling influence germination and vigor of crop seeds. Damaged seeds give rise to abnormal seedlings, have less resistance against pest and diseases and have minimum storage life (Salari et al., 2012). Jyoti and Malik (2013) revealed that deteriorated seeds reduces germination percentage, vigor, emergence, growth uniformity, yield impaired biosynthetic mechanisms, abnormal seedlings, and fungal infection such as purple stain. Any stage of post-harvest handling or production has the potential to degrade the quality of seed. All seed activities must be managed technically carefully in order to reduce these losses (Boxall et al., 2002).

Post-harvest management of vegetable seeds comprises a good harvesting method at proper maturity, curing, grading and sorting of fruits/pods for seed extraction, extraction of seeds from good quality fruits/pods, cleaning and grading, drying to maintain optimum moisture, seed treatment, packing and storing. Proper post-harvest handling and threshing techniques can enable more timely harvest with lower losses of seed quality. Maintenance of the seed quality is the major problem in the developing countries like Nepal. Thus, developing countries like Nepal needs to develop inexpensive, suitable and productive techniques for postharvest handling of seed crops and improvement in post-harvest management techniques. This paper discusses the required practices and approaches for post-harvest management of vegetable seeds in Nepal.

Post-Harvest Management Techniques in Vegetable Seed

1. Harvesting at proper maturity

Harvesting is a delicate process that requires careful timing (Alkimim et al., 2016). The method and condition of the harvest affect the further handling, processing, and storage of crops. Over-mature crop harvest causes biological and physical losses of crops by consistent wetting and drying of crops and harvesting too early can result in immature seeds that lack vigor and may not germinate properly (Kitinoja et al., 1999). Physiological traits such as the germination percentage, vigor, and yield are directly influenced by the stages of harvesting and drying. Inappropriate harvesting and handling can cause discoloration and damage on crops. Damage gives the open space for microbial assault that cause rotting, respiration increase and shortage (Yousaf et al., 2016). Different parts of plant are harvested by different harvesting methods; in case of fruit vegetables, the single fruit is trimmed off; in case of broad leaf mustard, whole branches of the plant are harvested and kept for curing.

2. Curing

Curing in seed production is a process of drying seeds to an optimal moisture level after harvest, ensuring that they maintain viability during storage and planting. The goal is to reduce the seed moisture content to a safe level that prevents microbial growth, seed deterioration, and physiological damage. Curing is essential for seeds with higher moisture content at the time of harvest. It not only ensures seed longevity but also helps in enhancing germination rates and preserving seed vigor. Curing can also improve the seed coat integrity, making the seeds more durable during handling and transport. In vegetables like Cole crops and Broad leaf mustard, pods are piled up for curing four to five days, and are again turned upside down to cure for another four to five days. This process makes seed threshing easy and improve the overall seed quality.

3. Grading and sorting of fruits/pods for seed extraction

It is a crucial step in ensuring the production of high-quality seeds. Proper grading helps in selecting fruits or pods with the best genetic traits and highest seed viability. It also ensures uniformity, reducing the chances of extracting poor-quality seeds. Navitha (2019) reported that medium sized fruits can be selected for good crop establishment and also assurance is given for production of good quality seeds and produce vigorous seedlings in cucumber. Fruits or pods with symptoms of fungal infections (rotting, black spots, mold growth) or insect pests damage (holes, chewed areas) should be discarded to prevent contamination of healthy seeds.

4. Extraction of seeds from good quality fruits/pods

Extraction of the seed is the process of removing seeds from the fruits, pods and siliques of vegetable plants to prepare them for cleaning, drying, curing, and storage. The method of extraction varies depending on the type of vegetable and the seed's location within the fruit or pod. Proper seed extraction ensures that high-quality seeds are harvested without damage to their structure, enhancing their viability and germination potential. Dry seed extraction technique is used for vegetables that produce seeds in pods, capsules, or dry fruits (cowpea, beans, peas, okra, lettuce etc). Seeds from these vegetables becomes dry at the time of harvest and require minimal processing. Wet seed extraction technique is used for fleshy-fruited vegetables (tomatoes, cucumbers, peppers, melons etc.), where seeds are embedded in the pulp or flesh. This method requires the removal of seeds from the moist flesh and subsequent cleaning to ensure no pulp or debris is left.

5. Cleaning and grading

Cleaning and grading of vegetable seeds are critical steps after seed extraction to ensure that only the best, viable seeds are kept for storage and planting. These processes involve removing dirt, debris, and damaged seeds while also sorting seeds by size, weight, and quality, thereby enhancing the overall uniformity, vigor, and germination potential of the seed lot. Seed cleaning can be done through manual cleaning (hand picking, sieving or screening), winnowing (tossing the seeds in an air, hand held fan, winnower, mechanical blowers), water cleaning (floatation or washing), mechanical cleaning (air screen cleaners, gravity separator, magnetic separator) according to nature of seed materials and available facilities. Grading, is done again to sort the seeds by size, shape, weight, and sometimes color to ensure uniformity and quality. Size grading can be done through sieving or screening for small scale and rotary graders for large scale size grading. Weight or density grading can be done by gravity separator for large scale and manual water floatation for small scale. Color sorting are also done to prepare seed uniform seed lot by using optical color sorters for commercial purpose.

6. Drying

Drying of seed lots means the lowering down the seed moisture content to safe moisture limits. It is important step

to maintain seed viability and vigor, which may otherwise deteriorate fast due to mold growth, heating and increased micro-organism. When seeds have a moisture level between 10% and 14%, temperature has an impact on how long they can be stored. Timely drying of crops is essential for a high-quality yield. In most cases, fungal infection, insect and pests attack cause biologically active seeds to degenerate quickly. Reducing respiration in seeds is the primary goal of drying (Kiaya, 2014). The seed may deteriorate if it is dried extensively at a high temperature.

The drying of seeds can be done by two methods; sun drying and forced air drying. In the absence of forced air-drying facilities, the moisture content of seeds has to be reduced in the field before harvest, and later by sun drying on the threshing floor. The main advantage of sun drying is that it requires no additional expenditure, or special requirement. The disadvantages are delayed harvests, risks of weather damage and increased likelihood of mechanical admixtures. Dust, air pollution, insect infestation, and human or animal disturbance are all potential sources of yield contamination. For forced air drying, new technologies like mechanical driers, tray driers, radial drying bins, continuous flow dryers, cross flow, counter flow, concurrent flow, mixed flow tower and store-based or in store drying like large scale floor storage, bin drying and bag dryers are employed (Boxall et al., 2002). In our country, majority of vegetable seeds are dried while forced air drying is practiced in small scale.

7. Seed treatment

Seed treatment refers to the application of physical, chemical, or biological agents to seeds before planting to protect them from seed borne or soil borne pathogenic organisms, storage insect and environmental stress, or to enhance their germination and growth. Seed treatment helps improve seed quality, ensure better crop establishment, and reduce the need for pesticides and other interventions after planting. It comprises seed disinfection, disinfestation and protection.

8. Packaging

Seed packing is the final stage of seed processing before distribution or storage. After processing and treating are completed, seeds are packaged into containers, bag or other materials of specified net weight. Proper packing is crucial to maintaining seed quality, protecting seeds from environmental factors (like moisture, pests, and temperature fluctuations), and ensuring the seeds remain viable until they are used or sold. The packaging consists of the following operations

- Filling of seed bags to an exact weight.
- Placing leaflets in the seed bags regarding improved cultivation practices.
- Attaching labels, certification tags on the seed bags, and sewing of the bags.
- Storage/shipment of seed bags.

Common packaging materials for vegetable seeds include paper bags, plastics bag (polyethylene or polypropylene), foil packets, laminated pouches, jute or cloth bags, and vacuum sealed bags. Specialized packing technique like vacuum packing, control atmosphere packing and hermetically sealed containers are being utilized in Nepal by private seed companies.

9. Seed storage principles and practices

Seeds, when stored in natural environment or room temperature respond to changes in temperature, relative humidity and oxygen presence. Metabolic activities, age, and longevity of seeds can be manipulating by controlling the humidity temperature and oxygen (Mohammed, 2014). Reduction of seed moisture content up to an appropriate limit is prerequisite for storage as seed could be damaged because of desiccation. Seeds can be stored for a longer period due to lower level of humidity. According to the thumb rule, the life of the seed doubles by decreasing the moisture content to 1% in case if seed moisture content is between 5 and 14%. Higher moisture content is more affected by higher temperature so seeds need to be stored in cool location. The life of the seed doubles by decreasing the temperature to 5°C and is applicable between 0 and 50°C (Harrington, 1972).

The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted. Vegetable seeds can be classified into different categories based on their storage behavior. Three main storage behavior categories have been described: 'recalcitrant' seeds are sensitive to drying; 'intermediate' seeds are tolerant of at least some drying (but less than orthodox seeds), and sensitive to freezing; and 'orthodox' seeds are tolerant of both drying to low moisture content and freezing.

9.1 Seed Storage Methods

Short-Term Storage: Used when seeds will be stored for up to one year. Seeds can be stored in cool, dry places like

cabinets, shelves, or rooms with good ventilation. Paper bags or breathable containers are often used to prevent moisture buildup. These storages are ideal for small-scale farmers or those planning to use seeds for the next planting season.

Medium-Term Storage: Suitable for storing seeds for 1-3 years. Seeds should be stored in a cool, dry environment, such as a refrigerator or a dedicated storage room.

Long-Term Storage: Used for storing seeds for more than 3 years. Requires highly controlled conditions with low temperatures (below 0°C) and low moisture content.

Seed/gene Banks: Seeds stored in seed banks are typically dried to very low moisture content and stored in hermetically sealed containers at extremely low temperatures (-18°C or lower). Vacuum-sealed or inert gas-sealed bags (e.g. nitrogen) are commonly used to reduce oxidation and maintain seed viability.

Post-Harvest Management Practices for Vegetables Seed followed in NARC Stations and DoA Farm

1. Radish

- Seed plants are allowed to mature fully before harvesting.
- Plants are cut when most of the pod turns brown.
- The crop is cut by sickle and brought to threshing and cured for 3-4 days.
- Threshing is done by beating with sticks.
- Seed after sifting is dried to 6-8% moisture content before storage.

2. Okra

- Only healthy fruits are chosen for seeding, malformed and distorted fruits are removed earlier.
- Healthy and straight type fruits are selected from plants free from disease and insect attack.
- Fruits are harvested as soon as they become mature and before shattering.
- Fruits are harvested by hand individually and thereafter fruits are dried in the sun.
- Threshing is also done by hand after the fruits are sufficiently dry.
- Light seeds are then removed by cleaning and winnowing.
- Collected seeds are sun dried to moisture level not exceeding 12% for open storage and up to 9% for sealed packets.
- During rainy day there is every possibility of damaging seeds if fruits are not harvested at proper stage.
- In rainy day if there is no sun, seeds are dried keeping them under electric fan.

3. Brinjal

- Ripened fruits are handpicked and usually seeds are collected from fruits formed at early and mid-fruited stage.
- Good quality fruits are harvested from plants free from disease and insect attack.
- Seeds are collected through wet extraction method.
- Harvested fruits are cut into thin slices and these are then softened by soaking till the seeds are separated from the pulp.
- After extracting and washing, the seeds are cleaned and dried.
- Drying is done by spreading the seeds in the partial sunlight for few hours for one or two days up to a moisture content of 8% or below.

4. Tomato

- Larger size healthy properly ripened fruits are harvested from 1st and 2nd tier fruits for determinate varieties and up to 8th tier for indeterminate varieties and kept in room temperature for 2-3 days before extraction of seeds.
- Tomato seeds are extracted mainly by fermentation method.

- After cutting the tomato fruits seeds along with pulp are fermented for 12 hours.
- The pulp is stirred several times to maintain a uniform rate of fermentation and to avoid discoloration of the seed.
- Seeds are then cleaned with clean water and dried thereafter.

5. Carrot

- The crop is harvested when the secondary umbels are fully ripe and the tertiary umbels begin to turn brown.
- The umbels may ripen unevenly, hence 2-3 pickings may be required.
- Harvested umbels kept for curing and it require 5 to 12 days or even more depending on weather conditions.
- After the umbels are dried completely threshing and cleaning is done manually or mechanically. Then the seed is graded.

6. Cucumber

- Healthy fruits are chosen for seed purpose, malformed and deformed fruits are removed earlier.
- Brown or yellow colored straight type fruits are allowed to ripen fully.
- Fruits are collected from vines when fruit stalk adjacent to the fruit withers.
- After full maturity fruits are harvested and kept 5-7 days for post-harvest maturity.
- Fruits are cut into half and scoop out the seeds by hand.
- Bold size, fully filled and better looking seeds are extracted, cleaned and stored.

7. Spinach

- Spinach seeds mature in sequence even in the same plant and first formed inflorescence seeds mature first.
- When the seed stalks and seeds turn brownish yellow and harvesting is done by cutting.
- Harvested branches are dried in the sun over drying floor.
- Threshing is done by hand beating with a stick after being seed stalks are properly dried.
- Seeds are cleaned by winnowing and dried to 8-9% moisture content.

8. Bottle gourd, sponge gourd, ridge gourd and summer squash

- For seed purpose the earlier set, full size ripe/dried fruits are harvested as such fruits produce plump seeds and higher yield.
- Seed is extracted when fruits are dry and seeds rattle inside the shell.
- The shells have to be broken to extract the seed and clean them.

9. Onion

- Harvesting the seed heads at about 30% moisture (the heads have some opened capsules with black, ripened seed exposed) by hand cutting 10 to 15 cm of the flowering stem below the umbel. When cutting, the umbel is supported in the palm of the hand and held between the fingers to avoid seed shattering.
- Harvesting at 20-30% dehiscent capsules resulted in seed with better quality.
- The seeds are dried enough for threshing when the capsules and small seed stems are brittle and readily break when rolled in the palm of the hand.

10. Chili and sweet pepper

- Red ripe fruits of chili are harvested and dried in the sun. Completely dried fruits are threshed and winnowed. Thereafter, the seed is dried to 8% moisture content.
- The fruits of sweet pepper should be picked when red ripe, cut and crushed. Seed is repeatedly washed to make it free from pulp and skin. After washing it should be dried in the sun.

11. Cauliflower, cabbage and broccoli

- The harvesting is done when the pods turn into brown color.
- After harvesting it is piled up for curing. After 4 to 5 days it is turned upside down and allowed for further curing for 4 to 5 days.

- Then the pods are threshed with sticks and then the seeds are dried to 7 % moisture content, and cleaned.

12. French bean

- The harvesting is done when the pods become completely dry.
- Dried beans are subjected to threshing by beaten with sticks followed by cleaning and dried up to 9% moisture level.

13. Cowpea

- The pods are harvested when it becomes yellowish brown. Then pluck the pods and dried in threshing floor for 1 to 3 days for drying.
- The dried pods are placed on bags and threshed by beaten with stick.
- Carry out the winnowing for removing the chaff and kept in sun drying for 2 to 4 days depending on the weather and maintain the moisture to 9%.

14. Lablab bean

- The pods will turn from green to tan/straw colored.
- The pods are then beaten using pliable sticks to prevent damage to seeds. After thorough beating, the seeds are separated from pods.
- The plant debris are removed and seeds cleaned by winnowing. Cleaned seeds are then dried on tarpaulin on the threshing floor until the moisture content is reduced to 10%.

15. Garden pea

- When almost 90% pods on the plants mature and turn dry, the whole plants are uprooted and collected on the threshing floor.
- After about a week the seeds are separated out from the pods by threshing and winnowing.
- Usually the moisture content of seeds at this time is higher therefore the drying must be resorted to maintain the specified moisture content of 8%.

16. Broad leaf mustard

- Harvesting of plant is done before complete drying of plant when the pod become yellow.
- At 2 days' interval, the heap should be aerated by inverted turning of plant in heap.
- Threshing is done either by manual or beating with stick or mechanical method or by any other means.
- The shattered seed should be collected and winnowing should be done.
- The winnowed seed should be sun dried 3-4 times.
- The moisture percentage should be 6-8 %.

17. Swiss chard

- When the seed stalks and seeds turn brownish yellow and harvesting is done by cutting.
- Harvested branches are dried in the sun over drying floor.
- Threshing is done by hand beating with a stick after being seed stalks are properly dried.
- Seeds are cleaned by winnowing and dried to 8-9% moisture content.

Conclusion

Post-harvest management of vegetable seeds is a crucial element in strengthening the overall seed sector development. Quality maintenance of the seeds is the major problem in the developing countries like Nepal these days. This paper has highlighted the key practices and approaches currently in use, along with the challenges that hinder effective seed management, such as limited access to technology and inadequate storage facilities. The integration of traditional knowledge with modern innovations, such as climate-controlled storage and improved drying techniques, has shown significant potential to improve seed quality and longevity. Governments and stakeholders should focus on capacity-building initiatives, facilitating access to affordable technology, and improving infrastructure to support better seed management. Further research is needed to explore innovative, low-cost solutions tailored to the unique needs of these nations, as well as the long-term socioeconomic benefits of improving seed post-harvest practices.

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Effect of Potassium Levels on Growth, Yield and Quality of Potato (*Solanum tuberosum* L.)

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Abstract

This experiment assessed the influence of potassium (K) levels on the growth, yield and quality of potato with a focus on determining the optimal potassium application rate. The experiment was conducted in a randomized complete block design in JICA, Tsukuba International Center, Ibaraki, Japan, from March 4, 2024, to July 12, 2024, on the Kitakari variety. There were four different levels (0, 75, 150 and 225 kg/ha) of potassium treatment with three replications. The result showed a significant difference in plant height, stem number, marketable yield, dry matter and starch level based on potassium level. The highest marketable yield (4.1 kg/m²) and highest dry matter were observed at 150 kg/ha of potassium. Conversely, potassium levels of 225 kg/ha resulted in larger tubers but decreased overall quality. The study concluded that 150 kg/ha of potassium optimizes potato yield and quality. This finding recommended an application rate of 150 kg/ha for optimal growth and yield in potato cultivation. Further research is suggested to validate these results across various geographical conditions.

Keywords: Dry Matter, Nutrient Management, Potassium, Potato Yield, Tuber Quality

Introduction

Potato (*Solanum tuberosum* L.) is an herbaceous annual plant, belonging to the Solanaceae family and is widely recognized as a staple food and vegetable. Ranking as the third most consumed food globally, following rice and wheat, potatoes are the leading non-grain food commodity. Over one billion people consume potatoes, which are cultivated in more than 100 countries. In 2022, global potato production reached an impressive 375 million tons (FAOSTAT 2022).

Potato is important for food security, as it is a rich source of energy, nutrients, and protein. It is a major crop due to their rich content of starch, vitamins B and C, and minerals. Nutritionally, potato is made up of about 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1% fiber, and 0.9% ash. They also provide essential amino acids like leucine, tryptophan, and isoleucine (Khurana and Naik, 2003).

Potato is one of the major vegetable crops in Nepal, grown from tropical terai areas to high mountain regions. It is consumed as staple food in the high Himalayan region. Currently, the area of potato is 198,256 ha and production is 3,410,829 mt., and it ranks first in productivity, second in production, and fifth in area in comparison to cereal crops cultivated in Nepal. It contributes 6.35% to AGDP (MoALD 2023). However, the incidence of disease and insects, low soil fertility, unavailability of quality seed, and lack of improved technology for potato cultivation results in lower productivity of Nepalese potato compared to global scenario.

Potassium (K) is an essential nutrient for all plants and has a major effect on the yield and quality of potato and the crop's general health and vigor. It is involved in regulating the amount of water in the plant; in the absence of sufficient potassium, crops cannot use water efficiently. Also, adequate K levels in the plant helps to withstand water stress during periods of drought. Potassium also plays a vital role in maintaining the turgidity (rigidity) of plant cells. Because of its importance in turgor maintenance, potassium is essential for obtaining maximum leaf extension and stem elongation.

Another need to ensure an adequate supply of K is that it plays a vital role in the movement of sugars produced in the leaf by photosynthesis, to the tubers, where the sugars are converted to starch. Potassium also contributes to various aspects of tuber quality that are vital for marketing. The balance between nitrogen (N) and K supply is of particular importance for this crop. Insufficiency of potassium makes the plant susceptible to disease and pests, poor marketable quality, weaker stems, lower starch content of the tubers, increasing susceptibility to brushing and mechanical damage, greater susceptibility to adverse effects of drought, and lack of response to nitrogen and

consequently reduces yield and quality of potato (Umar and Moinuddin, 2002).

The nutrient recommendation dose in Nepal for potato crops is 100:100:60 NPK kg/ha along with 20 mt Farmyard Manure (FYM) (Khatri and Shrestha, 1998). Most Nepalese farmers apply Nitrogen and Phosphorus to a greater extent and the application of Potassium is usually ignored (Pervez et al., 2013). Potassium deficiency is majorly seen in acidic soil where there is high rainfall that causes leaching of K (Getachew et al., 2009)

Therefore, there is a pressing need to understand the effect of K application on growth, yield and quality of potato. This study aims to determine appropriate amount of K to bridge existing knowledge gaps and contribute to the advancement of understanding in this critical area.

Objective

The objective of this study is to determine the appropriate amount of potassium required for optimum growth, yield, and quality of potato.

Materials and Methods

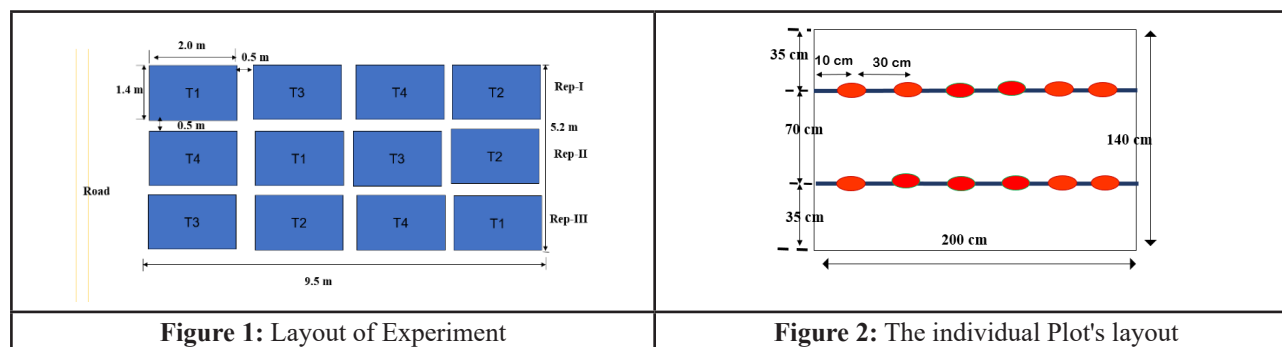
1. Field experimentation

The experiment was conducted at the farm of Tsukuba International Training Center (TBIC), Ibaraki, Japan from 4th March to 12th July 2024. The experimental site is located at the temperate climatic zone of Japan. The experiment was conducted using a Randomized Block Design (RBD) to evaluate the performance of the crop variety *Kitakari* under different treatment conditions. The study comprised one factor with four treatment levels (**Table 1**), each replicated three times, resulting in a total of 12 experimental plots.

Table 1: The fertilizer treatments of the experiment

Treatments no	Nutrient Used (kg/ha)			Compost (t/ha)
	N	P ₂ O ₅	K ₂ O	
T1	120	200	0	20
T2	120	200	75	20
T3	120	200	150	20
T4	120	200	225	20

Each plot measured 2.8m² (2m × 1.4m) (Figure1), and the total experimental area was 49.4m² (13.1m × 3.9m). A uniform number of 12 plants were maintained per plot, summing up to 144 plants in the entire experiment (Figure 2). From each plot, five representative plants were randomly selected for data collection, resulting in a total of 60 sample plants. This design ensured reliable comparisons among treatments by minimizing field variability.



2. Soil analysis

The soil in the experimental site was tested for its P^H, carbon, nitrogen, available P and exchangeable K. The different parameters of soil chemical properties in the experimental site is presented in Table 2.

Table 2: Soil chemical properties of experimental plot

Experiment Field	Soil p ^H (H ₂ O)	Total carbon g/kg	Total nitrogen g/kg	Available P (Bray No.2) mg/kg	Exchangeable K cmolc/kg
TBIC, Annex field	6.6	29.8	2.86	63.0	1.40

Source: JICA Tsukuba field (2024)

3. Seed tuber disinfection and seed tuber preparation

Potato seed tubers were disinfected by dipping in a 200 times dilution of validamycin (300 ml in 60 liters of water) for 10 seconds. The tubers were placed in a ventilated area to sprout. Seeds weighing less than 70 g were cut with a kitchen knife and then dipped in ashes to prevent contamination. The knife was disinfected with sodium hypochlorite after each cut to avoid spreading diseases. The tubers were placed in trays inside a greenhouse, away from direct sunlight, to promote sprouting.

4. Seed tuber selection

The seed tubers were kept in the greenhouse for 20 days at an optimal temperature of 15–20 °C to develop sprouting eyes of 3–5 mm diameter. This sprouting process ensured that the sprouts germinated uniformly and became dark green and robust. To avoid uneven germination, the positions of the potato seeds were upside down weekly during the treatment period. Weak and non-sprouted seeds were discarded, and only strong and healthy seeds were selected for planting.

5. Seed tuber planting

Seed potato were planted in the field at 70 cm row-to-row and 30 cm plant-to-plant distance. The depth of sowing was 10–12 cm from the surface. There were 6 seeds in a row and 2 rows per plot. The details of the field activities are presented in Table 3.

Table 3: Details of field activities

Date	Activities
March 4	Tuber exposed for sprouting
March 19	Field Layout
March 25	Cutting seed tubers used ash
April 11	Basal dose fertilizer application (50 % N and K ₂ O and 100 % P ₂ O ₅).
April 11	Tuber planting
May 11	Top dressing 50 % of N and K ₂ O
May 20	First growth data collection (40 DAP)
June 4	Spray of Jiman daisen (mancozeb) fungicide
June 9	Second-time growth data collection (60 DAP)
June 11	Spray of Jiman daisen (mancozeb) fungicide
June 20	Spray of Kasumin Boardeaux fungicide
July 9	Third-time data collection (90 DAP)
July 12	Harvesting and yield data collection

6. Disease control

Different agrochemicals were applied to treat potato disease in the experimental site. The details of agrochemical applications are presented in Table 4.

Table 4: Agrochemical application

Date	Brand Name	Active ingredient	Target disease
4 th June, 2024	Jiman daisen	Mancozeb	Late blight, Alternaria leaf spot
11 th June, 2024	Jiman daisen	Mancozeb	Late blight, Alternaria leaf spot
22 nd June, 2024	Kasumin Bordex	Copper oxychloride	Late blight

7. Data collection

7.1. Growth parameter

Plant growth of potato plants was measured three times in 60 DAP (Days after Transplant), 80 DAP and 100 DAP. During these times the data regarding the number of stems, plant height, and leaf color (SPAD value) were measured. Plant height was measured using measuring tape and SPAD value was measured using SPAD meter.

27.2 Yield data

After harvesting, tubers were categorized into different grades according to their weight and number. The tuber weighing less than 20 g was considered unmarketable, and more than 20 g were categorized into marketable tubers. The marketable tubers were further categorized into 20-60 g, 71-100 g, and more than 100 g and unmarketable (disease-infected, deformed size and less than 20 g weight).

7.3. Dry matter analysis

Dry matter was analyzed by chopping 200 g tubers into small pieces about 2 X 2 cm cubes and putting them in a hot air oven at 80°C for 72 hrs. After completion of this time dried potato cubes were weighed again and dry matter was calculated using equation 1.

$$\text{Dry Matter (\%)} = (W_i/W_f) \times 100 \text{ ---- (1)}$$

Where, W_i is the initial weight of the fresh sample, and W_f is the final weight of the dried sample.

7.4 Specific gravity (SG) and starch content

The potato gauge method is a practical approach to measuring the specific gravity of potato. The following method was used (Kleinkopf, Westermann, Wille, and Kleinschmidt, 1987). The potato was weighed in the air and reweighed in water using a potato gauge. The specific gravity was determined using equation 3.

$$\text{Specific gravity (SG)} = \text{Weight of potato in air} / (\text{weight of potato in air} - \text{weight of potato in water}) \text{ ---- (3)}$$

The starch content was calculated using equation 2.

$$\text{Starch Contents (\%)} = 214.5 \times (\text{Specific gravity (SG)} - 1.05) + 7.5 \text{ ---- (3)}$$

8. Organoleptic evaluation of potato tubers

An organoleptic test was conducted using a structured approach to assess the sensory attributes of different potato tuber treatments. The test aimed to evaluate the potato based on four key criteria- testiness, sweetness, flakiness, and flavor. In this test, potato tubers were boiled separately for 20 minutes to ensure each treatment was prepared under consistent conditions to avoid any bias in the results. A total of 20 participants were involved in the evaluation. They were asked to evaluate each sample against the given criteria and provide their range (1 to 4) accordingly. Twenty evaluators tasted the boiled potato pieces and rated them on a scale of 1 to 4, where 4 is very good, 3 is good, 2 is medium and 1 is very poor. The total score from all participants was calculated.

Results and Discussion

1. Growth parameters

1.1 Plant height

The result of the plant height measurement is presented in Figure 3. The results revealed that the plant height was not significantly different in 40 DAP (Days after planting) and 60 DAP. However, there was a significant difference at 90 DAP. The highest plant height was observed in 150 kg /ha at 90 DAP. The similar results, the vegetative growth parameters like plant height were gradually and significantly increased by increasing the level of potassium application from up to 285 kg K_2O /ha (Asmaa, R.M. and Magda, M.H., 2010).

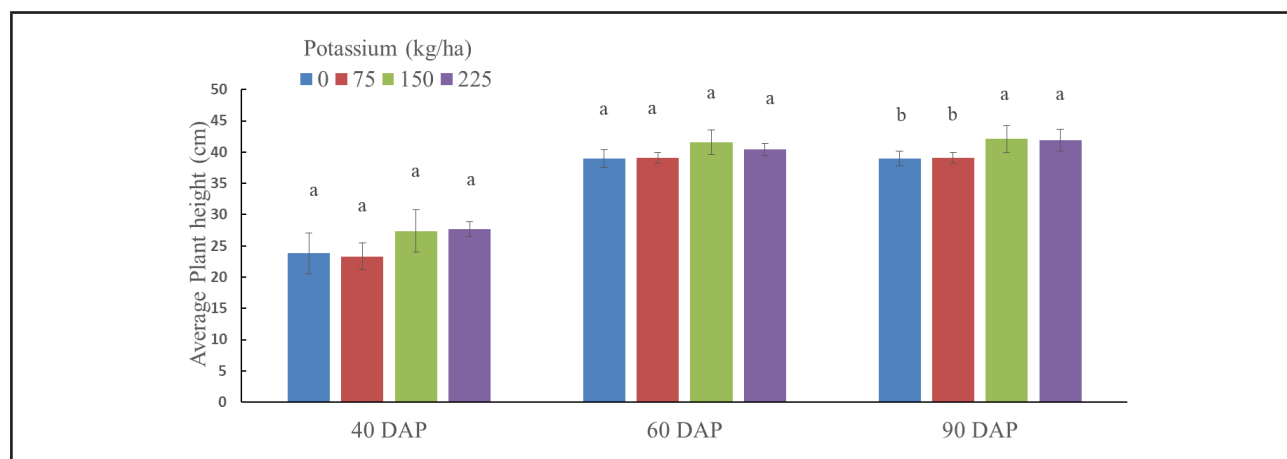


Figure 3: Effect of Potassium on the plant height of potato. The values of the graph are mean and standard deviation. The different alphabet in the figure shows a significant difference at $p = 0.05$ by LSD.

1.2 SPAD reading

The leaf color, as measured by SPAD values, provides an indirect estimation of chlorophyll content and nitrogen status in plants (Uddling et al., 2007). In the present study, SPAD readings at 40, 60, and 90 days after planting (DAP) showed no significant differences among treatments (Table 5). This suggests that the treatments did not substantially affect leaf chlorophyll content during the observed growth stages. Similar findings were reported by Hafez and El-Metwally (2007), who found that different fertilizer regimes had a minimal influence on SPAD values in maize, indicating a possible threshold beyond which additional inputs do not enhance chlorophyll concentration. Moreover, Zhao et al. (2016) argued that SPAD readings tend to stabilize under optimal growth conditions, with limited variation unless plants are exposed to significant nutrient stress or environmental changes. Therefore, the uniformity in SPAD values across treatments in this study may reflect comparable nitrogen availability and photosynthetic efficiency across the experimental plots.

Table 5: Effect of different levels of potassium on the leaf color of potato

K ₂ O (kg/ha)	(Mean ± SE)		
	40 DAP	60 DAP	90 DAP
0	48.0 ± 0.2 a	43.2 ± 1.0 a	35.2 ± 0.8 a
75	46.2 ± 0.2 a	44.1 ± 1.4 a	35.5 ± 0.5 a
150	47.5 ± 0.6 a	43.8 ± 1.0 a	36.3 ± 0.2 a
225	46.2 ± 0.0 a	42.8 ± 1.5 a	36.7 ± 1.2 a
<i>p</i> -value(%)	6.9	87.7	43.0

Note: The different alphabet in the figure shows significant difference by LSD; *p*- value =5%.

1.3 Stem number

The number of stems per plant increased progressively with potassium levels, reaching a maximum (4.8) at 225 kg K₂O/ha and a minimum (3.6) at 0 kg/ha at 90 DAP. This suggests that potassium promotes stem development, likely by enhancing cell division and bud activation. Potassium plays a key role in physiological functions such as enzyme activation and carbohydrate translocation, which support vegetative growth (Marschner, 2012). Consistent with this, Abay and Sheleme (2011) also observed increased stem numbers in potatoes with potassium fertilisation.

Table 6: Effect of different levels of potassium on the stem number of the potato

K ₂ O (kg/ha)	(Mean ± SE)		
	40 DAP	60 DAP	90 DAP
0	3.0 ± 0.3 a	3.3 ± 0.2 b	3.6 ± 0.2 b
75	2.6 ± 0.5 a	3.5 ± 0.3 b	3.6 ± 0.1 b
150	3.4 ± 0.4 a	4.3 ± 0.0 a	4.5 ± 0.1 a
225	4.2 ± 0.1 a	4.6 ± 0.2 a	4.8 ± 0.2 a
<i>p</i> -values (%)	15.6	3.4	0.8

Note: The different alphabet in the Figure shows significant difference by LSD; *p*- value =5%.

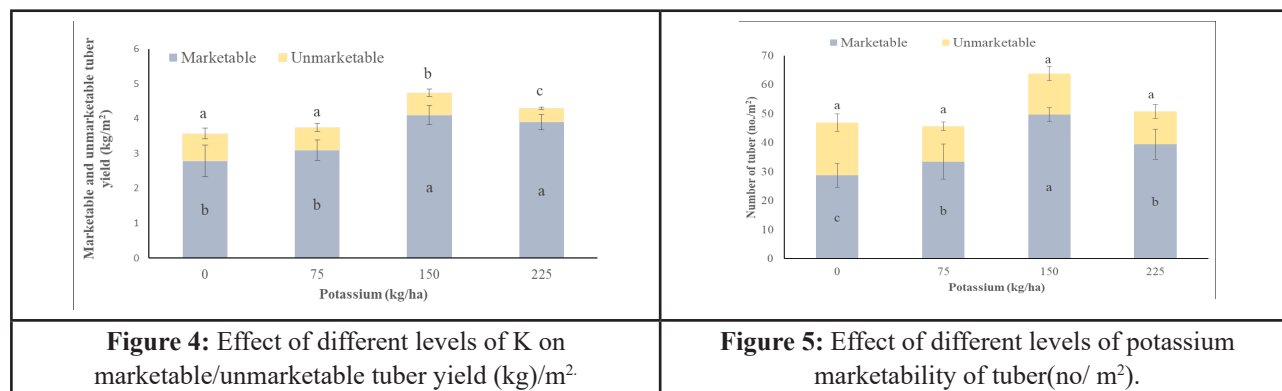
2. Yield data

2.1 Marketable and unmarketable tuber weight/number

Figure 4 revealed that there was significant effect of potassium treatment on the marketable yield. The highest marketable yield (4.1kg/m²) was recorded at 150 kg/ha followed by 225 kg/ha of potassium. The lowest marketable tuber yield (2.7 kg/m²) was recorded in 0 kg/ha of potassium.

The highest unmarketable yield was observed at 0 kg/ha of potassium and the lowest in 225 kg/ha. This might be the role of potassium in the transformation of photosynthate from leaf to tubers (Romheld and Kirkby, 2010).

Figure 5 revealed that there was a significant difference in marketable numbers within treatments. The higher tuber number was observed at 150 kg/ha, and the lowest was at 0 kg/ha of potassium. There was no significant difference in unmarketable tuber number within treatments.



Note: The different alphabet in the Figure shows a significant difference by LSD; p -value = 5%.

2.2 Grade of marketable tuber

Table 7 revealed that the potassium level increases the tuber size. The largest size marketable tuber number and weight were significantly different among different levels of potassium, the highest > 100 g tuber number was found in 150 kg/ha and weight was found in 225 K₂O kg/ha followed by 150 kg/ha.

Table 7: Effect of different levels of potassium on grades of marketable tuber

K ₂ O (kg/ha)	(Mean ± SE)							
	Tuber Number (No./m ²)				Tuber Yield (kg/m ²)			
	Marketable				Marketable			
	20-60 g (S)	61-100 g (M)	>100 g (L)	Total	20-60 g (S)	61-100 g (M)	>100 g (L)	Total
0	6.2 ± 0.8 a	10.0 ± 2.2 a	12.5 ± 2.4 b	28.8 ± 4.1 b	0.3 ± 0.0 a	0.9 ± 0.1 a	1.7 ± 81.3 c	2.8 ± 0.5 b
75	12.8 ± 4.0 a	9.2 ± 2.1 a	11.9 ± 2.1 b	33.5 ± 6.0 a	0.5 ± 0.2 a	0.7 ± 0.2 a	2.0 ± 75.2 c	3.1 ± 0.3 b
150	19.1 ± 2.5 a	9.4 ± 1.6 a	21.3 ± 1.3 a	49.8 ± 2.4 a	0.8 ± 0.1 a	0.8 ± 0.1 a	2.6 ± 63.6 b	4.1 ± 0.3 a
225	11.3 ± 3.3 a	9.7 ± 2.1 a	18.5 ± 1.7 a	39.5 ± 5.2 a	0.5 ± 0.2 a	0.8 ± 0.2 a	2.7 ± 73.6 a	3.9 ± 0.2 a
p -value(%)	5.6	79.7	0.6	4.1	11.9	79.8	2.7	4.6

Note: The different alphabet in the Figure shows a significant difference by LSD; p -value = 5%.

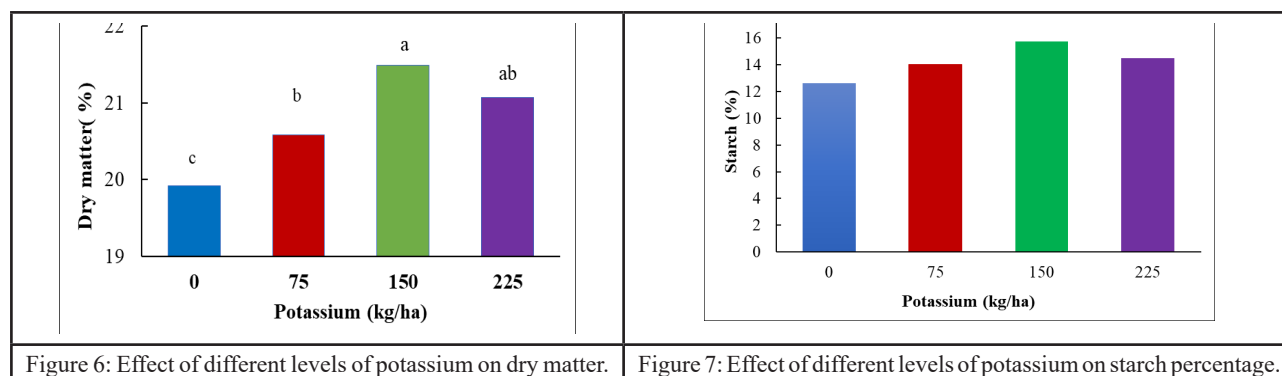
3. Quality data

3.1 Dry matter and starch content

Dry matter refers to the portion of the potato that remains after moisture is removed, comprising structural compounds. It helps to determine the quality of processing. The high dry matter is associated with better texture and yield of processed food.

Figure 6 revealed that there was a significant difference in dry matter between the treatments. The highest dry matter % was observed at 150 kg/ha followed by 225 kg/ha. The lowest dry matter was observed in 0 kg/ha of potassium. The DM contents at a higher rate of K application were also reported by Dicking et al. (1962). This similar result is also observed by Khan, M.Z et al (2010) where the highest DM content was found in K₂O application at 150 kg/ha.

Figure 7 revealed that the highest starch content was found in 150 kg/ha, however the lowest starch content was found in 0 kg/ha of potassium treatment. Potassium sources could be important in promoting photosynthates, increasing the transport of their products to the tubers, and enhancing their conversion into starch, protein, and vitamins (Mengel and Kirkby, 1987). This finding is also similar to the specific gravity of potato tubers increased with an increase in K application up to 150 kg/ha and decreased at the higher rate of 225 kg/ha (Khan M.Z et al., 2010).



Note: The different alphabet in the Figure shows a significant difference by LSD; p -value = 5%.

4. Organoleptic test

4.1 Testiness test and sweetness test

On the organoleptic test of potato, the 75 kg/ha potassium treatment got the highest score 59 out of 80 followed by 150 kg/ha treatments. The 225 kg/ha treatment had got the lowest score 40 out of 80 (Figure 8). Whereas, on the sweetness test of potato, the 75 kg/ha potassium treatment had got highest score 60 out of 80 followed by 150 kg/ha treatments. The 0 kg/ha and 225 kg/ha treatments had got the lowest score 48 out of 80 (Figure 9).

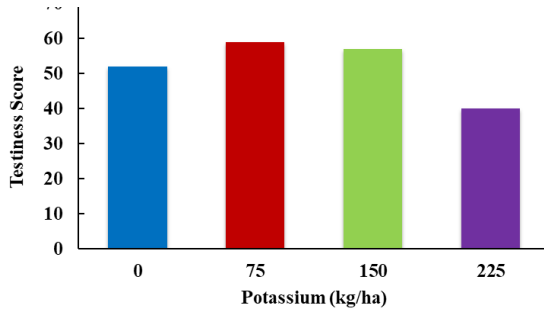


Figure 8: Effect of different levels of potassium on testiness test

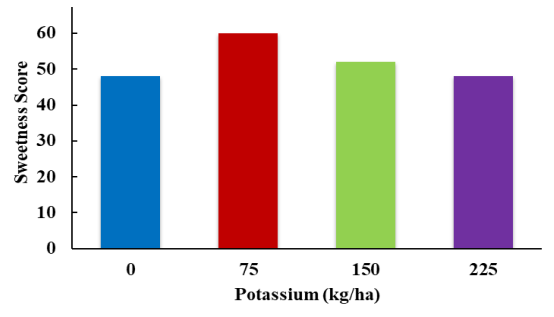


Figure 9: Effect of different levels of potassium on sweetness test

4.2 Flakiness and flavor test

On the flakiness test of potato, the 150 kg/ha potassium treatment had got highest score 66 out of 80 followed by 225 kg/ha treatments. The 0 kg/ha treatment had the lowest score of 40 out of 80. Whereas the flavor test of potato showed that the 150 kg/ha potassium treatment had got highest score 58 out of 80 followed by 0 kg/ha treatments. The 225 kg/ha treatment had the lowest score of 52 out of 80.

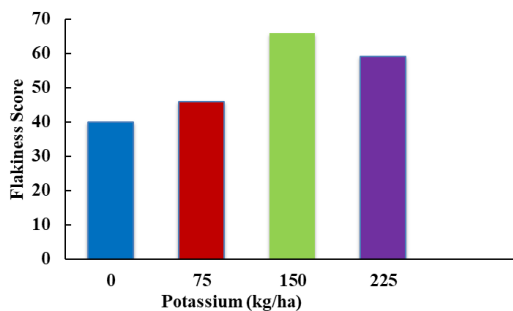


Figure 10: Effect of different levels of potassium on flakiness test

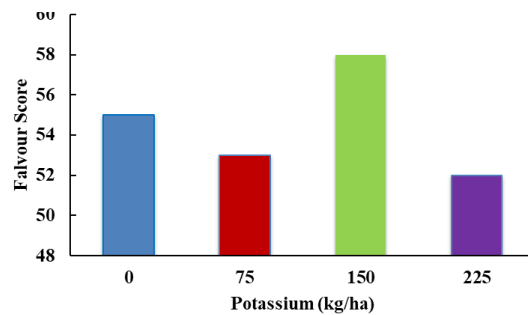


Figure 11: Effect of different levels of potassium on flavor test

Conclusion and Recommendation

This study concluded that the application of potassium has a significant and positive effect on the growth and yield of potato. For optimal growth and yield, 150 kg/ha of potassium appears to be the most effective, providing a balance of high marketable yield, dry matter, starch content, flakiness, and flavor. However, 225 kg/ha of potassium also enhances certain aspects such as large tuber yield and reduces unmarketable tuber yield.

It is recommended that farmers can use 150 kg/ha potassium for the best yield, dry matter and starch content. Both deficiency and excessive application can adversely affect the potato crop's dry matter and starch accumulation. Experiments should be conducted in different geographical conditions to find out the consistency of the results.

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Annex





Figure 15: Cow dung manure application in potato field



Figure 16: Covering the potato seed after sowing



Figure 17: Top dressing



Figure 18: Growth data recording



Figure 19: Agrochemical spraying



Figure 20: Plant height measurement



Figure 21: Disease inspection by the supervisor



Figure 22: Potato field



Figure 23: Potato yield



Figure 24: Harvested potato observation



Figure 25: Grades of potato



Figure 26: Cutting of potato for dry matter analysis



Figure 27: Dried potato after drying in hot oven



Figure 28: Measuring the specific gravity by potato gauge.



Figure 29: Organoleptic test

Potential Vegetable Crops for Hybrid Seed Production and its Strategies in Nepal

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Abstract

Nepal's horticulture sector holds significant potential for growth, yet remains heavily reliant on imported hybrid vegetable seeds. This strategic paper evaluates the prospects and challenges of developing a robust domestic hybrid seed industry, with a focus on six key vegetable crops: tomato, hot and sweet pepper, brinjal, cucumber, brassicas, and cucurbits. These crops were selected based on technical feasibility, agro-ecological adaptability, seed market demand, and potential for import substitution.

The study combines a desk review, key informant interviews, and expert consultations with seed companies and researchers. Findings revealed both the strengths such as growing market demand, successful pilot programs, and youth engagement potential and critical barriers including limited RandD capacity, inadequate infrastructure, lack of skilled breeders, and regulatory challenges.

- To address these issues, the paper presents a three-tiered strategy roadmap:
- Short-term (0-2 years): Simplify seed licensing and variety registration, pilot production of feasible hybrids, and strengthen basic infrastructure and extension services.
- Mid-term (2-5 years): Establish a hybrid seed production unit (HSPU), integrate advanced breeding technologies (e.g. cytoplasmic male sterility, marker assisted selection, double haploid), and strengthen public-private collaborations among research, extension and academia.
- Long-term (>5 years): Position Nepal as a regional hub for custom hybrid seed production, claim GI tags for native varieties, and build mega seed enterprises with strong IPR protection.

The study concluded that a coordinated national effort anchored in science, policy, and market intelligence is vital for transforming Nepal's vegetable seed sector. By investing in innovation and building institutional capacity, Nepal can achieve seed sovereignty, reduce import dependency, and become a competitive player in the regional seed market.

Keywords: Diverse geography, Hybrid seed, Phenotypic selection, Strategy road map

Introduction

Agriculture is the backbone of Nepal's economy, supporting around 60% of the population (Yogi et al., 2025). Vegetable production is crucial for food security and nutrition, and with rising urbanization and changing dietary preferences, the demand for high-quality vegetables is increasing. Nepal's diverse geography and climate provide excellent opportunities for vegetable crop research and hybrid seed production (Devkota and Mishra 2020). mean comparison, correlations, and biodiversity indices were used for data analysis. On the basis of biodiversity index, evenness, the adequate number of species, and Sorenson's coefficient, open-pollinated (OP). The country's different agroecological zones support numerous vegetable species, making it ideal for developing hybrid varieties that can improve crop yields, enhance disease resistance, and provide farmers with greater income stability (Reddy et al., 2011).

Vegetables can generate 3 to 5 times more income than cereal crops, enabling farmers to buy at least three times more food than if they grow traditional cereals (Pandey, 2013). The importance of high-quality seeds is crucial, as they are the foundation of successful vegetable cultivation, impacting yield, disease resistance, and overall crop performance (Tiwari et al., 2023). Hybrid seeds, known for their superior traits such as increased productivity and enhanced resilience, are particularly beneficial. The current market for hybrid seeds in Nepal is expanding, driven

by both local demand and advancements in cultivation practices (Keller 2024, Chakrabarty et al., 2023). In such background, vegetable research initiatives should focus on developing hybrid varieties for key crops of Solanaceae, Brassicaceae, and Cucurbitaceae families.

The characteristics of Nepalese fresh vegetable production play a crucial role in shaping the size and demand of the vegetable seed market. Despite the sector's considerable potential, it faces multiple interconnected challenges that hinder its growth and sustainability. One of the primary issues is the limited awareness and access to quality seeds among farmers, many of whom continue to rely on traditional varieties with lower yield potential and resistance to pests and diseases. This contributes to a significant yield gap and restricts productivity (Joshi, 2017a). Inadequate infrastructure further compounds the problem; poor transportation networks, lack of secure market linkages, and insufficient storage facilities make it difficult for farmers to sell their produce efficiently, often resulting in post-harvest losses (Yogi et al., 2025). Price volatility due to seasonal supply fluctuations and market demand, combined with unhealthy competition among traders and the dominance of middlemen, reduces farmers' profitability and makes the adoption of high-quality seeds less affordable for smallholders (Poudyal et al., 2023). Additionally, production and transaction costs remain high due to limited mechanization, fragmented landholdings, and poor road access. Labor shortages, driven by the migration of youth away from agriculture, have also led to an expansion of fallow lands, while increasing human-wildlife conflict continues to damage crops and dissuade farming activity (Rai et al., 2019). Overlaying all of these issues is the growing threat of climate change, with unpredictable weather patterns and extreme climatic events posing significant risks to both the stability and productivity of vegetable farming (Sapkota et al., 2023, Ghimire et al., 2023). Together, these factors create a complex environment that challenges last-mile seed delivery and limits the overall development of the vegetable seed market in Nepal. In countries with strong seed systems, the private sector significantly contributes to national agricultural gross domestic product. Nepal should follow the example of neighboring South Asian countries, for instance India, that have successfully adopted modern hybrid breeding technologies by inviting joint ventures and implementing robust plant variety protection (PVP) laws (Gauchan, 2016). Currently, the size of the Nepalese seed enterprise is estimated at around \$45 million, with about 20 seed companies and over 70 foundation seed producers (SQCC, 2025).

Hybrid seeds are produced by crossbreeding two different parent lines to develop new variety with desirable traits. Over 20,000 hybrid varieties are available to farmers globally, with seed companies investing 15–25% of their turnover in RandD (Keller, 2024). This investment fosters innovation to incorporate essential traits such as higher yield potential, improved disease and pest resistance, and better adaptability to diverse environmental conditions. Countries like Vietnam, China, and India have made significant progress in their seed sectors by adopting modern hybrid breeding technologies supported by robust plant variety protection (PVP) laws and investment-friendly policies. However, the adoption of hybrid seed technologies in Nepal faces various challenges. This paper aims to discuss these opportunities and challenges, identify potential vegetable crops, explore innovative production techniques, and propose strategic recommendations for hybrid seed production.

Methodology

1. Study site and data collection

The study tried to cover Nepalese seed sub-sector across the country. Special focus given to areas producing hybrid seeds of tomato and cucumber like Chandragiri, Kathmandu; Pawati, Dolakha and Khatigaunda, Dailekh. Seed companies based in Kathmandu were consulted, particularly scientists looking after RandD activities of private sector seed companies (PSCs), e.g. SEAN SEED CO. LTD., Gorkha Seed Co. Pvt. Ltd., and Karma Seed Co. Pvt. Ltd., were consulted. The study used a rapid, mixed-methods approach, combining both qualitative and quantitative tools for data collection.

2. Desk review

The initial phase involved a desk review of relevant secondary data, reports, and publications. This included information on status of seed import, hybrid seed production, the agro-ecological suitability, climatic requirements, and market trends for hybrid seed production of vegetables. Sources included PowerPoint presentations, government reports, newspapers, peer-reviewed journal articles, policy documents, manuals, and official information from Ministry of Agriculture and Livestock Development of Nepal.

3. Key informant interviews (KIIs)

Field data collection consisted of KIIs with farmers from the Dolakha, Dailekh, Kathmandu and with scientists from the PSCs. Total 6 KIIs were conducted, providing an in-depth understanding of seed companies aim and their current activities and plans on hybrid seed production of vegetables.

4. Analytical approach

The study team comprised experts from both the public and private sectors, representing research, quality control, extension, and academia. Each member independently collected data relevant to their area of expertise. The selection of potential vegetable crops for hybrid seed production was primarily guided by seed import-export data maintained by the Seed Quality Control Center, alongside the technical feasibility of hybridization within the Nepalese context. Insights from scientists at seed companies and farmers regarding hybrid seed production technologies and potential market demand were gathered through personal consultations. Additionally, the authors have incorporated their insights and experiences during the data analysis where relevant. Based on information collected through desk reviews and key informant interviews (KIIs), a SWOT analysis highlighting the strengths, weaknesses, opportunities, and threats was conducted for the selected vegetable crops using established criteria (Section 2.5).

5. Selection criteria of vegetable crop for hybrid seed production

The selection of vegetable crops for hybrid seed production was guided by a set of strategic and technical criteria aimed at ensuring both viability and long-term sustainability. Market demand was a key consideration, assessed through formal seed import data to determine economic potential and commercial interest. Germplasm access was also critical, focusing on the ease of acquiring or developing genetic resources, with particular attention to the challenges faced by the private sector in accessing proprietary germplasm. The technical feasibility of hybridization, including the capacity to maintain generation-wise seed supply, was evaluated to ensure practical implementation. Adaptability of crops to Nepal's diverse agro-climatic zones was prioritized to maximize agro-ecological suitability and success rates. In addition, emphasis was placed on import substitution and identifying opportunity crops that could not only reduce dependency on foreign seeds but also create local income and employment. Finally, the potential for custom seed production was explored to address specific market needs and preferences.

Current Scenario of Hybrid Seed Research and Production

1. Status of vegetable production

Nepal's diverse geography and climatic conditions allow for the cultivation of a wide range of vegetables, from root crops to leafy greens. In FY 2022/023, the total area under vegetable cultivation was 302,135 hectares, with a production of 4,370,77 metric tons, an increase of 4% and 5.4%, respectively, compared to the previous year (MoALD, 2024). Agriculture, forestry and fishing contributed 24.1% to the gross domestic product in FY 2022/023, where vegetables contributed 13.4 % to the agricultural GDP, with significant contributions to rural incomes and local diets (MoALD, 2024).

Key vegetable crops registered in Nepal consist of over 277 varieties from more than 41 different species (SQCC 2024), all recommended for cultivation by the National Seed Board (Table 1).

Table 1: Number of vegetable crop varieties notified by the Nepal government till 2024

S. N.	Vegetables	Registered	Released	Total notified varieties	Hybrids
1	Cauliflower	24	4	28	24
2	Tomato	18	6	24	20
3	Cabbage	23	1	24	23
4	Cucumber	23	1	24	22
5	Hot pepper	15	1	16	15
6	Radish	10	4	14	6
7	Squash	11	1	12	10
8	Bitter gourd	10	1	11	10
9	Sweet pepper	2	1	3	1
10	Brinjal	5	1	6	4
11	Broccoli	7		7	7
12	Others	108	28	76	32
	Total	277	170	224	53
Among 277 varieties	National hybrid varieties	3	2	5	
	Imported hybrid varieties	170	-	170	

Extension services are offered by 753 local government units and 77 provincial agricultural knowledge centers or development offices. Nepal's top vegetable-producing regions include the Terai plains, known for their fertile soils and favorable climate, as well as hilly areas where farmers grow a diverse range of crops, including vegetables. Due to the scarcity of locally bred hybrid vegetable varieties, extension service centers often recommend seeds of imported crop varieties for commercial use.

2. Research activities

The National Horticulture Research Centre, in collaboration with different research centers and their stations under the Nepal Agricultural Research Council (NARC), is spearheading variety development activities in the country. To date, a total of 277 varieties across 41 vegetable crops have been developed. Of these, 53 varieties have been released and 224 registered in Nepal (Table 1). A significant majority of the registered varieties (89%) are exotic, with only 11% developed locally. In contrast, among the released varieties, 95% are locally developed in Nepal (SQCC 2024).

The Seed Act 2045 and Seed Rules 2081 of Nepal mandate both public and private sectors to participate in crop research and variety development. Notably, no hybrid varieties from the private sector have been released or registered in the country to date. Among the domestic varieties, only five are hybrids (two released and three registered), while out of the 224 registered exotic varieties, 75.9% are hybrids. NARC has developed several hybrids: Srijana (registered in 2010), Khumal Tomato Hybrid-2 and Khumal Tomato Hybrid-3 (both released in 2021) for tomatoes, as well as Madhu and Krishna (both registered in 2022) for cucumbers. The National Seed Vision 2013-2025 (NSV) aimed to develop 30 hybrid varieties of vegetable crops (20 from public and 10 from private research institutes), but current progress has fallen short of this target (SQCC, 2013).

In Nepal, variety improvement traditionally relies on phenotypic selection of parent plants and their offspring, resulting in a slow process that does not meet the demands of modern commercial agriculture. Agro-morphological characterization dominates crop research and a variety improvement activity. Additionally, this phenotypic selection can be unreliable, as phenotypes can be changed due to age, environmental influences, and agro-ecological conditions. Moreover, phenotypic traits often arise from the interaction of multiple genes, resulting in complex inheritance patterns that may not be immediately apparent (Miko 2008).

Nepalese vegetable breeders are not getting the advantage of modern 'omics' approaches (Joshi and Ayer 2020). Genotyping approaches like quantitative trait loci mapping, association mapping, markers assisted selection and genomic selection, which are crucial for trait discovery, inbred development and parent selection. Optimization of hybridization protocols, use of cytoplasmic male sterility (CMS) and thermosensitive genic male sterile (TGMS) lines is necessary for potential vegetable crops to accelerate the hybridization process which is currently limited around manual emasculation and pollination (Simko et al. 2021). National agriculture research systems lag in participatory plant breeding and variety selection activities in the case of vegetables. Involvement of farmers in the variety development process right from the beginning of trait and parent selection is important. At later stage, seed increase of promising pre-released vegetable varieties facilitates large-scale participatory variety selection in target environments. However, increasing the F1 seed production for a portfolio of pipeline varieties requires more time, dedicated manpower, and guaranteed financial resources (De Jonge et al., 2021).

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In Nepal, investment in research and development remains relatively low. The Nepal government allocates approximately 1% of its budget to research activities, reflecting limited prioritization of innovation and long-term productivity gains within the sector (Dhakal 2024, TKP 2024). In contrast, the private sector's contribution to research is even more modest, with allocations estimated to be less than 1%, often described as merely traceable. This disparity highlights a critical gap in sustained research investment needed to drive advancements in technologies, including agricultural research and development, crop diversification, and climate-resilient practices. Strengthening public-private partnerships and increasing funding for research are essential steps toward achieving sustainable agricultural growth (Sokona et al. 2013).

3. Hybrid seed research and production activities in Nepal

Hybridization in Nepal was first initiated in 1964 with potato by Gopal R. Rajbhandari, a scientist at the NARC.

Later, in 1999, formal crop breeding program at Agriculture Botany Division began in rice. Beyond NARC, involvement from academia and the private sector in hybridization and hybrid seed research and production began only much later (Joshi 2017b). Universities in Nepal have initiated basic research activities focused on testing hybrid varieties of vegetable that are better suited to local climatic conditions and market demands. Current curricular activities often emphasize the theoretical knowledge of the use of basic breeding techniques at the undergraduate level and advanced breeding techniques, including molecular markers and genomic selection at postgraduate and doctorate levels. However, hybrid-focused practical activities on research and variety development are still lacking in almost all universities. The academic landscape is still static, positioning the universities merely as a tuition center for hybrid seed production techniques. Advanced field-testing facilities, climate chambers, greenhouses, and laboratories equipped with modern molecular facilities at Nepalese agricultural universities are still a distant reality. Private sector seed companies share the same situation as universities in Nepal. Recently seven seed companies were permitted for hybrid seed production of crops and vegetables (SQCC, 2025).

4. Status of seed import

With the increasing demand for organic and high-quality produce in both domestic and international markets, the potential for vegetable exports has also grown. In Nepal, the total area under vegetable cultivation was 302,135 hectares, producing 4,376,077 metric tons of fresh vegetables (MoALD 2024). Based on this acreage, the estimated annual requirement for vegetable seeds is around 2,500 metric tons. Hybrid seeds contribute to over 80% of total fresh vegetable production, while the remaining share is met by non-hybrid, open-pollinated varieties. A significant number of seeds are being imported to Nepal to fulfill the demand for high-quality seeds. Table 2 summarizes the status of hybrid seed imports in FY 2022/23 (SQCC 2025).

In the fiscal year 2022/2023, the total value of formally imported hybrid seeds amounted to 5,022 thousand USD (Table 2). Of this total, cauliflower accounted for 27.1%, followed by cabbage with a 10.2% share. Radish contributed 9.1%, bitter melon 9%, and tomato 8.6% to the overall import value. During the same FY, Nepal has formally imported 569.93 MT of vegetable seeds of value 6,795 thousand USD where hybrid seed contributed by 12% to the quantity and 74% to the value (SQCC 2025).

Table 2: Status of seed import/export in the FY 2022/23

S.N.	Vegetables	Seed quantity, kg	Hybrid seed import, value in USD	Percent share in total value
1	Cauliflower	5,385.90	1,359,766.66	27.1%
2	Tomato	717.50	430,733.00	8.6%
3	Cabbage	3,148.85	513,476.50	10.2%
4	Cucumber	2,025.00	366,220.41	7.3%
5	Hot pepper	723.20	179,167.78	3.6%
6	Radish	23,800.00	452,725.00	9.0%
7	Squash	1,076.00	96,382.00	1.9%
8	Bitter melon	3,956.00	457,462.62	9.1%
9	Sweet pepper	110.00	32,312.78	0.6%
10	Brinjal	110.00	14,421.05	0.3%
11	Broccoli	353.00	121,822.00	2.4%
12	Other vegetables	28,863.00	997,580.19	19.9%
	Total	70,268.45	5,022,069.99	

5. Private sector in hybrid seed production

The private sector's involvement in hybrid seed crop research and development in Nepal is limited. Despite global success in hybrid seed production, the private sector in Nepal has made limited contributions to crop research and hybrid seed development, focusing primarily on the trade and distribution of imported hybrid seeds. The National Seed Vision (NSV) aimed to develop 10 vegetable hybrids from the private sector but did not outline a clear strategy to achieve this goal (SQCC, 2013).

Four seed companies have been granted licenses for hybrid seed production in Nepal, with five others awaiting approval from the National Seed Board (NSB). Additionally, three companies have received licenses for research for development (RandD) activities, but their scope remains minimal. Initial optimism around these licenses has not

resulted in significant progress due to constraints such as limited human resources, insufficient RandD investment, and lack of infrastructure.

Private companies also face challenges in accessing public germplasms and modern facilities, including laboratories and field trials, which are vital for effective research. At the International Seed Conference 2024 in Kathmandu, some private seed companies entered Memorandums of Understanding (MoU) with foreign counterparts to collaborate on custom seed production and joint research for developing new vegetable hybrids. However, the success of these collaborations might be challenging due to the Nepalese private sector's weak market intelligence and networking capabilities, hindering their ability to leverage international partnerships, access advanced technology, and respond to global market demands effectively. Sanitary and phytosanitary requirements in the exchange of seeds and planting materials can pose a significant hurdle to custom seed production in Nepal. Globally, practices such as Pest Risk Assessment (PRA) and the issuance of phytosanitary certificates supported by advanced laboratory facilities are standard in international seed trade. However, in Nepal, limited institutional capacity, poor infrastructure, and insufficient technical expertise will hinder timely compliance with these international standards. This may result in slow growth of Nepalese seed sub-sector.

6. Promising Vegetable Crops for Hybrid Seed Production

This study has selected few most promising vegetable crops for hybrid seed production. This is done based on the selection criteria mentioned in the methodology of the study. Starting with a selected number of successful varieties will be advantageous, as it enables the gaining of experience and promotes adoption among farmers. Once the seed production for these initial crops is established, other crops can be explored for hybrid development.

6.1. Tomato

The consumption of tomatoes has risen significantly, both in local markets and for export purposes. The cross-border Indian market, along with some global demand for fresh and processed tomato products, presents valuable opportunities for Nepalese farmers. Strong seed demand in the local market is evident from the import statistics (Table 2).

Hybrid tomato seed production has become a success story in Nepal, demonstrating both technical feasibility and economic viability. For over a decade, many farmers have been producing seeds of the hybrid tomato variety Srijana F1. In addition, several seed companies have developed and marketed their hybrid tomato varieties. For example, SEAN SEED CO. LTD. has introduced Chandragiri and Malika F1, while Gorkha Seed Co. Pvt. Ltd. markets Samjhana, Tirsana, and Jharana hybrids. However, all varieties developed by PSCs have to be registered with the National Seed Board. Hybridization technology is accessible and particularly suited for young farmers. Recently, custom seed production for tomatoes has been successfully tested in Dolakha and Lamjung districts of Nepal. This approach offers a dual benefit: farmers can earn income while gaining valuable experience. Additionally, it provides opportunities to enhance capacity in virus screening and phytosanitary measures.

6.2. Hot and Sweet pepper

Urbanization has led to an increased demand for fresh vegetables, including hot and sweet (bell) peppers. The trend towards healthy eating continues to drive their popularity. Seed demand for both crops is notable in the Nepalese seed market (Table 2).

Hybrids can provide improved fruit size, color, and taste while enhancing resistance to pests like aphids and thrips, thereby reducing losses. Hybridization techniques for sweet pepper are similar to those used in tomato, making them easier to learn and well-suited for youth engagement. In fact, custom seed production of sweet pepper has already begun in Nepal, particularly in Thankot, Kathmandu.

6.3. Brinjal

The data (Table 2) showed that there is good demand for brinjal seed in the domestic market. Hybridization techniques are easier like tomatoes and peppers. Custom seed production of wild brinjal is tested in Nepal targeting export to Japan, however it is still in the piloting phase. This needs to be expanded in the future.

6.4. Cucumber

Cucumber demand peaks during the summer months, and its popularity continues to rise in urban areas. The total annual sales value of cucumber seeds (Table 2) highlights the crop's market potential. Hybrid cucumber varieties, known for their faster growth, higher yields, and uniform fruit size, are particularly appealing to both consumers and retailers.

The NARC has already developed two hybrid cucumber varieties: Madhu and Krishna, which are ready for

commercial seed production. Additionally, the hybridization technique is well established, making it easily transferable to young farmers for widespread adoption.

6.5. Brassicas

Seeds of brassicas (e.g. cauliflower, cabbage, radish, broccoli, etc.) are being supplied in Nepal via import and share quite large amount of import values. This indicates huge market potential. Suitable hybridization techniques need to be researched and applied for the production of hybrid seeds in the country and substitute the imports.

6.6. Cucurbits

Like brassicas, hybrid seed of cucurbits (e.g., bitter gourds, pumpkins, gourds, etc.) possess good market demand and scientists working on them are required to start breeding programs.

7. SWOT analysis of six selected vegetables for hybrid seed production

A strength, weaknesses, opportunities, and threats (SWOT) analysis was conducted for hybrid seed production of vegetable crops discussed in section 3.6. The SWOT associated with hybrid seed production of vegetable crops tomato, hot and sweet pepper, brinjal, cucumber, brassicas and cucurbits are tabulated in Table 3.

Table 3: Strengths, weaknesses, opportunities and threats assessed for hybrid seed production of vegetables from the Solanaceae, cucurbitaceae, and Brassicaceae families

Strengths		Weaknesses	
Proven success in hybrid seed production (e.g. Srijana, Madhu)	Growing vegetable demand due to urbanization and health trends	Domestically developed hybrids need to be registered with National Seed Board	Shortage of skilled labor and limited extension services
Technically feasible and economically viable venture	Hybrids improve fruit quality and pest resistance	Limited skilled breeders and molecular lab facilities	Weaker law enforcement and field monitoring
Accessible hybridization techniques, suitable for youth	High demand for custom seed production	Increasing infestation of insect pests and diseases	Custom seed production is still in pilot stage
Seed companies have developed own hybrids (e.g. tomatoes)	High yield and uniformity in hybrids	Illegal inflow of sub-standard seeds from outside	Lack of dedicated breeding programs
Wide range of crops within Brassicaceae and Cucurbitaceae family		Limited market information and extension support	
Opportunities		Threats	
Strong local demand and potential for export	Opportunities for import substitution	Climate change and pest/disease pressure	Cross-pollination risks and lack of zoning
Custom seed production tested in Dolakha and Lamjung	Easy to transfer hybridization skills to youth	Policy and regulatory uncertainty	Unpredictable climate may affect yield and quality
Scope for youth employment and skill-building	Potential to scale up for export (e.g., to Japan)	Risk of seed purity loss due to poor isolation	Uncertainty in success of piloting phase and seed export
Potential to produce and distribute local hybrids	Could engage local producers in niche export markets	Sanitary and phytosanitary measures and issuance of phytosanitary certificate compliance to international standard	Low investment in infrastructure and technical support in academia, publica and private research institutions
Learning opportunities for agricultural graduates		Tough price competition in the local seed market	

Hybrid Seed Production Techniques

Hybrid seed production involves complex breeding techniques and technological innovations that require specialized expertise and careful field management (Chakrabarty et al. 2023) harnessing the advantage of heterosis between two

diverse genotypes to achieve maximum hybrid vigour, is widely recognized and commercially used for crop variety improvement both in field and vegetable crops. Hybrids can be developed using appropriate technology, irrespective of the mating and pollination system in the plant species. Production of hybrid seed depends on plant, pollinator and environmental factors, which influence it individually or in interactive ways. Hence, an understanding of these components is important to undertake hybrid seed production of a given crop species. The basic requirements for hybrid seed production at a commercial scale are (a. These three components, breeding techniques, technological innovations, and field management, play a critical role in ensuring the success of hybrid seed production and marketing programs. Their use and importance are briefly discussed in the following subsections, with reference to Nepalese context.

1. Breeding techniques

1.1. Inbred line development

Inbreeding is used to develop stable inbred lines which are then used in hybrid production. This is a common method to expand the gene pool. This involves self-pollination and repeated self-pollination over several generations to stabilize the desired traits in line to ensure genetic purity and stability. This will be followed by line selection. Line selection identifies and selects lines with consistent performance and desirable traits for hybridization.

1.2. Controlled pollination

Controlled pollination is essential in hybrid seed production. It involves deliberately cross-pollinating two distinct parent plants to combine desirable traits from both. The primary steps include:

- Selection of parent lines: Choosing two genetically distinct parent lines that exhibit desirable characteristics.
- Isolation: Preventing unwanted pollen from contaminating the flowers of the selected plants, often using physical barriers or spatial separation.
- Pollination: Transferring pollen from the male parent to the female parent, either manually or through controlled mechanical means.
- Seed harvesting: Collecting seeds from the fertilized flowers, which will carry the hybrid genetic material.

1.3. Hybridization

Hybridization is the process of crossing two different varieties or species to produce hybrids with specific traits:

- Interspecific hybridization: Crossing between different species within the same genus (e.g., different tomato species).
- Intraspecific hybridization: Crossing between different varieties within the same species (e.g., different varieties of tomatoes).

1.4. Selection methods

- Phenotypic selection: Based on morpho-physio and agronomical responses, a commonly used method in Nepal, time-consuming and costly.
- Marker-assisted selection (MAS): Using molecular markers linked to desirable traits to select parent plants for crossing. MAS accelerates the breeding process by identifying beneficial traits at the DNA level.
- Genomic selection: Utilizing high-throughput genomic data to predict the performance of hybrids based on the genetic makeup of the parents.

1.5. Field testing and evaluation

Performance metrics such as yield per hectare, disease resistance, climate resilience, nutritional content, seed production economy, and market competitiveness should be assessed. Comparisons are made between new and market-leading hybrid varieties to determine the advantages and limitations of each. Distinctness, uniformity and stability (DUS) testing and characterizations (genotyping and phenotyping) of each variety are imperative. Once hybrids are developed, they undergo rigorous field testing:

- Performance trials: Testing hybrids in various environmental conditions to evaluate their performance, including yield, disease resistance, and adaptation.
- Selection and optimization: Selecting the best-performing hybrids and optimizing production practices based on trial results.

Each technique is essential for developing hybrids that combine beneficial traits from different parent plants,

leading to enhanced crop varieties with improved performance and resilience. It's important to ensure meaningful participation from farmers, traders, and extension workers at every stage, fostering a participatory approach that promotes shared ownership of the newly developed products.

2. Technological innovations

Adopting modern technologies can significantly enhance hybrid seed production in Nepal by improving breeding efficiency, accuracy, and speed. Although still in very early stages of adoption in Nepal, methods such as genome-wide association studies (GWAS) and CMS are some potential tools to identify desirable traits and streamline hybrid development. Advanced genomic tools like MAS, double haploid (DH) technique, and gene editing can reduce the time and cost associated with conventional breeding by enabling early selection of superior genotypes. Furthermore, breeders can use information shared over digital sequence information (DSI) platform to access genomic data and shorten the breeding cycle.

2.1. GWAS: A GWAS is a method used to identify associated genomes of interest. When genome sequences are mapped to individual genes, GWAS can help preliminarily identify candidate genes that control these traits based on both genotypic and phenotypic data (Samineni et al. 2022).

2.2. CMS: CMS is a method used to produce hybrids by preventing the production of functional pollen in one parent. Hybrids are produced from crossing CMS lines with donor lines (producer of viable pollen).

2.3. Resequencing and decoding: Resequencing involves periodic gene sequencing to uncover potential genetic variants or polymorphisms within individuals and across groups.

2.4. Genomic-assisted breeding/Marker-assisted selection and gene editing: The use of genomic tools in plant breeding, known as genomics-assisted breeding, has evolved significantly over the past few decades. Nowadays Single Nucleotide Polymorphisms (SNPs), Diversity Arrays Technology (DArTs), Genotyping-by-Sequencing (GBS), and Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and CRISPR-associated protein 9 (CRISPR-Cas9) are being used to select genotypes with desirable traits early in the breeding process, reducing the time and cost of field trials while improving selection accuracy (Kumar et al. 2023, Li et al. 2022, Zafar et al. 2020) which poses serious threat to food security. Both heat and drought stress affects the production and productivity of wheat crop. The present study was undertaken to evaluate 34 landraces and elite cultivars of *Triticum* spp. for phenological and yield-related traits under optimum, heat, and combined heat–drought stress environments during 2020–2021 and 2021–2022. The pooled analysis of variance showed significant genotype $\times$ environment interaction, suggesting an influence of stress on trait expression. The trait performance of genotypes exhibited significant reduction under combined heat–drought stress as compared to optimum and heat stress environments. The maximum seed yield penalty was observed under combined heat–drought stress environment as compared to heat stress alone. Regression analysis indicated significant contribution of number of grains per spike towards stress tolerance. Based on Stress Tolerance Index (STI).

2.5. Haplotype-assisted breeding: It is a form of genomic assisted breeding (GAB), accelerates the breeding process and helps address issues related to linkage drag, enabling a more efficient selection of desirable traits (Sivabharathi et al. 2024). A haplotype refers to a specific combination of alleles at multiple loci that are inherited together (He et al. 2023). This method assists in targeting specific genetic markers associated with desirable traits, hence enhancing the likelihood of achieving favorable outcomes and reducing the resources and time needed to develop new varieties (Bailey-Serres et al. 2019).

2.6. Use of double haploid technique: This technique involves producing homozygous lines from haploid cells, which contain only one set of chromosomes. By inducing these haploids to double their chromosome number, researchers can create double haploids that are completely homozygous. This is particularly advantageous in plant breeding, as it allows for the immediate fixation of desirable traits in a uniform genetic background, reducing the number of generations typically required to achieve homozygosity through traditional breeding methods (Karkee et al. 2022, Dwivedi 2015). One common application of the double haploid technique is in the development of hybrid crops where breeders can quickly assess traits of interest (Karkee et al. 2022).

2.7. DSI: DSI refers to the nucleic acid sequence data obtained from genetic resources. It serves as a valuable research tool rather than a final product, aiding in securing patents and proprietary rights for innovations. Most DSI is freely accessible online, facilitating the exchange of information among academic researchers in studying hard-to-measure attributes during crop improvement and breeding. The ultimate aim is to produce innovative plant genetic resources in the form of seeds and other planting materials for farmers. DSI offers significant time and cost savings for plant breeders, as it streamlines the process of developing new crop varieties.

3. Field management practices

Effective input management is a crucial strategy for advancing vegetable crop research and hybrid seed production. Field management plays crucial roles while optimizing breeding techniques, using technological innovation and mobilizing various inputs. Upon efficient management of research plots and seed bulking zones, researchers and producers can enhance crop yields, improve seed quality, and streamline operations. Interconnected discussion at key inputs involved in this field is explained in subsequent subsections.

3.1. Infrastructure

Controlled environment greenhouses offer optimal conditions for stock seed maintenance, plant growth, and hybridization. Conditional storage ensures seed quality for a longer time. These facilities use advanced climate control systems to regulate temperature, humidity, and light, ensuring ideal growing conditions and storage year-round. Molecular laboratories equipped with cutting-edge technology enable detailed genetic analysis and gene editing facilities.

3.2. Irrigation

Efficient irrigation systems are vital for maintaining optimal soil moisture levels. Advanced techniques like drip irrigation and precision irrigation technologies ensure that water is delivered directly to plant roots, reducing waste and improving crop performance.

3.3. Soil health and fertilizer

Good soil health always keeps plants growing well and ensures higher production. The application of fertilizers must be managed carefully to provide the right nutrients at the right time. Precision agriculture tools help in tailoring fertilizer applications based on soil nutrient levels, thereby enhancing crop growth and minimizing environmental impact. The use of organic fertilizers and getting the produced hybrid seed certified organically will help in value addition. Organic fertilizers help increase soil organic matter, which can enhance carbon sequestration. This contributes to mitigating climate change by storing carbon in the soil.

3.4. Pest control

Integrated pest management (IPM) strategies combine biological, cultural, and physical methods to control pests while reducing reliance on harmful pesticides. Regular monitoring and the use of pest-resistant vegetable crop varieties also play a crucial role.

3.5. Skilled labor

Expertise in various aspects of vegetable crop research and hybrid seed production is essential. Skilled labor is needed for tasks such as plant breeding, gene editing, DH line development, disease diagnosis, data analysis, and precise handling of experimental procedures.

3.6. Mechanization

Modern mechanization, including planting machines, harvesters, processing equipment, seed coating, and pelleting facilities, increases efficiency and reduces labor costs. Automated systems also help in precise and consistent operations.

3.7. Software for data recording

Data management software is indispensable for recording and analyzing research data. It helps track crop performance, monitor experimental results, and make informed decisions based on comprehensive data analysis.

Challenges and Opportunities

Strengths, weaknesses, opportunities, and threats in the hybrid seed production of targeted crop varieties have been tabulated under the section 3.7 above. Here, overall challenges and opportunities were assessed and presented under this section for further clarity and recommendation.

1. Challenges

1.1. Technical know-how

There is a shortage of skilled labor and technical expertise including scientific manpower in hybrid seed production in Nepal. Almost all seed companies are running a shortage of full-time breeders in their RandD activities. Many farmers lack access to training and resources, limiting their ability to adopt new technologies. Research institutions are using traditional breeding methods instead of advanced genetic techniques, limiting the potential for yield improvements. There is a lack of agricultural extension workers to provide farmers with the necessary training and

support in hybrid seed production and promotion. Nepal's seed sub-sector lacks a modern molecular seed laboratory to profile DNA, screen viruses, and provide efficient phytosanitary services to the seed companies.

1.2. Economic barriers

The high initial investment required for hybrid seed production can deter small-sized seed companies and research institutions. Hybrid seed production demands high input costs from the very beginning of the activities. Access to credit and financial resources is often limited, making it difficult for them to invest in quality seeds and inputs. The poor economic status is well reflected in very low investment in infrastructure, transportation, processing, and storage facilities.

1.3. Quality assurance

Inadequate human resources and knowledge deficiency are well reflected in seed quality assurance. Seed quality control agencies also lack sufficient resources to keep the whole seed value chain on the right track. Inefficient seed certification systems can allow substandard seeds to enter the market, affecting overall crop performance. There exists a high risk of seed contamination at production fields and threshing floors. Inadequate measures to control cross-pollination can result in the mixing of hybrid and non-hybrid seeds, compromising purity. A lack of coherent policies supporting hybrid seed production can create uncertainty for investors. Lacking policies in seed zoning, germplasm acquisition, and foreign investment is another hindrance to hybrid seed production and long-term agricultural practices.

1.4. Environmental factors

Most of the seed production activities are dispersed in many small pockets, posing challenges in maintaining isolation. Proper zoning for seed production is lacking. Climate change poses significant risks to hybrid seed production in Nepal. Unpredictable weather patterns, such as erratic rainfall and increased temperatures, can adversely affect seed yields and stability. High pressure of pests and diseases exists in the seed production plots. A lack of integrated pest management practices can lead to significant crop losses due to pests and diseases.

1.5. Socio-economic factors

This also plays roles in the seed production environment. Most of the youth from households are not in farming. Lack of market information about market trends and the demand for specific hybrid varieties, impacting their production choices. Many farmers may prefer traditional varieties, leading to resistance against adopting new hybrids, even when they are potentially more productive. Women are often involved in seed production but face additional challenges in accessing resources and training. Traditional agricultural practices and beliefs may hinder the acceptance and adoption of hybrid seeds.

2. Opportunities

2.1. Emerging markets

The increasing demand for fresh, organic, and high-quality vegetables, both domestically and internationally, provides a significant opportunity for Nepalese farmers to capitalize on the hybrid seed market. Export of fresh and dried vegetables to Arabian countries and abroad has already been initiated. There are also higher possibilities to substitute the seed import from local breeding programs. Similarly, Nepal can be a custom seed production hub for international seed companies, for example, Japan. Testing for custom seed production of tomatoes has already been initiated.

2.2. Government support

The Nepal government has recognized the importance of agricultural innovation and has implemented policies to promote hybrid seed production. Newly formulated seed regulation (insert name/reference here) has opened the avenue for custom seed production and simplified the variety registration procedures of vegetables. Moreover, the Nepalese seed system is becoming digitalized where seed demand and supply can be placed, and breeders can apply for their variety registration (insert reference). There is a provision for hybrid seed production and RandD licenses for capable seed companies who are willing to invest in the sector. Nepal government has accepted the involvement of plant breeders and seed technologists from the public sector in the private firms as part-time service providers.

2.3. Scope for collaboration

Collaboration in the seed sub-sector is now a widely discussed concept and drawing multi-sectoral interests. Strengthening partnerships between the Department of Agriculture, Nepal Agricultural Research Council, Tribhuvan University, NGOs, and private sector players can enhance knowledge sharing and resource allocation, leading to more effective hybrid seed production initiatives. NARC and PSCs can jointly or individually develop new

varieties that DoA and Universities can use in their extension and teaching programs. Universities can utilize the opportunities to focus on market-led seed production curricula, where fresh graduates can be encouraged to start-ups with seed entrepreneurship. Expertise from academia and research institutes have scope for collaboration in hybrid seed production.

2.4. International funding and expertise

Engaging with international agricultural organizations can bring in technical expertise and funding to support research and development in hybrid seed production. Nepal seed sub-sector can collaborate to invite funds for hybrid seed production and technology transfer. Germplasm accessions and capacity-building programs with support from international line agencies seem possible.

Strategies

1. Short-term strategies

Some strategies are recommended as short-term strategies (0 – 2 years) anticipating their quick output in the field of hybrid seed production.

1.1. Policy and institutional reforms

- Simplify licensing and registration processes for hybrid seed producers. There are experienced farmers who do not have license for hybrid seed production. Seed act and rules demands long list of documents to fulfil the licensing requirement. Similarly, variety registration of locally bred hybrids should avoid registration processes and should allow to sale in market as research variety at commercial scale.
- Prioritize hybrid seed production in national agricultural policies. Government agencies should put local varieties in the list of subsidized seed mini-kits and household nutritional program.
- Provide tax breaks, soft loans, and revolving funds to private seed companies those actively engaged in variety development and hybrid seed production in the country.

1.2. Pilot hybrid seed production

- Begin with technically feasible crops like brinjal, sweet pepper, and brinjal for testing hybrid seed production in the specified location.
- Scale up the seed production of already tested crop varieties like tomato and cucumber at commercial scale.
- Implement contract seed production with buy-back guarantees.

1.3. Capacity building and extension

- Conduct hands-on training for agricultural students, farmers and technicians on hybrid seed production, pest management, soil revitalization techniques, socio-economic importance of seed business.
- Launch awareness campaigns and field demonstrations at model government and private sector farms showcasing performances, comparative tolerances to surroundings, and yield and quality potentials of hybrid varieties.

1.4. Infrastructure and lab development

- Establish a molecular lab for RT-PCR testing, genotyping, and quality assurance of produced seed before distribution.
- Improve basic infrastructure required for field trials, post-harvest handling of seeds and value addition, for instance, irrigation, net/poly houses, threshing floors, and compost pits.

2. Mid-term strategies

Some strategies are recommended as mid-term strategies (2 – 5 years) anticipating their impact for long run in the field of hybrid seed production.

2.1. Institutional strengthening

- Establish a hybrid seed production unit (HSPU) under Seed Quality Control Centre (SQCC) with representation from NARC, universities, and PSCs. Such a unit should aim at looking after hybrid seed production and monitoring activities, and facilitating the genetic resources management for the national hybrid seed production programs. The HSPU should maintain data related to hybrid seed production, import, export and marketing and provide support to PSCs for data analysis and interpretation. The team may also conduct training sessions for researchers and practitioners on hybrid seed production, data analysis, modern tools and techniques in the field of plant breeding.

- Set up demo farms or convert existing seed production farms of Nepal government as hybrid seed production learning centers in close collaboration with local governments.

2.2. RandD and technology adoption

- Initiate use of GWAS, CMS, MAS, and double haploid techniques at laboratories that were established under short-term strategy. Allocate sufficient human resources and lab equipment for the full functioning of molecular labs.
- Promote public-private breeding partnerships and incentivize breeders through bonuses and royalties.

2.3. Policy formulation for foreign investment and intellectual property rights (IPR)

- Introduce provisions for tax incentives and financial leverages to encourage investment in hybrid seed production.
- Formulate and implement a policy framework that attracts foreign direct investment (FDI) in Nepal's hybrid seed industry.
- Develop and enforce a Plant Breeders' and Farmers' Rights (PB and FR) Act to effectively manage intellectual property rights (IPR) in the seed sector.

2.4. Hybrid seed production expansion

- Extend hybrid seed production to moderately complex but highly market potential crops like cauliflower, cabbage, and gourds.
- Position Nepal as a custom hybrid seed production hub for international seed companies by facilitating phytosanitary and pest surveillance services by Nepal government.

2.5. Market development

- Promote locally bred hybrid varieties through public campaigns and integrate into government procurement/subsidy programs.
- Conduct market study and survey, understand the dynamics of seed market and create market for Nepal-produced hybrid seeds through advertising and championing.
- Encourage cooperatives to take up contract production linked to seed markets.
- Provide financial support or subsidy to PSCs for organizing market promotional visits like rewards, farmer's tours, traders' visits, etc.

2.6. Education and curriculum

- Integrate hybrid seed production into university and school curricula.
- Provide assistantships and scholarships for graduates to do research on hybrid seed production and value addition technologies.
- Establish non-degree seed entrepreneurship programs in seed production areas.
- Link theories of seed production and marketing with seed entrepreneurship via motivational classes, demos and visits to the national seed companies.

3. Long-term strategies

Some strategies are recommended as long-term strategies (>5 years) anticipating flourishing the Nepalese seed industry via advancement in hybrid seed production and marketing.

3.1. Advanced RandD and innovation

- Fully integrate genotype–phenotype mapping and use of DH technique, CMS, MAS, DSI in plant breeding programs.
- Develop species-specific reference genomes for key vegetable crops.
- Claim and secure geographical indication (GI) tag for developed vegetable varieties, existing landraces for their unique trade values, facilitating the 'trade of traits'.
- Extend hybrid seed production to complex crops like radish, onion, cowpea, carrot, soybean, etc.

3.2. Infrastructure and enterprise development

- Support the formation of mega seed companies to drive hybrid innovation and export.

- Invest in long-term infrastructure for seed processing, storage, and logistics.

3.3. Policy evolution and evaluation

- Regularly monitor and adjust/optimize hybrid seed policies based on field impact.
- Strengthen plant variety protection laws and IPR for breeder innovations.
- Optimize and execute the tax, FDI, and subsidy policies in favor of agricultural industry.

Conclusion

Hybrid seed production of vegetable crops holds immense potential to transform Nepal's vegetable seed sub-sector by enhancing productivity, improving seed sovereignty, and opening pathways for commercial horticulture and seed export opportunities. This strategic review identifies key vegetable crops such as tomato, pepper, cucumber, and brinjal as immediate candidates for hybrid seed development due to their technical feasibility, market demand, and past production success. Despite these opportunities, Nepal's hybrid seed industry remains in its infancy, hindered by limited investment in RandD, inadequate infrastructure, weak policy enforcement, and low private-sector innovation. However, the convergence of growing domestic demand, evolving seed policies, and international interest in custom seed production presents a critical window for intervention. To harness these prospects, Nepal must adopt a multi-tiered approach in seed sub-sector: investing in modern breeding technologies (e.g., CMS, MAS, DH), enabling public-private-academic partnerships, and fostering youth involvement through entrepreneurship and education. Establishing a strong institutional backbone such as a national hybrid seed coordination unit and molecular seed labs will be crucial. Ultimately, achieving seed security through hybridization requires more than technical solutions; it demands political will, collaborative leadership, and long-term strategic commitment. If aligned effectively, Nepal can reduce dependency on seed imports, empower farmers, and position itself as a regional hub for hybrid vegetable seed innovation.

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तरकारी बीउ उत्पादन तथा व्यवस्थापन (Vegetable Seed Production and Maintenance)

काली प्रसाद पाण्डे र केशव पाण्डे

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सारांश

नेपाल कृषि प्रधान देश हो र अधिकांश नेपालीहरूको जिविकोपार्जनको पहिलो आधार कृषि पेशा हो । यसैले कृषि उत्पादन मार्फत व्यक्तिको जीवनस्तर वृद्धि गर्दै समग्र देशको आर्थिक अवस्था सुदृढ बनाउन कृषिको पहिलो अंग नै बीउ हो । त्यसमा पनि तरकारी बीउ पोषण र खाद्य सुरक्षामा महत्वपूर्ण भूमिका खेल्ने भएकोले गुणस्तरयुक्त जातिय शुद्धता कायम गरी नेपाली हावापानी सहने तरकारी बीउ उत्पादन र बजारिकरण गर्ने उद्देश्यले यस लाईफ सिड्स उद्योग स्थापना भएको हो । यस उद्योगले नेपालमा विकास भएका तरकारीका जातहरूको बीउ उत्पादन र बजारिकरण गर्दै आएको छ ।

परिचय

बीउ अन्य सामान्य कृषि उपज जस्तो वस्तु होईन । यसको उत्पादन र बजारीकरण ज्यादै संवेदनशिल हुन्छ । गुणस्तर कायम नभएमा बीउले उत्पादन प्रणालीमा पूर्ण असर गर्दछ । माग अनुरूप बीउ उत्पादन हुनु पर्दछ । आवश्यकता भन्दा बढी उत्पादन भएमा बीउ वजारीकरण हुन सक्दैन । त्यसैले ठाउँ र क्षेत्र अनुसार कुन स्थानमा कुन-कुन जातको बीउ उत्पादन गर्ने र बितरण गर्ने भन्ने बिषय महत्वपूर्ण हुन्छ । त्यसैले मागमा आधारित उत्पादन गर्नुपर्ने हुन्छ । तसर्थ बीउको भौतिक र जातीय शुद्धता कायम राखी नेपालमा लोप हुन लागेका चलन चल्तीका जातहरू बढि उत्पादन दिने र किसानले मन पराएका जातहरूलाई रैथाने वालीको रुपमा संरक्षण गर्नेगरी नेपाल सरकारका निकाय, ईजाजत प्राप्त सहकारी र निजी फार्महरूबाट मूल बीउ प्राप्त गरी उत्पादन अगाडी बढाउँदै उत्पादीत बीउहरूको प्रशोधन, प्याकेजिङ र संरक्षण गर्नेगरी सहकारी मार्फत कृषकहरूद्वारा उत्पादन सुरु गरिएको हो र सोही बीउहरू संरक्षण र प्रवर्धन गर्नेगरी यस उद्योग स्थापना गरिएको हो । यसरी उत्पादन गरिने बीउ स्वच्छ, गुणस्तरीय हुने कुरामा यो लाईफ सीड्स उद्योग प्रतिवद्ध छ ।

लाईफ सीड्स उद्योगका उद्देश्यहरू

- स्थानीय जातहरूको संरक्षण गर्ने ।
- उत्पादन पहिचान गरी प्रविधिहरू कृषकहरू माझ विस्तार गर्ने ।
- सहकारी मार्फत बीउ उत्पादन गराइ कृषकको आयस्तर वृद्धि गराउने ।
- कृषकहरूलाई आवश्यक कृषि तालिम प्रदान गरि बीउ उत्पादनमा प्रोत्साहन गर्ने ।
- बीउ प्रशोधन, ग्रेडिङ, लेबलिङ गरि बजारीकरण गर्ने ।
- स्थानीय तहसँग समन्वय गरि कृषकहरूको सहभागितामा काम गर्ने ।
- नेपाल सरकारका कृषिसँग सम्बन्धित निकायबाट दिईएको निर्देशन र नियम अनुसार मुल बीउ उत्पादन व्यवस्थापन गर्ने ।
- आयातित बीउको परिक्षण गर्ने-गराउने र स्वदेशी बीउ उत्पादनमा जोड दिने ।
- वर्णशंकर बीउ उत्पादन प्रविधि कृषकहरू माझ लगी गुणस्तरीय हाईब्रिड बीउहरू उत्पादन गराउँदै बजारीकरण गर्ने ।
- आयतलाई कम गर्नेगरी नेपाली बीउको जातीय विकास र उन्नत बनाउन नेपाल सरकार, बीउविजन गुणस्तर नियन्त्रण केन्द्र आदिसँग समन्वय गरि काम गर्ने गरेको ।
- राष्ट्रीय तथा अन्तराष्ट्रिय बीउ कम्पनीहरूसँग सहकार्य गरि बीउ उत्पादन तथा बजारीकरण गर्ने ।
- बजारको माग र आवश्यकता पहिचान गर्ने ।
- लोपोन्मुख स्थानीय जातका बीउहरू संरक्षण गरि आयातित बीउहरूको परिक्षण, सम्बर्द्धन र प्रवर्द्धन गर्न सहजिकरण गर्ने ।
- सहकारिसँग बीउको दररेट सम्झौता गर्ने ।

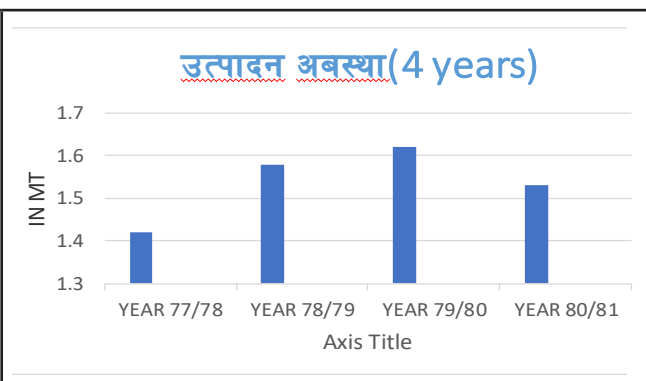
यस उद्योगमा आवद्ध बीउ उत्पादक सहकारी संस्थाहरू

- फूलवारी तरकारी बीउ उत्पादक स.सं.लि., तेमाल-१, काभ्रे
- पञ्चकन्या तरकारी बीउ उत्पादक स.सं.लि., तेमाल-१, काभ्रे
- शुभ प्रभात तरकारी बीउ उत्पादक स.सं.लि., नमोबुद्ध-५, काभ्रे
- जोरसल्ला तरकारी बीउ उत्पादक स.सं.लि., नमोबुद्ध-४, काभ्रे
- पञ्चमूखी तरकारी बीउ उत्पादक स.सं.लि., रोसी-२, काभ्रे
- ठाकुरदेवी तरकारी बीउ उत्पादक स.सं.लि., रोसी-६, काभ्रे
- समशितोष्ण उन्नत तरकारी बीउ उ.सं., रुकुम
- साँखबेसी उन्नत तरकारी बीउ उ.सं., रुकुम
- रुकुमेली उन्नत तरकारी बीउ उ.सं., रुकुम

४. यस उद्योगको मुख्य मुख्य उत्पादित बीउहरू

पालुङ्गो-पाटने	केराउ-सिक्किमे
चम्सुर-ठिमी-१	बकुल्ला-स्थानीय
सिमि-चौमासे	लौका-स्थानीय
सिमि-त्रिशुली	घिरौला-कान्तिपुरे
सिमि-भाँगे	चिचिन्डा-स्थानीय
गोलभेडा-बि.एल.	प्याज-रेड क्रियल
गोलभेडा-सृजना हाईब्रिड	रायो-मार्फा चौडापात
काक्रो-भक्तपुर स्थानीय	रायो-खुमल चौडापात
करेला-लामो सेतो	मूला-मिनोअर्ली
खुर्सानी-अकबरे	मूला-प्यूठाने रातो
काउली-खुमल ज्यापू	मूला-४० दिने
काउली-काठमाण्डौ स्थानीय	मूला-अल सिजन
सिमि-राजमा	बकुल्ला-स्थानीय
सिमि-भि.एस.पि	लौका-स्थानीय
फर्सी-लोकल	सलगम-पर्पल टप, काठमाण्डौ रातो; गान्ते लगायत अन्य बालीहरू

५. लाईफ सिड्स उद्योगको बिगत ४ वर्षको बीउ उत्पादन अवस्था



६. मूल बीउ व्यवस्थापन

नेपाल सरकारको मातहतमा रहेका बागबानी केन्द्र तथा नेपाल कृषि अनुसन्धान परिषदका फार्म केन्द्रहरू

ईजाजत प्राप्त बीउ उत्पादक कम्पनी

तरकारी बीउ उत्पादक सहकारी संस्थाहरू

बलम. सहकाय

बीउ बिजन गुणस्तर नियन्त्रण केन्द्र
नेपाल कृषि अनुसन्धान परिषद
प्रदेश बीउ बिजन गुणस्तर नियन्त्रण केन्द्र
नेपाल सरकारका कृषि कार्यालयहरू
स्थानिय तह
सहकारी तथा बीउ उत्पादक कृषकहरू

८. बजारिकरण

नेपालका बिभिन्न बीउ बिजन कम्पनि, एगोभेट, सघं सस्था, स्थानिय सरकार, लगायतका र विशेषगरी खुद्रा ब्यापारिहरूलाई २ ग्राम देखि ५० किलोग्राम सम्मका प्याकमा बीउहरू प्रसोधन, प्याकेजिङ गरि बजारीकरण गरिरहेको ।



९. लक्ष्य

- वार्षिक १५५ मे. टन बीउ उत्पादन गरि प्रशोधन र प्याकेजिङ गरि बजारीकरण गर्ने
- बीउ बैंक र बीउ ल्याव स्थापना गर्ने ।
- बीउ उत्पादन गराउदै आयातलाई कम गराउन पहल गर्ने ।
- उन्नत तथा हाईब्रिड बीउ नेपालमै उत्पादन गरि अन्तराष्ट्रिय बजार सम्म पुर्‍याउन पहल गर्ने ।
- एक प्रसोधनशाला निर्माण गर्ने ।
- देशभरको कृषि तथ्याङ्कलाई वास्तविक तथ्याङ्क बनाउन सहजीकरण गर्ने ।
- विदेशीने युवाहरूलाई बीउ उत्पादनमा प्रेरित गरी उत्पादन बढाउन पहल गर्ने ।
- सम्पूर्ण कृषकलाई गुणस्तरीय सेवा प्रदान गर्ने ।
- निरन्तर नेपाल सरकार अन्तर्गतका कृषि विकास कार्यालय तथा कृषि विभागको निर्देशनमा काम गर्ने ।



१०. समस्याहरू

- जनशक्ति अभाव
- बीउ उत्पादन कार्यलाई उत्पादनशील जमिन अभाव
- गुणस्तरयुक्त मूलविउ अभाव
- समयमा किसानले कृषि सामाग्री नपाउनु
- उत्पादन एकिन नहुँदा बजारमा उतारचढाव भई बजारीकरणमा समस्या
- उच्च प्रतिस्पर्धाका कारण उत्पादनपछि बजारीकरणमा असहजता

- मूल्यमा एकरूपता नहुनु र अस्थिरता कायम हुनु
- उत्पादन पश्चात् बिचौलिया हावी हुनु
- सरकारी निकाय तथा गुणस्तर नियन्त्रण केन्द्रको सहयोग समयमा प्राप्त नहुनु
- बीउबिजन नियमावली कार्यान्वयनमा समस्या

११. समस्या समाधानका लागि गरिएका पहलहरू

- केही बालीको मूल बीउलाई सहकारी क्षेत्रमै छनोट गरी सुधार गरीएको
- बजारको मागमा आधारित बीउहरू मात्र उत्पादन गर्ने गरिएको
- माग अनुसारका उच्च गुणस्तरका बीउ प्याकेजिङ गरि बजारीकरण गरिएको
- अनुगमन निरीक्षण सम्बन्धित निकायबाट बेलाबेलामा गराइएको
- गुणस्तरयुक्त धेरै बीउहरू उत्पादन गर्ने कृषक सहकारी लाई पुरस्कार व्यवस्था गरी उत्पादनमा सहजीकरण गरिएको
- बीउ उत्पादक कृषकहरूलाई बेलाबेलामा उत्पादन क्षेत्र अन्य ठाउँहरूमा भ्रमण गोष्ठी आदिमा समावेश गराइएको
- उत्पादक संस्थाको नीति र कार्यविधिमा रही उत्पादन र बजारीकरण गर्ने गरेको
- नेपालमा उत्पादन गर्न सकिने केही बालीको ९०% सम्म सम्म तरकारीका बीउहरूको मागलाई पूरा गर्ने गरी जिल्ला तहमा उन्नत जातका तरकारी को बीउहरू समग्रमा ३८% मागलाई सहकारी र कृषकहरू बीचको एक साभेदार उत्पादक मार्फत यस उद्योग प्रशोधन र प्याकेजिङ गरी बजारीकरण मा पूर्णता दिने कार्य गरिरहेको छ ।

बीउ उत्पादनका केहि भलकहरू



Cardamom Sapling Production

TCP/NEP/FAO Nepal

Brief of the TCP Project

Cardamom sapling production program is under the Technical Cooperation Program (TCP) which was created to enable FAO to make its know-how and technical expertise available to member countries upon request. FAO Nepal is promoting Large Cardamom Value Chain in Nepal under One Country One Priority Product (OCOP) Framework. The expected starting date of this project was 01 November, 2022 and the end date was 31 October 2024. The total budget for this project was USD 350000.

Implementation Progress of TCP

- National Project Coordinator, focal point, focal implementing agency designated/ identified
- Project Steering Committee Formed
- Project implementation support unit at field identified, communicated
- SPS and other Expert recruited.
- Scoping mission conducted – Field visit, consultation with major stakeholders in the Koshi Province- to identify gaps, the potential district for the implementation and major actions
- TOT manual for GAP and training.

FAO in collaboration with MoALD

- 4 nurseries in Farmers field has been established
- 4 GAP farmers field school conducted
- 1 training of GAP ToT conducted and 2 training in the schedule.
- Tissue culture lab equipment provided.
- Market research has done and found couple of international market in Gulf.

Cardamom Sapling Production Through Tcp

- 4 primary nurseries from seed in Ilam and Panchthar had been established:
 - 3 primary nurseries in Ilam district (1 in Rong Rural Municipality, 1 in Cardamom Development Center, Fikkal and 1 in Nayabajar Ilam)
 - 1 primary nursery in Panchthar district (Ranitar)
- Each primary nursery covers 1 ropani and is estimated to produce 5000 in first year.
- In second year these 5000 cardamom sapling will produce 25000-50000 cardamom sapling, Ceteris Paribus.
- Sapling produce from secondary nursery will distribute to nearby farmers.

Tcp Had Supported Some Tissue Culture Lab Equipment

- Zoom stereo microscope with camera
- Glass bead steriliser
- Plant growth chamber
- Lux meter
- Multi-channel micro-poppet
- BOD incubator
- Centrifuge
- Air curtain
- Laboratory trolley

- Glassware drainage rack
- Laboratory tray
- Media storage rack
- Shoes rack

List of chemicals supported by FAO Nepal

Chemicals	Quantity
Copper Sulphate ($\text{CaSO}_4 \cdot 5\text{H}_2\text{O}$), 100 gm	5
Ammonium Nitrate 1 kg	10
Potassium Iodide, 100 gm	5
EDTA disodium salt, 100 gm	5
Nicotinic Acid, 100 gm	5
Thaimine HCl, 25 gm	5
Pyridoxine HCl, 25 gm	5
Murishige and skoogs media with vitamins and sucrose without agar, 500 g or 1 kg (BOT)	5 bot
Micropipette tips, pack of 1000 pieces	4 packs
Boat shaped plastic 75 ml capacity size (L*W*H) (115*30*20)	10 pcs
2 ml Polypropylene Deep Well Plate 96 well plate	One packet
Test tube (dimension 12*75), 5 ml volume, pack of 100 pcs	4 packs
Test tube (dimension 12*75), 5 ml volume, holder rack	6 pcs
Falcon tube (15 mL), pack of 25 pcs	5 box
Culture bottle with white transparent cap, 400 ml	500 pcs
Forceps of various size, stainless steel	12 pcs
ELISA plate, 1*96 well plate	25
Plant agar or agar agar for tissue culture, 1 kg	5
Sodium Carbonate (Na_2CO_3), 500 g	2
Sodium Hydrogen Carbonate (NaHCO_3), 500 g	2
Sodium Chloride (NaCl), 500 g	2
Potassium Hydrogen Phosphite (KH_2PO_3), 500 g	2
Monosodium Phosphate ($\text{NaH}_2\text{PO}_4 \cdot 12\text{H}_2\text{O}$), 500 g	2
Potassium Chloride (KCl), 500 g	2
Tween-20, 500 ml	1
Polyvinyl Pyrolidone (PVP-40), 100 g	2
Ovalbumin (OVA), 500 g or 500 ml or equivalent	1
Diethanol Amine, 500 ml	2
Sodium Hydroxide, 500 g	2
PRSV Papaya ringspot virus IgG, 0.1 ml	2
PRSV Papaya ringspot virus Conjugate, 0.1 ml	2
PRSV Papaya ringspot virus Positive control, 2.5 ml	1

- Equipment and chemicals support increase capacity of tissue culture lab in CDC.
- More saplings will be produced by tissue culture lab.
- CDC will able to establish more than 40 secondary nurseries in farmers' field.
- Virus testing of produce sapling.

Further intervention needed

- Certification of saplings
 - SQCC, DoA, NCPVSCD, CDC.
- Training to agriculture technician working on local level.
- Financial support to local level for establishing secondary nurseries.

Current Status and Programs of Cardamom Seeds: Cardamom Development Center, Fikkal, Ilam



नेपाल सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विभाग



राष्ट्रिय आलु, तरकारी तथा मसलाबाली विकास केन्द्र

अलैंची विकास केन्द्र,
फिक्कल, इलाम

राजन परियारा
माटो विज्ञ
निमित्त केन्द्र प्रमुख

फार्म/केन्द्रमा उत्पादित बीउ/बेर्नाको उत्पादन स्थिति विगत ३ वर्षको

फार्म/केन्द्र	आ.व.	अलैंची बेर्ना उत्पादन र बिक्री परिमाण			
		उत्पादन	बिक्री	मौज्दात	मौज्दात रहनुका कारण
अलैंची विकास केन्द्र	२०७८/७९	८००००	८००००	०	
	२०७९/८०	१०६०००	१०४४००	१६००	केन्द्रमा रोपण गरिएको
	२०८०/८१	१३५०००	२३९३६०	६४४०	अलैंची व्यवसायी महासंघको सहकार्यमा बृद्ध अलैंची रोपण कार्यक्रम इलाममा शुरू गरिने भएकोले

2

अलैंची खेतीका समस्या र चुनौती

१. कृषक स्तरमा

समस्याहरू	चुनौतीहरू
अलैंची बालीमा काम गर्ने युवा जनशक्तिको कमी	अलैंची खेतीमा युवालाई आकर्षित गराउनु
रोग कीराका कारण अलैंची बगानको क्षेत्रफलमा ह्रास आएको - डढुवा रोग, गानो कुहिन र झर्ने, छिक्रे फुके	युवालाई स्वदेशमा टिकाई राख्नु बगानलाई डढुवाबाट बचाउनु
कृषकहरूमा उन्नत खेती प्रविधि, गुणस्तर सुधार र उत्पादन पछिका प्रविधिबारे ज्ञान र सीपको कमी	कृषकहरूमा उन्नत प्रविधि विस्तार गर्नु
कृषक स्तरमा संकलन केन्द्रको अभाव, भण्डारण सुविधाको अभाव	उत्पादन स्थलमा संकलन केन्द्र
परम्परागत भट्टी र उन्नत भट्टीको प्रशोधनमा अलैंचीको बिक्री मूल्य फरक नरहेको	परम्परागत भट्टी र उन्नत भट्टीको प्रशोधनमा अलैंचीको बिक्री मूल्य फरक बनाउनु
छहारील अलैंची बारीमा रोग कीराको प्रकोप बढाएको	छहारीको वैज्ञानिक प्रयोग गर्नु
प्राविधिक सेवा किसान समक्ष पुग्न नपाएको	प्राविधिक सेवा कृषक समक्ष पुऱ्याउनु

अलैंची खेतीका समस्या र चुनौती.....

२. व्यवसायी स्तरमा

समस्याहरू	चुनौतीहरू
गुणस्तरीय अलैंची नभएको	कृषकबाट गुणस्तरीय अलैंची खरिद गर्नु
तेस्रो देशमा अलैंची पठाउन नसक्नु	अलैंचीको निर्यात कर घटाउनु/छुट गराउनु - • बंगलादेशमा ३५% कर लाग्ने • दुई देश बीच द्विपक्षीय सम्झौता गराउनु
बजार सर्वेक्षण नभएको	सरकारी पसबाट बजार सर्वेक्षण गराउनु
वेयर हाउस नहुनु	अन्तर्राष्ट्रिय स्तरको मापदण्डको वेयर हाउस बनाउनु
अलैंचीको व्यापारको लागि स्पेशल लोन र छुट नभएको	अलैंचीको निर्यातमा कर छुट गराउनु
अलैंची स्टक गर्दा डुसी आउने	मापदण्ड पुगेका वेयर हाउस बनाउनु
अवैधानिक रूपमा स्थानिय एवं जिल्ला स्तरमा कर र फि ठाईने गरिएको	संघ, प्रदेश, जिल्ला र स्थानिय तहमा समन्वय

अलैंची खेतीका समस्या र चुनौती.....

३. प्राविधिक स्तरमा

समस्याहरू	चुनौतीहरू
स्थानिय तह प्रदेश र संघमा कार्यरत प्राविधिकहरूको समन्वयन अभाव	समन्वयन प्रभावकारी बनाउनु।
अलैंची खेतीको प्रविधि अनुदानमा आधारित हुनु	अनुदानलाई सबैको पहुँचमा पुऱ्याउनु। उत्पादनमा आधारित अनुदान उपलब्ध गराउनु।
Technology supply driven हुनु	अनुसन्धानमा आधारित प्राविधिक विकास।
सिमित स्रोत साधन र जनशक्तिको अभाव	दरबन्दी अनुसार पदपूर्ति हुनुपर्ने।

सुझाव/भावी दिशा

- अलैंचीको अनुसन्धानलाई सघन बनाउनु पर्ने - कृषकको समस्यामा आधारित अनुसन्धान, revalidation गरिनु पर्ने।
- अनुसन्धान र प्रसार - अलैंची विकास केन्द्र, नेपाल कृषि अनुसन्धान परिषद, प्रधानमन्त्री कृषि आधुनिकीकरण परियोजना अन्तर्गतका जोन, ब्लक र पकेट क्षेत्रहरू बीच अनुसन्धान र प्रसार सम्बन्धी तालमेल मिलाउनु पर्ने।
- गुणस्तरीय बेर्ना र प्राविधिको उपलब्धता - तन्त्र प्रजनन प्रयोगशाला र निरोगी बीउबाट उत्पादित बेर्नाको उपलब्धता सहज गराउनुपर्ने र प्राविधिक कृषक समक्ष पुऱ्याउनु पर्ने।
- प्राज्ञारिक खेती - अलैंची खेतीको प्राज्ञारिक खेती प्राविधिको प्रचार प्रसार गर्नु पर्ने।
- नीति कार्यान्वयन - पर्याप्त अध्ययन पछि नीति तयार गरी तदारुकताका साथ कार्यान्वयनमा ल्याउनु पर्ने।

Current Status and Programs of Potato Seeds: Potato Crop Development Center, Nigale, Sindhupalchowk



Government of Nepal
Ministry of Agriculture and Livestock Development
Department of Agriculture
National Center for Potato, Vegetables and Spice Crops Development



Potato Crop Development Center,
Nigale, Sindhupalchowk

Bijaya Kumar Giri
Senior Horticulture Development Officer
Farm Chief

Pre-basic Seed (PBS) Production, Demand and Supply in Different Fiscal Year

S.N	Fiscal Year	Number of In-vitro Jars	Pre-basic Seed (No. of Tubers)	Demand of PBS Tubers	Supply of PBS Tubers
1.	2076/77	0	12,500	20,300	8,500
2.	2077/78	60	28,180	50,500	26,000
3.	2078/79	1800	45,000	65,000	39,500
4.	2079/80	4220	56,850	95,000	51,208
5.	2080/81	6500	95,240	1,61,000	-

Source: Annual Reports of PCDC

Basic Seed and Ware Potato Production, Demand and Supply in Different Fiscal Year

S. No.	Fiscal Year	Production of Basic Seeds (MT)	Demand of Basic Seeds (MT)	Supply of Basic Seeds (MT)	Production of Ware Potato (MT)
1.	2076/077	8.45	15	5.0	4.4
2.	2077/078	7.43	25	4.5	5.57
3.	2078/079	15	40	9.7	8.5
4.	2079/080	22.97	45	16.1	9.7
5.	2080/081	21	69	15.5	7.123

Source: Annual reports of PCDC

- The demand is in the increasing trend every year
- Demand from Farmers, Farmers groups, Cooperatives, Local governments, AKC, Agricultural Projects i.e. PMAMP

True Potato Seed (TPS) Production Status in Different Fiscal Year

S.No.	Fiscal Year	TPS Seeds (Kg.)
1.	2080/81	19.50
2.	2079/80	32.00
3.	2078/79	9.80
4.	2077/78	8.30
5.	2076/77	9.50

Source: Annual reports of PCDC

Challenges

1. Unbalanced demand and supply of seed potato i.e. demand far exceeding the supply
2. New technology is not adopted in PBS production (Aeroponics, Hydroponics)
3. No functional Seed certification scheme of Seed Potato
4. Difficulty in Seed cycle maintenance
5. Same Parental line of TPS are using from long time
6. Infestation destructive diseases and pest i.e. Late Blight, Wart, Wilting, Semi-lopper
7. Negative impact of climate change on potato production i.e. long drought, incidence of hailstorm and frost

Way Forward/Recommendation

1. It is necessary to change the perception of farmers between PBS, Basic seeds and ware potato
2. Produce quality pre-basic seeds at government farms/centers by utilizing in-vitro jars from certified government tissue culture laboratories
3. Three level of Government organizations should actively involved in Seed Potato Production and Distribution (Central: In-vitro plants & PBS; Provincial: PBS & Basic Seed and Local Level: Improved Seed Production)
4. Rapid Multiplication Technology: Plantlets/Tissue Culture
5. Introducing genetic diversity to enhance crop resilience and disease resistance
6. Encouraging the use of advance methods to produce PBS
7. Training programs and knowledge dissemination are essential to enhance productivity and efficiency

Current Status and Programs of Vegetable Seeds: Vegetable Crops Development Center, Khumaltar, Lalitpur



नेपाल सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विभाग



राष्ट्रिय आलु, तरकारी तथा मसलाबाली विकास केन्द्र

तरकारी बाली विकास केन्द्र,
खुमलटार, ललितपुर

दिनेश प्रसाद सापकोटा
वरिष्ठ बागवानी विकास अधिकृत
केन्द्र प्रमुख

तरकारी बीउ तथा तरकारी बेर्ना उत्पादन हुने बाली

क्र.सं.	तरकारी बीउ	जात	क्र.सं.	तरकारी बेर्ना	जात
१.	काउली	खुमल ज्यापू र काठमाण्डौ स्थानीय	७.	रबीसचाई	सुखाग
२.	गोलभेंडा	सिर्जना	८.	सुर्जानी	बकबरे सुर्जानी, एन एच १७०१
३.	मूला	मिर्जे बाली	९.	भेडिसुर्जानी	ब्यालिसोर्ने
४.	शलम	काठमाण्डौ रातो	१०.	भन्टा	पुष्पा पल्ल संग, जुम्ली भन्टा
५.	पाचुहो	पाटने	११.	प्याज	रैड क्रिगेस
६.	बोडी	मालेपाटन, खुमल तने	१२.	कुरिलो	मेरी बारीबटन
७.	सिमी	बौमासे, झांग, त्रिभुली घ्यूसिमि	१३.	काँको	भक्तपुर सोक्स
८.	भटमास	तरकारी भटमास	१४.	बिरौला	न्यू नारायणी
			१५.	सोखा	बनमोल
			१६.	फर्सी	बर्जुन
			१७.	करैला	पाली
			१८.	जुकिनी	बन्ना ३०३

क्र.सं.	तरकारी बेर्ना	जात
१.	काउली	खुमल ज्यापू र काठमाण्डौ स्थानीय
२.	गोलभेंडा	सिर्जना
३.	रायो	मार्फा बोहा पात र खुमल रातो पात
४.	बन्टा	ग्रीन कोरेनेट, टि ६२१
५.	क्रोकाउली	ग्रीन स्लाउटिङ्ग, सेन्टाउरी
६.	न्याँठकोबी	नेप बल

फार्ममा संरक्षित जर्मप्लाज्महरू

- जिम्बु
- काँडे भण्टा
- जुम्ली भण्टा
- भिण्डी (जुली)
- रुख टमाटर
- कालो खुर्सानि
- गोलभेंडा (मनप्रेकस)
- ओल
- लिक
- थाई अदुवा
- इन्डोनेसियन बोडी
- अष्ट्रेलियन सर्ड बिन
- निदरलैण्ड घ्यूसिमि

तरकारी बीउ/बेर्ना उत्पादन र बिक्री विवरण

क्र.सं.	कार्यक्रम/क्रियाकलाप	इकाई	वार्षिक		
			उत्पादन लक्ष्य	उत्पादन प्रगति	बिक्री वितरण प्रगति
१.	सुजना गोलभेंडाको बीउ उत्पादन	के.जी.	१०.००	१२.००	१७.३८
२.	विभिन्न तरकारी बालीहरूको मूल तथा उच्चत बीउ उत्पादन	के.जी.	४००.००	४००.००	२०८.१०
३.	रायो तथा काउली बालीहरूको बेर्ना उत्पादन	संख्या	७०००००	५५००००	४५७४४९
४.	प्याज बेर्ना उत्पादन	संख्या	२००००००	२९०००००	२८७४४२५
५.	लहरे तथा सुर्जानी समूहका बेर्ना उत्पादन	संख्या	६५००००	४५००००	४२५०१५
६.	कुरिलो तथा फूलका बेर्ना उत्पादन	संख्या	१५००००	१५००००	३५८७३

फार्मले भोग्नुपरेका समस्या, चुनौती तथा समाधानका उपाय

❖ डुबान:

- वर्षेनी वर्षातको समयमा ढल निकासको अभावका कारण जमिन डुबान भई नर्सरी तथा बीउ बाली नष्ट हुने गरेको र आवास समेत प्रभावित भएको
- सोको लागि स्थानीय निकाय तथा कृषि अनुसन्धान परिषदसंग समन्वयको प्रयास गरिएता पनि भरपर्दो निकास हुन नसकेको

फार्मले अवलम्बन गर्ने भावी कार्यदिशा

- ❖ तरकारीका बीउ/बेर्ना उत्पादन, प्रमाणिकरण एवं अन्य प्राविधिक कार्य
 - तरकारीका क्षेत्रमा नवीनतम प्रविधिको प्रयोगलाई समावेश गर्दै Center of Excellence को रूपमा कार्य गर्ने
 - तरकारीका बीउहरूको जातीय सम्बर्द्धन र संरक्षण एवं प्रशोधन र बीउ प्याकेजिङ्ग कार्यलाई वैज्ञानिक बनाउदै लगिने
 - तरकारीका क्षेत्रमा राष्ट्रिय नीति निर्माणमा राज्यलाई पृष्ठपोषणका कार्य गर्ने
- ❖ जर्मप्लाज्म संरक्षण र विकास
 - देश/विदेशमा भ्रमणको सिलसिलामा प्राप्त जर्मप्लाज्महरूको संरक्षण तथा सम्बर्द्धन, अध्ययन परीक्षण गर्ने

Current Status and Programs of Vegetable Seeds: Vegetable Seed Production Center, Rukum



नेपाल सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विभाग



राष्ट्रिय आलु, तरकारी तथा मसलाबाली विकास केन्द्र

तरकारी बीउ उत्पादन केन्द्र,
मुसीकोट, चापा, रुकुम पश्चिम

पदम बहादुर सुवेदी
वरिष्ठ बागवानी विकास अधिकृत
केन्द्र प्रमुख

फार्म/केन्द्रमा लगाइएका मुख्य-मुख्य बालीहरू

मूल बीउ			
क्र.सं.	तरकारीको नाम	जात	क्षेत्रफल (रोपनी)
१	काउली	काठमाडौं लोकल	३
२	रायो	खुमल चौडापात	३
३	मुला	मिनो अर्ली	१२
४	प्याँज बीउ गानो	रेड क्रियोल	५
५	प्याँज बीउ	रेड क्रियोल	१२
६	केराउ	सिक्किमे	१३
७	केराउ	आर्केल	५
८	सिमि	चौमासे	६
९	काक्रो	भक्तपुर लोकल	१
जम्मा			६०

क्रमशः

ख.उन्नत बीउ			
क्र.सं.	तरकारीको नाम	जात	क्षेत्रफल (रोपनी)
१	बोडी	मालेपाटन	३
२	गोलभेंडा	मनप्रेकश	१
३	गोलभेंडा	श्रृजना हाइब्रिड	१
४	सिमि	त्रिशुली	३
		कण्टेण्डर	३
५	स्वीसचार्ड	फोर्डहुक जायन्ट	१
६	भिन्डी	पार्वती	५
		अर्का अनामिका	
७	चम्सुर	स्थानीय	८
८	धनिया	स्थानीय	४
जम्मा			२९

फार्ममा उत्पादन हुने तरकारी बीउ बालीहरूको विवरण (तरकारी आलु मसलाबालीहरूको विभिन्न जात,प्रजनन,मुल,उन्नत बीउ उत्पादन परिमाण)

१. मूल बीउ

क्र.सं.	तरकारी बालीहरूको नाम	जात	उत्पादन परिमाण (केजी)
१.	प्याँज	रेड क्रियोल	२४२
२.	रायो	खुमल चौडापात	५१
३.	मुला	मिनो अर्ली	१४२
४.	काउली	काठमाडौं लोकल	३४
५.	केराउ	सिक्किमे	७५०
६.	केराउ	आर्केल	१०४
७.	सिमि	चौमासे	३४१
८.	काक्रो	भक्तपुर लोकल	१०५
जम्मा			१६६५.०५
९.	गोलभेंडा	सृजना हाइब्रिड	१.३०

क्रमशः

उन्नत बीउ

क्र.सं.	तरकारी बालीहरूको नाम	जात	उत्पादन परिमाण (केजी)
१.	बोडी	मालेपाटन	३७
२.	गोलभेंडा	मनप्रेकश	१
३.	सिमि	त्रिशुली	४४
४.	सिमि	कण्टेण्डर	४६
५.	स्वीसचार्ड	फोर्डहुक जायन्ट	५४
६.	भिन्डी	पार्वती/ अर्का अनामिका	१६
७.	चम्सुर	स्थानीय	१८५
८.	धनिया	स्थानीय	५०
जम्मा			४३३

समस्या तथा समाधानका उपायहरू

क्र.सं.	समस्याहरू / चुनौतीहरू	समस्या समाधानका उपायहरू
१.	सिचाईको अभाव	डिप ट्यूबेल जडान अध्ययन गरी काम अगाडी बढाउनु पर्ने
२.	गहा सुधार नभएको	गहा सुधारको लागि पर्याप्त बजेट विनियोजन गरिनु पर्ने
३.	तरकारी बीउ उत्पादक कृषकहरूको बीउ स्थलगत प्रमाणिकरण गर्न नसकिएको	बीउ प्रमाणीकरणको लागि बजेट सहितको बीउ बाली निरीक्षकहरूको व्यवस्थापन गरिनुपर्ने।

भावी कार्य दिशा

- फार्मलाई Centre of Excellence को रूपमा जानुपर्ने
- मूल बीउ उत्पादनको श्रोत/केन्द्रको रूपमा लैजाने

Current Status and Programs of Vegetable and Potato Seeds: Tropical Horticulture Center, Nawalpur, Sarlahi



नेपाल सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विभाग
राष्ट्रिय फलफूल विकास केन्द्र



उष्ण प्रदेशीय बागवानी केन्द्र,
नवलपुर, सर्लाही

राम कुमार यादव
निमित्त केन्द्र प्रमुख

केन्द्रमा लगाइएका मुख्य-मुख्य बालीहरु

- केन्द्रभित्र रहेका फलफूलहरु: आँप (३५ जात), लिचि (८ जात), अम्ला (६ जात), एभोकाडो, केरा, नरिवल, रुखकटहर, अनार, बयर, बेल, अमला, कागती आदि
- नयाँ जातका आँपका थप बोटहरु लगाइएको जस्तै मियाजाकी, काटिमोन, जर्दालु, अल्फान्सो, पुसा अरुनिमा, बनाना म्याङ्गो, ब्ल्याक म्याङ्गो, ब्राजिल म्याङ्गो आदि
- तरकारी बीउ तथा बेनी उत्पादन: गोलभेंडा, भण्टा, भिन्डी, काउली, मूला, लौका, फर्सी, घिरौला, काँक्रो, आलु आदि
- आलुका फूल बिरुवा उत्पादन: गुलाब (७७ जात), बगनविलिया (२४ जात), क्रोटन (२५ जात), पाम (७ जात), मालति, धुप्री, अशोक, सुसुण्डा आदि

तरकारी बीउ/बालीको जातिय जर्मप्लाज्म संकलन, संरक्षण तथा सम्बर्द्धन

क्र.सं.	तरकारी बाली	जात	स्तर	कैफियत
१.	गोलभेंडा	पुसा रुबी, एन सी एल ११३१	मूल/उन्नत	संरक्षण भईरहेको
२.	बोडी	सर्लाही तने	उन्नत	संरक्षण भईरहेको
३.	काउली	पुसा कातिकी	उन्नत	संरक्षण भईरहेको
४.	आलु	कुप्री सिन्दुरी, खुमल लक्ष्मी, काठिनल	उन्नत	संरक्षण भईरहेको
५.	आलु (TPS)	TPS-II (HPS 7/67)		संरक्षण भईरहेको
६.	करेला	सर्लाही सेतो	उन्नत	संरक्षण भईरहेको
७.	काँक्रो	सर्लाही ग्रीन	उन्नत	संरक्षण भईरहेको
८.	फर्सी	स्थानीय	उन्नत	संरक्षण भईरहेको
९.	भण्टा	परवानीपुर सेलेक्सन, पि. पि. एल.	मूल/उन्नत	संरक्षण भईरहेको
१०.	लौका	समर प्रोलिफिक लङ्ग	उन्नत	संरक्षण भईरहेको
११.	भिन्डी	अर्का अनामिका, पार्वती, जुली	मूल/उन्नत	संरक्षण भईरहेको
१२.	खुर्सानी	पुसा ज्वाला	उन्नत	संरक्षण भईरहेको
१३.	पालुङ्गो	अलम्रीन	उन्नत	संरक्षण भईरहेको
१४.	मूला	चालिस दिने	उन्नत	संरक्षण भईरहेको

विगत ५ वर्षको तरकारी बीउ फलफूल बिरुवाहरुको उत्पादन तथा बिक्री वितरण

विवरण	२०७६/७७	२०७७/७८	२०७८/७९	२०७९/८०	२०८०/८१
उत्पादन	मि.कि.	उत्पादन	मि.कि.	उत्पादन	मि.कि.
बिक्री	मि.कि.	उत्पादन	मि.कि.	उत्पादन	मि.कि.
सर्व फलफूल बिरुवा (संख्या)	१९३४५९	३६७४८	१६९८४०	४३०८९	३५९३८
तरकारी बीउ (कि.ग्रा.)	८०२७२	३२४९३	८२८	४३९२७	९४९९
सर्लाही केरी (संख्या)	३८४०००	३७२२५२	४२४०००	४०६४९०	२०२९८९
मिर्ची आलु (TPS) (कि.ग्रा.)	३.४	२.९६	३	३	करिबन नभएको
बीउ आलु (कि.ग्रा.)	२०	११.८९	१०.२	१.९	१४
बेसार (कि.ग्रा.)					
आलु (कि.ग्रा.)					
मासुवाटि बिरुवा (संख्या)	३४२९४	१८४४७	२८०२०	९२९८	२९९३४
पुसा पुसा बिरुवा (संख्या)	२९०००	३३३४	२९०००	३६९४	१२०००
सिचकाई पुसा बिरुवा (संख्या)					
मासिक बिरुवा संख्या	१९०००	७७४९	३३४०	३३४०	३३४०

नोट: आ.व. २०८१/८२ मा बेसार लगाईएको क्षेत्रफल: करिब १ हेक्टर

केन्द्रमा देखिएका समस्या तथा चुनौतीहरु

- सिचार्डको अभाव (४०-५०% क्षेत्रमा मात्र सिचार्ड पुगेको)
- नीलगाई र बौदरको समस्या
- फार्मभित्र जङ्गल क्षेत्रको कारण बीउ उत्पादन क्षेत्र विस्तारमा समस्या
- दरबन्दी अनुसारको कर्मचारीहरु नरहेको
- तरकारी बीउ/बेनी, आलु तथा मसलाबाली तर्फ अति न्यून बजेट
- आन्तरिक तारबार नरहेको
- प्राविधिकहरुको लागि Technical Exposure Visit, Training को कमी

सुझाव/भावि कार्य दिशा

- फार्मको सम्पूर्ण ठाउँमा विद्युत र सिचार्डको पहुँच पुऱ्याउनु पर्ने।
- सिचार्डको लागि डिप बोरिङ तथा कुलो निर्माण गर्नु पर्ने।
- फार्मभित्रको जङ्गल क्षेत्रलाई हटाई फलफूल बगैँचाको विस्तार गर्ने।
- स्थापना कालदेखि नै लगाईएका पुराना आँपका बगैँचाहरु मध्ये केहीलाई रेजुभिनेट गर्ने तथा केहीलाई पूर्ण रुपमा हटाई नयाँ बिरुवा लगाउने।
- नीलगाईको स्थानान्तरण तथा व्यवस्थापनको लागि थप पहल गर्ने।
- फार्ममा प्रयोग नभएका खाली जग्गाहरुलाई व्यवस्थापन गरी तरकारी बीउ उत्पादन कार्यको लागि अधिकतम प्रयोग गर्ने।

Current Status and Programs of Vegetable Seeds: Citrus Fruit Development Center, Tansen, Palpa



नेपाल सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विभाग
राष्ट्रिय फलफूल विकास केन्द्र



सुन्तलाजात फलफूल विकास केन्द्र,
तानसेन, पाल्पा

जोगेन्द्र कान्त
केन्द्र प्रमुख

फार्म/केन्द्रमा लगाइएका मुख्य-मुख्य बालीहरू

- फलफूल बालीहरू:
 - सुन्तला
 - बौप
 - नास्पाती
 - जुनार
 - लिची
 - बाख्खडा
 - कागती
 - कटहर
 - बोखरा
 - तीनपाते सुन्तला
 - मेकाडेमिया नट
 - किची
 - बिमिरो
 - बनार
 - प्यासन फुट
 - मुन्तला
 - एभोकाडो
 - बोगटे
 - कफी
 - निबुवा
- तरकारी बालीहरू:
 - मूला - प्यूठाने रातो
 - प्याज - फोरसिङ

फार्ममा उत्पादन हुने बालीहरूको विवरण (बा.व.२०८०/८१)

१. सुन्तलाजात फलफूल बिरुवा उत्पादन:-

- सुन्तला बीज ४५ हजार
- कागती बीज ३५ हजार
- स्ट्रटक बिरुवा १३० हजार
- कागती कलमी ५ हजार
- सुन्तला कलमी ५ हजार
- जुनार २ हजार

२. अन्य बीज/बेनी/बिरुवा उत्पादन:-

- तरकारी बेनी उत्पादन १४६१४ बटा
- खपची फूल १११५ बटा
- विभिन्न जातका फूलको बिरुवा ५०० बटा
- मूलाको बीज ६९.६५ के.जी.
- पुक ११.४ के.जी.
- खपची फूल ९ के.जी.

फार्ममा उत्पादन हुने तरकारी बीज बालीहरूको विवरण

बा.व.	बाली	स्रोत बीज/बेनी उत्पादन र बिक्री परिमाण			
		उत्पादन	बिक्री	मौज्वात	मौज्वात रहनुका कारण
२०७६/७७		७५	७५		
२०७७/७८		४०	४०		
२०७८/७९	प्यूठाने रातो मूला	९०		९०	
२०७९/८०	प्यूठाने रातो मूला	३९.५५	९०	३९.५५	३९.५५ के.जी. मौज्वात रहेको
२०८०/८१	प्यूठाने रातो मूला	३३.६	३९.५५ + ३३.६ = ७३.१५		मौज्वात नरहेको

केन्द्रमा रहेका प्रमुख समस्या

- सिंचाई: उपयुक्त स्रोत अभावको कारण तानसेन नगरपालिका बजारको ढलबाट निस्केको पानीलाई सिंचाईको निर्विकल्प स्रोतको रूपमा प्रयोग गर्नु पर्ने बाध्यता
- फार्मको भौगोलिक बनावट नमिलेको
- समयानुकूल आवश्यक तन्तु प्रजनन प्रयोगशालाको लागि स्थायी कर्मचारीको दरबन्दी नभएको
- आन्तरिक तथा बाह्य प्राविधिक सेवाको लागि आवश्यक प्राविधिक जनशक्तिको उपलब्धता नहुनु
- बौद्ध लगायतका बन्धुजन्तुको आतंक
- समयसापेक्ष कर्मचारीहरूको क्षमता विकास कार्यक्रम नहुनु
- बार बन्दैज अत्यन्त जीर्ण, १८४ रोपनीको परिधि समेट्न धेरै खर्च लाग्ने

सुझाव/भावी कार्य दिशा

- फार्मको उत्पादकत्व वृद्धि गर्न उपलब्ध सिमित स्रोत साधनको उच्चतम प्रयोग
- फार्ममा बिरुवाहरूलाई बड-मुड सर्टिफिकेशन विधि मार्फत उत्पादन गर्ने
- सुन्तलाजात फलफूलको जातिय संरक्षण एवम् सम्बर्द्धन गर्ने
- प्यूठाने रातो मूलाको जातिय संरक्षण एवम् सम्बर्द्धन गर्ने
- कार्यमुखी अध्ययन परिक्षण (Action oriented research) संचालन गर्ने
- सुन्तलाजात फलफूल विकासको लागि सरोकारवालाको समन्वयमा बाह्य सेवाका गतिविधिहरू संचालन गर्ने
- सुन्तलाजात फलफूल विकास सम्बन्धी राष्ट्रिय नीति तथा योजना तर्जुमा गर्न केन्द्रलाई पृष्ठपोषण गर्दै जानी
- सिंचाईको लागि सोझै प्रयोग गर्ने गरेको ढलको पानीलाई शुद्धिकरण गरेर प्रयोग गर्ने

Current Status and Programs of Vegetable Seeds: Temperate Horticulture Center, Marpha, Mustang



नेपाल सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विभाग
राष्ट्रिय फलफूल विकास केन्द्र



शितोष्ण बागवानी विकास केन्द्र,
मार्फा, मुस्ताङ

पद्मनाथ आग्नेय
वरिष्ठ बागवानी विकास अधिकृत
केन्द्र प्रमुख

Breeder Seed Production

1. Rayo- Marpha Broad Leaf Mustard
2. Radish- Tokinashi
3. Cabbage- Copenhagen Market
4. Carrot- New Kuroda
5. Swiss chard/Susag- Ford Hook Joint
6. Turnip- Purple Top

❖ Use for foundation seed production in center only

Foundation Seed Production

1. Rayo- Marpha Broad Leaf Mustard
2. Radish- Tokinashi
3. Cabbage- Copenhagen Market
4. Carrot- Nantes Forte
5. Swiss chard/Susag- Ford Hook Joint
6. Turnip- Purple Top
7. Coriander- Local
8. Garlic- Local (Bhote Lasun)
9. Potato- Cardinal

❖ Sell/distribut to farmers/farmers group, seed producer, cooperatives etc

Work Performed Till Date

- Production of Potato Pre-basic Seed (PBS) under screen house Mustang local (3500 tuber)



Production of PBS of Mustang Local

तरकारी बीउ उत्पादनको विवरण

क्र.सं.	तरकारी बाली	जात	प्रजनन बीउ (ग्राम)	मूल बीउ (किलोग्राम)
१.	रायो	मार्फा चौडा पात	३००	१९३
२.	मूला	टोकिनासे	२००	९०
३.	बन्दा	कोपन हेगन मार्केट	१५०	४६
४.	गाजर	नान्टिस फोर्टे	२००	४४
५.	सलमस	पर्पल टप	३००	४५
६.	स्वीसचाई	फोर्ड हुक जायन्ट	२५०	६०
७.	धनिया	स्थानिय	-	३६
८.	लसुन	भोटे लसुन	-	१५५
९.	ब्रासु	काईगल	-	४५००

बीउ उत्पादनमा देखिएका मुख्य मुख्य समस्याहरू तथा समाधानका उपायहरू

समस्याहरू	समाधानका उपायहरू
बाली काट्ने समयमा धेरै पानी पर्ने	विस्तारै स्थान परिवर्तन गर्ने
रोग/कीराको समस्या	रोग/कीरा व्यवस्थापनका कार्यहरू
फिजियोलोजिकल विकृतिहरू	रगिङ्ग गरेर हटाउने, गुणस्तरीय बीउ प्रयोग गर्ने
न्यून मूल्य/बीउ उत्पादनको लागि लामो समय लाग्ने	मूल्य संसोधन गर्नुपर्ने

Current Status and Programs of Vegetable and Potato Seeds: Horticulture Center, Phaplu, Solukhumbu



कोशी प्रदेश सरकार
भूमि व्यवस्था, कृषि तथा सहकारी मन्त्रालय
कृषि विकास निर्देशनालय



बागवानी केन्द्र, फाप्लु, सोलु

दुर्गा बहादुर तिरुवा
कृषि प्रसार अधिकृत
कृषि ज्ञान केन्द्र, सोलुखुम्बु

फार्मको विगत ३ वर्षको फलफूलबिरुवा उत्पादन

क्र.सं.	फलफूल बिरुवा	आ.व.२०७८/७९	आ.व.२०७९/८०	आ.व.२०८०/८१
१.	किवि: हेवाई रेड किवि गोल्डेन भाले	३२८७	२६१५ २५	५२२९ २४२ १६० ८९७
२.	स्याउ	७३६	२५४०	२५५५
३.	नास्पाती	५१३	१२५०	८५५
४.	आरु	९३८	१४०	२५०५
५.	फूल आरु	०	०	१००
६.	आरुबखडा	३३०	३९५	०
७.	खुर्पीनी	०	२८	०
८.	ओखर	३८१	०	०
	जम्मा	६,१८५	६,९९३	१२,५४३

विगत ३ वर्षको तरकारी तथा फलफूल बिक्री वितरण

क्र.सं.	विवरण	आ.व.२०७८/७९	आ.व.२०७९/८०	आ.व.२०८०/८१
१	तरकारी	५,०१९ के.जी.	७,०११ के.जी.	६,५६८ के.जी.
२	फलफूल	३,२६७ के.जी.	२,०९४.२ के.जी.	५,५९५ के.जी.
३	तरकारी बेर्ना	१८,२१७ बटा	२९,४२३ बटा	२०,९८१ बटा
४	फलफूल बिरुवा	६,१८० बटा	६,९९८ बटा	५,६०१ बटा
५	रायो र मूलाको बीउ	३५ के.जी.	७६ के.जी.	१९.८ के.जी.
	जम्मा राजस्व प्राप्त	रु १५,७३,४००/-	रु १४,११,९९०/-	रु १३,३५,५८०/-

तरकारी बीउबालीहरूको उत्पादन तथा बिक्री वितरण

तरकारी बालीहरू	उत्पादन तथा बिक्री	२०७६/७७	२०७७/७८	२०७८/७९	२०७९/८०	२०८०/८१
आलु (मोटो), नाम्बेली, खुम्बुली	उत्पादन (के.जी.)				७२००	६८००
	बिक्री (के.जी.)				६७००	६०००
मूला (गान्ठे)	उत्पादन (के.जी.)				३१	१७
	बिक्री (के.जी.)				१४	१२
रायो (खुमल चौडा पात)	उत्पादन (के.जी.)				२७	२३
	बिक्री (के.जी.)				१५	१९

फार्मले भोग्नु परेका समस्या तथा चुनौती

- दरबन्दी अनुसारको कर्मचारी नहुँदा लक्ष्य अनुसारको कार्य गर्न नसकिएको।
- कृषि ज्ञान केन्द्र अन्तर्गत मर्ज भएको हुँदा कर्मचारी अभावको साथै कार्यक्रम संचालनमा पनि सहज नभएको।
- पर्याप्त बजेटको अभाव।
- कर्मचारी व्यवस्थापनमा समस्या।
- कृषकहरूसँग प्रविधि विस्तारको रूपमा जोडिन नसकिएको।

सुझाव/भावी कार्य दिशा

- फलफूलका बिरुवा र तरकारीका बीउको उत्पादन बृहत रूपमा वृद्धि गर्ने।
- हिउँदे फलफूल र तरकारी बीउको लागि स्रोत केन्द्रको रूपमा स्थापना गर्ने।
- प्रविधि प्रसारको मुख्य थलोको रूपमा विकास गर्ने (Resource Center Strengthen)
- फलफूल प्रशोधन प्रविधि विस्तार गर्न काष्ठफल परियोजनाको सहयोगमा किविको ब्रान्डी बनाउने।
- बागवानीजन्य उपजहरूको भण्डारणको उपयुक्त प्रविधि विकास गर्ने।
- विभिन्न जातको फलफूलको जर्मप्लाजमा संरक्षण गर्ने।
- प्राविधिकको क्षमता अभिवृद्धिको लागि तालिम तथा भ्रमणमा सहभागिता हुनुपर्ने।

Current Status and Programs of Vegetable Seeds: Tropical Horticulture Nursery Development Center, Janakpur



मधेश प्रदेश सरकार
भूमि व्यवस्था, कृषि तथा सहकारी मन्त्रालय
कृषि विकास निर्देशनालय



उष्ण प्रदेशिय बागवानी नर्सरी विकास केन्द्र जनकपुर, धनुषा

राजीव कुमार यादव
केन्द्र प्रमुख

केन्द्रको भौगोलिक अवस्थिति

- अक्षांश: २५.२५° देखि २७.५०° उत्तरी अक्षांश
- देशान्तर: ८५.५०° देखि ८६.२०° पूर्वी देशान्तर
- उचाई: समुद्री सतह देखि १०० मिटर (३०० फिट)
- औषत वर्षा: १२०० मि.मि.
- तापक्रम: अधिकतम ४२°C र न्यूनतम १५°C-१७°C
- हावापानी: उष्ण मनसुनी हावापानी
- माटो: दोमट किसिमको
- प्रदेश: मधेश प्रदेश
- जिल्ला: धनुषा
- स्थान: जनकपुरधाम उपमहानगरपालिका वार्ड नं. ८

केन्द्रको सिमाना

- पूर्व: आर.टि.ओ. रोड
- पश्चिम: रत्नसागर
- उत्तर: रेल्वे लाईन
- दक्षिण: गौज बस्ती (अपाङ्ग संघ)

केन्द्रको भू-उपयोग

यस केन्द्रको क्षेत्रफल ७ हेक्टर छ।

भू-उपयोग यस प्रकार रहेको छ:

- फलफूल बगैँचा- ३.९५ हेक्टर
- फलफूल नर्सरी- १.२० हेक्टर
- तरकारी बाली- १.०५ हेक्टर
- अन्य-कुलो, बाटो, घर- ०.८० हेक्टर

स्रोत समग्री उत्पादन तथा बिक्रिवितरण विवरण

स्रोत समग्री	उत्पादन	बिक्रिवितरण	मौजदात
वर्षे फलफूल बिरुवा	२८२३२	८३५२	मौजदातमा रहेका १९८८० मध्ये कागती ३८६५ लिची ९७५ कटहर २९८० अम्ला ४८० अम्ला ९६५ कागजी बदाम ४८० औप १०१३५
पुष्प बिरुवा	६७०५	४७४०	१९६५
तरकारी बीउ (के.जी.)	२०२.७	२०२.७	
तरकारी बेनी (संख्या)	२९५०९४	२९५०९४	
ताजा तरकारी (के.जी.)	५१०३.७५	५१०३.७५	

स्रोत समग्री उत्पादन तथा बिक्रिवितरण विगत ५ वर्षको

वा.व.	फलफूल बिरुवा (संख्या)	पुष्प बिरुवा (संख्या)	तरकारी बेनी (संख्या)	ताजा तरकारी (के.जी.)	तरकारी बीउ (के.जी.)
२०७५/७६	८००३	५६६९	३०२५३२	६२५३.५	१९२
२०७६/७७	८२१५	५५५५	३१५८६८	९२९९	१८६
२०७७/७८	१२००३	६६९३	२०२७२०	७२९२	२११.१
२०७८/७९	७९०७	५३४०	२०९३०४	५५०४	२२६
२०७९/८०	१३२५५	५१८६	२१२०९७	५२८५	२०२.०५
२०८०/८१	८२५२	४७७०	२९५०९४	५१३०.७५	२०२.७

केन्द्रमा रहेका फलफूल, तरकारी र पुष्प बिरुवाको विवरण

फलफूल	माउबोट संख्या	तरकारी	मूल बीउ केजी	पुष्प	माउबोट संख्या
बन्वाई	१०	बोडी	७५	हुरहुर	१०
मालवह	२०	मुला	१००	ईन्द्रकमल	५
अन्नपाली	५०	मिन्डी	३०	कामनी	५
मल्लिका	५०			एकजोरा	५
अल्फान्सो	५			एकालिफा	५
कलकतिया	१०			रातकी रानी	५
दराहरी	२०			करवीर	५
अम्बा	२०			चौदनी	६
कागती	२०			गुलाम	४०
अनार	२०			सयपत्री	५०
लिची	२०			डुसिना	५०
जर्दा	५			पेडिलेन्स	५
अन्य	१०			ज्यासमिन	४

Current Status and Programs of Vegetable and Spice Crop Seeds: Horticulture Development Center, Panchkhal, Kavrepalanchok



बागमती प्रदेश सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विकास निर्देशनालय



बागवानी विकास केन्द्र

पाँचखाल, काभ्रेपलाञ्चोक

विष्णु बोगटी

वरिष्ठ बागवानी विकास अधिकृत
केन्द्र प्रमुख

मुख्य कृषाकलापहरू

- बीउआलु उत्पादन
- तरकारी बेनी उत्पादन
- फलफूल बिरुवा उत्पादन-
- मसलाबालीको (बेसार) बीउ उत्पादन
- धानको बीउ उत्पादन
- तरकारीको बीउ उत्पादन
- आलुझारीक बिरुवा
- समस्यामूलक परीक्षणहरू संचालन
- जर्मप्लाज्महरू संकलन, सम्बर्द्धन, संरक्षण
- कृषकस्तरमा तालिम
- प्राविधिक सेवा

वर्तमान उद्देश्य

- मसलाबाली, तरकारीबाली, आलुबाली तथा उपोष्ण प्रदेशीय फलफूलको बीउ/बेनी उत्पादन
- विभिन्न जातका तरकारीको मूल, उन्नत तथा वर्णशंकर बीउ उत्पादन
- बाली चक्रको रूपमा धानको मूल एवं उन्नत बीउ उत्पादन
- गुणस्तरीय तरकारी बेनी उत्पादन
- जर्मप्लाज्म संकलन, सम्बर्द्धन तथा प्रवर्द्धन गर्ने।
- बगैँचा व्यवस्थापन तथा उत्पादनोपरान्त प्रविधि प्रदर्शन तथा कृषि प्रसार गतिविधि सञ्चालन
- सैदान्तिक तथा व्यवहारीक तालिम प्रदान गर्ने।

लगाईएका मुख्य मुख्य बालीहरू

फलफूल बिरुवाहरू

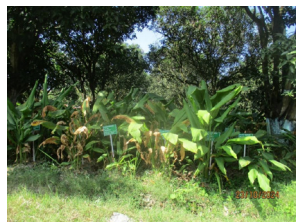
- आँप
- लिचि
- अम्बा
- मेकाडेमियानट
- सुन्तलाजात माउबोट (जाली घर भित्र)
- Quince, Tropical walnut, Dates (परीक्षणको रूपमा लगाईएको)

बीउ उत्पादन

- आलु
- धान
- चौमासे सिमि
- ग्रेटवाल बोडी
- काँक्रो
- बेसार
- लसुन

जर्मप्लाज्म संकलन संरक्षण सम्बर्द्धन विवरण

- गोलभेडा- लामो कस (CL2037) र होचो कस
- तिथेकरेला- हाईटलफ
- बेसार- सुगन्धा
- बेसार- १०० वटा Accessions हरू safety Backup को रूपमा जीन बैंकको समन्वयमा लगाईएको।



बेसारको फिल्ड जीन बैंक स्थापना



Current Status and Programs of Vegetable Seeds: Horticulture Development Center, Sindhuli



बागमती प्रदेश सरकार
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कृषि विकास निर्देशनालय



बागवानी विकास केन्द्र

सिन्धुलीमाढी, सिन्धुली

दिवाकर न्यौपाने

बागवानी विकास अधिकृत



फलफूल बालीहरूको जातिय/जर्मप्लाज्म संरक्षण

क्र. सं.	बाली	जातहरू
१.	आँप	डकमाई, मल्लिका, आम्रपाली, दशहरी, मालदह
२.	लिची	शाही चाईनिज
३.	भुईकटहर	जायन्ट क्यू, क्विन, एम डी २ र स्थानीय
४.	मेकाडेमियानट	केउहाउ, काकी, ईकैया
५.	केरा	विलियम हाईब्रिड, मालभोग र जि नाईन
६.	अनार	कान्धारी
७.	सुपारी, मेवा, रुखकटहर, बेल, एभोकाडो र अमला	जात नखुलेको

केन्द्रमा भएका कन्दमूल बालीहरूको जातिय/जर्मप्लाज्म संरक्षणको अवस्था

क्र. सं.	बाली	जातहरू
१.	तरुल	सर्लाही रातो, सर्लाही सेतो, पाङ्गनाङ्ग, पहेलो र सेतो जाँते/हात्तीपाईले, हात्तिदारे पाताले
२.	सिमल तरुल	स्थानीय रातो र सेतो
३.	पिडालु	पन्चमुखी, सप्तमुखी, हात्तिपाउ, खरी, दुधे
४.	सकरकन्द	स्थानीय सेतो र रातो
५.	ओल	गजेन्द्र, गजराज र स्थानीय रातो
६.	मिश्रीकन्द भुईस्याउ सुठुनी भ्याकुर गिठ्टा	स्थानीय

विगत पाँच वर्षको बीउ बिक्रीको विवरण

बीउको स्तर: उन्नत

परिमाण: केजी मा

क्र.सं.	बाली	जात	२०७६/७७	२०७७/७८	२०७८/७९	२०७९/८०	२०८०/८१
१.	मुला	चालिस दिने	८३.४०	२५.१	५२.३५	३४.५५	२६.०५
२.	बोडी	सर्लाही तने	४१.८	१०	३२.५५	७६.८५	२७.२५
३.	भिण्डी	पार्वती	७७.०५	१६१	९१.७	८८.३०	३९.६५
४.	लौका	PSPL	६.१८	०.२५	०.७२५	०	०.३०
५.	फर्सि	स्थानिय	५.३०	२	०	०	०.५०
६.	सिमि	चौमासे	१	१५	१४.१	३.२०	२८.६०
		जम्मा	२१४.७३	२१३.३५	१९१.४६	२०२.९	१२२.३५

प्रमुख समस्या एवम् समाधानका उपाय

क्र.सं.	समस्याहरू	समाधानका उपायहरू
१.	स्विकृत दरबन्दी अनुरूप कर्मचारी नहुनु	सरुवा वा पदपूर्तिको माध्यमबाट कर्मचारीको व्यवस्थापन गर्ने
२.	केन्द्रमा उत्पादित बीउ तथा बिरुवा बिक्री नहुनु	जिल्ला स्थित कृषि कार्यालय, स्थानिय निकाय, स्थानिय एगो भेट र माथिल्लो निकायसंग समन्वय गरी बिक्रीको व्यवस्था गर्ने
३.	वर्षाको पानी जमि डुबानको समस्या	निकासको व्यवस्थापन तथा डुबान सहने बाली तथा प्रविधिको अवलम्बन गर्ने
४.	अतिक्रमणको समस्या	माथिल्लो निकायसंग समन्वय तथा अनुरोध गर्ने
५.	नयाँ प्रविधि अवलम्बन नहुनु	केन्द्रमा रहेका स्क्रिन हाउस तथा कोल्डरुम जस्ता संरचनाहरू संचालनमा ल्याउने व्यवस्था मिलाउनु पर्ने

भावी कार्यदिशा

- तरकारीको गुणस्तरिय उन्नत बीउ उत्पादन गर्नका लागि बीउ प्रमाणीकरणको थालनी गर्ने।
- कन्दमूल बालीको जर्मप्लाज्म संकलन तथा संरक्षण गरी बीउ श्रोत केन्द्रको रूपमा बिकास गर्ने।
- उदयमान फलफूलको माउबोट बगैचा स्थापना तथा बिरुवा उत्पादन थालनि गर्ने।
- बीउ बालीको उत्पादनका लागि अनुसन्धानात्मक कामको शुरुवात गर्ने।
- डुबान सहन सक्ने बालीको उत्पादन शुरुवात गर्ने।

Current Status and Programs of Vegetable and Potato Seeds: Horticulture Development Center, Daman, Makawanpur



बागवानी प्रदेश सरकार
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कृषि विकास निर्देशनालय



बागवानी विकास केन्द्र
दामन, मकवानपुर

दिपेन्द्र मणी लामिछाने
वरिष्ठ बागवानी विकास अधिकृत
केन्द्र प्रमुख

फलफूल र पुष्प बिरुवाको माउबोटको विवरण

क्र.सं.	फलफूल बोट	माउबोट संख्या	आलुआरिक्त बोट बिरुवा	माउबोट संख्या
१.	स्याउ	३५६	चाइनिज गुलाब	४
२.	हलुवावेद	३९	गुलाब	२५
३.	आरु	२९८	चाइनिज लिन्सी	५०
४.	आरुबखडा	२८६	लालिगुराँस	८०
५.	ओखर (बिजु)	१६४०	रल्याडियोलस	५०
६.	कटुस	१००	हंसराज	१५
७.	खुर्पानी	४६		
८.	हेजालनट	३१		
९.	किबि	११०		
१०.	नास्याती	४०३		
११.	चेरी	२०		
१२.	ओखर (कलमी)	१६		
	जम्मा	३३४५ बटा		

केन्द्रमा उपलब्ध फलफूलका बिरुवा

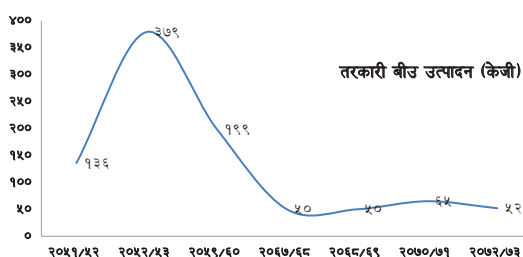
क्र.सं.	फलफूलको नाम	जात	संख्या
१.	स्याउ (कलमी)	अन्ना, भेरिङ, समर पिपिन, रेड डेलिसियस, गोल्डेन डेलिसियस	९६३
२.	नास्याती (कलमी)	होसुई, कोसुई, निजिलाके	३७६०
३.	आरु (कलमी)	पेरिग्रीन	७६०
४.	आरुबखडा (कलमी)	मैथली	३६९०
५.	ओखर (बिजु)	थिनसेल	५००३
६.	हलुवावेद (कलमी)	जिरो, फुयू	४७३
७.	किबि (कलमी)	हेवाई, आलिसन	३९४०
८.	कटुस (बिजु)	जापानेज	१४८३
९.	फुल आरु (कलमी)		२००
	जम्मा		२०२७२

स्रोत सामग्री उत्पादन र बिक्री वितरणको अवस्था

आ.व.	स्रोत सामग्री	बीउ आलु उत्पादन (केजी)	बीउ आलु बिक्री वितरण (केजी)	हालको मौज्जात (केजी)
२०७६/७७	बीउ आलु	४०००	३८४४	
२०७७/७८		४५१०	४२३०	
२०७८/७९		३०१५	२८७०	
२०७९/८०		२५००	२०००	
२०८०/८१		४०५०	३८२५	२७५६

तरकारी बीउ उत्पादन

- ✓ आ.व. २०२१/२२ देखि तरकारी बीउ उत्पादन शुरू
- ✓ मूला (टोकिनासे), रायो (मार्फा चौडापात), केराउ (सिक्किम लोकल)
- ✓ आ.व. २०७२/७३ सम्म बीउ उत्पादनको कार्यक्रम भएको



केन्द्रको आगामी कार्यदिशा

- आलु तथा विभिन्न तरकारीका बीउ उत्पादन
- पुष्प सम्बन्धी कार्यक्रम
- बाँझो जमिन तथा झाडी वुट्यान रहेको जमिनको उपयोग
- कृषि पर्यटन
- प्रविधि प्रदर्शन/ अध्ययन परीक्षण
- जर्मप्लाज्म संकलन, सम्बर्द्धन तथा प्रवर्द्धन
- Center of Excellence/ Learning Center को रूपमा विकास गर्ने

Current Status and Programs of Vegetable and Potato Seeds: Horticulture Development Center, Boanch, Dolkha



बागमती प्रदेश सरकार
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कृषि विकास निर्देशनालय



बागवानी विकास केन्द्र

बोच, दोलखा

सिर्जना न्यौपाने
वरिष्ठ बागवानी विकास अधिकृत
केन्द्र प्रमुख



परिचयात्मक विवरण

स्थापना: वि.सं.२०३४ सालमा स्विस सरकारको सहयोगमा Integrated Hill Development Project अन्तर्गत कार्यालय स्थापना भएको; २०४५ सालमा बागवानी केन्द्र; २०६१ सालमा शीतोष्ण फलफूल रुटस्टक विकास केन्द्र, र २०८० सालमा बागवानी विकास केन्द्र, भि.न.पा.,८ बोच

जम्मा क्षेत्रफल: ३२५ रोपनी (१६.५ हेक्टर)

कमाण्ड क्षेत्र: दोलखा, रामेछाप, सिन्धुपाल्चोक जिल्लाहरू

उचाई: समुन्द्र सतहबाट १९००-२२०० मिटर उचाईको फैलावटमा

माटो: बलौटे दोमट

हावापानी: शीतोष्ण प्रकृतिको, तापक्रम: औसतमा ८-२० डिग्री सेल्सियसका बीच

वर्षा: औसतमा ३९०० मिलिमिटर

केन्द्रमा मुख्य मुख्य तरकारी बालीहरूको विवरण

क्र.सं.	तरकारी बालीको नाम	प्रयोजन	कैफियत
१.	आलु	खायन/बीउ	स्थानीय, रोजीटा
२.	काउली, बन्दा, ब्रोकाउली	बिरुवा बिक्री वितरण	स्थानीय मागको आधारमा (हाईब्रिड)
३.	मूला	बीउ बिक्री वितरण	चालिस दिने
४.	खुर्सानी, गोलभेंडा	बिरुवा बिक्री वितरण	स्थानीय मागको आधारमा (अकबरे, सिर्जना)
५.	प्याज	बिरुवा बिक्री वितरण	स्थानीय मागको आधारमा (रिड कियोल- मूल बीउ)
६.	सिमि	बीउ बिक्री वितरण	त्रिसुली, चौमासे

3

मुख्य मुख्य फलफूल सम्बन्धी विवरण

क्र.सं.	फलफूल	प्रयोजन	जात
१.	किवी	खायन/बीउ/वेर्ना	हेबार्ड, एलिसन, मोन्टी, वुनो टोमरी र मचुवा (भाले)
२.	कटुस	बिरुवा उत्पादन र बिक्रीवितरण	चाइनीज र जापानीज
३.	लप्सी	बीउ उत्पादन र बिक्रीवितरण	स्थानिय डल्ले र मादले
४.	आरु	बिरुवा उत्पादन र बिक्रीवितरण	रुटस्टकको लागि बीउ उत्पादन, स्थानिय जंगली जात
५.	मयल	रुटस्टकको लागि बीउ उत्पादन	स्थानिय जंगली जात
६.	चिया	बिरुवा उत्पादन र बिक्रीवितरण	चाइनिज जातहरू

4

प्रमुख समस्या तथा समाधानका उपायहरू

- केन्द्रमा कम्पाउण्ड वाल/तारबार नभएको कारण सुरक्षाको अवस्था अत्यन्त कमजोर रहेको
- केन्द्र परिसर भित्र पटक पटक स्थानीयहरूबाट सार्वजनिक संरचना निर्माण गर्ने प्रयास भएको
- खानेपानीको स्याई स्रोत नभएको
- मुख्य सडकबाट कार्यालयसम्म पुग्न कच्ची सडक रहेको र सो को स्तर उन्नतिको लागि बजेटको अभाव
- फार्म/केन्द्रहरूलाई center of excellence को रूपमा विकास गर्ने भनिए पनि सो अनुसार Strategic action plan बनाइ सो को कार्यन्वयनको लागि कार्यक्रम बजेट बिनियोजन तथा जनशक्ति व्यवस्थापन हुन जरुरी
- विस्थान गृह, प्रयोगशाला सामग्री आदिको आवश्यकता

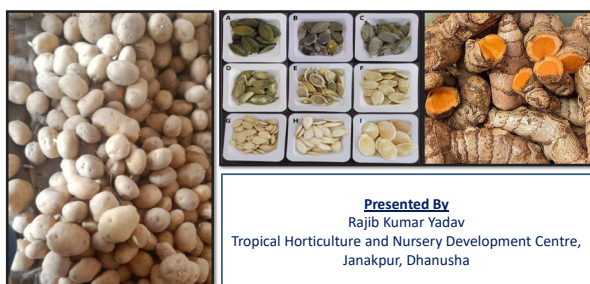
भावी कार्यदिशा

- बीउ आलु उत्पादन तर्फ केन्द्रित हुने
- Nuts and fruits, कार्यक्रम मार्फत देशभर किविका स्वस्थ बिरुवाहरू supply गर्ने
- किविका नयाँ जातहरू दर्ता गरि हावापानी (ठाउँ) अनुसार जातहरू सिफारिस गर्ने
- किविमा मुख्यतया पोलिनेशनमा समस्या भएको हुँदा नयाँ प्रविधिको खोजि हुनु जरुरी
- प्रयोगमा नआएको बौझो जग्गा प्रशस्त भएको हुँदा साथै केन्द्रको कमाण्ड क्षेत्रमा उपयुक्त हुने फलफूलहरू जस्तै स्वीट चेरी, खुर्पानी, जापनिज आरु आदिको माउबोट ब्लकहरू विस्तार गरी गुणस्तरीय कलमी बिरुवा उत्पादन गर्ने
- जापानिज/चाइनीज कटुस र चियाको बिरुवाको समेत माग बढ्दो क्रममा रहेको हुँदा त्यस तर्फ पनि कार्य गर्न सकिने

6

Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province: Madhesh Province

Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Madhesh Province

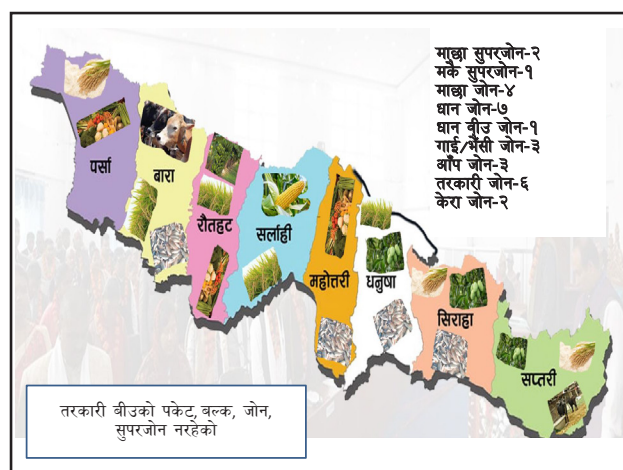


Presented By
Rajib Kumar Yadav
Tropical Horticulture and Nursery Development Centre,
Janakpur, Dhanusha

Overall progress status of AKCs and Farm Centres Involved in the Vegetable seed research, Production and Distribution

SN	AKC/Farm Centres	Vegetables	Production	Distribution
1	Saptari			
2	Siraha			
3	Dhanusha			
4	Mahottari			
5	Sarlahi			
6	Parsa			
7	Rauthat	Cauliflower (Kartik, Terai land 2, Late paush)	350 kg	350 kg
		Cowpea (Thailand)	700 kg	700 kg
		Ridge gourd (Local)	750 kg	750 kg
		Lady finger (VNR)	20 kg	20 kg
		Tomato (Harbhajan)	15 kg	15 kg
		Brinjal (Sarlahi green)	25 kg	25 kg
		Bottle gourd (Local)	41 kg	41 kg
		Cucumber (Local)	27 kg	27 kg
8	Tropical Horticulture and Nursery Development Centre, Janakpur, Dhanusha	Radish (Chalis dine), Cowpea (Sarlahi Tane)	200 kg	200 kg
9	Tropical Horticulture Centre, Nawalpur, Sarlahi	Vegetable seed	329 kg	498 kg
		TPS Seed	0.7 kg	2.6kg
		Potato seed	10.3 Mt	9.15 mt

Source : AKC/ Farm centres 2081/82



Status of Area, Production and Productivity of vegetable seeds and seedlings

SN	Commodity	Area	Production	Productivity
1	Vegetable seed (Cauliflower, Cowpea, Ridge gourd, Lady finger, Tomato, Brinjal, Bottle gourd, Cucumber)	-	2626 kg	
2	Vegetable Seedlings	-	603650	Private Nursery datas are not available but so many private nurseries are raising vegetable seedlings
3	TPS Seed	-	2.6kg	
4	Potato Seed	-	10.3 Mt	Most of the data are missing we will recollect very soon

Source: AKC/ Farm Centre 2081/82

Vegetable seed (Potato, Vegetable and Spice crop)

SN	Vegetable seed	Production	
1	TPS seed	2.6 kg	
2	Potato seed	10.3 Mt	
3	Vegetable seed	2626 kg	
4	Spice	-	Data not available

Vegetable crops including (Protected Horticulture)

- Majority of farmers are not growing vegetable in Protected Horticulture in Madhesh Province.
- Uses in Vegetable seedling production specially in Cucurbits and Cole crops

Potato Crops

SN	Vegetable	Area (ha)	Production (Mt)	Productivity (Mt/ha)	
1	Potato	27648	446390	16.5	

Source: Statistical information on Nepalese Agriculture, 2021/2022

Spice crops including large cardamom

SN	Spices	Area (Ha)	Production (Mt)	Productivity (Mt/ha)
1	Large Cardamom	-	-	-
2	Ginger	611	18839	30.83
3	Garlic	801	4663	5.82
4	Turmeric	1155	14387	12.46
5	Dry Chilli	2298	11548	5.03

Source: ADD, Madhesh Province, 2081/82

Status of Vegetable Nurseries

- Most of the nurseries are working on fruit and flower commodities.
- They prepare their own seedlings by grafting, seed and other mode of propagation by them selves.
- Most of them direct purchase flower and fruit plants from India and other private nurseries.
- Very few nurseries are working on vegetable seedlings and sell them to farmers.

Challenges

- Inadequate Seed Marketing Information and Infrastructure
- Diseases and Pests Introduction Due to Quarantine Problem
- Lack of a Clear Seed Strategy
- Limited Extension Services
- Private Companies Tend to Concentrate on Profitable Crops
- Lack of Awareness and Knowledge Gap About Seed Production
- Inadequate Source Seed Supply
- Lack of Postharvest Handling Experiences
- Budget Limitation for Field Inspection
- Lack of Effective Large Scale Seed Enterprise and Industry

Opportunities

- Presence of High Seed Demands with a Limited Seed Supply
- Governments and Assisting Agencies are Currently Reassessing their Strategies
- Government Investments in Rural Infrastructure and General Agricultural Policies
- Availability of Human Resource with Trained Person
- Presences of Strong National and Regional Initiatives in Seed Production
- Presence of Development Agents and Different Cooperatives
- Non-Governmental Organizations (NGOs)

Measures

- Coordination among AKC/Farm Centres and NARC related to vegetable seed production program in farmer level
- Capacity Development program for Technical staff as well as farmer
- Seed production program
- Strengthen provincial farm regarding vegetable seed production
- Seed village concept
- Establishment and maintenance of seed bank
- Quality control arrangement on seeds
- Transport Subsidy on movement of seeds
- Seed storage facilities

Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province: Bagmati Province




“बीउ (आलु, तरकारी तथा मसला बाली)को वर्तमान अवस्था, रणनीति, नीतिगत व्यवस्था तथा कार्यक्रमहरू”

बागमती प्रदेश सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय



अरुण खनाल, प्रमुख
कृषि विकास कार्यालय, सिन्धुली परिवार




प्रदेशको सामान्य परिचय

बागमती प्रदेश अन्तरगतका कृषिसंग सम्बन्धित संस्थागत संरचना

कृषि तथा पशुपन्छी विकास मन्त्रालय (सहित ३७)

कृषि विकास निर्देशनालय
(सहित २०)

- कृषि विकास कार्यालयहरू ७ वटा
- अनुसन्धान केंद्र २ वटा
- अनुसन्धान केंद्र विकास कार्यक्रमहरू ३ वटा
- गैरपारित विकास केंद्रहरू १ वटा
- मानवनी विकास केंद्रहरू ५ वटा
- पुन विकास केंद्र १ वटा

बागमती विकास केंद्र, काभ्रे
सिन्धुली (सिन्धुली)
सुनकोट (सुनकोट र रतुवा)
विनयन (विनयन र मकवानपुर)
रामेछाप (रामेछाप र दोलखा)
काभ्रेपलान्चोक (काभ्रे र सिन्धुली)
सल्लुवा (सल्लुवा, काठमाडौं र मकवानपुर)

मकवानपुर विकास केंद्र, विनयन
मकवानपुर (मकवानपुर)
सुनकोट (सुनकोट र रतुवा)
काभ्रेपलान्चोक (काभ्रेपलान्चोक)
दोलखा (दोलखा र सिन्धुली)
सिन्धुली (सिन्धुली र रामेछाप)
सल्लुवा (सल्लुवा, काठमाडौं र मकवानपुर)

पशुपन्छी तथा मत्स्य विकास निर्देशनालय, डेटाडा (सहित १३)

- पशु सेवा कार्यालयहरू ८ वटा
- माछा विकास फार्म १ वटा
- मत्स्य विकास फार्महरू २ वटा
- सल्लुवा केंद्र १ वटा

बागमती विकास केंद्र, काभ्रे
बागमती विकास केंद्र, मकवानपुर
बागमती विकास केंद्र, सिन्धुली
बागमती विकास केंद्र, सुनकोट
बागमती विकास केंद्र, दोलखा

कार्यालय नमूना कृषि/पशु सेवा केंद्र सञ्चालनमा न्याहाल्ने




प्रदेशको सामान्य परिचय

बागमती प्रदेशमा कृषि उपजको उपलब्धता

खाद्यान्नबाली १४,५०,७४२ मे.टन
उत्पादन नपुग ४१,८४२ मे.टन

तरकारी ७,६१,९९२ मे.टन
उत्पादन + ७४,१०६ मे.टन

तेलहन ३२,०१४ मे.टन
उत्पादन नपुग ६७,६१९ मे.टन

मासु १,४२,२०१ मे.टन
उत्पादन ६६,५६४ मे.टन बढी

दूध ४,८२,२०४ मे.टन
उत्पादन नपुग ७४,४३० मे.टन

माछा ३,८७६ मे.टन
उत्पादन नपुग ६३,४०९ मे.टन

दलहनबाली २२,१७७ मे.टन
उत्पादन नपुग १,३८,४४३ मे.टन

फलफूल १,८७,५८१ मे.टन
उत्पादन + ४,०७५ मे.टन

अण्डा ७८ करोड ६२ लाख गोटा
उत्पादन ४९ करोड २६ लाख बढी

Source: MoALD, 2077/78




तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ अनुसन्धान, बीउ उत्पादन तथा वितरणमा संलग्न प्रदेशस्तरका ज्ञान केंद्र/कृषि विकास कार्यालय तथा बागमती केंद्रहरूको समष्टिगत प्रगति स्थिति

विभिन्न बागमती विकास केंद्रहरूको कार्य विवरणमा नै बीउ

- विभिन्न जातका तरकारीको मूल, उन्नत तथा वर्णसंकर बीउ उत्पादन तथा बिक्री वितरण गर्ने।
- विभिन्न जातका तरकारीको गुणस्तरीय बीउ उत्पादन तथा बिक्री वितरण गर्ने।
- मसलाबालीका मूल एवं उन्नत बीउ तथा गुणस्तरीय बीउ उत्पादन तथा बिक्री वितरण गर्ने।
- आलुको पूर्व मूल बीउ, मूल बीउ तथा उन्नत बीउ उत्पादन तथा बिक्री वितरण गर्ने।
- संघीय तथा प्रदेश मन्त्रालय अन्तर्गत संचालन हुने फलफूल, तरकारी तथा मसलाबालीको उत्पादन, बीउ र बिरुवा सम्बन्धी कार्यमा सहयोग गर्ने।
- केंद्र परिसर वा कमाण्ड क्षेत्रभित्र सम्बन्धित बालीको उत्पादन तथा उत्पादनोपरान्त प्रविधि सम्बन्धी समस्यामा आधारित स-साना कार्यमुखी (action oriented) अध्ययन, परीक्षणका क्रियाकलापहरू संचालन गरी प्रचार प्रसार गर्ने।




तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ अनुसन्धान, बीउ उत्पादन तथा वितरणमा संलग्न प्रदेशस्तरका ज्ञान केंद्र/कृषि विकास कार्यालय तथा बागमती केंद्रहरूको समष्टिगत प्रगति स्थिति

बागमती विकास केंद्र, पाँचखाल, काभ्रेपलान्चोक

- वि.सं.२०३१ सालमा नुहल बागमती केंद्रको रूपमा स्थापना, बागमती विकास केंद्र हुँदै मसला बाली विकास केंद्र र २०८० माघ देखि बागमती विकास केंद्र, (१५२ रोपनी)
- बीउ उत्पादन (यस वर्षको लागि)
 - अनुवा. बैसार, मसलाबालीको बीउ उत्पादन- ६ मे.टन
 - तरकारी बीउ उत्पादन (सि. बोडी र काको)- १२० के.जी.
 - तरकारी वर्णसंकर उत्पादन (काको - मधु १ F1 Hybrid)- ४ के.जी.
- बीउ आलु उत्पादन- २५ मे. टन

बैसी/ बिरुवा उत्पादन

- तरकारी बैसी उत्पादन तथा बिक्री वितरण - ८ लाख
- फलफूल बिरुवा उत्पादन तथा बिक्री वितरण - १३०००

बासी	२०७८/७९	२०७९/८०	२०८०/८१	२०८१/८२	२०८२/८३
आलु (मे.टन)	१५	२५	२५	३३	३९
बागमती (मे.टन)	५	४.२	५.७	४.६	५.२
सि.बोडी/काको/बोडी/डेटाडा (के.जी.)	५००	१००	१००	१११	११४
काको/मकवानपुर/सोकोल (के.जी.)	२०	१०	१०	२	२
बैसार (मे.टन)	६	६	६.७	६.२	६.९




तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ अनुसन्धान, बीउ उत्पादन तथा वितरणमा संलग्न प्रदेशस्तरका ज्ञान केंद्र/कृषि विकास कार्यालय तथा बागमती केंद्रहरूको समष्टिगत प्रगति स्थिति

बागमती विकास केंद्र, सिन्धुलीमाडी, सिन्धुली

- वि.सं.२०३१ सालमा सिन्धुली कृषि फार्मको रूपमा स्थापना, बागमती विकास केंद्र हुँदै कर्मचारी तरकारी विकास केंद्र र २०८० माघ देखि बागमती विकास केंद्र (१३३ रोपनी)
- बीउ उत्पादन

क्र.सं.	बासी	जात/वर्ण
१	तरकारी	सल्लुवा रतुवा, सल्लुवा रतुवा, पाख्रा, पहेलो र केतो/काको/काको/काको, सल्लुवा, पाख्रा
२	सि.बोडी/काको	सल्लुवा रतुवा र केतो
३	पाख्रा	सल्लुवा रतुवा, सल्लुवा रतुवा, सल्लुवा रतुवा, सल्लुवा रतुवा
४	मकवानपुर	सल्लुवा रतुवा, सल्लुवा रतुवा
५	मोस	सल्लुवा रतुवा र सल्लुवा रतुवा
६	मुहुरेवा/मकवानपुर	सल्लुवा रतुवा
- बैसी/ बिरुवा उत्पादन: विभिन्न तरकारीका बैसी बिक्री गरिएको, मकवानपुरको सल्लुवा बि, सि.बोडी/काकोको डेटा

क्र.सं.	बासी	जात	२०७८/७९	२०७९/८०	२०८०/८१	२०८१/८२	२०८२/८३
१	कुल	सल्लुवा रतुवा	८३.४०	२५.१	४२.३४	४४.४४	२६.०४
२	बैसी	सल्लुवा रतुवा	४१.८	१०	४२.३४	४६.८५	२७.२५
३	बैसी	सल्लुवा रतुवा	७७.०४	१६.१	४१.७	८८.३०	४९.६४
४	बैसी	PSPL	६.१८	०.२४	०.७४	०	०.७०
५	सल्लुवा	सल्लुवा रतुवा	४.३०	२	०	०	०.४०
६	बैसी	बैसी	१	१५	१५.१	३.२०	२८.६०
	कुल		२१४.७३	२१३.३४	१९१.४६	२०२.९	१२२.३४

तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ अनुसन्धान, बीउ उत्पादन तथा वितरणमा संलग्न प्रदेशस्तरका ज्ञान केन्द्र/कृषि विकास कार्यालय तथा बागवानी केन्द्रहरूको समष्टिगत प्रगति स्थिति

बागवानी विकास केन्द्र, बोंच, दोलखा

- वि.सं. २०३४ सालमा तिव्र उल्हाको सहयोगमा एकिकृत पहाडी विकास योजना अन्तर्गत बागवानी फार्मको रूपमा स्थापना, बागवानी विकास केन्द्र हुने मितोमा फलफूल स्टलक विकास केन्द्र र २०८० माघ वैशाख बागवानी विकास केन्द्र (३२५ रोपनी)
- बीउ उत्पादन: सन्ध २०० केजी
- वेर्ना/ बिस्वा उत्पादन: सन्ध २५ हजार

क्र.सं.	तरकारी बालीको नाम	प्रयोग	कैलिया
१.	बालु	खान/बीउ	स्थानीय, ठेकीबाट
२.	काजली, बन्ना, बोकजली	बिस्वा बिर्की वितरण	स्थानीय मागको बाजारमा (हाईवे)
३.	मुवा	बीउ बिर्कीवितरण	पालिहा सिने
४.	बुर्ज्या, गोल्फेडा (अकन, सिर्वा)	बिस्वा बिर्कीवितरण	स्थानीय मागको बाजारमा
५.	प्याज (रुद्र किचोला)	बिस्वा बिर्कीवितरण	स्थानीय मागको बाजारमा (मुल बीउ)
६.	सिमी	बीउ बिर्कीवितरण	विशुली, चौमारे

वेर्ना/ बिस्वा उत्पादन: कुनै बेला ३ लाख सम्म बलैकी बिस्वा बिर्की वितरण गर्दथे

तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ अनुसन्धान, बीउ उत्पादन तथा वितरणमा संलग्न प्रदेशस्तरका ज्ञान केन्द्र/कृषि विकास कार्यालय तथा बागवानी केन्द्रहरूको समष्टिगत प्रगति स्थिति

बागवानी विकास केन्द्र, त्रिशुली, नुवाकोट

- वि.सं. २०१६ सालमा ३२६ रोपनीमा बागवानी फार्मको रूपमा स्थापना, बागवानी विकास केन्द्र हुने उमेमा प्रदेशीय बागवानी विकास केन्द्र र २०८० माघ वैशाख बागवानी विकास केन्द्र
- बीउ उत्पादन
- वेर्ना/ बिस्वा उत्पादन: १४०२६६ तरकारी वेर्ना उत्पादन एवं बिर्की वितरण

क्र.सं.	बाली	जात	उत्पादन
१.	सिमी	त्रिशुली च्चु सिमी, चार माये, समीलंग	६२३ के.जी. बीउ
२.	बालु		१३८६ के.जी. बीउ ३२८३ के.जी. खान

बागवानी विकास केन्द्र, दामन, मकवानपुर

- बीउ उत्पादन: प्रदेश हुनु भन्दा बागवानी काजली, केण्ड, मुला, उमेको बीउ उत्पादन गर्ने गरेको
- वेर्ना/ बिस्वा उत्पादन: बाग हुने गरेको र उत्पादन भएकैको बलैकी वेर्ना उत्पादन समेत प्रवाह गरिएको

क्र.सं.	बाली	जात	उत्पादन
१.	बालु	बिर्की, काजिन्त, चुमल सेतो, जानकदेव	३ टन बीउ

तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ अनुसन्धान, बीउ उत्पादन तथा वितरणमा संलग्न प्रदेशस्तरमा संचालित वैदेशिक आयोजनाहरू र तिनको कार्यक्षेत्र तथा लक्षित तरकारी बीउ (बालु, तरकारी र मसला) बालीहरू

- प्रदेशस्तरमा यस्ता आयोजनाहरू संचालनमा नरहेको
- पहाडी क्षेत्र काठफल तथा फलफूल विकास आयोजना-NAFHA मा तरकारी सम्बन्धी पनि कार्य हुनेहुनाले गुणस्तरीय बीउको आवश्यकता रहने

तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

- तरकारी बीउ (बालु, तरकारी र मसला) बालीहरूको बालीगत ब्लक तथा पकेटहरूको प्रोफाइल
- सुपरजोन: बालुको काभ्रेपलान्चोक १, सुन्तलाबाटको सिन्धुली १ गरि जम्मा २
- जोन: धानको नुवाकोट, मकवानपुर, चितवन गरी ३ वटा, मकैको सिन्धुपाल्चोक, धादिङ गरी २ वटा, तरकारीको नुवाकोट, धादिङ २, चितवन, मकवानपुर, ललितपुर, भक्तपुर, काठमाण्डौ गरी ८ वटा, बालुको रामेछाप, रसुवा, नुवाकोट, भक्तपुर, काठमाण्डौ, दोलखा गरी ६ वटा, सुन्तलाबाटको रामेछापमा १, केरा चितवनमा १, किमीको दोलखा १, बलुवा बेसारको सिन्धुली १, गाईपैसीको सिन्धुपाल्चोक, काभ्रे, ललितपुर गरी ३, बाखा भेडा प्याप्राको रामेछाप, रसुवा गरी २, मारीको चितवन १ गरि जम्मा २९ वटा
- ब्लक: २०७५/७६ सम्म कुल ५७ ब्लक संचालन
 - २०७५/७६ मा कुल २७ ब्लक मध्ये तरकारीको ९ र बालुको २
 - २०७६/७७ मा १९ ब्लक मध्ये तरकारी ७ र बालुको २
 - २०७७/७८ मा ५४ मा तरकारी ३४, बलुवा/बेसार २, बालु ६
 - २०७८/७९ मा पुरानो १०३ जसमा तरकारी ३९, बलुवा/बेसार २, बालु १३ र नया ५७ मध्ये तरकारी ८, बलुवा/बेसार २, बालु ७
 - २०७९/८० मा पुरानो ५७ जसमा तरकारी ८, बलुवा/बेसार २, बालु ८
 - २०८०/८१ मा १३ (तरकारी ४ र बालु १) र २०८१/८२ मा त्यसको निरन्तरता

तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ (बालु, तरकारी र मसला) बालीहरूको क्षेत्रफल, उत्पादन, उत्पादकत्व र बीउ/वेर्ना उत्पादनको स्थिति (हेक्टर, मे.टन र मे.टन/हे.)

क्र.सं.	जिल्ला	बालु	तरकारी बाली	मसलाबाली
१.	दोलखा	३०७९	५५९४८	१८९७
२.	सिन्धुपाल्चोक	३४१५	५८०५५	१७००
३.	रसुवा	२५९५	५५३८७	७४९९
४.	रामेछाप	३३७८	५९९२४	१४७८
५.	सिन्धुली	२३५३	५२१६६	१७९२
६.	काभ्रे	८९०९	१९४७६६	२१८६
७.	भक्तपुर	१०८५	२६५८३	२४५०
८.	ललितपुर	११४५	२८२१६	२०८०
९.	काठमाण्डौ	२५४६	६३६४०	२४५०
१०.	नुवाकोट	४४५३	८९२६३	१८२५
११.	धादिङ	१८००	३५१००	१९५०
१२.	मकवानपुर	४९३५	१०५२१४	२१३२
१३.	चितवन	१९६०	३३३२०	१७००
जम्मा		३५१५९	७०११८८	१९९४

तरकारी बीउको अनुसन्धान, बीउ उत्पादन तथा वितरणको वर्तमान अवस्था

तरकारी बीउ (बालु, तरकारी र मसला) बालीहरूको क्षेत्रफल, उत्पादन, उत्पादकत्व र बीउ/वेर्ना उत्पादनको स्थिति

क्र.सं.	मुख्य बाली	लगाउने क्षेत्रफल हे.	आवश्यक उन्नत बीउ मे.टन	क्र.सं.	मुख्य बाली	लगाउने क्षेत्रफल हे.	आवश्यक उन्नत बीउ मे.टन
१.	बालु	३५१५९	७०३१७	१४.	रायो साग	२६७३	०.५३
२.	बलुवा	३४५६	१७२८०	१५.	भेडे खुर्चानी	७०८	०.४२
३.	बेसार	१२७२	३९८०	१६.	प्याज	६४७	६.५
४.	लसुवा	१६१०	८०५	१७.	फर्सी	१९६९	३.९४
५.	गोल्फेडा	६९६६	१.२३	१८.	करैला	१२६८	२.५४
६.	काजली	६८३७	४.१	१९.	घिरेला	७९०	१.५८
७.	बन्ना	६७३३	३.४	२०.	भाण्डा	८१६	०.४९
८.	काँको	२४२६	६.१	२१.	भिडी	११४७	११.५
९.	मुला	३८१८	२.३				
१०.	गाजर	१३७१	८.२				
११.	खुर्सानी	१०६७	०.६४				
१२.	सिमी	२१४६	४२.९				
१३.	बोडी	३५३	१.४				

Seed Vision अनुसारको सक्थ प्राप्तिको लागि पनि (SRR rate %)

बाली	सक्थ
बालु	१५
तरकारी	९०

Current Status, Strategy, Policy and Programs of Seed (Potato, Vegetable and Spice Crops) in the Province: Sudurpashchim Province



सुदूरपश्चिम प्रदेश सरकार
कृषि तथा पशुपन्छी विकास मन्त्रालय
कृषि विकास निर्देशनालय
दिपायल, डोटी



“बीउ (आलु, तरकारी तथा मसला बाली) को वर्तमान अवस्था, रणनीति, नीतिगत व्यवस्था तथा कार्यक्रमहरू”

खगेन्द्र प्रसाद शर्मा
प्रमुख

सुदूरपश्चिम प्रदेशको कृषि सम्बन्धी संक्षिप्त विवरण

क्र. सं.	विवरण	प्रादेशिक तथ्याङ्क	राष्ट्रिय तथ्याङ्क	राष्ट्रिय तुलनामा सु.प.को अवस्था
१.	कुल खेति योग्य जमिन (हे.)	३,६९,७९६ हेक्टर	४१,२९,००० हेक्टर	८.९८%
२.	खेति गरिएको क्षेत्रफल (हे.)	३,९८,५२६ पुरानो तथ्याङ्क १,९२,८८४ हेक्टर*	२२,९८,४०९ हेक्टर*	८.६९%
३.	कृषि पेशामा निर्भर जनसंख्या (%)	७९ प्रतिशत* (पहिले ८४ %)	६०.४%	
४.	कुल सिंचित क्षेत्रफल जम्मा (हे.)	१,७९,७५० हे. (५६.४३%) १,९६,५६४ हे.* (६०.४३%) (खेती गरिएको क्षेत्रफलमा)	१५,३३,२६९ (आर्थिक सर्वेक्षण २०७९/८०)	५.८२%
५.	प्रति कृषक परिवार खेतियोग्य जग्गा (हे.)	०.५३ हेक्टर	०.५५ हेक्टर	

* राष्ट्रिय कृषि गणना २०७८ अनुसार

प्रदेशको कृषि सम्बन्धी संक्षिप्त परिचय ...

जिल्ला	कुल क्षेत्रफल (हे.)	खेतीयोग्य जमिन (हे.)	खेती गरिएको जमिन (हे.)*		सिंचित क्षेत्रफल (हेक्टर)*	
			प्रदेशमा प्रयोग भएको	राष्ट्रिय कृषि गणना २०७८ अनुसार	प्रदेशमा प्रयोग भएको	राष्ट्रिय कृषि गणना २०७८ अनुसार
कैलाली	३२३५००	९००००	८६४५०	६२७३४.२	७६०००	५५०४२.३
कञ्चनपुर	१६९७४९	५९६०२	५६६०२	४२२४९.०	३९९८५	३७६९९.४
अछाम	२९१०८५	५६३४७	४२४९३	१६४५३.९	१०३०८	५३९०.७
डोटी	१९६०९८	३२२७६	२५५००	१२७९०.८	१४५९७	४८९०.९
डडेल्धुरा	१५३८००	१९६९६	१०६६७	१०९९२.३	४८९७	३२९३.०
बैतडी	१४५९९३	३९४८५	२५७००	१९९२५.६	१०५००	२९९५.०
बाजुरा	२९८८००	२४३९९	२०९५५	६७९२.५	५२३५	१९६९.३
बझाङ	३६७८५५	३४६०७	२८२९४	९९४२.३	१०८५०	३३५४.३
दार्चुला	२३२२००	२९५४४	२२८२५	१९८०४.४	७४५८	२९०५.३
जम्मा	२०९०९०२	३६९७९६	३९८५२६	१९२८८५	१७९७५०	१९६५६४
सिंचित क्षेत्रफल प्रतिशतमा				५६.४३		६०.४३

प्रदेशमा आलु, तरकारी तथा मसला बालीहरूको क्षेत्रफल, उत्पादन र उत्पादकत्व

क्र.सं.	बाली	क्षेत्रफल (हेक्टर)	उत्पादन (मे.टन)	उत्पादकत्व (मे.टन/हे.)
१	आलु	१८,९९९	२,४७,९४३	१३.६३
२	तरकारी	२४,५४२	३,२४,२००	१३.२९
३	अदुवा	१,५२९	२२,५६८	१४.७६
४	लसुन	१,८९३	२०,४८२	१०.८२
५	बैसार	१,४९४	१६,२५४	१०.८८
६	खुर्सानी	१,५७७	३९,०४६	२४.७६
७	अलैची	३४.५ (२५.१० उत्पादनशिल)	२६.०५	१.०४

तरकारी बीउ उत्पादनमा संलग्न कृषक समूह/सहकारी /फर्महरू/बीउ कम्पनीहरू

क्र. सं.	जिल्ला	बीउ उत्पादनमा संलग्न समूह/सहकारी	बीउ उत्पादन गरिने बालीहरू	बीउको स्तर
१.	डोटी	जैविक विविधता कृषि सहकारी संस्था लि., जोरायल गा.पा.	केराउ, रायो, मूला, पालुङ्गो	उन्नत
२.	डडेल्धुरा	डडेल्धुरा कृषक सहकारी संस्था लि. शैलेधर महादेव कृषि सहकारी संस्था लि. मणिलेक बीउ प्रवर्द्धन कृषि सहकारी स. ली. बेडुपानी शिखरधुरा बीउविज्ञ केन्द्र प्रा. लि. धोलाकोट एम. के. कृषि नर्सरी फर्म	सिमि, भिन्डी, केराउ केराउ मूला, रायो, केराउ, सिमि सिमि	उन्नत उन्नत उन्नत उन्नत उन्नत
३.	दार्चुला	दार्चुला सिड्स एण्ड सप्लायर्स, शैलेशिखर	मूला, रायो, पालुङ्गो	उन्नत

सहकारी/फर्महरू/बीउ कम्पनीहरू.....

क्र. सं.	जिल्ला	बीउ उत्पादनमा संलग्न समूह/सहकारी	बीउ उत्पादन गरिने बालीहरू	बीउको स्तर
४.	बाजुरा	दलित एकता मिश्रित कृषक समूह स्वाभिमानीक १ हाम्रो सहकारी कृषक समूह, बुढिगंगा १ नाथ बहुउद्देश्यीय तरकारी फर्म बडिमालीका ४	प्याज प्याज प्याज	उन्नत उन्नत उन्नत
५.	कैलाली	पञ्चशक्ति बीउ कम्पनी, धनगढी, कैलाली युनिक बीउ कम्पनी, धनगढी, कैलाली	रायो, मूला, शलगम, प्याज, घ्यूसिमी, पालुङ्गो, चम्सुर, मेथी, लहर तरकारी, रामतोरिया, गोलभेडा, काउली, बन्दा, ब्रोकाउली रायो, मूला, केराउ, घ्यू सिमी, बोडी, रामतोरिया, काँक्रो, चम्सुर र आलु	उन्नत उन्नत
६.	डडेल्धुरा	युनाइटेड सिड्स इन्टरनेशनल प्रा.लि. धुरा एग्रो एण्ड सिड प्रा.लि.	सिमि, मूला, धनिया, केराउ सिमि	उन्नत उन्नत

तरकारी जर्मप्लाज्म सम्बर्द्धन तथा तरकारी बीउ उत्पादन केन्द्र, डडेल्धुराद्वारा विगत २ आ.व. मा उत्पादित तरकारी बीउको विवरण

क्र.सं.	तरकारीको नाम	जात	उत्पादित परिमाण (के.जी.)		कैफियत
			आ.व. २०७९/८०	आ.व. २०८०/८१	
१	रायो	खुमल रातोपात	१०२	२०५	मूल बीउ
२	मूला	मिनोब्रली	१५०	१५७	मूल बीउ
३	केराउ	सिक्किमे	१००	२२	मूल बीउ
		सलाही अकेल	१२०	११	मूल बीउ
४	स्वचास	ग्रे जुकिनी	३	७	उन्नत
५	स्विसचाई	सुसाग	-	३०	उन्नत
६	काँक्रो	भक्तपुर लोकल	-	०.५	उन्नत
७	प्याज	रेड क्रियोल	३	७	उन्नत
८	घनिया	पन्त कलमी	-	३५	उन्नत
९	आलु	कार्डिनल	५००	-	PBS दोश्रो पुस्ता
	जम्मा		९७८	४७४.५	

तरकारी बीउ उत्पादन र प्रवर्द्धनका लागि प्रदेश सरकारले संचालन गर्ने गरेका कार्यक्रम तथा क्रियाकलापहरु

- श्रोत बीउ उत्पादन, वितरण तथा उन्नत बीउ उत्पादनमा सहयोग।
- बीउ उत्पादन प्रविधि सम्बन्धी कृषक तालिम।
- बीउ प्रशोधन मेशिनरी, सामग्री तथा प्रशोधन गृह निर्माणमा सहयोग।
- बीउ भण्डारणका लागि गोदाम घर, रष्टिक स्टोर र कोल्ड च्याम्बर निर्माणमा सहयोग।
- बीउ प्याकेजिङ तथा बजारीकरणका लागि आवश्यक सहयोग।
- रैथाने/स्थानीय बाली एवं जात संरक्षण र प्रवर्द्धनमा सहयोग।
- सरोकारवालाहरूसँग समन्वय र सहकार्यका कार्यक्रम।

बीउ उत्पादनमा देखिएका समस्याहरू

- प्रयास मात्रामा गुणस्तरिय श्रोत बीउ उपलब्ध नहुनु।
- खुला सिमानाका कारण गुणस्तरहिन, विशेषगरी बीउआलु ठूलो परिमाणमा आयात भइरहेको।
- विदेशी वर्णशंकर (Hybrid) जात एवं बीउको बिगबिगी हुनु।
- स्वदेशी वर्णशंकर (Hybrid) जात एवं बीउको विकासको गति सुस्त रहनु।
- कतिपय रैथाने/स्थानीय बाली र जात लोप हुने अवस्थामा पुगनु।
- बीउ उत्पादन गर्न बढी समय लाग्ने हुँदा कृषकहरू ताजा खायन उत्पादन तर्फ आकर्षित हुनु।
- गुणस्तरीय बीउ उत्पादन गर्न कृषकहरूमा उन्नत ज्ञान, सीपको कमी
- बीउको गुणस्तर कायम गर्न नसकिनु।
- जनशक्तिको अभाव।

बीउ उत्पादनमा देखिएका समस्याहरू ...

- भरपर्दो सिंचाई र मलखादको कमी हुनु।
- प्राकृतिक प्रकोप विशेषगरी सुख्खा खडेरी र असिनाले बीउ बालीलाई क्षति पुऱ्याउने गरेको।
- उत्पादित बीउको उचित मूल्य पनि प्राप्त नहुनु।
- जग्गा बाँझो रहने तथा जंगली जनावरको समस्या बढ्दै जानु।
- बसाई सराई र युवा पलायन बढ्दै जाँदा तरकारी बीउ उत्पादनमा संलग्न कृषकहरूको सहभागिता पनि घट्दै जानु।
- बीउ उत्पादन क्षेत्र भौगोलिक रूपले प्रायः विकट हुनु।

समस्या समाधानका लागि सुझावहरू

- भारत संगको खुला सिमानालाई व्यवस्थित बनाउँदै तथा कृषि क्वारन्टाइन प्रणालीको सुदृढीकरण मार्फत बीउको आयातमा कडाई गर्नु पर्ने।
- सरकारी, गै.स.स., सहकारी र नीजि क्षेत्रको समन्वय र सहकार्यमा प्रयास मात्रामा गुणस्तरिय बीउ (श्रोत र उन्नत) उपलब्ध हुने व्यवस्था मिलाउनु पर्ने।
- स्वदेशी खुला सेचित (Open Pollinated) तथा वर्णशंकर (Hybrid) जात एवं बीउको विकासका लागि विशेष जोड दिनु पर्ने।
- महत्वपूर्ण रैथाने/स्थानीय बाली र जातलाई लोप हुन नदिन संरक्षण एवं प्रवर्द्धनका कार्यक्रमहरू संचालन गर्नु पर्ने।
- बीउ उत्पादनका उन्नत प्रविधिहरूको विकास र विस्तारलाई एकिकृत रूपमा अघि बढाउनु पर्ने।
- गुणस्तरीय जनशक्तिको व्यवस्था मिलाउनु पर्ने।

समस्या समाधानका लागि सुझावहरू ...

- सिंचाई विस्तार तथा मलखादको उपलब्धतामा सुधार ल्याउनु पर्ने।
- प्राकृतिक प्रकोपबाट बीउ बालीलाई जोगाउने उपायहरू तथा बाली बीमामा जोड दिनु पर्ने।
- उत्पादित बीउको उचित मूल्य प्राप्त हुनेगरी करार सम्झौता गरेर मात्र खेती गर्ने तथा प्रतिफलमा आधारित अनुदान दिने परिपाटी बसाल्नु पर्ने।
- बाँझो जग्गाको उपयोग बढाउने तथा जंगली जनावरको समस्या हल गर्ने खालका नीति, कानून र कार्यक्रम ल्याउनु पर्ने।
- बीउ उत्पादन पकेट क्षेत्रहरूको पहिचान गर्दै तिनको विकास र विस्तार गर्नु पर्ने। आवश्यकता अनुसार वैदेशिक लगानी भित्र्याउनु पर्ने।
- आधारभूत पूर्वाधार विकास मार्फत बसाई सराईलाई कम गर्दै बीउ उत्पादनमा समेत युवाहरूलाई आकर्षित गर्नु पर्ने।

Recommendations of the Seminar

Following recommendations are made for strengthening seed sector of potato, vegetable and spice crops:

Details of activities to be performed in accordance with recommendation

S. No.	Recommendation	Responsible Organization	Support Organization
(A) Policy and Strategy Level			
1.	Germplasm acquisition Policy	MoALD	SQCC/PQPMC
2.	Plant Variety Protection act and breeders right	MoALD	SQCC/NHRC
3.	Hybrid Seed Sector Promotion Policy	MoALD	SQCC/NHRC
4.	Cold Storage Seed Potato Insurance policy	MoALD	SQCC/NPRP
5.	Strategy for declaration of vegetable seed production zone e.g. Jumla for carrot seed production	MoALD/DoA	NARC/NCPVSCD/ Universities
6.	Strategy to provide tax breaks or other incentives for companies and researchers/breeders involve in developing innovative hybrid vegetable varieties	MoF	MoALD
(B) Program Level/Implementation Level			
1.	Allocate sufficient Budget for research in Variety Development and hybrid seed production	MoF	MoALD
2.	Prioritize human resource development and management for vegetable breeding	MoALD/MoF	NARC/Universities
3.	Expedite variety registration process and promote PPP for private sector led variety registration	MoALD	SQCC
4.	Conduct action research by all government farms, farmers field and private seed companies	DoA/NARC	NCPVSCD/seed companies
5.	Collaborative/Co-ordinated research program	MoALD	NARC/DOA/ Universities
6.	Ginger and turmeric seed promotion program in farmers/ groups/co-operatives level (Identification of pocket and program implementation)	MoALD	NCPVSCD/NARC/ Province
7.	Protecting landraces with geographical indication tag and domestication and commercialization of wild vegetables as well as Banking VGRs (through agro gene sanctuary, field Gene Bank etc.)	NARC/Gene Bank	DoA/NCPVSCD/ Farm Centers
8.	Assurance of vegetable breeder seed and assign NARC Centers/government farm center for breeder seed maintenance under designated breeders	NARC	DoA/SQCC/ NCPVSCD /STL
9.	Strategy to encourage banks and financial institutions to invest in seed research projects	NRB	MoALD
10.	Vegetable seed data collection and documentation	NARC/NCPVSCD	SQCC/SEAN/Seed Companies
(C) Other Cross Cutting Issues			
1.	Contract facilitation of the vegetable, potato and spice crops seed with buy-back guarantee	MoALD/ NCPVSCD	Private Sector/Farm Centers
2.	Seed cycle maintenance of vegetables, potato and spices	SQCC/STL	DoA/NCPVSCD/ Provincial farm/AKC
3.	Certification of vegetable seeds produced by government farms	SQCC/STL	DoA/NCPVSCD
4.	Linkage with international consortiums like Asian Vegetable Research and Development Center (AVRDC), World Vegetable Centre etc.	MoALD/ NCPVSCD/ NARC	Private Sector/ Seed Companies
5.	Establish a molecular lab capable of doing RT-PCR test and other test on demand	SQCC/NARC	SEAN/Seed companies