Annual Report
FY 2024-2025

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National Centre for Organic Agriculture, Yusipang
Department of Agriculture
Ministry of Agriculture and Livestock
Thimphu, Bhutan

Published by:
National Centre for Organic Agriculture, Yusipang, Thimphu
Department of Agriculture
Ministry of Agriculture & Livestock
Royal Government of Bhutan
June 2025

Editor:
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Suggested Citation:
NCOA Yusipang. Annual Report 2024-2025, Department of Agriculture, Ministry of Agriculture and Livestock, Thimphu

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INTRODUCTION TO NATIONAL CENTRE FOR ORGANIC AGRICULTURE YUSIPANG

The National Centre for Organic Agriculture (NCOA) is located at Yusipang which is about 15 km from Thimphu city on the Thimphu-Punakha highway. The Centre falls under Chang Gewog of Thimphu Dzongkhag and it is located at an altitude of 2700 meters above sea level (masl). The Centre has a very rich and dynamic history that dates back to Bhutan's second Five Year Plan. The important historical events and shifts in organogram ever since the establishment of the Centre is presented below in a chronological order.

1969 His Majesty, the Third Druk Gyalpo, Jigme Dorji Wangchuk marked the opening of the Centre on 21st May, 1969 as the Horticulture Research Station. Since then, the Centre has been working on the evaluation of temperate fruits and promotion of improved horticulture production technologies.

1987 Between 1981 and 1987 the International Potato Centre (CIP) initiated a nationwide program on Potato which was coordinated from Yusipang. This led to the establishment of the Applied Research Centre with the focus on potato. With support from SDC/Helvetas new infrastructures were developed and the research scope expanded to other crops.

1989 The Department of Agriculture (DoA) initiated the organization of the research programs by setting up commodity-focused Agriculture Research Centres. Accordingly, the Applied Research Centre Yusipang was renamed as Agriculture Research Centre (ARC) and it was recognized as one of the then five research Centres in the country. The Centre was also assigned with the national mandate to lead potato research and promote potato-based farming system.

1994 Livestock, forestry and agriculture which are the three sectors under Ministry of Agriculture and Forest (MoAF) were functioning independently until 1994. With ministry's new objective of integrating all sectors under one umbrella was yet another historic move to enhance collaboration between different sectors. The three sectors were formally consolidated and renamed as Renewable Natural Resources Research Centre (RNRRC) with Field Crops, Horticulture, Livestock, and Forestry as the four major research programs. Council of Renewable Natural Resource Research of Bhutan (CoRRB) was created as the administrative apex body to coordinate and regulate various research across all RNRRCs. RNRRC Yusipang was given the national mandate to coordinate forestry research.

2009 The MoAF further felt the need to strengthen the research and extension linkages among the line departments at the regional level by assigning development mandates to all RNRRCs. Accordingly, all four RNRRCs were re-designated as RNR Research and Development Centre (RNR RDC). By its national mandate RNR RDC Yusipang was administratively realigned to the Department of Forest and Park Services (DOFPS).

2016 The first Organizational Development Exercise (ODE) recommended the restructuring of all RNR RDCs under their respective departments (Forestry, Livestock and Agriculture). Accordingly, the mandate of RNR RDC-Yusipang was shifted from Forestry to Agriculture and it was subsequently renamed as the Agriculture Research and Development Centre (ARDC)-Yusipang. It was also identified as a potential Centre to coordinate the National Organic Program (NOP).

2017 The second ODE recommended the realignment of the National Organic Program (NOP) at Semtokha to be shifted to Yusipang and function as one unit under ARDC, Yusipang and ARDC Yusipang was assigned the national mandate to coordinate and lead the Organic Agriculture (OA) research and development programs. The same exercise recommended transfer of National Potato Program (NPP) from National Seed Centre (NSC), Paro to ARDC Yusipang and was assigned national mandate to coordinate potato research and development programs.

2020 ARDC-Yusipang was renamed as the National Centre for Organic Agriculture (NCOA) and it was identified as the apex body to coordinate and facilitate the overall development of organic plans and programs in the country. NCOA is also responsible for regulation and certification of organic farms in accordance with Bhutan Organic Guarantee System (BOGS) and Local Organic Assurance System (LOAS). NCOA is administratively under the Agriculture Research and Innovation Division (ARID) of Department of Agriculture (DoA). To strengthen efficient service delivery for low altitude areas, a new sub-Centre under NCOA Yusipang has also been approved at Khaibeytar, Samphelling Gewog under Chhukha Dzongkhag.

Vision

A self-reliant, productive, diverse, resilient, and sustainable agriculture food system.

Mission

Achieve food and nutrition security, agricultural transformation through innovative and sustainable technologies, diversified and competitive economic/production options, inclusive and sustainable policies and programs.

Mandates

NCOA is mandated to serve both at national and regional level as follows:

National Mandate

1. As an apex body for Organic Agriculture, NCOA develop guidelines, implement policy directives and decisions of the National Organic Board (NOB) and National technical Working Group (NWG) on Organic Agriculture.
2. Facilitate the Registration, Certification, and Regulation of Organic Sector within the purview of the Bhutan Organic Guarantee System (BOGS) and Bhutan Organic Standards (BOS).
3. Register and regulate Certifying Bodies and other stakeholders engaged in the organic value chain in the country.
4. Coordinate and lead organic research and development programs including adaptive research on crop improvement and generation of organic production technologies.
5. Develop and maintain the database in the organic sector.
6. Serve as the Secretariat for the National Technical Working Group on Organic Agriculture.
7. Facilitate knowledge management, dissemination, and capacity development needs on Organic Agriculture.
8. Coordinate the National Potato Research and Development Program
9. Coordinate the National Vegetable Research and Development Program
10. Coordinate National Oil Seeds Commodity Program
11. Coordinate and implement project plans and programs under the supervision of Department of Agriculture.

Regional Mandate

1. Provide technical support to the Dzongkhag Agriculture Sector of four client Dzongkhags namely Chhukha, Haa, Paro, and Thimphu in planning and implementation of agriculture development programs.
2. Collaborate and support other ARDCs and Central Programs under DoA in implementing nationally coordinated activities in the region.

ORGANOGRAM

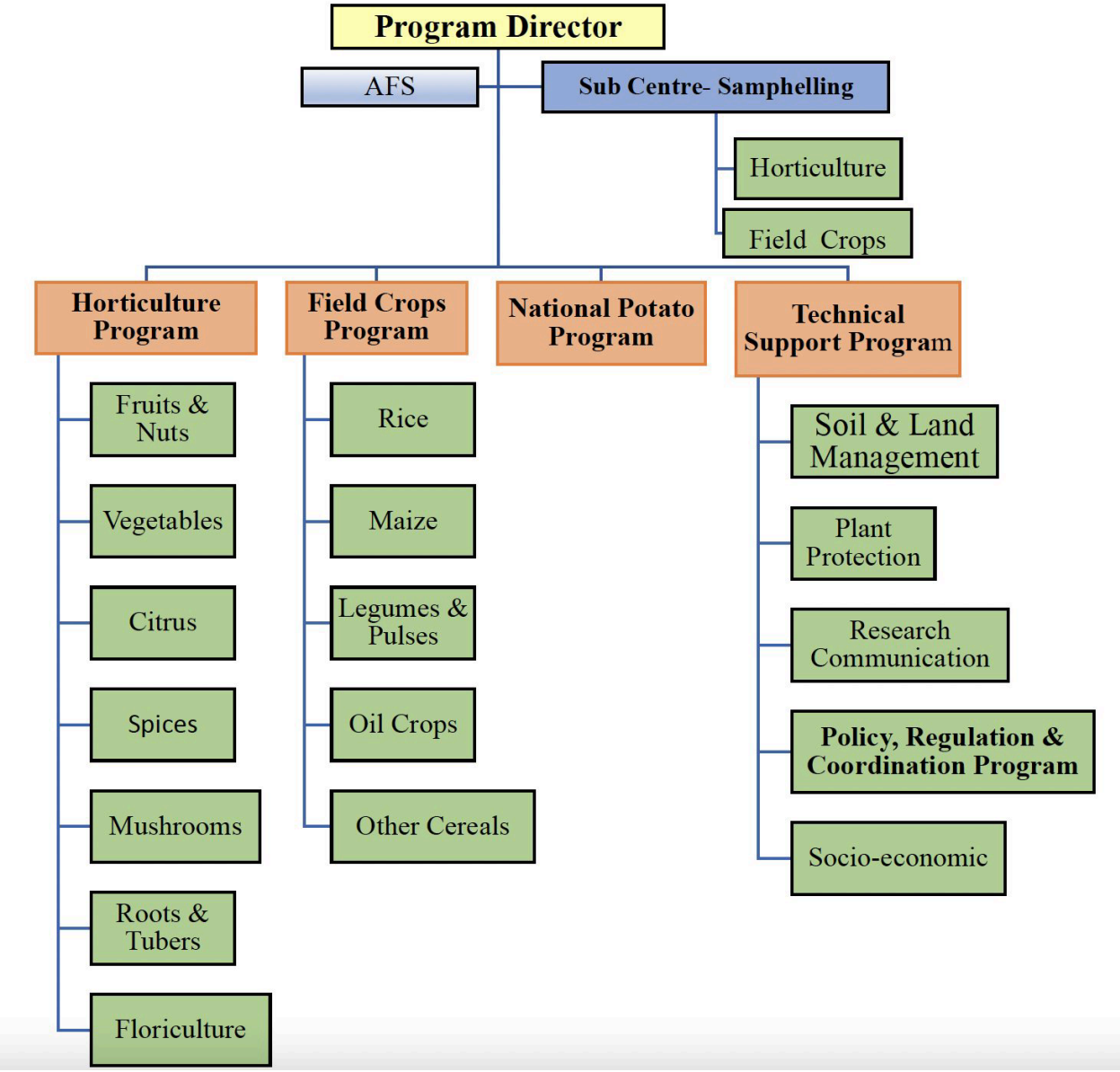

Figure i. *Organogram of National Centre for Organic Agriculture-Yusipang*

ACKNOWLEDGEMENT

The National Centre for Organic Agriculture (NCOA) would like to sincerely acknowledge and express its gratitude to all individuals and institutions whose support and collaboration made the successful implementation of activities during the financial year 2024–2025 possible.

We extend our deep appreciation to the Department of Agriculture for its continued guidance and oversight in the implementation of our programs. We are also grateful for the financial support received from the Royal Government of Bhutan (RGoB), which enabled the overall coordination and management of our initiatives. Our sincere thanks go to the Integrated Temperate Fruit Crop Promotion (INTECrop-JICA) for their technical and financial support in strengthening the temperate fruit nursery and orchard management systems, and to the Asian Food and Agriculture Cooperation Initiative (AFACI) for their support in the development of vegetable varieties.

We would also like to acknowledge the invaluable cooperation of our regional partners-Dzongkhag and Gewog Agriculture Extension Centres and the dedicated farmers across the four Dzongkhags, whose active participation and commitment were instrumental in the testing and expansion of farming technologies in the region. Their contributions have been vital in advancing our shared goals of sustainable and resilient agriculture.

This NCOA annual report documents all major activities undertaken during the financial year 2024-2025 and report either completion or status for the long-term and ongoing activities.

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1. FIELD CROPS RESEARCH AND DEVELOPMENT PROGRAM

The Field Crops Program at the National Centre for Organic Agriculture (NCOA), Yusipang, is nationally mandated to work on oilseeds and high-altitude rice, with key research activities in high-altitude rice, quinoa, wheat, and Neglected and Under-utilized Species (NUS). The program, staffed by four researchers, supports four Dzongkhags: Thimphu, Paro, Haa, and Chhukha. Since 2017, it has conducted high-altitude rice research in Ramthangkha, Paro, focusing on variety selection, seed production, and conservation of traditional varieties. It leads the FAO's Flexible Voluntary Contribution (FVC) output 1 under the OCOP initiative, implementing a project (FAO/FVC/RAS/209/MUL) to enhance quinoa productivity, which Bhutan has prioritized under its 13th Five-Year Plan. The FAO Director General visited NCOA in March 2025 to hand over equipment to farmers supported by this project.

The Program in close collaboration and fund support from the National Biodiversity Centre (NBC) also implemented the activities of the Neglected and Underutilized Species (NUS) projects.

1.1. FIELD CROPS RESEARCH ACTIVITIES

1.1.1. Rice production evaluation research, 2024

Two Evolutionary Plant Breeding (EPB) mixtures and three other varieties were compared with Yusiray Kaap 3 as the Standard Check. The trial design followed was RCBD with three replications with a plot size of 2 m X 5 m. The EPB mixtures were generated by mixing different high-altitude varieties and allowed to evolve over time in the high-altitude rice growing environment. The other three varieties were Sashanishiki, Sticky rice and D-10 (a local selection of Dumbja). The agronomic parameters are presented in **Table 1.1** and yield parameter in **Table 1.2**. There was significant difference in plant height, mean tiller numbers; days to maturity and 100 grain weight. D-10 was the tallest variety, had highest 100 grain weight and was late in maturity. The Japonica varieties Sashanishiki and Sticky rice had the highest number of tillers.

There was significant difference in grain yield. The highest yield of 2949.54 kg/ac was recorded for D-10 which was not significantly different from the check variety Yusiray Kaap 3. There was no significant difference in the harvest index (HI) among the varieties indicating that all the varieties were equally efficient in the production of economic yield. The HI ranged from 24.57% to 31.33%.

Table 1. 1. Plant height, tiller numbers, days to maturity, 1000 grain weight of six varieties, PET 2024

Varieties	Plant Height (cm)	Mean Tiller Numbers	Days to Maturity (Days)	1000 Grain Weight (gm)
EPB Mixture- Shari	102.20^{b}	13.37^{abc}	129.33^{b}	18.93^{ab}
EPB Mixture- Mitse	134.73 ^{a}	10.47^{bc}	130.33^{b}	21.00^{ab}
Sashanishiki	76.27^{d}	19.93^{a}	137.00^{a}	19.47^{ab}
Sticky rice	73.73^{d}	18.67^{ab}	136.67^{a}	18.37^{b}
D-10	132.07^{a}	11.20^{bc}	137.67^{a}	23.07^{a}
Yusiray Kaap 3 (Check)	94.20^{c}	7.73^{c}	136.33^{a}	20.63^{ab}
P Value	p<0.001	<0.05	p<0.001	<0.05
CV (%)	1.87	22.32	1.01	7.83
SE	1.56	2.47	1.11	1.29

Table 1. 2. Yield parameters, PET 2024

Varieties	Grain Yield (kg/ac)	Straw Yield (kg/ac)	Harvest Index (%)
EPB Mixture- Shari	2214.38^{bc}	6833.33	24.57
EPB Mixture- Mitse	3034.61^{a}	7433.33	29.48
Sashanishiki	1903.93^{c}	5600.00	25.41
Sticky	1847.85^{c}	4866.67	27.70
D-10	2949.54^{a}	6500.00	31.33
Yusiray Kaap 3 (Check)	2609.54^{ab}	8033.33	24.81
P Value	p<0.001	p>0.05	p>0.05
CV (%)	9.5	18.40	14.89
SE	188.16	983.15	3.31

1.1.2. Determination of cost of production (CoP) of organic rice

NCOA Yusipang research farm is a certified Organic farm. It was certified under the Local Organic Assurance Scheme (LOAS) which follows the Bhutan Organic Standards (BOS) of the Bhutan Organic Guarantee System (BOGS). High altitude organic rice was cultivation at Yusipang was started in 2023. In 2024, the nursery for the two varieties was raised on 1st February, 2024 and transplanted on 29th April, 2024. The crop was harvested on 28th November, 2024.

After successful adaptation of two cold tolerant varieties namely Khangma Maap and Jakarray Naab under organic management regime, the CoP of organic rice was determined. The CoP of Organic rice was estimated to be Nu. 80.80 per kg. The COP of Organic rice was 1.65 times higher than the COP conventional rice which is estimated at Nu. 49 per kg. The details of the COP are presented in **Table 1.3**.

Table 1. 3. Cost of production (CoP) of organic rice at Yusipang, 2024

Total Yield of organic rice (kg) per acre at NCOA, Yusipang					1643.85	
A. Variable cost						
1. Labor cost						
Sl. No.	**Variables**	**Unit**	**Quantity**	**Cost/unit (Nu)**	**Total cost (Nu) for 0.3 acres**	**Total cost/acre (Nu)**
i.	Nursery establishment	No	3	1000	3000	10000
ii.	Nursery weeding and management	No	3	1000	3000	10000
iii.	First ploughing and field preparation	No	1	1000	1000	3333.33
iv.	Puddling and bund preparation	No	3	1000	3000	10000
v.	Nursery uprooting and transplanting	No	3	1000	3000	10000
vi.	Weeding and irrigation	No	8	1000	6000	20000
vii.	Power tiller with operator	No	2.5	3500	8750	29166.67
ix.	Harvesting and threshing	No	3	1000	3000	10000
Total Labor cost/acre						**102500.00**
2. Input cost						
	Variables	**Unit**	**Quantity**	**Cost per unit (Nu)**	**Total cost (Nu) for 0.3 acres**	**Total cost per acre (Nu)**
i.	Plastic for nursery	m	15	80	1200	4000
ii.	Chicken manure	Bags	20	170	3400	11333.33
Total Input cost/acre						**15333.33**
A. Fixed cost						
	Variables	**Unit**	**Quantity**	**Cost per unit (Nu)**	**Total cost (Nu) for 0.3 acres**	**Total cost per acre (Nu)**
i.	Land rent	Decimal	100	150	4500	15000
Total Fixed cost/acre						**15000**
Total variable cost/acre						**117833.33**
Total Fixed cost/acre						**15000**
Total Cost of production/acre						**132833.33**
Cost per unit (Kg)						**80.80**

1.1.3. Effect of different biopesticides on pest infestation and yield of quinoa

Quinoa crop is severely affected by Leaf miners (suspected to be Agromyzidae flies) which damage the plants in their early stages. For quinoa production under organic management, finding effective bio-pesticides is essential to protecting crop. The use of bio-pesticides could provide an organic solution to control leaf miner infestations, ensuring successful organic production. To assess the effectiveness of various bio-pesticides in managing leaf miner infestations in quinoa grown under organic regime, a replicated trial was conducted during the 2024 season at NCOA, Yusipang.

A field trial was conducted to assess five different bio-pesticides following Randomized Complete Block Design (RCBD) with three replications. The treatments included Neem oil (4 ml/liter of water), Artemisia Extract (1 liter/10 liters of water), Jhol Mol (1 liter/liter of water), Wood vinegar, and Control (no treatment). After dilution, 15 liters of each treatment was applied to the respective plots, each measuring 8 m^2 (4 m × 2 m) in size. For soil fertility management, 5 Mt/acre of farmyard manure (FYM) was applied at sowing. Quinoa seeds were sown in rows with spacing of 50 cm, ensuring uniform growth. Weed management involved two to three manual weeding to maintain optimal crop health. Bio-pesticide applications commenced once leaf miner infestation was observed (defined as a single tunnel on a leaf) and continued weekly until the vegetative stage, when infestation levels were highest. The treatments were applied on a weekly basis. The trial was sown on 17th April, 2024 and harvested on 21st October, 2024.

Data collection was conducted one day before and after each spray, following a weekly interval. In each treatment plot, a total of five plants were selected and tagged for monitoring. These sample plants were chosen from the middle row for visual counting of leaf mines. The total number of leaves on each plant, along with the number of infested leaves showing leaf miner activity, was recorded to determine the percentage of infested leaves. Additionally, the total number of infected plants were recorded to calculate the percentage of infested plants. These observations were conducted both before and 48 hours after treatment application.

The number of mined leaves and total infested plants did not show significant differences among treatments ($P = 0.94$ and $P = 0.66$, respectively). However, grain yield kg/ac exhibited a statistically significant response ($P = 0.005$). The number of mined leaves ranged from 8.1 (Artemesia extract) to 9.19 (Neem oil), with no clear trend suggesting the comparatively better effect of Neem oil in reducing infestation. Similarly, the total number of infested plants varied from 98.94 (Wood vinegar) to 128.75 (Neem oil), but these differences were not statistically significant. Grain yield differed significantly among treatments. Wood vinegar (633.62 kg/ac) and Neem oil (604.52 kg/ac) recorded the highest yields, significantly outperforming Artemesia extract (397.12 kg/ac), Jholmol (474.25 kg/ac), and Control (423.68 kg/ac). The higher yield may be due to wood vinegar, known for its antimicrobial and plant growth-promoting properties, which may have enhanced nutrient

uptake. Neem oil, a widely used botanical insecticide, likely reduced pest-induced stress, thereby improving crop performance.

Table 1. 4. Effect of different biopesticides on pest infestation and yield of Quinoa, 2024

Treatments	Mined Leaves (No.)	Total Infested Plants (No.)	Yield (kg/ac)
Neem oil	9.19	128.75	604.52a
Artemesia extract	8.1	103.44	397.12b
Jholmol	8.6	113.44	474.25b
Wood vinegar	8.97	98.94	633.62a
Control	8.26	111.12	423.68b
P Value	0.94	0.66	0.005
CV (%)	24.96	26.55	16.54
SE	1.52	20.86	59.26

Figure 1. 1. Data collection (L) and application of biopesticides on quinoa (R)

1.1.4. On-farm seed storage and germination assessment of quinoa

Researchers and farmers working with quinoa are facing the issues of poor seed germination. NCOA, ARDCs and the National Seed Center (NSC) have received complaints from Extension Agents and farmers on lack of seed germination in quinoa. Quinoa seed is an orthodox seed like other cereals. There is very poor or no seed germination in quinoa when seeds are stored under ambient conditions like other cereals. Not much is known about the cause of poor seed germination. Seed storage conditions like temperature and humidity play a critical role in seed viability. The seed storage aspects of quinoa are not adequately understood.

Why is there poor or no seed germination of quinoa when sown under right growing season? To tests the hypothesis that quinoa seed viability and germination is affected by seed age and storage methods, a trial has been initiated at NCOA, Yusipang. The objective of the trial is to evaluate different quinoa seed storage methods that can be adopted by farmers at household levels. Six different on-farm storage methods are compared. Quinoa seeds harvested in November 2023 were stored from December 2023 to April 2025 in six different storage methods under ambient conditions.

The different on farm seed storage methods comprise SM1=Seed Stored in Polypropylene bags (bags used for rice packaging) and stacked, SM2= Seed Stored in Plastic buckets with lids (Research practice)/ or sealed containers, SM3 = Seed stored in Plastic bags with Zip lock, put on carry bags and hanged, SM4= Seeds stored in PET bottles – Used Mineral water bottles (Farmers Practice), SM5= Seeds stored in cloth bags and hanged (Research Practice) and SM6= Seed stored in glass bottles (washed and cleaned whisky bottles) with lids. Seeds were sown in plastic pots in Mid-April 2024 and mid-April 2025 and replicated. Trial was terminated after seedlings attain height of 10-15 cm. The trial design followed was Completely Randomized Block Design (CRD) with three replications. compared in a potted experiment to test the germination percentage alongside a control that comprise seed stored at 4°C in a fridge.

1.1.5. Evaluation of sunflower varieties for yield and other agronomic traits

Sunflower (*Helianthus annus L.*) production is greatly affected by biotic and abiotic factor. Among abiotic factor, drought stress is one major limiting factor and water deficit can reduce the yield by approximately 15-50%. Despite, the low importance given to oil crops research and development, there is a need to diversify the oil crops. In keeping with this objective, sunflower varieties were introduced and evaluated for its performance. This research aimed to evaluate different varieties of sunflower for yield and adaptability to diversify oil crops to changing environment.

This study was conducted on station following the Randomized Complete Block Design (RCBD) with three treatments and seven replications. The trial plot size was 12 m² with a total of 21 experimental units, each measuring 4 m x 3 m. A planting distance of 50 cm between rows and 25 cm between plants was maintained, and thinning was carried out to ensure proper spacing. The three treatments included Bumthang White Local (T1), Kendo Europe (T2), and Bari Shurjo Mukhi (T3). To minimize border effects, data collection excluded border rows, and only data from the center rows was considered. The data was gathered using a random sampling method. Key parameters that were measured included days to 50% germination, days to 50% flowering, days to maturity, plant height, head diameter, seed yield (kg/ac), stem diameter, and 1000-grain weight. Additionally, the dates of sowing, thinning, and harvest were also recorded as part of the data collection process. The trial was sown on 16th April 2024 however; the maturity differed among the treatments. The variety of Barishurjomukhi and Kendo Europe was harvested on 15th August 2024 but for Bumthang local it was harvested on 6th September 2024.

Bumthang White had significantly higher plant height (323.97 cm) compared to Kendo Europe (187.40 cm) and Bari Shurjo Mukhi (186.66 cm). The highly significant P-value (0.0001) suggests that Bumthang White's superior growth in terms of height is likely due to its genetic characteristics or favorable growing conditions. However, it was found to be more susceptible to lodging. Similarly, Bumthang White had a significantly larger stem diameter (26.90 mm) than both Kendo Europe (23.11 mm) and Bari Shurjo Mukhi (22.30 mm). The significant P-value (0.0001) shows the strong stem structure of Bumthang. In terms of head diameter, no significant differences were

observed across the treatments (P-value = 0.087). Kendo Europe (16.67 mm) and Bari Shurjo Mukhi (16.83 mm) had slightly larger head diameters than Bumthang White (15.17 mm). Bumthang White also had the highest 1000-grain weight (86.77 g), significantly outperforming Kendo Europe (55.84 g) and Bari Shurjo Mukhi (66.59 g), as confirmed by the highly significant P-value (0.0001).

In terms of seed yield, Bumthang White yielded the highest seed yield (1.15 Mt/ac), significantly outperforming Kendo Europe (0.55 Mt/ac) and Bari Shurjo Mukhi (0.67 Mt/ac), with a significant P-value (0.0004). The higher yield of Bumthang White suggests it has better overall plant vigor and productivity compared to the other two varieties. In conclusion, Bumthang White performed significantly better than Kendo Europe and Bari Shurjo Mukhi in terms of plant height, stem diameter, 1000-grain weight, and seed yield, demonstrating its potential as a high-yielding and robust variety however due to its longer height, it was more prone to lodging compared to other two varieties.

Table 1. 5. Agronomic traits of different sunflower varieties

Treatment	Mean PH (cm)	Mean SD (mm)	Mean HD (mm)	TGW (gm)	Seed Yield (Mt/ac)
Bumthang White	323.97^{a}	26.90^{a}	15.17	86.77^{a}	1.15^{a}
Kendo Europe	187.40^{b}	23.11^{b}	16.67	55.84^{c}	0.55^{b}
Bari Shurjo Mukhi	186.66^{b}	22.30^{b}	16.83	66.59^{b}	0.67^{b}
P-value	0.0001**	0.0001**	0.087	0.0001**	0.0004*
CV (%)	12.96	17.07	21.15	10.88	26.27
SE	7.21	0.98	0.82	4.05	0.11

Figure 1. 2. Sunflower trial and data collection

1.1.6. Evaluation of different organic manures on sweet buckwheat yield

In recent years, Bhutan has witnessed a significant decline in production. It was once considered as a staple in many regions of the country but now it's regarded as a neglected and underutilized crop. Despite its declining cultivation, buckwheat holds deep nutritional, cultural, and religious significance in Bhutan. It is one of the nine traditional cereals known as *Dru-Na Gu*, considered vital to Bhutanese heritage and agricultural history. While many of these traditional grains have

been overlooked in modern farming practices, certain regions continue to cultivate in a limited area following their traditional farming methods.

With increasing consumer interest in safe and healthy food, and the growing potential of niche markets for organic buckwheat, there is a clear need for more research on organic buckwheat farming practices. In response to this, a replicated field trial was initiated in April 2025, using a Randomized Complete Block Design (RCBD) with seven treatments and three replications. The main objective of the trial is to evaluate the effectiveness of different organic manures on both buckwheat yield and soil organic matter. As the crop is currently in the seedling stage, detailed findings and analysis from the trial will be included in the next financial year's annual report.

Figure 1. 3. Status of sweet buckwheat trial at NCOA

1.1.7. Evaluation of durum wheat (Semolina) under different agro-ecological zone

Durum wheat (Triticum durum) has been introduced in Bhutan to boost the local wheat production and support the growing pasta industry. Due to its unavailability in the country, the CEO of Gen-Sum Pasta in Genakha, Thimphu, requested its import for domestic pasta-making. In response, the Department of Agriculture has requested ARDC Bajo to source high-quality seeds, leading to its initial introduction during the 2023-2024 wheat season. As the national coordinating center for cereals, ARDC Bajo has initiated a Nationally Coordinated Trial across various ARDCs to assess the performance of durum wheat semolina in Bhutan's agro-ecosystem and now it is in second year.

The Field Crops Program of the National Center for Organic Agriculture has collaborated on this trial and implemented following a Randomized Complete Block Design with five treatments and three replications in 5 m × 2 m plots. Currently, the crop is at a vegetative stage and most of the data collection is scheduled during harvest therefore, a detailed report on the trial will be included in the upcoming financial year's annual report.

1.1.8. Evaluation of different mixed cropping combinations of Quinoa with Foxtail millet

Mixed cropping is seen a futuristic for sustainable farming option to adapt to climate related challenges through smart crop combinations. Foxtail millet is an important food security crop cultivated by smallholder Bhutanese farmers especially in the dry-sub tropical agro-ecosystem. Foxtail millet has low protein and other essential nutrients. There is need to enhance the nutrient content of foxtail milled through smart strategies. Farmers normally sow Foxtail millets in marginal lands in December and harvest the crop during June. Quinoa as a new nutri-cereal has been successfully adapted in the dry-subtropical agro-ecological zones in Bhutan and has similar climatic requirements as the Foxtail millet. The crop architecture and grain size are very similar to quinoa. One big advantage of quinoa is its rich nutrient content mainly high protein and all nine amino acids. Mixed cropping of quinoa with foxtail millet that will help to mix quinoa at source will serve as an important and smart strategy to supplement nutrient intake of the rural communities that consume foxtail millet as a staple. Mixed cropping od foxtail millet with quinoa was planned with the objectives to evaluate the feasibility of mixed cropping of nutri-cereal quinoa with foxtail millet to enhance the nutrient of different millet-based diet at source and to diversify the sole foxtail based cropping system through mixed cropping.

Six different on-farm mixed cropping combinations are evaluated at Zamsa village under Bongo Gewog, Chhukha Dzongkhag. The trial design used is RCBD with three replications. The six treatments are:

T1 = Foxtail Millet + Quinoa mixed sowing – 50:50 seed ratio
T2 = Foxtail Millet + Quinoa mixed sowing – 60:40 seed ratio
T3 = Foxtail Millet + Quinoa mixed sowing – 30:70 seed ratio
T4 = Foxtail Millet + Quinoa mixed sowing – 25:70 seed ratio
T5 = Sole Foxtail Millet
T6 = Sole Quinoa

The trial was established on 26th of December, 2024 in farmer Nima's field.

1.2. FIELD CROPS DEVELOPMENT ACTIVITIES

1.2.1. In-Situ Conservation of Traditional High Altitude Rice Varieties

The Field Crops Program in collaboration with the National Biodiversity Center (NBC), Serbithang has been continuously maintaining five high altitude rice varieties namely Dumbja, Themja, Janam, Sabjakuchum, Zhuchum. The nursery was raised on 25th February, 2024 and transplanted on the first week of June, 2024. These varieties are maintained and conserved in-situ through participatory engagement of custodian farmers of Dopshari who provide their indigenous knowledge on these varieties for seed selection.

The seeds produced are made available to any farmers who are interested to cultivate these traditional varieties. These varieties are also used as local check in other variety evaluation trials. The different accessions of Dumbja initially sourced from the National Gene Bank and further selected with farmers knowledge of this variety have been restored back at the National Gene Bank at NBC for conservation. The other collections have been maintained by NCOA as working samples.

1.2.2. Basic seed production and maintenance of released high altitude rice varieties

Nine released high altitude varieties (Table 1.7) were cultivated in single large plot. The released varieties were cultivated for basic seed production to support farmers with good quality source seeds in high altitude rice growing areas across the country. The nursery was raised on 13th February 2024, and transplanted on the last week of May, 2024. The crop was harvested in the second week of November 2024. The trial was transplanted in a line spacing of 20x20cm using single large plot. Butachlor (Punch 10G) was applied at the rate of 14 kg/ac, 2-3 days after transplanting as pre-emergence for weed control. Fertilizer was applied at the rate of 80:40:30 NPK Mt/ha. Half of the nitrogen and the entire amount of P and K were applied as basal application at the time of transplanting. The remaining nitrogen was top dressed at maximum tillering and flowering stages at the rate 40 kg/ha. The quantity of basic seed produced is summarized in Table 1.6. The details of basic seed supplied to farmers is presented in Table 1.7.

Table 1. 6. Basic seed production of released rice varieties in 2024

Sl. No.	Varieties	Basic Seed Produced (kg)
1	Yusiray Maap1	50
2	Yusiray kaap 2	50
3	Yusiray Khathramathra	70
4	Yusiray Kaap 3	435
5	Yusiray Maap 2	225
6	Khangma Maap	400
7	Jaka ray Naap	200
9	Yusiray Maap 3	35
	Total	**1465**

Table 1. 7. Basic seed of high-altitude rice varieties supplied to different beneficiaries, 2025

No	Varieties	Seed Supplied (kg)	Beneficiaries	Purpose
1	Khangma Maap	365	Haa, Chhukha, ARDC Wengkhar, Paro Dzongkhag	Research Outreach Program, demonstration as upland rice for trials
2	Jakar Ray Naap	130	Chukha Dzongkhag	Research Outreach Program

3	Yusiray Kaap3	100	FMCL, ARDC Wengkhar	Tendriltang & Research Outreach Program
4	Yusiray Maap 3	10	ARDC, Wengkhar	Research Outreach Program
5	Yusiray Maap 1	0		
6	Yusiray Maap 2	95	Chukha, ARDC Wengkhar	Research Outreach Program
7	Yusiray Khathramathra	25	ARDC, Wengkhar	Research Outreach Program
	Total	**725**		

In addition to the released varieties 40 kg seeds each of the two new varieties namely Sticky and Chandannath were also produced for trials in the next season. In order to have pure seed for all the released varieties, panicle selection was done to maintain the seed for next season.

1.2.3. Upscaling Quinoa Cultivation under Chhukha Dzongkhag

Chhukha Dzongkhag was identified as one for the priority quinoa production Dzongkhag under the FVC funding. This project supported the promotion of Quinoa as a potential commodity in all the 11 Gewogs with free seeds and technical skills to upscale quinoa production. The Field Crops program lead the activity. Area and production under different Gewogs of Chhukha is presented in Table 1.8.

Table 1. 8. Status of Quinoa Promotion under Chhukha Dzongkhag, 2024

Gewog	Seed supplied (kg)	Estimated Area (acre)	Number of farmers	Male	Female	Total Production (kg)
Dungna	40	13.2	62	34	28	200
Metakha	10	3.2	21	14	7	0 (affected by heavy rain)
Darla	14	3.2	21	2	19	
Bongo	15	5	29	16	13	95
Gelling	27	9	11	9	2	730
Logchina	15	5	11	7	4	0 (affected by heavy rain)
Sampheling	36	12	30	22	8	300
Getena	20	6.6	13	2	11	0 (affected by heavy rain)
Phuentsholing	30	10	60	48	12	200
Chapcha	6	2	21	7	14	200
Bjabchog	3	1	2	1	1	90
Total	**216**	**70.2**	**281**	**162**	**119**	**1815**

Figure 1. 4. Honourable Minister, MoAL and Honourable Director General of FAO, handing over quinoa equipment to farmers

1.2.4. Training of trainers (ToT) on quinoa cultivation and utilization for agriculture extension officers of Chhukha Dzongkhag

In order to enhance the technical capacity and hands on skills of Agriculture Extension Officers (AEOs) of Chhukha Dzongkhag on Quinoa crop, its cultivation, crop management and household utilization two days ToT was organized. It was held on 2nd - 3rd October, 2024 at NCOA Yusipang. It was funded by the FAO/FVC/RAS/209/MUL project on quinoa. A total of 9 participants, 7 male and 2 female AEOs attended the ToT. The training covered the general introduction of quinoa crop, quinoa production systems, value chain and challenges in the value chain, basic taxonomy, agronomy, seed production, marketing, product development and household utilization. To create awareness to the grassroot workers a video presentation of Regional One Country One Priority Product (OCOP) of FAO RAP Bangkok, video presentation of OCOP, Bhutan and overview of the Flexible Voluntary Contribution (FVC) project was also done. Practical demonstration on seed selection, pest management, seed storage and milling were also conducted. Finally, to encourage farming communities to consume this nutritious cereal, Extension Officers were demonstrated how they could advocate communities to prepare and consume simple local dishes from Quinoa. Five types of products were prepared and demonstrated during the training which included Quinoa porridge, Quinoa Dresi, Quinoa Kheer, Quinoa Pancake and Quinoa + Rice. These efforts aimed to showcase how quinoa could be incorporated into local cuisine, improving its utilization by the Bhutanese people for enhancing their nutrition.

In addition, the Program Officer/Specialist also supported and served as the resource person for the ToT on Quinoa organized by ARDSC Tsirang for the AEOs of Tsirang and Dagana on the 25th to 26th September, 2024. This ToT also aimed to enhance the capacity of agriculture extension officers in quinoa production, ensuring they are equipped to support and promote quinoa cultivation in their respective Dzongkhags.

1.2.5. Farmers field days at Gelling and Samphelling Gewogs

Farmer's field days are very effective forums to create awareness and promote new technologies. Fields are conducted when the Research Outreach Program (ROP) and demonstration of technologies in a target area is successful. Two field days on quinoa was conducted at Gelling and Samphelling Gewogs with fund support the FAO/FVC/RAS/209/MUL and Global fund projects of the FAO. The main objectives of the Farmers Field Day were to demonstrate the success of quinoa cultivation and showcase the success inspire more farmers who had doubts about this crop. It also aimed to create awareness by educating the farmers on crop management, harvesting, and processing techniques, and finally to demonstrate the household level utilization of quinoa through hands on training on how to prepare local quinoa-based.

The field day at Gellingkha village of Gelling Gewog was held on 12th December, 2024 which was attended by 68 participants. Of the 68 participants, 46 were farmers of which 27 were male and 19 females. The remaining 22 participants were Local government and agriculture officials. The event covered the high-altitude production areas of Gelling Geog and was attended by Dasho Dzongrab of Chhukha Dzongkhag, Lam of Gelling Geomba, and representatives from various organizations including Local Government of Geling, Bjabchog, and Chapcha, NCOA-Yusipang, NPPC and Dzongkhag agriculture and livestock sector.

In Samphelling Gewog, one cooperator farmer Mr. Padam Singh Ghalley had taken up quinoa cultivation in two acres area under Tshogchuna village. The crop was sown on 7th November, 2024 and harvested on 13th March 2023. Farmers Field Day (FFD) was conducted at the time of harvest that represents the low-altitude production zone under Chhukha Dzongkhag. The FFD was held on 13th March, 2025. This FFD was jointly organized by Samphelling Gewog Administration, Gewog Agriculture Sector, Chhukha Dzongkhag Agriculture Sector and the National Center for Organic Agriculture (NCOA). This FFD was funded by FAO through the global fund for quinoa. The yield recorded was 400 kg/ac. The theme of the FFD was "Eat Quinoa for food and nutrition security". The event was attended by 38 individuals, comprising farmers, local government officials, media, and guests. The total male participant was 28 and female 10. The event was graced by Dasho Dungpa of Phunetsholing Dungkhag as the Chief guest. Dasho Dungpa inspected the quinoa field and advised farmers to focus on production if they wanted to earn cash income and derive health benefits from a nutri-cereal like quinoa. He also rewarded the cooperator farmer Mr. Padam Singh Ghalley with irrigation pipe as an incentive to encourage him to cultivate quinoa on a commercial scale. The Chief DAO Chhukha and Agriculture Specialist from NCOA explained in detail the benefits of quinoa, future plans and production targets for Chhukha. CDAO Chhukha also informed the participants on the receipt of three multi-crop threshers from FAO Director General as a big support to mechanize quinoa production. He informed that Geling, Samphelling and Bongo quinoa farmers will immensely benefit from these machines.

1.2.6. On station seed production of two mustard varieties

To enhance the adoption of improved varieties, Field Crop Program initiated the production of source seed two mustard varieties Yusi Peka 1 and 2. The two new high yielding varieties Yusi Peka1 (Lumle Tori) and Yusi Peka 2 (BARI Sharisha 15) are introduced from Nepal and Bangladesh respectively. The seeds of the two varieties were multiplied by planting in spring season. The planting was done in the month of March and harvested in the month of June. The crop was sown in line by keeping row to row distance of 20 cm. The seeds were produced under organic management. In the financial year 2024, a total of 11 kg seeds were produced for two varieties namely Yusi Peka 1 (6 kg) and Yusi Peka 2 (5 kg).

1.2.7. Research Outreach Program on On-farm seed improvement of maize to enhance maize self sufficiency

Maize, being a cross-pollinated crop, is prone to out-crossing and varietal contamination, leading to variability in traits such as plant height, ear shape, and yield. To minimize these variations and improve productivity, the use of high-quality seed is essential. Community-Based Seed Production (CBSP) is a sustainable approach that empowers farmers to produce quality maize seed through training on maize breeding, cultivation, and seed selection. The model requires one to two seasons for farmers to fully grasp its principles, after which CBSP groups are formed to ensure consistent seed production at the community level.

In 2024, the Research Outreach Program (ROP) on CBSP was introduced in Chhukha and Haa Dzongkhags to promote on-farm quality maize seed production. In Chhukha, the program was implemented in Chadokha, Logchina Gewog, where 38 farmers (28 males and 10 females) were trained, and 200 kg of improved Yangtsipa seed was distributed. In Haa, the program was conducted in Setena Chiwog under Gakidling Gewog, training 28 farmers (13 males and 15 females) on improved seed selection techniques. The CBSP concept and its requirements were explained in detail, with follow-up assessments planned to evaluate the feasibility of scaling up CBSP in these regions.

2. HORTICULTURE RESEARCH AND DEVELOPMENT PROGRAM

The Horticulture Research and Development Program at NCOA encompasses Fruits and Nuts, Vegetables, and Medicinal and Aromatic Plants (MAPs), with a national mandate to coordinate research on temperate fruits, vegetables, high-altitude MAPs, and hydroponics. The program leads research on key crops such as tomato, cole crops, and edible stems, while also supporting a broader range of vegetables through collaboration with other centers. Since 2019, it has managed a project on vegetable variety development funded by AFACI. The Fruits and Nuts Unit focuses on temperate fruit crops like apple and citrus, undertaking research on production practices, packaging, germplasm conservation, and floriculture, along with major projects such as the Integrated Temperate Fruit Crops Promotion and Million Fruit Tree Plantation Phase II. The MAPs Unit, established in 1996, specializes in high-altitude medicinal plants research, aiming to conserve endangered species through cultivation packages, sustainable collection, value addition, and generating policy-relevant information to support extension and training activities.

2.1. HORTICULTURE RESEARCH ACTIVITIES

2.1.1. Performance evaluation of World Veg chilli lines

A trial to evaluate seven WorldVeg chili lines for its yield, diseases resistance and desirable pungency in Bhutanese condition was conducted. The trial was set up at the center with the selected lines of chili. The lines were selected in 2023 with high scoring of pungency level through Participatory variety selection (PVS)**.** The experiment was laid out in a randomized complete block design (RCBD) with 3 replications in an open field. Bed size of 4 m x 1.5 m bed was prepared to grow chili plants spaced at 45 cm between the plants and 50 cm between the rows. There were two rows in each plot. A total of 12 plants were planted in each plot and 6 plants per row were maintained. Trials were managed under organic conditions. Plants were weeded as and when required depending upon the weed pressure. Fruits were harvested fresh in green. This is mainly because of the market demand of green chili in Bhutan is more than the red fresh chili.

Data for yield, yield components and pest and diseases were collected using the standard format for variety evaluation of the WorldVeg Centre. Lines evaluated: AVPP 1111, Sha Ema, AVPP 1337, AVPP 1502, AVPP 1328, AVPP 1510, Yusi selection

Table 2. 1. Mean yield differences of seven selected chili lines

Treatments	Mean yield (kg)
AVPP 1111	0.603^{c}
Yusi-selection	0.767^{c}
AVPP 1510	0.353^{b}
AVPP 1337	0.347^{b}
AVPP 1328	0.160^{ab}
Sha ema	0.652^{c}

Out of the seven varieties only six varieties were taken into consideration for analysis as one variety AVPP 1502 could not be harvested due to the very low plant stand. The yield result indicated significant differences among the varieties. Three varieties namely AVPP1111, Yusi selection and Sha ema yielded similarly with higher yield compared to AVPP 1337, AVPP 1510 and AVPP 1328 with significant low yield.

2.1.2. Participatory Variety evaluation of World Veg chilli lines for pungency

In September 2024, when plants were in fruiting stage, participatory variety evaluation on chili variety was conducted with fifteen farmers from nearby Dzongkhag /Districts (Thimphu and Chukha) at NCOA, Yusipang. The participants were asked to visit the trial plots where standing plants are available and observe the plant for diseases. They were then asked to taste the fruits, presented without any labels, to assess their pungency. The participants were then provided with six grains and voted as per the following instruction:

a. 3 grains for the most tolerant to disease
b. 2 grains for moderate tolerance to disease
c. 1 for least tolerance to disease

Similarly for pungency with the higher number of grains corresponding to higher pungency. From the result of PVS, it was evident that AVPP 1337 which was put as check was the most preferred in terms of diseases tolerance and pungency which was followed closely by traditional variety Sha ema and AVPP 1111. Although Yusi selection yielded better with good score on diseases tolerance, its pungency level need improvement.

Table 2. 2. Result of the PVS

Variety	Diseases tolerance	Taste (Pungency)	Total	Rank
AVPP 1111	19	29	48	3
AVPP 1337	62	34	96	1
AVPP 1328	4	12	16	6
AVPP 1510	15	15	30	4
AVPP 1502	15	7	22	5
Yusi-Selection	33	15	48	3
Sha-ema	20	47	67	2

2.1.3. Evaluation and Screening of New WorldVeg Chili Lines at NCOA Yusipang

As part of the ongoing support from AFACI, the project sent 35 new entries of chili lines to be tested for yield performance, disease resistance and pungency level. RCBD with 2 replications in a greenhouse. Bed (4 m x 1 m) bed was prepared to grow chili plants spaced at 45 cm between the plants and 50 cm between the rows. There were two rows in each plot. A total of 12 plants were

planted in each plot and 6 plants per row were maintained. Trials were managed in organic conditions. Fruits were harvested fresh in green. This is mainly because of the market demand of green chili in Bhutan is more than the red fresh chili. Data for yield, yield components and pest and diseases were collected using the standard format for variety evaluation of the WorldVeg Centre.

Out of the 35 new varieties tested in 2024 in Yusipang Condition, sixteen varieties were analyzed for their yield and pungency. The rest of the varieties yield data were not consistent for statistical analysis. The varieties that exhibited healthy phenotypic characteristics and good fruiting were selected.

Table 2. 3. Mean marketable yield and median of pungency ranking by participants

Lines	Mean yield per plant	Median pungency rank	Interquartile range
AVPP2001	1.81 a	2	1.75
AVPP2003	1.46 ab	2	1
V1037607	1.02 ab	2.5	1
V1047030	0.98 ab	2	1
AVPP1811	0.96 ab	2	1
AVPP1609-085	0.86 ab	3	1
AVPP1130	0.78 ab	2	0
AVPP1105	0.71 ab	2	2
AVPP1806	0.68 ab	2	1.75
AVPP2008	0.44 ab	3	2
AVPP2004	0.33 b	2	1
AVPP1609-022	0.33 b	4	1
AVPP1971	0.26 b	3.5	1
V1041283	0.25 b	4	1
V1037449	0.25 b	4	1.75
V1044930	0.24 b	3	0.75

The yield result of chili indicated yield differences among the sixteen varieties, with AVPP 2001 yielding highest followed closely by AVPP 2003 and V1037607. Six varieties that can be taken into consideration for selections in terms of yield are V1047030, AVPP1811, AVPP1609-085, AVPP1130, AVPP1105 and AVPP1806. Median ranking of the lines shows AVPP1609-022, V1037449, V1041283 ranked as the most pungent among the varieties. However, considering the smaller Inter Quartile Range, AVPP1609-022 and V1041283, it can be noted that most participants ranked similarly for these varieties as opposed to V1037449 which has a slightly larger IQR.

Participatory Variety Selection (PVS)

Sixteen varieties were than evaluated for its taste and pungency by the staff and elementary support staff of NCOA. The selection process allowed farmers to express their preferences, providing valuable insights for varietal adoption.

30 respondents participated in ranking the pungency of 16 lines from a scale of 1-5(1- no pungency, 2-mild pungency, 3-moderate pungency, 4-strong pungency and 5-extreme pungency). The participants were provided with diced fruits and asked to savor the taste for each line. They were advised to take breaks between each line and provided with water to cleanse their palate.

Friedman test confirmed that there was significant difference in pungency ranking among the lines indicating at least one variety was ranked differently. Nemenyi All-Pairs Comparison test was conducted as post hoc, and it showed several significant differences among the lines.

Median ranking of the lines shows AVPP1609-022, V1037449, V1041283 ranked as the most pungent among the varieties. However, considering the smaller Inter Quartile Range, AVPP1609-022 and V1041283, it can be noted that most participants ranked similarly for these varieties as opposed to V1037449 which has a slightly larger IQR.

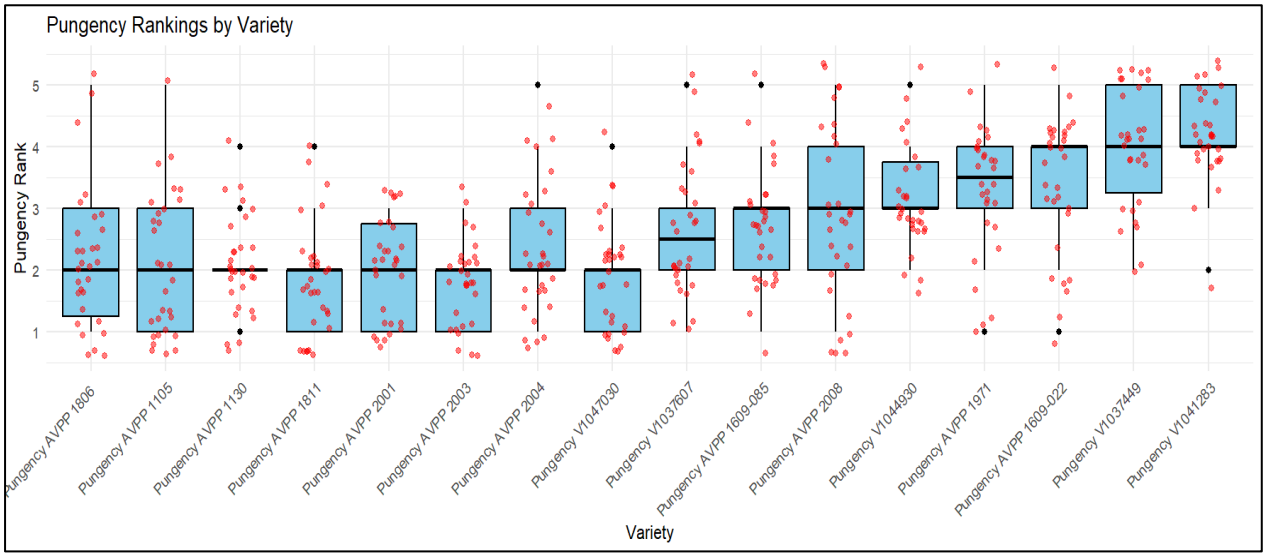

Figure 2. 1. Boxplot of pungency ranking by variety

Figure 2. 2. Pungency ranking by participants and PVS set up

2.1.4. Breeding initiated Chilli and Tomato

Nursery of F2 tomato (KT local-local cherry x AVTO 1954) was sown. The F1 crossed in 2024 (AVTO 1972 x AVTO 1954) and the paternal lines of AVTO 1712, cherry KT, AVTO1954 were sown. Characterization of the of F2 hybrid and F1 generation with the parents will be studied in the experiment.

Table 2. 4. Details of hybridization in tomatoes

Year	Parent male	Parent Female	Product	Method
2024	AVTO 1712	AVTO 1954	F1	(Hybridization)
	AVTO 1954	AVTO 1712	F1	(Hybridization)
	AVTO KT	F1	F2	(Back cross)
2025	AVTO 1712	AVTO 1954	F1	(Hybridization)
	AVTO 1954	AVTO 1712	F1	(Hybridization)

Chili hybridization was also initiated at NCOA, Yusipang. The objective of the chili hybridization is to; Develop F1 chili with chili blight resistance, better yield performance and acceptable taste. F1 seeds extracted will be regrown to ensure segregation of characteristics. Desirable characteristics will be identified from the F2 lot for disease resistance.

Table 2. 5. Result of hybridization, 2024 and plan to 2025

Year	Parent male	Parent Female	Condition	Status
2024	AVPP1111	Sha Ema	Open field and polyhouse	Successful
2024	Sha ema	AVPP 1111	Poly house	Successful
2024	AVPP0520	Sha Ema	Open field	Unsuccessful
2024	AVPP1337	Sha Ema	Open field and polyhouse	Successful
2024	Sha ema	AVPP 1337	Open field and polyhouse	Successful
2024	AVPP1510	Sha Ema	Open field and polyhouse	Unsuccessful
2024	Yusi selection	Sha Ema	Open field and polyhouse	Unsuccessful
2024	Yusi selection	AVPP1510	Polyhouse	Unsuccessful
2024	AVPP1111	AVPP1510	Polyhouse	Unsuccessful

2.1.5. Study of viruses in major vegetables in Bhutan

Eighteen samples were collected from various on farm locations by the Bhutanese researchers and Dr. Jisuk Yu of Seoul National University (SNU), KOREA under the AFACI RDA collaboration. The samples were prepared and RNA was extracted in Bhutan in the National Plant Protection Centre Laboratory. Samples were taken to Korea for analysis by Dr. Jisuk Yu.

Table 2. 6. Results of the virus diagnosis

Sl. No.	Sample Name	Plant	Region	Collection Date	NGS (RT-PCR)	Remarks
1	V1037603	Chili	Yusipang, NCOA	2024-08-21	Chilli veinal mottle virus, Cucumber mosaic virus	
2	AVPP721	Chili	Yusipang, NCOA	2024-08-21	Cucumber mosaic virus, Broad bean wilt virus 2, Pepper vein yellows virus	PCSV
3	AVPP1319	Chili	Yusipang, NCOA	2024-08-21	Cucumber mosaic virus, Chilli veinal mottle virus, Pepper vein yellows virus	PCSV
4	Sample4	Tomato	Yusipang, NCOA	2024-08-21	N/d (plant virus), Fusarium graminearum dsRNA mycovirus-2 (FgV2)	
5	V1037522	Chili	Yusipang, NCOA	2024-08-21	Cucumber mosaic virus	
6	V1037607	Bean	Bajo, Wangdue	2024-08-22	N/d (plant virus), FgV2	
7	Sample7	Tomato	Ngachaygaykha (Wangdue Ecolodge)	2024-08-22	Potato virus Y	
8	Sample8	Chili	Ngachaygaykha (Wangdue Ecolodge)	2024-08-22	Pepper vein yellows virus, Pepper cryptic virus 2, FgV2	
9	Sample9	Chili	NCOA	2024-08-21	veinal mottle virus	

10	Sample10	Cucumber	Zanglakha	2024-08-23	Bell pepper endornavirus, Phytophthora infestans RNA virus 4(NGS)	
11	Sample11	Chili	Zanglakha	2024-08-23	Bell pepper endornavirus, Phytophthora infestans RNA virus 4(NGS)	
12	Sample12	Tomato	Zanglakha	2024-08-23	N/d (plant virus)	
13	Sample13	Chili	Wangbama	2024-08-23	Low quality RNA (not available)	
14	Sample14	Bean	Wangbama	2024-08-23	Cucumber mosaic virus	low titer
15	Sample15	Bean	Jimina	2024-08-23	Low quality RNA (not available)	
16	Sample16	Bean	Jimina	2024-08-23	Chilli veinal mottle virus	low titer
17	Sample17	Tomato	Jimina	2024-08-23	Potato leafroll virus, Southern tomato virus (NGS)	
18	Sample18	Cucumber	Jimina	2024-08-23	Potato leafroll virus, Southern tomato virus (NGS)	

Southern tomato virus, tobacco vein clearing virus, pepper chlorotic spot virus, bell pepper endorna virus, and potato leafroll virus are not determined by RT-PCR yet.

2.1.6. Fast track evaluation of hybrid cabbages

The available cabbage varieties include OP (open-pollinated varieties) as well as one F1 hybrid cultivars. The introduction of F1 hybrid began very recently with the vegetable commercialization movement and the cultivation of hybrids among the farmers is gaining popularity these days. The hybrids with high yielding ability and other desirable traits have not only helped farmers cultivate domestic consumption but have also enabled the export of vegetables. Bhutan agroecological conditions favor cabbage production year-round however, production challenges of pest and

disease hamper optimal yield. Disease such as club root, Alternaria and black rot are common in major cabbage growing regions. With the increase in popularity of hybrids among farmers due to their high yielding ability, uniform appearance, wider adaptability, and disease/ pest resistance, demand for hybrids in the market is increasing. Recently, during the BATIF consultation, hybrid F1 cabbage was identified as one of the potential crops for collaboration for revenue generation opportunities of the agricultural commodities. The current study was conducted to assess the yield performance and adaptability of the seven new hybrid cabbage varieties received through the BATIF collaboration.

The experiment was carried out at National Center for Organic Agriculture, Yusipang. The experiment was laid out in a randomized complete block design with three replications. Each experimental plot consisted of eight plants in bed sizes of 2 m x 1.2 m. The distance between rows to row and plant to plant was 50 cm and spacing between beds was 50 cm. The seeds were sown on 12th July, 2024 and seedlings were transplanted on 21st August 2024.

The trial was managed organically. Data was collected from all plants from each treatment plot. Yield parameters such as head weight, length, and width were collected. The treatments comprised of seven hybrid varieties; Marvel35, 561, G22, 102, G26, Grand Blue, 8686 and one check variety; Golden cross. Statistical Tool for Agricultural Research (STAR) Version: 2.0.1 was used for data analysis.

Statistical analysis using ANOVA and Tukey's HSD test revealed significant differences among the varieties for head weight, head length and head width($P>0.05$). Hybrid variety 102 produced the biggest and the heaviest heads while the check Golden cross produced the lightest and smallest heads. All the hybrid varieties outperformed the check in all yield parameters as shown in Table 2.7.

Table 2. 7. Yield parameters of cabbage heads by variety

Treatment	Head weight(kg)	Head Length(cm)	Head width(cm)
102	1.29 ± 0.05^{a}	16.00 ± 0.43^{a}	14.08 ± 0.32^{a}
561	0.86 ± 0.22^{bc}	12.65 ± 1.13^{bc}	13.56 ± 1.73^{ab}
8686	0.72 ± 0.10^{bc}	13.10 ± 0.26^{b}	11.98 ± 0.32^{abc}
G22	1.02 ± 0.08^{ab}	13.83 ± 0.18^{b}	13.46 ± 0.85^{abc}
G26	0.84 ± 0.12^{bc}	12.65 ± 0.56^{bc}	13.04 ± 1.26^{abc}
Golden cross (Check)	0.61 ± 0.09^{c}	10.67 ± 0.54^{c}	10.96 ± 0.49^{c}
Ground blue	0.96 ± 0.25^{abc}	13.98 ± 1.50^{ab}	11.48 ± 0.56^{bc}
Marvel	0.85 ± 0.03^{bc}	12.06 ± 0.33^{bc}	13.85 ± 0.20^{ab}

However, in the Bhutanese market with relatively small family size, small size cabbage heads are preferred in urban markets weighing close to half kilogram is preferred. There are verbal reports that bigger cabbages are preferred in the school feeding program and hotels, a study needs to be conducted to confirm the claims. Although the plants were monitored for pests and diseases, no incidence was observed in all the treatments. Overall, adaptability issues were not observed for all treatments.

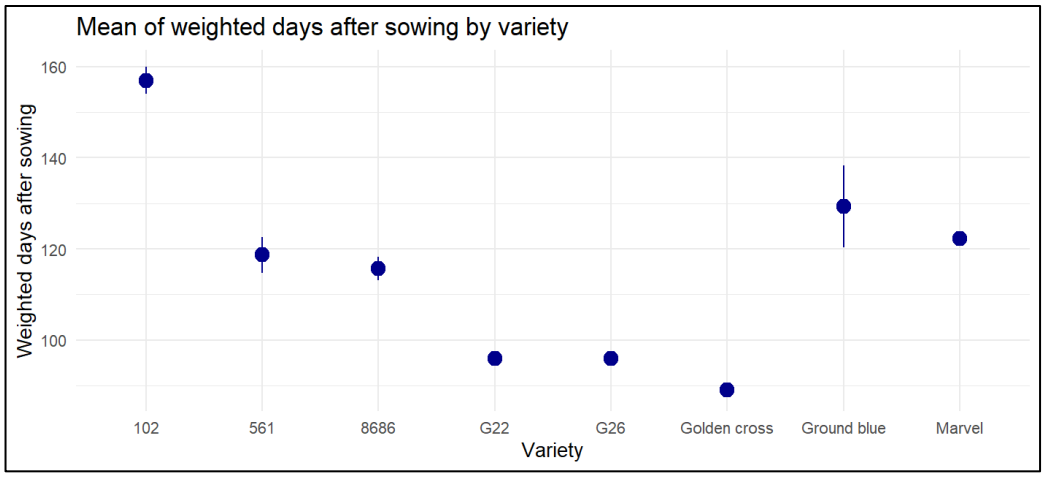

Figure 2. 3. Mean plot with standard deviation for weighted days after sowing for each treatment

Figure 2.3. shows the mean weighted days after sowing of the treatments. The treatments which showed uniform maturity were G22 and G26. Marvel and Golden cross were also uniform with a standard deviation of 1.15 and 1.73. All treatments matured later than the check with the treatment 102 taking the longest to mature with a mean of weighted days after sowing of 157, longer by 68 days. If a variety requires longer to mature, the cost of production for that also increases. Ground blue shows a wider range of variation in date of harvest. For small-scale farmers targeting regular but small markets, variation in maturity may be optimized alongside staggering. Uniformly maturing crop varieties provide farmers with an assurance that enables farmers to predict the scale and quality of production.

Although statistical significance could not be established due to the small number of samples, practical significance in differing date of harvest for all treatments need to be considered. Based on the nature of maturity, a grower can utilize the varieties to meet one's needs.

2.1.7. Observation trial on kohl rabi seed production

Kohlrabi is a vegetable that's related to the cabbage family. It's widely consumed in Europe and the health benefits and culinary uses of kohlrabi are numerous. It's a good source of nutrients, such as vitamin C and fiber. The center received male and female seed stock of Kohlrabi from National Seed Center, Paro under BATIF collaboration. The Objective of the trial is to study the possibility of producing seeds of Kohl Rabi in Yusipang condition.

The trial was conducted at the center. Nursery and plantation were established following protocols provided by the seed company. A plant spacing of 50 cm by 50 cm were maintained with male plants planted between rows of female plants. Germination rate of both seed lots were above 50%.

Table 2. 8. Seed germination of Kohlrabi seed stock

Seed stock	Total seed received	Total seed germinated	Germination (%)	Average height of plant (cm)	Average Diameter of bulb (mm)	Average length of bulb (cm)
YK009 Stock seed Female Lot 23049	60	38	63.3%	38.1	59.9	6.2
YK009 Stock seed Male Lot. 23040	30	17	56.6%	33.4	68.2	6.9

The female plants have entered the flowering stage by March 4th March 2025. Female flowers began to bloom on March 4th, and flowering was completed across all female plants by March 18th, 2025. However, the male flowers did not bloom simultaneously with the female flowers, exhibiting a different flowering timeline. This shows the need to delay seed sowing of female plants or earlier sowing of male plants in future studies.

2.1.8. Performance evaluation of hybrid broccoli

In Bhutan, broccoli still grown in a very limited scattered areas and the total cultivated area is not exactly known. There are only two varieties of broccoli currently available for cultivation in Bhutan: Dessico (open-pollinated variety) and Centauro (F1 hybrid) recently introduced in 2012. With the introduction of high yielding F1 hybrid, commercialized cultivation of broccoli is gaining popularity in Bhutan and has helped meet the domestic demand. Variety plays an important role in agricultural production and on farm income. It is necessary to test the varieties incoming to our country especially when huge numbers of hybrid vegetable seeds are being imported. Hybrids are generally high yielding, have wide adaptability and tolerant to both abiotic and abiotic stresses and they do well even in summer season. The main objective of the current study was to assess the adaptability and performance of the new F1 hybrid broccoli (Green Pia) in different regions of Bhutan.

The experiment was laid out in RCBD with 13 replications and two treatments (Green Pia against check variety Centauro). The trial was conducted at the center. Each plot was a raised bed of 25 cm high, measuring 2.5 m long by 1.0 m wide with a plot area 3.75 m^2. The adjacent plots were

separated by 50 cm wide drains. Data was collected from 8 plants per plot. Data was collected for floret diameter (cm), weight (g) and length (cm). Data was analyzed using STAR.

No significant difference was observed for means of floret weight, floret length, and floret diameter between the two hybrids. Mann-Whitney Utest was used for floret diameter and independent t test for the other parameters set at 0.05 level of significance.

Table 2. 9. Table of means by treatment

Treatment	Mean Floret weight(cm)	Mean Floret length(cm)	Mean Floret diameter(cm)
Centauro	252.55± 214.59	16.72± 3.41	3.63± 1.30
Green pia	256.58± 193.81	17.53± 2.93	3.62± 1.15
t value	-0.0503±	-0.6507	
p- value	0.9603	0.5214	0.9387

The large standard deviation for both varieties in floret weight is largely due to marshy nature of some parts of the experimental visit. However, the standard deviation for Green pia is lower for all parameters showing lower variability. Since the yield and its parameters are comparable to the standard check, Green pia can be recommended for release for commercial cultivation in the upcoming Variety release committee.

2.1.9. Evaluation of Chinese cabbage varieties across different date of sowing

Chinese cabbage is gaining popularity in the Bhutanese population especially among the younger pool. However, there is only one variety available for cultivation which has in recent years been observed to not form marketable heads. One plausible reason has been the lack of knowledge about the appropriate planting time. This knowledge gap and the unavailability of diverse varieties prompted this experimental trial. INTECrop supported the import of two new open pollinated Chinese cabbage varieties from Japan. The main objective of the trial is to identify a suitable variety and the appropriate planting time.

The trial was laid out in RCBD in split plot design with subplot factor as time of sowing (three levels: T1=August 15, T2= August 30 and T3=15th September, 2025) while the main plot factor was the variety (three levels: V1=Kyoto, V2= Matsushima 2, V3= New Matsushima 2). The seedlings were transplanted at 3 to 4 leaf stages and trial was managed organically with use of neem oil, bokashi and other organic amendments applied equally to all treatments. Yield parameters were collected for all plants per treatment only if the seedling did not bolt once the cabbage heads were ready for harvest.

It was observed that Kyoto variety completely bolted across all three times of sowing. In addition, all varieties failed to form heads for seeds sown on 15th September equivalent to 100% bolting. Matsushima 2 performed much better across the treatments with an average of 32.58 plants successfully forming heads followed by New Matsushima 2 with 26.70%.

Table 2. 10. Mean yield parameters and percentage of bolting by treatments

Treatment	Mean head diameter (cm)	Mean Head Length (cm)	Mean Weight(g)	Percentage of plans not bolted	Percentage of plants bolted
T1	4.27	7.02	366.93	28.24	71.75
T2	4.94	11.72	293.35	31.25	68.75
T3	0	0	0	0	100.00
Kyoto	0.00	0.00	0.00	0.00	100.00
Metsushima 2	4.90	11.99	373.28	32.58	67.42
New Metsushima 2	4.28	6.66	284.85	26.70	73.30

Further study is required to establish these findings. In the coming season, similar trial with more dates of sowing will be conducted.

2.1.10. Performance evaluation of World Veg tomato lines

Tomato production in Bhutan is constrained by lack of high yielding varieties, frequent pest and diseases outbreaks and unorganized marketing channels. The major disease affecting the tomato cultivation in Bhutan is fungal diseases called blight. (NPPC, 2021) The production season of tomato coincides with the rainy season which makes conducive for fungus to thrive and affect the tomato plants. The problem is more severe in the organically managed farms due to no or limited organic inputs available to control the blight diseases. Further, Bhutan has only two officially released varieties namely Ratan and Roma. These varieties are highly susceptible to blight, possess shorter shelf life, low yield, old and degenerated. As an alternative effort to increase tomato production in the country, hybrid tomatoes namely *Cosmic* and *Garv* were tested for adaptability and performance and are being promoted. However, the sustainability as well as the cost of such imported hybrids remains a serious concern. It has therefore become necessary for Bhutan to initiate proper research to select sustainable and economical tomato varieties with desired traits for promotion in the farmer's field. One such method is through introduction and evaluation of open pollinated varieties which are sustainable due to their ability to produce seeds year after year with improved adaptation. Furthermore, the open pollinated varieties are preferred for organic farming due to their high adaptation and climate resilient capabilities. The main objective of current study was to evaluate and select best varieties with desirable traits of high yields, disease resistance and adaptation to Bhutan's climatic conditions. The activities were funded by AFACI.

The study was laid out in a RCBD with five varieties (viz., AVTO 1288, AVTO 1464, AVTO 1712, AVTO 1713 and AVTO 1954 recently released as Yusi- Lambenda 1) as treatments replicated four times in the open field at NCOA. A planting distance of 50 cm x 50 cm was maintained in raised beds measuring 2 m x 2 m. PVS was also done. This was done by allowing a group of farmers to vote for their preferred varieties during a field day conducted in one of the mother trials just before

harvesting. To take gender preference into research consideration, 6 maize seeds were given to male participants and 6 bean seeds to female participants. Each participant was asked to vote three for the best, two for the second best and one for the third best variety tolerant to blight by observing the extent of symptoms on the plants.

Significant differences could be observed in Fruit Length(mm) with AVTO 1288 producing significantly longer fruits, followed by AVTO 1954 and AVTO 1712. The shortest fruits were produced by variety AVTO 1713. AVTO 1954 had significantly wider fruits compared to AVTO 1712. Statistically greater number of fruits were observed in AVTO 1712 in comparison to AVTO 1713 in Yusipang. This shows that AVTO 1712 produces the highest number of marketable fruits while it also produced the highest number of non-marketable fruits among the varieties.

2.1.11. Evaluation of the effect of different locally available bagging materials on fruit quality in pear

Pear cultivation is a significant component of the global fruit industry, valued for its economic importance and nutritional value. However, pear growers often face challenges related to pest infestations, diseases, and adverse environmental conditions that can impact fruit quality. One horticultural practice that has gained attention for mitigating these issues is fruit bagging. Fruit bagging involves covering individual fruit or clusters with bags made of different materials to protect them from external factors. Bagging is an important practice to reduce the need for chemical sprays, which could prove beneficial for organic fruit farms. This study aims to evaluate the effect of using various bagging materials on pear fruit quality, including factors such as appearance, size, pest and disease resistance, and overall marketability.

The experiment was conducted on-station. Nitaka variety of pears was selected as test material. Pear bagging was carried out in the first week of June 2024 by selecting 6 pear trees. On each tree, four treatments (bagging with butter paper, Kunsel paper, commercial mango bagging paper and control) were administered for 5 pear fruits. Data was collected on 22/08/2024 to study the effect of different bagging materials on fruit quality parameters of pear. Each tree was treated as a replication. Fruit quality parameters such as fruit weight (mm), height (mm), diameter (mm), TSS (Brix %), acidity and fruit firmness were measured.

Analysis conducted using JASP (version 0.19.3.0) revealed that treatments had a significant effect on fruit weight, diameter, and firmness, with p-values of 0.006, 0.016, and 0.005 respectively. However, no significant differences were observed in fruit height and total soluble solids (TSS) across the treatments. Additionally, the weighted average across all parameters indicates that Butter paper was the most effective treatment, followed by Kunsel paper and Mango bagging paper. The control treatment, however, demonstrated the lowest overall performance. Details are given in in the table below.

Table 2. 11. Descriptive and ANOVA statistics for each parameter by treatment

Treatment	Average Fruit weight (g)	Average Fruit height (mm)	Average Fruit Diameter (mm)	Average TSS (%)	Average Fruit firmness (kg/cm^3)	Weighted average
Butter paper	180.60	60.97	69.31	14.16	8.15	66.64
Control	149.93	58.02	65.60	14.32	6.58	58.89
Kunsel paper	172.25	61.76	69.64	13.74	7.31	64.94
Mango bagging paper	171.12	59.85	68.10	13.92	6.88	63.97

Figure 2. 4. Different types of bagging in pear fruits

2.1.12. Effect of fruit thinning on fruit parameters in apple

Six varieties of apple were used to conduct this study at an on-station farm at our centre. Fruit thinning was conducted in the last week of June on three trees each on six varieties of apple (Co-op 12, Well spur, Red spur, Red Chief, Oregon Spur and Vance delicious). In each apple variety, three trees were subjected to fruit thinning, while another three trees were left untreated as controls. From each treatment unit, a total of 10 fruits were sampled and analyzed for quality parameters including fruit weight, total soluble solids (TSS), fruit height, fruit firmness, and fruit diameter on 26/09/2025.

Figure 2. 5. Fruit thinning in apple

The data collected were analyzed using JASP version 0.19.3.0 for fruit parameters like TSS, fruit weight, fruit height, fruit diameter and firmness. Based on the weighted average of these parameters across all varieties, the thinning treatment yielded better results in four varieties: Oregon Spur, Red Chief, Vance Delicious, and Well Spur. In contrast, the non-thinning treatment performed better in the Red Spur and Co-op 12 varieties. Details are given in the table below.

Table 2. 12. Effect of thinning and non-thinning treatments on fruit parameters

Variety	Treatment	Average of Fruit weight (g)	TSS (%)	Fruit Height (mm)	Fruit Diameter (mm)	Fruit firmness (kg/cm^3)	Weighted average
Co-op 12	NT	118.20	10.70	57.02	61.61	4.55	50.42
Co-op 12	T	111.17	10.17	54.88	60.35	4.91	48.30
Oregon spur	NT	100.93	10.80	53.58	58.44	4.82	45.71
Oregon spur	T	121.87	10.50	58.23	63.87	4.30	51.75
Red chief	NT	99.18	11.39	52.90	58.19	4.36	45.20
Red chief	T	105.66	9.44	55.43	59.32	4.45	46.86
Red spur	NT	123.22	10.81	57.84	62.80	4.76	51.88
Red spur	T	115.32	10.50	57.15	61.00	4.74	49.74
Vance delicious	NT	115.15	11.33	57.13	62.25	4.37	50.05
Vance delicious	T	148.15	11.40	60.25	65.86	4.22	57.98
Well spur	NT	146.19	13.60	58.48	70.17	4.05	58.50
Well spur	T	167.16	13.88	61.56	72.19	3.98	63.75

2.1.13. Performance evaluation of new apple varieties

In the first week of October 2024, a total of 10 fruits each for Kou kou and Miyabi Fuji varieties from Japan were randomly collected from farmers field in Genekha and on-station farm at Yusipang to analyze for fruit parameters like weight, height, diameter and TSS. Results were analyzed using JASP version 0.19.3.0.

The comparative performance of Kou kou and Miyabi Fuji apple varieties varied noticeably between the on-farm site at Genekha and the on-station site at Yusipang. Overall, both varieties tended to perform better in terms of fruit size attributes such as weight and height at the on-station site, suggesting that the station's growing conditions were more favourable for physical growth. Miyabi Fuji showed a more pronounced response to the on-station environment compared to Kou kou, indicating that it may be more sensitive to management or environmental factors. However, when it came to fruit sweetness, as reflected in total soluble solids, both varieties performed better on-farm, pointing to possible differences in microclimate, maturity, or nutrient availability affecting sugar accumulation. While Kou kou displayed a more stable performance across the two locations, Miyabi Fuji exhibited greater variation, excelling in some traits at the station but showing better quality in sweetness on-farm.

Table 2. 13. Results of the descriptive statistics and two-way ANOVA for the weight, height, diameter and TSS parameter

Site	Variety	Mean weight	SD	Coefficient of variation
Site 1: On-farm	Kou kou	162.46	28.611	0.176
	Miyabi Fuji	119.94	21.969	0.183
Site 2: On-station	Kou kou	196.86	50.806	0.258
	Miyabi Fuji	200.37	36.218	0.181
Site	p value		< .001	
Variety	p value		0.096	
Site ✻ Variety	p value		0.051	

Site	Variety	Mean height	SD	Coefficient of variation
Site 1	Kou kou	60.451	3.917	0.065
	Miyabi Fuji	53.766	3.634	0.068
Site 2	Kou kou	65.72	6.641	0.101
	Miyabi Fuji	64.931	6.183	0.095
Site	p value		< .001	
Variety	np value		0.031	
Site ✻ Variety	p value		0.085	

Site	Variety	Mean diameter	SD	Coefficient of variation
Site 1	Kou kou	71.174	7.004	0.098
	Miyabi Fuji	64.879	3.002	0.046
Site 2	Kou kou	69.777	16.172	0.232
	Miyabi Fuji	76.425	5.279	0.069
Site	p value		0.094	
Variety	p value		0.953	
Site ✻ Variety	p value		0.035	

Site	Variety	Mean TSS	SD	Coefficient of variation
Site 1	Kou kou	10.95	1.127	0.103
	Miyabi Fuji	10.36	1.007	0.097
Site 2	Kou kou	7.25	0.534	0.074
	Miyabi Fuji	8.22	0.611	0.074
Site	p value		< .001	
Variety	p value		0.488	
Site ✻ Variety	p value		0.007	

Figure 2. 6. Kou kou and Miyabi Fuji Fruits

2.1.14. Performance evaluation of cape gooseberry

Physalis (Physalis peruviana L.), is known as cape gooseberry or ground-cherry and belongs to Solanaceae family. Physalis is a domed shrub that can grow up to 1 m tall. The fruit is a juicy berry that can reach 1.25 to 2.50 cm in diameter and can contain around 100 to 200 small seeds. The plant production starts from nine to eleven months from the time of the first harvest after which both the productivity and fruit quality decrease. The shelf life of the fruit is 3-4weeks with the calyx, and around 1 week without the calyx. It is well adapted to any warm climate and can even tolerate to cold but it does not like excess moisture or frost. It can be propagated through seeds, cuttings and layering.

Physalis plays an important role in nutrition and dietary. It has a unique flavor, texture and colour. The physalis fruit is rich in pro-vitamin A, ascorbic acid, and in some vitamins of the B. The health benefits of physalis are blood purification, reduction of the albumin in the kidneys, reconstruction and strengthening of the optic nerve, alleviation of throat infections, elimination of intestinal parasites, and treatment of prostate problems.

The trial was established on 30th April, 2024 with 3 different planting spaces i.e., (Treatment 1 = 1 m, Treatment 2 = 1.2 m and Treatment 3 = 1.5 m) with replicated 4 times. The row-to-row distance was maintained at 1.5 m. Cultural operations were carried out as and when required. Each treatment has 27 plants. 20 randomly selected fruits from each treatment were sampled for collection of data.

The overall yield of the trial ranged from 13-35 kg per harvest. The 3rd harvest had the highest yield of 35.3 kg, and the 1st harvest had the least yield with 13.08 kg. The probable reason for this can be due to the plants being young and not fully established during the first harvest, which makes it invest its energy more on vegetative growth. In the case of the 3rd harvest the yield is the highest due to peak vegetative and reproductive growth and more branches and nodes for bearing fruits. The total yield from the plot is 105.82 kg from the four harvests. Among the three treatments, Treatment 2 showed the highest average fruit weight from all 4 harvests.

2.1.15. Assessment of essential oil content of Thyme

With almost 100 species found worldwide, Thymus vulgaris L., commonly referred to as garden thyme, is a very valuable plant. Thymus is a genus of medicinal plants that have many therapeutic uses and are very useful. The ideal growing conditions for thymus are well-aerated soils with a pH between 5.0 and 8.0. Vermicomposting encourages the growth of thyme plants. Additionally, a good output of thyme essential oil requires proper spacing. Because of its antifungal, antibacterial, and anti-inflammatory qualities, thyme essential oil is well-liked all over the world. Thymol, carvacrol, linalool, apigenin, eugenol, p-cymene, γ-terpinene, and rosmarinic acid are the main components of thyme essential oils. Thymol is a common component among these. Additionally, thyme has an extremely high nutritional profile.

The global Thyme essential oil market was valued at approximately $310 million in 2022 and is projected to grow at a compound annual growth rate (CAGR) of 6.2% from 2023 to 2030. The essential oil of thyme is rich in thymol and has other volatile compounds. The main compound typically includes thymol (40-83%), p-cymene, y-terpene and carvacrol. This growth is basically driven by the increasing demand for natural products in personal care, food and culinary and aromatherapy.

The thyme seed- Tomillo was imported in 2020 from the USA and it was grown in NCOA, Yusipang. The essential oil of Thyme was extracted through hydro distillation. The experiment was conducted using Randomized Complete Block Design (RCBD) with three treatments and three replications. Each treatment in each replication was comprised of one kg. All samples were collected on the same day. The treatments are-

1. Oven dried leaves at 21 degrees for 10 hours
2. Dried at Room temperature for 17 days.
3. Dried at room temperature for 21 days.

The samples were chopped into small pieces and put in the 10 L flask containing water enough to submerge the materials and the unit will be carried to boiling at oven temperature of 80ºC for 90 minutes ensuring no more essential oil is obtained. After condensation, the oil will be separated from water by decantation. Since water is heavier than the oil, water will be at bottom and oil on top. The hydrosol was collected in one container and the oil in another container. Analysis was done using STAR software.

Yield is calculated using this formula:

$$\text{Yield (\%)} = \frac{\text{Amount of extracted oil (g)}}{\text{Amount of dry vegetal matter mass (g)} \times 100}$$

Treatment 1 showed a higher oil yield compared to other treatments and treatment 2 had the lowest yield. However, no significant difference was detected among the treatments.

2.1.16. Assessment of essential oil content of oregano

Oregano (Origanum vulgare), a member of the Lamiaceae family, is widely recognized for its culinary and medicinal properties. Among its bioactive constituents, essential oils derived from oregano have attracted significant attention due to their potent antimicrobial, antioxidant, and anti-inflammatory effects. These essential oils, rich in compounds such as carvacrol and thymol, are commonly extracted through various methods, with hydro distillation being one of the most traditional and widely used techniques.

The Oregano was imported in 2020 from the USA and it was grown in NCOA, Yusipang. The experiment was conducted using Randomized Complete Block Design (RCBD) with four treatments and three replications. All treatments for each replication were 1.5 kg at harvest. The treatments are-

1. Freshly harvested leaves and stems
2. Oven dried leaves at 21 degrees for 10 hrs.
3. Dried at Room temperature for 5 days.
4. Dried at room temperature for 8 days.

There is a statistically significant difference among treatments in terms of final oil accumulated. Treatment 1(Fresh oregano) resulted in the highest oil accumulation and is statistically superior to the other treatments.

Table 2. 14. Treatment-wise comparison of mean oil yield

Treatment	Mean Oil accumulated (ml)
T1 (Fresh)	9.27^{a}
T2 (10 hrs in Oven)	5^{b}
T3 (5 days at RT)	4.57^{b}
T4 (8 days at RT)	3.6^{b}

2.1.17. Observation trial of sweet basil

The herb sweet basil (Ocimum basilicum L.) is extensively grown and prized for its aromatic, culinary, and therapeutic qualities. It's essential oils, which are abundant in substances like estragole and methyl eugenol, have shown antibacterial, anti-inflammatory, and antioxidant properties, making it a lucrative crop for the pharmaceutical and agricultural sectors. It is still difficult to grow sweet basil as efficiently as possible in a variety of environmental settings. Its development, yield, and essential oil content are greatly influenced by elements like water availability, nitrogen management, and abiotic challenges like salinity and drought.

Despite its popularity, sweet basil has not yet been released and assessed, so rather than depending on imports, this gap must be filled to satisfy local restaurant and upscale hotel demand. The sweet basil was planted with an objective to see the feasibility and growth of the plant at an altitude of 2700 masl. 120 numbers of sweet basil were planted in 4 beds with a spacing of 45 cm spacing. Five plants were randomly selected for the data collection. The parameters observed are plant height, weight, number of branches, number of nodes and yield.

The overall growth was healthy and the average height of basil was observed to be the tallest during the time of the third harvest and shortest at the first harvest. The average yield per harvest was observed highest in the second harvest with 10 kg with average weight per plant of 83 g. The least yield was observed at the fourth harvest as it was 1.7 kg with an average/plant of 0.014 g with the plant population of 120 plants. This difference in yield could be mainly due to basil being annual and the final harvest was done in October and the weather was relatively cold as compared to the other harvests. The average weight of sweet basil is generally 200-300 g/plant and the average weight of the plant sums up to 241.6 g/plant annually which is in range and can be recommended and is feasible in an altitude of 2700 masl.

Table 2. 15. Mean yield parameters by harvest time

Harvest	Average height	Average yield /harvest	Average weight/plant
1	36.4	9.5	79.5
2	48.8	10.0	83.0
3	51.9	9.5	79.1
4	45.7	1.7	0.014

The sweet basil was observed to be free of pests and disease as well. The following year replicated trials can be done to see the adaptation and feasibility in other locations.

2.1.18. Evaluate the production of different crops including Cost-benefit analysis under smart automated greenhouse technologies

By growing crops in a stacked vertical tower hydroponics system, a soilless farming method, makes the most of available space. Using sensors and intelligent technologies, it integrates automation to regulate light, water, nutrients, and climate. This sustainable approach offers year-round production with low inputs of labor, water, and land, addressing issues of resource efficiency, food security, and urban farming. The objective was to assess the operational and financial viability of an automated vertical tower hydroponics system. It aims to evaluate its potential for resource-efficient, high-yield farming in urban or space-constrained settings. By examining the system's investment, operating expenses, benefits, and break-even point, the objective is to assist data-driven decisions on the adoption of smart agriculture technologies.

The crop evaluated in the smart hydroponics vertical towers are bowl salad lettuce, pakchoi, blush butter oak and the green oak leaf lettuce. The smart hydroponics system was operational from 5th September, 2024. The whole structure has 80 vertical towers accommodating 5280 plants.

The number of plants, weight of the plant and the production each year is assumed for the whole year based on a few month's data for a year to analyze the break-even point.

Table 2. 16. total fixed cost incurred in the construction of smart greenhouse

Sl. No.	Components	Cost (in Nu.)
1	Structure of greenhouse	963422
2	Foundation work for the installation of greenhouse	503717
3	Vertical towers	1679680
4	Vertical tower delivery system	176392
5	Irrigation distribution components	253040
6	Automation components	333986.319
7	Labour, Expertise (TADA)	350000
8	Maintenance (Sensor replacement and microcontrollers)	8325
	TOTAL	**4268562.319**

Assuming the depreciation of 15 years the total fixed cost comes to an amount of Nu. 284570.8213 per year. The variable cost mainly includes the nutrient, the electricity bill, labour wage and the seed price.

Table 2. 17. Variable Cost associated with smart Greenhouse

Sl.No.	Entities	Cost (Nu)
1	Cost of nutrients	87600
2	Labour cost per annum	6450
3	Maintenance/Tools	8325
4	Electricity	25524
5	Seed cost	216.70
	Total	**128115.7**

Table 2. 18. Break Even Point (in years) of different crops

Crop	Break-even point (in years)
Bowl salad lettuce	12.65
Pakchoi	17.93
Pakchoi	19.57
Blushed Butter Oak	24.79
Green Oak Leaf	11.47

Among the 5 crops evaluated and analyzed, the crop which will take the longest to reach the BEP in years is the blush butter oak lettuce which will take approximately 25 years to reach the break-even point and if the green oak leaf is grown, it may take the least time to reach break-even point which is of 11 years. The price of the crop and yield are assumed with respect to the price fetched in the centre and for a duration of 1 year respectively, though the hydroponics has not been operational for a year yet.

The assumptions made in analysis of this report are based on the cost incurred, price fetched and crop duration of real-time data from just one site and in context to Yusipang conditions, which may be subjective and can differ by place. Thus, this report may serve as a basis for the future trials and can be regarded as a reference for interested entrepreneurs and progressive farmers.

2.2. HORTICULTURE RESEARCH ACTIVITIES

2.2.1. Demonstration and promotion of World Veg tomato and chilli lines

Production of seeds and seedlings of Yusi-Lambenda1, 2, 3 and AVTO 1712 was conducted. In addition, rain-shelter technology of tomato production has also been demonstrated. A total of 10 rain shelters of 10 m x 1.8 meters has been put under the demonstration with World veg released lines.

Figure 2. 7. On farm tomato production from demonstration of AVTO 1712

Table 2. 19. Production of seeds and seedlings of Yusi-Lambenda1, 2, 3 and AVTO 1712

Name of items supported	Size	Quantity	Village	Gewog	Dzongkhag
Polyhouse	20 m x 5 m	1	Jadhingkha	Mewang	Thimphu
Polyhouses	20 m x 5 m	3	Genekha	Genekha	Thimphu
Polyhouses	10 m x 5 m	1	Chanachen	Gelling	Chukha
Polyhouses	10 m x 5 m	2	Dophulakha	Phuntsholing	Chukha
Polyhouses	20 m x 5 m	1	Dophulakha	Phuntsholing	Chukha
Polyhouses	10 m x 5 m	1	Upper Saurini	Darla	Chukha
Poly house	20 m x 5 m	2	Pangbisa	Luni	Paro
Mega greenhouse	22 m x 20 m	1	Yusipang	Chang	Thimphu
Mega greenhouse	44 m x 22 m	1	Thakoling	Patshaling	Tsirang
Total		**13**			

2.2.2. Capacity development for vegetable researchers and seed producers

Training Workshop on Vegetable Variety Development and Breeding was conducted at Agriculture Research and Development Center (ARDC) Samtenling, Sarpang from 9.03.2025 to 13.03.2025 for the following objectives:

- To provide participants with a comprehensive understanding of the principles and methodologies in vegetable variety development and breeding.
- To familiarize the participants with modern breeding techniques.
- To enhance knowledge on variety selection and evaluation.

A total of 23 participants attended the training. The training was attended by officials from different organization including National Center for Organic Agriculture (NCOA), ARDCs (Bajo, Samtelling, Wengkhar), Agriculture Research and Development sub-centers (ARDSC) (Pangbang and Tsirang), National Seed Center (NSC), and Bhutan Alpine Seeds. The event was organized by NCOA in collaboration with ARDC Samtenling, with external resource persons from the College of Natural Resources (CNR) and the World Vegetable Center. The training was funded by Asian Food & Agriculture Cooperation Initiative (AFACI).

The program began with an introduction to AFACI vegetable project, 'Development of Vegetable Breeding Technology in Asia Region Phase II,' followed by a presentation on priority vegetable crops in the 13th Five-Year Plan. The session also covered the principles of plant breeding, objectives and applications. Additionally, there was a group discussion on the status of variety development activities conducted at the respective ARDCs and the sub-centers. Dr. Derek Barchenger presented virtually on varietal maintenance, seed production, seed health, quality, and parental selection for hybrid development in chilli. The first day concluded with a field visit to vegetable field trials in the center.

The second day focused on prospects of vegetable variety development and breeding in Bhutan, including standard procedures, strategies, and vegetable breeding methods along with a session on major pest and diseases of chili and tomato in Bhutan and its management. This was followed by a practical demonstration on tomato seed extraction and hybridization in both tomato and chilli. The day started with a presentation on the virus diagnosis research findings and a virtual session by Dr. Assaf Eybishitz on breeding multiple disease resistant tomato. Presentations were made by each agency on their planned-breeding activities followed by discussions on plans for vegetable development and breeding. The workshop received positive responses from the participants. The workshop provided the participants an opportunity to share emerging needs of farmers specific to each region and facilitated streamlining of research efforts to meet national priorities in addition to capacity development of the researchers.

Figure 2. 8. Participants practicing hybridization

2.2.3. Participation at the 10th Biodiversity fair

The vegetable unit participated in the Bio-diversity fair held at Tsirang on 17th December 2025 organized jointly by the Tsirang Dzongkhag Administration and the National Biodiversity Centre. The unit showcased traditional crops seeds and promoted open pollinated newly released tomato and chilli varieties where the World Veg seeds were displayed and seeds of released varieties were sold.

Figure 2. 9. Exhibition at the 10th Biodiversity fair

2.2.4. Demonstration and capacity building program by INTECrop

Many on-farm activities were carried out under the Integrated Temperate fruit Crops Promotion Project (iNTECrop). The project mainly focuses on promoting market-oriented promotion of fruit crops in Thimphu, Paro and Haa with support from Japan International Cooperation Agency.

A training of trainer's program for the farmers and extension personnel from Thimphu, Paro and Haa was conducted from 21/01/2025 to 23/01/2025. The program was attended by a total of 34 participant including tsogpas from the target gewogs and staff member from our centre. The training program provided an important platform for participants to learn about temperate fruit management and fruit nursery propagation techniques. Participants also had the opportunity to visit on-station sites, where they were exposed to practical demonstrations and technologies, further enhancing their understanding and skills. Most importantly, on the final day of the training, participants from each target site developed tailored action plans to implement follow-up trainings in their respective gewogs.

Subsequently, as per the action plan drawn by participants, a need based in-field training for 233 farmers in SHEP iNTECrop project sites encompassing 8 gewogs in Thimphu, Paro and Haa was conducted from 10/02/2025 to 03/03/2025. The training program emphasized on essential techniques in fruit farming which encompasses activities such as pruning, grafting, and top-working. In addition, the training program was customized to local requirements, with certain gewogs including supplementary subjects such as Bokashi composting, plant protection, and the formulation of activity calendars. The objective of these trainings was to enhance farmers' proficiency in optimizing orchard productivity and sustainability. Details of the training programs are given in the table below.

Table 2. 20. Details of trainings carried out in iNTECrop project sites

Sl. No.	Site	Training program	Participants
1	Samar, Haa	Training/Pruning and feasibility of different fruit types	40
2	Katsho, Haa	Training/Pruning and grafting	26
3	Eusu, Haa	Pruning and training (top working included) and grafting	52
4	Doten, Paro	Pruning and Training/ development of calendar of activities/ plant protection (TSO application)	23
5	Luni, Paro	Kiwi pruning and grafting/ Bokashi making	29
6	Tsento, Paro	Pruning and Top-working	18
7	Chang, Thimphu	Grafting and pruning	25
8	Dagala, Thimphu	Grafting and pruning	20

Figure 2. 10. Participants of SHEP ToT program

As a follow up activity to the in-field training, a top-working initiative involving 156 temperate fruit trees was successfully carried out for 32 beneficiaries at Katsho Geog under Haa Dzongkhag from 25/03/2025 to 29/03/2025. This activity was conducted as a follow-up to the in-field training held in February, during which farmers expressed the need for more marketable fruit varieties. Also, the primary objectives of the SHEP iNTECrop project is to promote market-linked production. Hence, this initiative focused on top-working of late and early varieties of apples and other temperate fruits. By introducing improved varieties, the project aimed to enhance both marketability and productivity, directly addressing the needs identified during the earlier training sessions.

Figure 2. 11. Top-working of cherry and apple in Haa

Most importantly, on 23/08/2024, a Stakeholder Forum was held at Jambayang Resort in Thimphu, bringing together 50 participants, including farmers from nine target gewogs in the Paro, Haa, and Thimphu dzongkhags who are active Smallholder Horticulture Empowerment & Promotion (SHEP) approach practitioners. Key players in the agriculture value chain—such as fruit and vegetable importers, wholesalers, exporters, representatives from Bhutan Agro Industries Limited, Bhutan Alpine Seeds, and the National Seed Centre—were also in attendance. The forum, funded by the Integrated Temperate Fruit Crops Promotion Project (iNTECrop), served as a crucial platform for farmers to deepen their understanding of current market trends and demands while forging vital connections within the agriculture value chain. Through direct interactions with these key stakeholders, farmers gained valuable insights into market needs, helping them to better align their production with demand. Additionally, the forum provided an opportunity for farmers to

showcase their finest agricultural produce, creating potential avenues for new business partnerships and collaborations.

Figure 2. 12. Group photo and produce display at the stakeholder forum

2.2.5. Participation in the International Volunteer Day

The unit participated in the International Volunteer Day celebrated on the 5th December 2024 at Changyul Park in Thimphu. The unit prepared tree samples and fruit samples of all fruit crops supplied under the Million Fruit Tree Plantation project over the past three years comprising of both subtropical and temperate fruit trees. The exhibition was well received by the audience composed mainly of young students and young adults, many of whom were Desuups. The exhibition seemed to increase awareness of the type and taste of fruit plants that were supplied.

2.2.6. Inauguration of an organic sales outlet

A sales outlet was constructed within the vicinity of the centre with support from the iNTECrop and was inaugurated on the 4th of December 2024. Outlet serves as a single window through which any surplus in research by-products and demonstration blocks can be sold to interested clients at predetermined prices based on cost of production. The outlet will be restricted to only organic produce.

The outlet is expected to demonstrate organic marketing and compliance to standards of labelling and packaging for small to medium organic farmers. It is also expected to provide a platform for customers to access package of practices and improved technologies through information sharing. In addition, it also serves to facilitate and promote new crop and crop varieties to determine its acceptance for the Bhutanese palate.

Figure 2. 13. Inauguration of the outlet

2.2.7. Maintenance of germplasm for fruits

Winter pruning, training, and top-working operations on temperate fruit trees at NCOA were done. Key activities included structural pruning for orchard rejuvenation, training young trees to desired forms, and top-working select mature trees for variety conversion. All work was completed within the targeted January-February 2025 window, with follow-up cultural practices implemented to support recovery and spring growth.

Table 2. 21. Summary of pruned trees

Activity	Target Trees	Quantity Completed	Methodology
Pruning & Training	Apples, Pears, Peaches, plum, apricot, walnut, prune.	450 trees	Modified central leader system and open center system
Top-working	Mature trees (variety change)	35 trees	Cut grafting (3-5 scions/tree)

Table 2. 22. Seedling grafted for promotion and support

Fruit	Quantity	Method	Special Notes
Pear	450	Whip-and-tongue	Local pear rootstock
Apple	180	Whip-and-tongue	M9 and M111 rootstock
Walnut	170	Side graft/whip & tongue	Wild walnut rootstock
Loquat	30	Air layering	Sphagnum moss & top soil.
Other*	233	Side/whip-and-tongue	Wild peach

2.2.8. Development of mixed fruit blocks and other facilities

A mixed fruit trellis system was developed comprising overhead and y-system trellis for grapes and pear and trellis for high density apple production. The trellis will include a total of 18 vines, 18 pear and 18 apple trees. The main objective is to demonstrate methods other than traditional method of cultivation. It will also be used to study yield efficiency for a changing farming demographic in limited land for fruits. A berry block was also established at the centre. The blocks

hosts black berries, strawberries, currants and Boysen berries and will be maintained for demonstration to farmers. In addition, two nursery shed houses for fruits were also developed.

Figure 2. 14. Trellis for pear and Shed house

2.2.9. Enhancement of floriculture

The National Centre for Organic Agriculture (NCOA) has initiated a range of floriculture activities as part of its landscape beautification and ornamental horticulture development program. These activities aim to enhance the visual appeal of the campus, promote the conservation of ornamental plant varieties, and build technical capacity in the propagation and management of floriculture species. The initiative also aligns with Principle of Ecology in Organic Agriculture, where natural habitat of natural predators and pollinators are protected.

2.2.10. Establishment of an Ornamental Peach Garden

A dedicated mixed ornamental peach garden was established at the NCOA campus near the administration building. Seven saplings of ornamental peach (Prunus persica) grafted on local rootstock. The planting was done in triangular system layout of 3 meters apart in early spring, and bushy flowering plant will be planted in the next coming season. Seasonal pruning is undertaken to maintain tree shape and health.

2.2.11. Propagation of Roses and Ornamental Shrubs via Cuttings

A variety of ornamental shrubs were propagated such as tea Roses (various colors), Lady bank's roses, Spirea, Japanese quince, Hydrangea and Ornamental cherry/ Sakura propagated using semi-hardwood cuttings taken from healthy mother plants and planting in a forest leaf mould–sand medium. Preliminary success rate of rooting was observed to be 65–75%.

2.2.12. Maintenance of Potted Flower Plants around the Office

Ornamental peach, Sakura, hydrangea, kumquat almond bush and citrus saplings were planted in flower pots and placed strategically at the entrances, pathways, and key office zones. These were regularly maintained to ensure year-round duration of flowering.

Outcomes and Benefits

- Aesthetic Improvement: The peach garden and potted flowers have visibly enhanced the landscape and created a more welcoming office environment.
- Biodiversity Conservation: The initiative supports the preservation of both native and introduced floriculture species.
- Visitor Experience: Positive feedback has been received from stakeholders and visitors regarding the visual and environmental improvements on campus.
- Sustainability Practices: All activities adhered to organic standards, avoiding synthetic fertilizers and pesticides.

2.2.13. Maintenance of MAP germplasm

The MAP unit maintains germplasm for both the culinary and MAPs comprising 16 culinary herbs and 45 species of MAPs. These are maintained and propagated annually based on the type of herb. The germplasm block serves as a display block for students at College of Natural Resources (CNR) who visit the block as part of their curriculum, for farmer groups and visitors. This year, 26 different types of MAPs were collected from Changkhaphu and Barshong, Thimphu.

Table 2. 23. List of MAPs collected from Changkhaphu

Sl.No.	Plant name	Botanical name	No. of plants collected	Survival	Natality %
1	Subka	Anemone rivularis	5	3	60
2	Kechi Karpo	Gentiana robusta	5	2	40
3	Wangla	Dactylorhiza hatagirea	6	0	0
4	Lagang	Geranium refractum	10	10	100
5	Ja poe	Valeriana jatamansi	9	0	0
6	Dho chu kewa (Thoksampa)	Paris polyphylla	9	2	22
7	Chaktik raguma (Pseudo chirata)	Helenia elliptica	21	0	0
8	Chu tsa	Rhuem australae	12	5	42
9	Tsendu / Bong nga Nakpo	Aconitum lacinatum	4	3	75
10	Ngotin	Thilactum reniforme	14	12	86
11	Drey lang	Pedicularis siphonantha	15	0	0
TOTAL			**110**	**37**	**34**

Figure 2.15. Wild collection from Barshong

Table 2. 24. MAP collected from Barshong, Thimphu

Sl. No.	Plant name	Botanical name	Family	No. collected	Survived	Survivability %
1	Bong nga karpo	Aconitum orochryseum	Ranunculaceae	4	2	50
2	Wangla	Dactylorhiza hatagirea	Orchidacese	3	0	0
3	Balu(red)	Rhododendron anthopogon	Ericaceae	4	1	25
4	Sulu(white)	Rhododendron setosum	Ericaceae	17	2	12
5	Udpal serpo	Meconopsis paniculata	Papaveraceae	6	0	0
6	Udpal ngonpo	Meconopsis simplicifolia	Papaveraceae	4	0	0
7	Tser ngon	Meconopsis horridula	Papaveraceae	1	0	0
8	Re-Sgog	Allium wallichii	Amaryllidaceae	7	7	100
9	Hong-len/ Puti-shing	Neopicorhiza scrophulariiflora	Scrophulariceae	42	30	71
10	Pang-poe	Nardostachys grandiflora	Valerianaceae	67	58	87
11	Dremog chok/ Muktse	Onosma hookeri	Boraginaceae	6	5	83
12	Sonam choeja	Hypericum patulum	Hypericaceae	5	5	100

13	Koenpo gabkay	Saussurea nepalensis	Asteraceae	2	1	50
14	Drezin	Maharanga emodi	Boraginaceae	17	16	94
TOTAL				185	127	69
15	Yoel-mo sel	Podophylum hexandra	Berberidaceae	1 pod	Seeds sown	

The saffron corms were also maintained under various condition. The details are given in the table below.

Table 2. 25. Details of saffron corms maintained at NCOA

Field condition	Diameter of corm(mm)	Qty. (gm)	Total corms
Open field (Rain shelter)	11 to 14	157	133
Open field (Rain shelter)	6 to 10	280	540
Green house	<5	156	
Green house	6 to 13	199	479
Open field	>15	47	20
Open field	11 to 14	100	80

2.2.14. Basic seed production of released herb (Yusi dill)

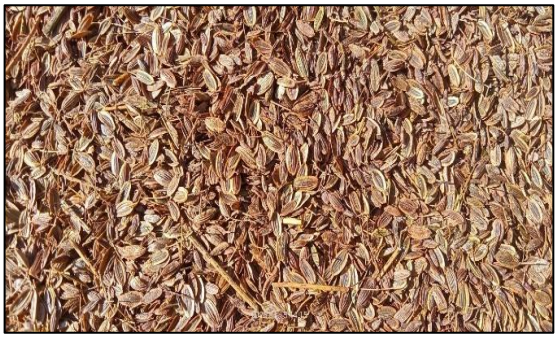

Figure 2.16. Picture of Yusi Dill 1 seeds

Goldkrone variety of dill imported from the United States of America was evaluated in three different agroecological zones viz. Warm Temperate, Dry Sub-tropical and Humid subtropical in the year 2021 and was released as Yusi dill through the 25th Variety Release Committee (VRC) meeting.

As required, the seeds of varieties approved by VRC need to be deposited to the National Seed Centre (NSC) for multiplication and to the National Biodiversity Centre (NBC) for maintenance as germplasm. Seeds are provided to interested farmers and urban dwellers for diversification.

128 grams of seeds were sown at 1 to 2 cm depth in the line with the row-to-row space of 50 cm. When the seedlings attained the height of 15 cm, thinning was done keeping the plant-to-plant distance of 30 cm. The intercultural operations like irrigation and weeding are carried out as and when required.

The Yusi dill seed was harvested on 8th August 2024 and 3.265 kg of seed was yielded. 1000 grams of Yusi dill seed were deposited to National Biodiversity Centre for maintenance in the gene bank.

2.2.15. Technical support for high altitude MAP and culinary herbs

The MAP unit has 70 species comprising high altitude medicinal and aromatic plants and culinary herbs. The unit supported seven farms, and eight interested clients with different types of culinary herbs and medicinal herbs along with technical guidance. The table below shows the types and quantity of herbs supported.

Table 2. 26. Seedling support provided to interested farms

Sl. No.	Herb	Potted plant (No.)	Seedlings (No.)	Seeds (g)
1	Parpata	101	400	5
2	Manu	52		5
3	Ruta	4		5
4	Potentilla arsena		100	
5	Ginseng			330
6	Zanthoxyllum	2		
7	Capegoose berry	80	20	
8	Wasabi	2		
9	Chamomile		20	5
10	Rosemary	18		
11	Oregano	18		
12	Thyme	20		
13	Sage	20		
14	Rocket salad			2
15	parsley	53		10
16	celery	50	30	5
17	Dill	2		105
18	fennel	2		5
19	Sweet basil	4		
Total		**428**	**570**	**477**

2.2.16. Demonstration of production of crops in NFT

The Nutrient Film Technique (NFT) system at the center is adaptable to a wide range of crops like leafy greens, herbs, and strawberries characterized by producing high-quality crops. The minimal use of water, labor, and nutrients has made it highly desirable in arid climates or non-arable land. Different crops like sweet basil, chives, bakchoi, saag, Japanese green (tawla saag), lettuce (green oak, blush butter oak, biscia rosa), tatsoi, cabbage and cauliflower were grown in the nutrient film techniques (NFT) hydroponics throughout the year for demonstration to visitors.

Table 2. 27. Crops and their yield grown in NFT

Sl. no	Crop	Yield /Plant (g)	Yield/structure (kg)
1	Basil	117.6	188.2
2	Chives	57.2	91.5
3	Pakchoi	33.3	53.3
4	Saag	53.3	85.2
5	Japanese green (tawla)	103.2	165.2
6	Green oak	124.7	199.5
7	Blush butter oak	146.4	234.2
8	Biscia rossa	132.0	211.1
9	Tatsoi	29.6	47.4
10	Cauliflower	68.7	110.0
11	Cabbage	124.2	198.7

3. NATIONAL POTATO RESEARCH AND DEVELOPMENT PROGRAM

3.1. NATIONAL POTATO PROGRAM RESEARCH ACTIVITIES

3.1.1. Evaluation of biofortified potato clones

The biofortified varieties are nutrient dense and rich in micronutrients such as iron, zinc, and vitamin A. The main aim behind the evaluation of biofortified potato clones is to come up with a potential variety that can address nutritional deficiencies and enhance food security. In the 2023-2024, five climate-resilient clones from International Potato Center (CIP); CIP 312725.376, CIP 312535.062, CIP 312725.055, CIP 312764.013, and along with Yusi-Maap as a control was evaluated in Bumthang. The plots were arranged in a randomized complete block design (RCBD) with three replicates. Land was ploughed with power-tillers and ridges were made manually. Potato tubers were planted with a distance of 20 cm between the plants and 70 cm between the rows covering an area of 2.8 m². The crop was fertilized based on the nutrient recommended rate i.e. 79:89:40 N:P: K kg/ha. Farmyard manure was also applied at 12 Mt/ha. Two manual weeding was carried out at 25 days after emergence (DAE) and 60 DAE. The crop was grown under rain-fed condition and no plant protection measures was used.

A significant difference (p =0.01) in yield was observed with none of the clone yielding higher than the control variety Yusi Maap which has 14 Mt/ac. During the harvesting a participatory varietal selection (PVS) was carried out. A total of 25 participants; 7 male and 18 female potato growers participated in the PVS which aimed to engage farmers in the selection process of a potential biofortified potato variety preferred by farmers. Additionally, the organoleptic test was conducted to assess the physical qualities of the different potato clones, including taste, texture, and appearance. Unfortunately, the response from farmers was not satisfactory, as the test clones showed lower yields compared to the control variety, *Yusi Maap*. Besides, the color of the biofortified were not preferred by the farmers. Due to the under performance of the biofortified clones in terms of yield and farmer preference, no variety has been selected for release at this stage.

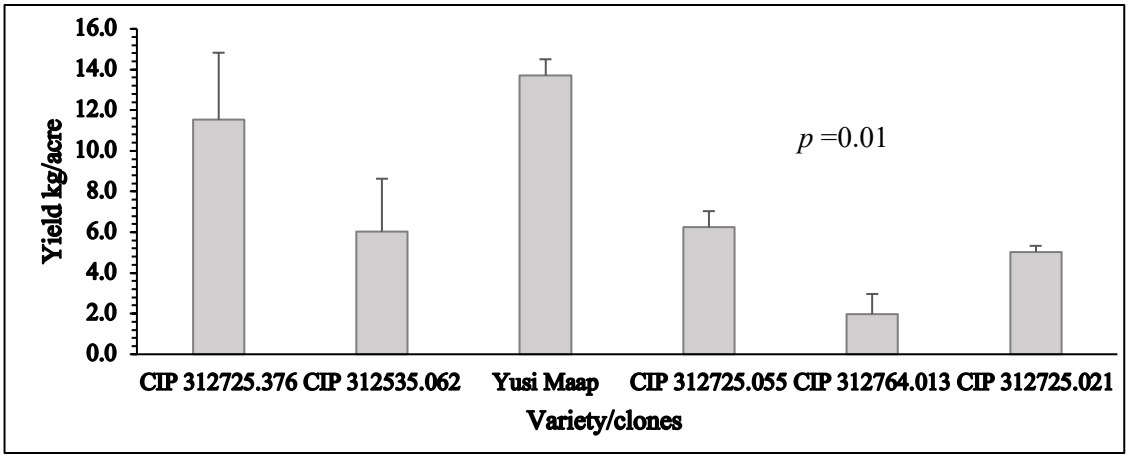

Figure 3. 1. The yield (Mt/acre) of biofortified clones in Nasphyel Farm

Further research and breeding efforts will necessary to develop improved nutrient-dense potato varieties that meet both agronomic and farmer acceptability standards.

Figure 3. 2. Farmers casting their votes for the most preferred variety during the participatory variety selection (left) and (right) Organoleptic test carried out during the PVS

3.1.2. Evaluation of Climate Resilient Potato Clones

With the climate changes impact on potato production, innovative steps in agriculture have led to the introduction of climate-resilient potato clones. These robust varieties are specifically bred to withstand adverse weather conditions, ensuring stability and productivity in potato cultivation. Considering the traits such as drought and heat tolerance, along with disease resistance, this trial aims to select and come up with a potential variety that can help farmers navigate the uncertainties of climate change while enhancing high potato yields.

In the 2023-2024, five climate-resilient clones from International Potato Center (CIP); CIP 302476.19, CIP 307196.3, CIP 309077.116, CIP 304357.31, and CIP 309028.56 along with Yusi-Maap as a control, were evaluated in Bumthang, Khangma, and Yusipang. The plots were laid out using a randomized complete block design (RCBD) with three replicates. In each treatment, 20 numbers of tuber were planted. Each plot occupied an area of 2.8 m^2 with a tuber-tuber spacing of 10 cm.

A one-way ANOVA comparing potato clones revealed significant differences in number of non-marketable tubers ($p < 0.001$) and total yield per acre ($p < 0.001$), but not in marketable tubers**.** The highest-yielding clones were Yusi Maap (26.5 Mt/ac) and 309028.56 (26.4 Mt/ac), which also produced the most marketable tubers (96 and 82, respectively). In contrast, 304357.31 had the lowest yield (9.4 Mt/ac) and the highest proportion of non-marketable tubers (69), indicating poor performance. The high coefficient of variation (CV) for non-marketable tubers (88%) and total yield (43%) suggests substantial variability among clones, with genetic differences likely driving yield and tuber quality. These results highlight 309028.56 and Yusi Maap as promising candidates for further evaluation due to their superior yield and marketability.

Table 3.1. Details of numbers of marketable tuber, non-marketable tubers and total yield (Mt/ac) of climatic resilient clones under organic condition

Clones	No. of marketable tubers	No. of non-marketable tubers	Yield t/acre
302476.19	61	13	11.5
397196.3	60	17	15.5
309077.116	85	8	18.2
304357.31	57	69	9.4
309028.56	82	20	26.4
Yusi Maap	96	19	26.5
Mean	73	24	17.9
SD	28.4	21.6	7.7
CV (%)	0.387	0.88	0.43
Sig	ns	***	***
Remarks: ns-not significant, *** significant			

3.1.3. Optimizing Fertilizer Application for tuber quality

Potato (*Solanum tuberosum*) holds significant importance as a primary food and cash crop in Bhutan, cultivated across all districts. Over the past few years, the National Potato Program has released several promising and high-yielding potato varieties. However, an issue arose with the Yusi maap variety, concerning the occurrence of oversized tubers. While the precise factors contributing to this oversized tuber phenomenon remain unclear, certain studies have suggested the importance of nitrogen (N) in tuber protein synthesis and growth (Westermann, 2005; Kavvadias et al., 2012). Moreover, it has been noted that excessive nitrogen supply during later stages of growth can continue crop growth and potentially lead to an abundance of oversized potatoes. In Bhutan, Suphala (15:15:15 NPK) stands out as the most commonly used fertilizer for potato cultivation.

Despite the widespread use of Suphala fertilizer, limited scientific evidence exists regarding its specific effects on potato tuber size in Bhutanese agricultural conditions. Given this context, understanding the response of potato tuber size to Suphala fertilizer application is essential for optimizing fertilizer management practices and improving potato yield (tuber size) and quality. Thus, this study was carried out in 2023-2024 with an objective to assess the effect of Suphala application rate and timing of application on the size of potato tubers. The plots were laid out using a randomized block design with two factors; Variety as main plot and fertilizer as sub-plot. Six fertilizer rates were assessed (Table 3.2). The varieties include Desiree, Yusi Maap and Yusi Maap 2.

Table 3.2. The fertilizer application rates and timing used in the treatment

Treatments (recommended rates)		To be applied in 2.8 m^2 (gm)	Basal dose (gm)	Top dress (gm)	Remarks
T1	248 kg/ac	148	148	0	All basal dose
T2	124_124 kg/ac	74_74	74	74	50% as basal & top dress
T3	267 kg/ac	158	158	0	All basal dose
T4	133_133 kg/ac	79_79	79	79	50% as basal & top dress
T5	200 kg/ac	118	118	0	All basal dose
T6	No Chemical fertilizer	No fertilizer	0	0	

A two-way ANOVA revealed significant main effects of variety on table tuber diameter ($p < .001$) and non-commercial tuber diameter ($p < .001$), but not on seed tuber diameter, with Yusi maap producing the largest tubers (70.9 mm) compared to Desiree (53.4 mm) and Yusi maap 2 (59.6 mm). In contrast, fertilizer rate and application timing had no significant impact on any tuber size category, and the variety × fertilizer interaction was nonsignificant ($p > .05$), indicating that tuber size differences were driven primarily by genetic factors rather than fertilization. Further trial with same treatment on Yusi Maap will be carried out to validate the result.

Table 3. 3. Variability in tuber diameter (mm) observed among three potato varieties under different fertilizer applications

	Table Tuber Diameter	Seed Tuber Diameter	NC Tuber Diameter
Varieties (A)			
Desiree	53.4	45.9	25.5
Yusi maap	70.9	49.1	28.3
Yusi maap 2	59.6	46.2	26.6
Fertilizer (B)			
248_0	64.0	48.5	26.8
124_124	61.1	47.6	26.3
267_0	62.8	45.6	26.8
133_133	61.9	46.0	27.1
200_0	62.1	47.8	26.9
0_0	65.3	47.9	27.1
ANOVA			
Varieties (A)	***	ns	***
Fertilizer(B)	ns	ns	ns
A x B	ns	ns	ns

*Remarks: Dia is the diameter meased in milimeter(mm); ns-not significant and ***- significant*

3.1.4. Evaluate climate resilient and sustainable potato storage technology (Study shelf life of five potato varieties under three storage condition)

Potatoes are a staple food crop worldwide, including in Bhutan, where they play a significant role in both agriculture and the local diet. The shelf life of potatoes critically affects their marketability, storage, and overall economic value. Understanding the impact of different storage conditions on the shelf life of various potato varieties can help farmers, distributors, and consumers make informed decisions to minimize post-harvest losses and maintain quality. The primary objective of this study is to evaluate the shelf life of five potato varieties (Yusi Maap, Yusi Maap-2, Yusi Chip-1, Nesaphel Kawa Kaap, and Desiree) under three distinct storage treatments: normal conditions, underground pit storage, and JICA storehouse. Data loggers were placed in each storage setup (to measure humidity and temperature), except for the JICA storehouse, which was kept under standard conditions. Each storage method offers unique environmental conditions that can significantly impact the potatoes' longevity and quality. In this study, normal conditions typically involve room temperature storage, which is common at the household level in farmers' fields. Underground Pit Storage includes utilizations of traditional techniques to maintain a cooler and more stable environment. JICA storehouse provides controlled storage conditions to assess the impact of a modern storage facility on potato shelf life. By comparing these storage methods, the study aims to identify the optimal conditions for maximizing the shelf life and quality of these potato varieties. The experiment was laid out using split plot design (where the main plot was the storage methods and sub-plot were the varieties) with three replicates. For data collection, each variety weighing 5 kilograms, consisting of large (table) and medium (seed) size tubers, were packed in bag. Two tubers from each sample were randomly selected and measured for height, diameter, and weight. Firmness was also checked before and after 120 days. Data were collected at 30-day intervals over a 120-day period according to the CIP storage protocol.

The results from the experiment indicate varying levels of weight reduction across potato varieties and storage conditions over time. For the Desiree variety, the weight reduction was 0.215 kg (4.0%) in the Modified Pit Store, 0.690 kg (10.5%) in the JICA Store, and 0.430 kg (8.3%) in the Normal Room. The Yusi Maap variety exhibited minimal weight loss of 0.070 kg (1.3%) in the Modified Pit Store, while reductions in the JICA Store and Normal Room were 0.150 kg (2.8%) and 0.395 kg (8.1%), respectively. For Yusi Maap-2, the highest weight loss occurred in the JICA Store (0.565 kg, 10.9%), followed by the Normal Room (0.395 kg, 7.8%) and the Modified Pit Store (0.140 kg, 2.5%). The Yusi Chip-1 variety experienced the greatest losses in the Normal Room (0.630 kg, 12.0%) and the JICA Store (0.595 kg, 11.7%), with the lowest reduction in the Modified Pit Store (0.130 kg, 2.3%). The NKK variety recorded similar weight reductions in the JICA Store and Normal Room (0.370 kg, 7.2% each) and a smaller loss in the Modified Pit Store (0.320 kg, 6.3%). On average, the weight reduction across all varieties and storage conditions was 0.380 kg (7.6%).

Among the storage conditions, the Modified Pit Store consistently demonstrated the lowest weight reduction, followed by the Normal Room, with the JICA Store showing the highest weight loss.

These findings highlight the efficiency of the Modified Pit Store in minimizing weight reduction and preserving potato quality over time.

Table 3. 4. Detailed results of the tuber weight collected over 120 days

Variety	Storage Condition	Tuber Weight 18/10/2024	Tuber Weight 19/11/2024	Tuber Weight 19/12/2024	Tuber Weight 7/2/2025	Tuber Weight 10/3/2025
Desiree	Modified Pit Store	5.19	5.13	5.09	5.01	4.99
	JICA Store	5.29	5.11	5	4.86	4.6
	Normal Room	5.18	5.14	5.07	4.86	4.75
Yusi Maap	Modified Pit Store	5.32	5.32	5.31	5.25	5.25
	JICA Store	5.27	5.24	5.19	5.13	5.12
	Normal Room	5.4	5.35	5.3	5.24	5.05
Yusi Maap-2	Modified Pit Store	5.5	5.49	5.48	5.39	5.36
	JICA Store	5.01	4.9	4.84	4.75	4.48
	Normal Room	5.14	5.09	5.01	5.12	4.75
Yusi Chip-1	Modified Pit Store	5.55	5.5	5.48	5.42	5.42
	JICA Store	5.12	4.97	4.73	4.53	4.52
	Normal Room	5.24	5.2	5.18	4.77	4.61
NKK	Modified Pit Store	5.05	5.05	5.04	4.96	4.73
	JICA Store	5.03	4.96	4.86	4.68	4.67
	Normal Room	4.98	4.93	4.89	4.72	4.59

3.1.5. Evaluation and promotion of traditional and improved sweet potatoes germplasm (NCT)

Considering the nutritional value and market potential of sweet potatoes, the National Centre for Organic Agriculture initiated a nationally coordinated trial (NCT) on evaluation of five improved and traditional varieties namely purple flesh, Murasaki, Local red, local pink and local white ARDC Bajo and Samtenling. A significant yield difference ($p < 0.05$) was observed between the five varieties on station. The trial was laid out using randomized complete block design with three

replicates. Each plot size measured 6 m^2 with 24 slips / plot (one slip per hill). The slips were planted 8-10 cm depth, with a spacing of 30cm plant to plant, and 75cm row-row. This result showed a significant (p <0.05) yield difference between the varieties. The popular Japanese variety Murasaki exhibited the highest yield with 13.1 Mt/ac.

The on-farm demonstration was carried out in 2024-2025 in Zhemgang and Phuntsholing. The result from both the side shows that Murasaki and purple flesh had higher yield and thus these two varieties; Murasaki and Purple flesh will be proposed for release in year 2025.

3.1.6. Effect of haulm cutting on tuber size of the released potato varieties

In 2021, Bhutan's national potato production reached 38,572.70 metric tons, with an average productivity of 4,678.79 kg per acre (Agriculture Survey Report, 2021). Potatoes are a significant cash crop in Bhutan, contributing substantially to the economy. In 2023, potato exports to India alone generated Nu. 311,577,225, highlighting their importance in the agricultural export sector.

To enhance potato productivity, Bajgai et al. evaluated CIP-originated clones for agronomic performance over two years. Based on their findings, clone 392977.22 was proposed and subsequently released as "Yusi-Maap" in 2017. This variety is moderately resistant to late blight, provides an alternative red-skinned option, is rich in micronutrients and offers high yield (88% higher than the control variety Desiree). However, in recent years, farmers have reported irregular or non-uniform tuber sizes in their fields, raising concerns about the consistency and marketability of Yusi-Maap. To address this issue, haulm cutting is being explored as a potential strategy to regulate tuber size.

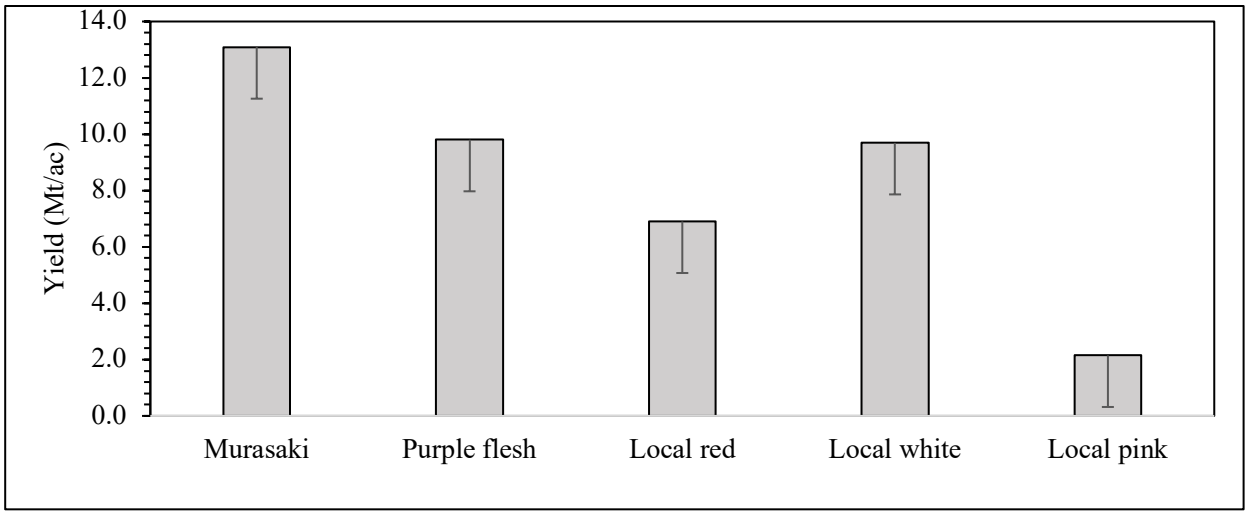

Figure 3. 3. The yield difference of the sweet potato varieties carried out as an on-farm trial in Zhemgang and Phuntsholing

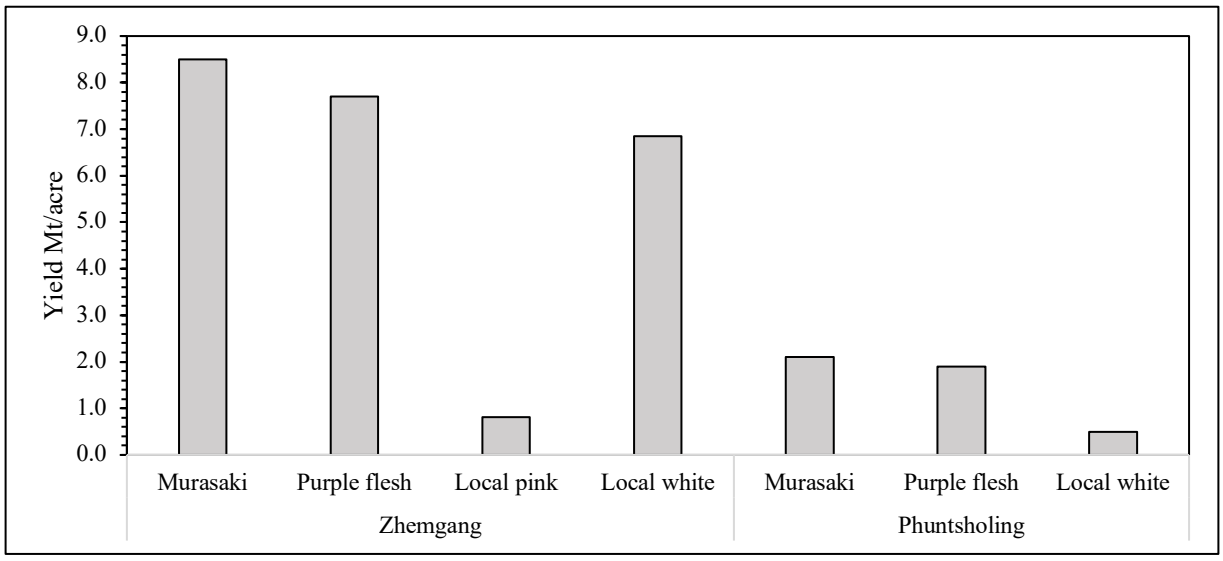

Figure 3. 4. The differences in yield of five sweet potato varieties including two Japanese and three local varieties from the trial carried out in ARDC Bajo and Samtenling

The trial was established in March. Haulm killing will carried out at specific intervals after planting to evaluate its impact. The first haulm killing will take place 90 days after planting, followed by subsequent killings at 95, 100, 105, and 110 DAP. As recommended by Virtanen & Seppänen (2014), harvesting will be conducted 10–14 days after haulm killing, as skin set typically took 10–14 days depending on the cultivar and soil conditions. Harvest and data collection will be carried out in July. From each replication, five sample plants will be tagged for detailed observation. The parameters to be recorded will include tuber size across all categories seed, table, and non-commercial tubers measured in kilograms. Additionally, the total number and weight of tubers in each category will be documented. Yield will also be calculated and expressed in terms of kilograms per acre.

The study is expected to determine the optimal timing for haulm killing to achieve the desired tuber size, suitable for seed potato production under the specific agro-climatic conditions of NCOA Yusipang. By identifying the most effective haulm killing interval, the trial aims to enhance the overall quality of tubers, particularly in terms of size uniformity and skin set. As a result, the quality and marketability of the Yusi-Maap variety are anticipated to improve, contributing to better returns for farmers and greater acceptance of the variety in both local and regional markets.

3.1.7. Effects of seed tuber size on growth and yield performance of potato (Solanum tuberosum L.) varieties under field conditions

Potato (Solanum tuberosum) is an important food and cash crop in Bhutan, grown in all districts across the country. Despite its importance, potato productivity and production in the country remains constrained by several factors. Optimizing potato production remains a challenge due to variations in agronomic practices, climatic conditions, and seed quality. Limited knowledge on the appropriate use of seed tuber size for optimal growth and yield could be one factor affecting the

production. Seed tuber size is a critical factor influencing the growth and yield performance of potato crops. It affects not only the initial establishment of the crop but also its vigor, canopy development, and ultimate tuber yield. While larger seed tubers may enhance plant establishment and yield potential, they also incur higher production costs compared to small tuber size. Optimizing the seed tuber size is therefore necessary to reduce the seeding rate and improve the economical production of potato. Understanding the relationship between seed tuber size and crop performance is therefore essential for achieving a balance between productivity and economic efficiency.

In Bhutan, the availability of high-quality seed tubers remains a constraint for farmers, with many relying on farm-saved seeds of variable sizes. The current recommended seed size for potato seed production by National Potato program is 35-60 g. However, the choice of potato varieties, each with distinct growth habits and yield potential, adds another layer of complexity to determining optimal seed tuber sizes. Despite the critical role of these factors, limited research has been conducted to explore their combined effects under Bhutan's agro-climatic conditions. This study aims to (i) to evaluate the effects of varying potato seed tuber sizes on yield parameters, including total yield, tuber number per plant, average tuber weight, and tuber size distribution and (ii) to develop evidence-based recommendations for optimal tuber size selection to maximize productivity, resource efficiency, and profitability in potato cultivation.

The trial was established on 19 April 2025 at NCOA-Yusipang, and will be harvested by August-September 2025. A RCBD design was employed with 6 treatments and 3 replications. Yusi Maap variety was used since it is one of the most promising varieties in the country. The treatments include the following.

Table 3. 5. Treatment used in the trial; different seed tuber size.

Treatments	Tuber Size (g)
T1	15-30 g
T2	31-45 g
T3	46-60 g
T4	61-75 g
T5	76-90 g
T6	> 90 g

The study is expected to understand the differences in yield parameters such as total yield, tuber number per plant, average tuber weight, and tuber size distribution across the varying seed tuber size treatments. It is expected that the medium-sized tubers (46–60 g and 61–75 g) will provide an optimal balance of yield performance and economic viability, aligning with the current recommendations. The findings will help establish evidence-based recommendations for optimal tuber size selection, thereby aiding farmers in reducing production costs while maximizing productivity and profitability. Moving forward, the outcomes will guide the National Potato

Program and other stakeholders in refining seed size guidelines and improving farmer access to high-quality, appropriately sized seed tubers. Additionally, further research on integrating varietal preferences and adapting the recommendations to varying agro-ecological zones in Bhutan will ensure the broader applicability and sustainability of the findings.

3.1.8. Initiate Pre-Basic Seed production of released (potato) and micro-tuber production through tissue culture for seed replacement

As part of a seed replacement initiative, the National Potato Program procured in-vitro plantlets of four released potato varieties; Desiree, Khangma Kewa Kaap, Yusi-Maap, and Yusi Maap 2 along with 12 new clones from the International Potato Centre (CIP) in Lima in March 2024. These disease-free, genetically pure materials will help reduce disease pressure, improve crop performance, and boost yields. The clean planting materials were propagated and multiplied at the tissue culture laboratories of the National Centre for Organic Agriculture (NCOA) in Yusipang and the National Seed Centre (NSC) in Paro. The details of the number of micro0tuber produced in two tissue culture laboratories are mentioned in. This season, these micro-tubers (micro-tubers derived from the multiplied plantlets, 2024) were planted in NCOA's greenhouse for mini-tuber production. In the following year, these mini-tubers (pre-basic seeds) will be cultivated at NSC farms and RSG for basic seed multiplication. Under the current potato seed production system, certified seeds from the four released varieties are expected to reach farmers by 2029. Meanwhile, the 12 new CIP clones will undergo evaluation, with one promising clone selected for release in the coming years. Further, the Apical Rooted Cutting technology was also be carried out this season for the true-to type varieties to enhance seed multiplication. Further a trial to assess the performance of apical cutting under open filed and protected condition will be carried out.This initiative is a crucial step toward improving seed quality and revitalizing potato production across the country.

Table 3. 6. Total micro-tuber produced at NSC and NCOA tissue culture laboratories in 2024

Sl.No.	Variety/Clones	No. of micro-tubers		Total
		NCOA	NSC	
1	Desiree	249	125	374
2	Yusi maap 2	229	85	314
3	Yusi maap	188	116	304
4	Khangma kaap	210	76	286
5	312887.075	77	60	137
6	312908.092	256	51	307
7	312890.040	186	141	327
8	312914.053	202	108	310
9	312908.138	203	108	311
10	312903.013	260	120	380

11	312914.020	238	110	348
12	312888.048	234	140	374
13	312725.047	150	103	253
14	396026.101	153	106	259
15	391034.103	124	115	239
16	312721.245	50	50	100

3.1.9. Initiate Study on major potato diseases

The potato industry presents significant economic potential, with seed potatoes representing a key sector for revenue generation. Currently, Bhutan exports potatoes primarily to India, where they are utilized as seed potatoes despite being classified as table potatoes. A major historical constraint to this trade was the outbreak of potato wart disease (*Synchytrium endobioticum)* between 1977 and the early 1980s, which posed a substantial threat to Bhutan's seed potato market. However, over the past three decades, with the introduction of improved potato varieties, there have been no recent reports of the disease. To verify the current status of potato wart and reinforce the viability of Bhutan's seed potato exports, a systematic assessment is urgently required.

Figure 3. 5. Pre-basic seed production of four released varieties using true-to type invitro plantlets received from CIP in 2024 along side mini tuber production of the plantlets received from CIP

This study has been initiated by the National Potato Program in collaboration with the National Plant Protection Centre, with technical guidance from the International Potato Centre. The research commenced in May 2025 with preliminary data collection, including farmer perspectives on wart disease and field tagging. Subsequent phases will involve visual inspections of harvested tubers and underground plant parts for disease symptoms, along with soil sampling, conducted between August and November 2025. The study encompasses eight major potato-growing districts, covering 20 gewogs, selected based on historical disease incidence and traditional cultivation areas. The final findings are anticipated to be compiled by the following year.

The outcomes of this study are expected to provide critical insights into the current prevalence- or absence-of potato wart disease in Bhutan. Confirming disease-free status would bolster confidence among domestic and international stakeholders, reinforcing Bhutan's position as a reliable supplier of high-quality seed potatoes. This, in turn, could facilitate market expansion and enhance export opportunities. Furthermore, the study will contribute to the formulation of sustainable potato production strategies, supporting economic growth and aligning with Bhutan's agricultural development goals under the 13th Five-Year Plan and future policy frameworks.

3.1.10. Observation trial and germplasm maintenance of CIP clones

An observation trial and germplasm maintenance of 74 biofortified and climate-resilient CIP (International Potato Center) clones were carried out in three different locations of Phobjikha Bumthang and NCOA, Yusipang from 2024 (Table 3.7). This trial is carried out mainly to evaluate the performance of the CIP clones under the different agro-climatic conditions to identify the good-performing varieties that will be suitable for cultivation in the future.

Table 3. 7. Details of potato germplasm of biofortified and heat and drought tolerant maintained in NCOA Yusipang, NSC Bumthang and NSC Phobjikha

Sl. No.	Clone No.	Sl. No.	Clone No.	Sl. No.	Clone No.	Sl. No.	Clone No.
1	30957.31	19	309103.85	37	312725.036	56	312782.011
2	301028.56	20	309121.6	38	312725.047	57	312827
3	302476.19	21	312535.062	39	312725.048	58	314079.1
4	302533.3	22	312545.053	40	312725.052	59	389087.2
5	302595.3	23	312609.525	41	312725.055	60	393062.199
6	302935.3	24	312621.097	42	312725.057	61	395436.8
7	303513.57	25	312637.024	43	312725.067	62	397196.3
8	304357.31	26	312637.069	44	312725.128	63	398098.203
9	306135.75	27	312680.01	45	312725.163	64	398098.209
10	306143.65	28	312682.005	46	312725.376	65	398180.289
11	306155.73	29	312682.042	47	312731.004	66	398180.292
12	306412.1	30	312721.029	48	312735.051	67	398190.605
13	308208.219	31	312721.038	49	312735.114	68	398192.213
14	309017.101	32	312721.169	50	312747.056	69	398192.592
15	309041.1	33	312721.241	51	312751.021	70	398208.219
16	309074.129	34	312721.245	52	312751.025	71	399004.19
17	309077.116	35	312721.286	53	312763.44	72	399073.18
18	309087.23	36	312725.001	54	312764.013	73	399078.11
				55	312767.014	74	598192.553

3.2. NATIONAL POTATO PROGRAM DEVELOPMENT ACTIVITIES

3.2.1. Research Outreach Program (ROP) of newly released potato varieties

The potato demonstration was conducted from October 2024 to April 2025. As part of a seed replacement initiative, a research outreach program demonstrated a total of 11.80 Mt of improved potato varieties, including Yusi Maap (11.5 Mt), Yusi Kaap (0.15 Mt), and Khangma Kaap (0.15 Mt). These varieties were distributed across eight districts: Trongsa, Zhemgang, Chhukha, Paro, Thimphu, Bumthang, Haa, and Trashigang, covering a total area of 11.80 acres. This season, the demonstrations were primarily carried out in new locations where these varieties had not been previously cultivated, including areas within chain-link fencing. A total of 0.9 Mt seeds were also used for on-station seed production, trials and on-farm potato wart assessment in several Dzongkhags such as Haa, Thimphu, Paro, Trongsa and Chhukha.

Table 3. 8. Details of improved varieties seed supported through research outreach program in 2024-2025

Sl. No.	Dzongkhag	Gewog	Variety	Households	Qty. (Mt)
1	Trongsa	Nabji-Korphu	Yusi maap	43	5.50
2	Zhemgang	Trong	Yusi maap	4	0.50
		Nangkhor	Yusi maap	10	0.50
3	Paro	Ramthangka	Yusi maap	1	1.50
4	Thimphu	Lingzhi	Yusi maap	5	0.10
		Soe	Yusi maap	5	0.15
	Mongar	Narang	Yusi maap	2	0.20
5	Bumthang	Chummey	Yusi maap	13	0.50
		Chokhor	Yusi maap	1	0.05
6	Chhukha	Phuentsholing	Yusi maap	12	1.00
		Bongo	Yusi maap	8	0.25
7	Wangdue	Kazhi	Yusi maap	4	0.35
8	NCOA	Yusipang	Yusi maap		0.90
		Total A		**108**	**11.50**
1	Trashigang	Kanglung	Yusi kaap	4	0.05
2	Chhukha	Lobneykha	Yusi kaap	4	0.05
3	Thimphu	Chang	Yusi kaap	5	0.05
		Total B		**13**	**0.15**
1	Trashigang	Kanglung	Khangma Kaap	4	0.05
2	Chhukha	Lobneykha	Khangma Kaap	4	0.05
3	Thimphu	Chang	Khangma Kaap	5	0.05
		Total C		**13**	**0.15**
		TOTAL (A+B+C)		**134**	**11.80**

3.2.2. Demonstration of organic potato production in potential organic landscapes

The National Potato Program (NPP) conducted an organic potato production demonstration in Lul and Zamsa-Phasuma Organic Village to promote sustainable agriculture and meet rising demand for chemical-free produce. Six and five households from Lul and Zamsa-Phasuma, respectively, were selected and provided with 1 Mt of Yusimap potato seeds, covering 1 acre. Farmers received training on organic techniques, including soil preparation, biological pest control, and compost application. The initiative aimed to enhance food security, improve soil health, and demonstrate the viability of organic potato farming. Results indicate strong potential for scaling sustainable practices, reinforcing NPP's commitment to eco-friendly agriculture and farmer capacity-building in Wangdue and Chhukha Dzongkhags.

Figure 3. 6. Demonstration and hands on training (left) and Yusi maap variety in the field (right)

4. POLICY REGULATION AND COORDINATION PROGRAM

4.1. RESEARCH ACTIVITIES OF POLICY REGULATION AND COORDINATION PROGRAM

4.1.1. Nationally Coordinated Trial on Evaluation of Different Organic Substrates for Oyster Mushroom Production

Oyster mushroom is the most widely cultivated mushroom in our country, primarily grown on paddy straw. It is relatively easier to grow compared to other mushroom species and can utilize a wide range of agro-residues. However, no research had been carried out in Bhutan using locally available substrates for oyster mushroom production. Therefore, a research trial was conducted to evaluate the feasibility of growing oyster mushrooms on locally available grasses and oak leaves and to compare their yields with the paddy straw substrate. It is the 2nd year of conducting the study at the National Centre for Organic Agriculture (NCOA) in collaboration with the National Mushroom Centre.

The research was carried out at the National Centre for Organic Agriculture (NCOA), Yusipang, Thimphu. The experiment was laid out in Randomized Complete Block Design (RCBD) with three treatments replicated 15 times (each replication represented by one cultivation bag). The treatments were sterilized in a petroleum drum for 3 hours after ballooning of plastic sheets, covering the mouth of the drum and inoculated using a sample size of 2 kg substrate bag with a spawn rate of 60 g/bag (3% on wet weight of substrate). The different substrates used to evaluate the oyster mushroom production are T1: Dried grass, T2: Dried oak (*Quercus griffithii*) leaves, and T3: Paddy straw (Control).

The study evaluated three organic substrates—grasses, oak leaves, and paddy straw (control). The Oak leaves recorded the earliest mycelium initiation, occurring 8 days after inoculation. In comparison, mycelium initiation on straw and grass substrates was observed after 10 and 13 days, unlike last year, which took more than a month.

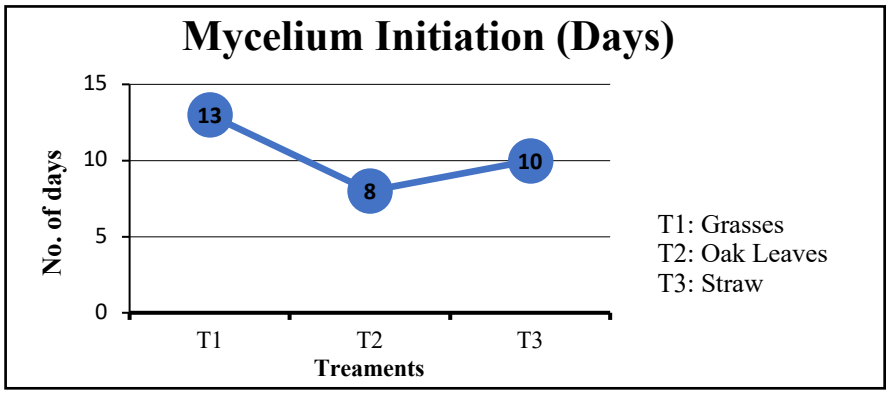

Figure 4. 1. Mycelium Initiation

The mycelium run, which was initiated on 17th April, 2025, was observed infected with green mold starting immediately from the fifth day after the mycelium run, and by the end of one week, all the replications of treatment 2 were removed and discarded.

Figure 4. 2. Mycelium initiation after inoculation (L) and infected with green mold (R)

The result observed was similar to last year, even though the size of the substrate has been reduced to 1-2 cm and the sterilization period has been increased. These consistent failures indicate that, although oak leaves are effective in promoting rapid mycelium growth, they are still highly vulnerable to green mold infection. Thus, it was concluded that failure could be due to poor substrate quality, such as contamination on the leaves, or unstable room temperatures and humidity.

4.1.2. Evaluation of white asparagus production methods under at Yusipang

Asparagus (*Asparagus officinalis L.),* one of the high-value crops in the 13th five-year plan, is a perennial dioecious plant belonging to the family Asparagaceae. The edible part is the young, thickened shoots, called spears. White asparagus is grown in conditions that allow the spears to develop in darkness. Thus, the chlorophyll is not synthesized, and the developing spear appears white (Makus and Gonzalez, 1991). Out of the two released varieties of asparagus (cultivated variety of Mary Washington and UC157), Mary Washington is the most popular variety widely cultivated in Bhutan. Farmers in Bhutan widely grow green type (without blanching), fetching an average retail price of around Nu. 148 in 2022, at the centenary farmer's market (CFM) (NSB, SYB, 2023). Therefore, this research aims to disseminate information about white asparagus and recommend a suitable production method for the temperate regions of Bhutan.

Objective:

- To compare the yield of Mary Washington (white asparagus) under various blanching methods.
- Compute the benefit-cost ratio of different blanching methods.

The trial has been established on the station (NCOA, Yusipang: 2600 masl) on 10th June 2024. One-year-old asparagus seedlings of the variety Mary Washington have been transplanted in trenches. Each trench measures 5.4 m^2 (18m x 0.3m). The Planting distance of 0.45m plant to plant

and 1.2m row to row (trench to trench) was maintained. Randomized Complete Block Design (RCBD) was employed with 5 treatments and 4 replications, where each treatment was allocated randomly in a trench. Each unit measures 2.025 m^2 (4.5m x 0.45 m) and there is a total of 20 experimental units. Spear harvest will be done 3 times a week. Components for data collection include date of harvest, spear height (cm), weight (gram), diameter (mm), and production costs will be captured. Spear quality aspects like colour and spear firmness will also be recorded during the data collection.

Asparagus seedlings should be nurtured for 2 years for the crown root development. Meanwhile, intercultural operations are being carried out. Treatment application and data collection will commence from February 2026.

4.1.3. Evaluation of Botanical Extracts and Biopesticides in Managing the Diamond Back Moth (DBM) of Cabbage

The Diamondback Moth (DBM), *Plutella xylostella*, is one of the most destructive pests of cruciferous crops worldwide, particularly in cole crops, causing significant yield losses (Halder & Rai, 2024). The moth's ability to rapidly develop resistance to chemical insecticides has led to an urgent need for alternative pest management strategies that are both effective and sustainable. While effective in the short term, conventional chemical insecticides have been associated with adverse environmental impacts, increased production costs, and the development of resistance in pest populations (Oaya et al., 2019).

In recent years, there has been growing interest in using botanical extracts as eco-friendly alternatives to conventional chemical pesticides. Bio-pesticides and botanical extracts are plant-derived substances that possess insecticidal properties, often acting as deterrents, repellents, or toxins to targeted pests. These bio-pesticides and botanical extracts are perceived as environmentally safe, biodegradable, and potentially more sustainable options for pest control. However, despite their promising potential, there is limited comparative research on the effectiveness of botanical extracts in managing DBM populations on cabbage in Bhutanese agricultural conditions. Therefore, this study seeks to address this gap by evaluating and comparing the efficacy of locally available botanical extracts and neem oil in DBM management approaches.

The trial has been established at NCOA Yusipang, located at an elevation of 2600 masl on 3rd May, 2025. The design used is Randomized Complete Block Design (RCBD) with seven treatments and 3 replications. The trial plot size was 2 m^2 (2 m x 1 m) and there was a total of 21 experimental units with a dimension of (2 m x 1 m) with a planting distance of 40 cm row to row and plant to plant. The botanical extracts evaluated are garlic, chilli, zanthoxylum extracts, artemisia, and neem oil. The data collection includes the number of DBM per plant, the number of leaves affected, and the total number of leaves. Apart from the above-mentioned parameters, height and yield of the cabbage will also be recorded. The trial is currently ongoing at NCOA Yusipang.

4.2. DEVELOPMENT ACTIVITIES OF POLICY REGULATION AND COORDINATION PROGRAM

4.2.1. Registration, inspection, certification and renewal of organic farms

The Policy Regulation and Coordination Program (PRCP) is one of the key sectors under the National Centre for Organic Agriculture (NCOA), which caters to registration, certification, and renewal of the Local Organic Assurance System (LOAS). The program works closely with various stakeholders, including Dzongkhag agriculture offices, organic farmers' groups, certification bodies, and relevant agencies to ensure that organic farming practices are implemented in line with the Bhutan Organic Standard (BOS). During the fiscal year 2024–2025, the PRCP registered new farms, conducted field inspections, and issued organic certificates to new farmers. Additionally, it renewed LOAS certificates for existing individual and group organic farmers from Punakha, Paro, Wangdue, Sarpang, Tsirang, Bumthang, Trashigang, Trashiyangtse, Lhentse, Mongar, and Chhukha Dzongkhags.

In FY 2024-25, the total registered and certified areas were 411.31 and 411.31 acres, respectively, while the total households (HHS) registered and certified were 397 and 397 HHS, respectively.

Table 4. 1. Total Area and household registered and certified

Sl. No.	Dzongkhag	Registered area (ac)	Area certified	HH Registered	Households Certified
1	Punakha	58.19	58.19	6	6
2	Wangdue	18	18	12	12
3	Mongar	26.276	26.276	25	25
4	Bumthang	113	113	130	130
5	Trashigang	90.44	90.44	80	80
6	Trashiyangtse	5	5	1	1
7	Lhentse	39.4	39.4	21	21
8	Chhukha	59	59	121	121
9	Paro	2	2	1	1
Total		**411.306**	**411.306**	**397**	**397**

The total renewed registered and certified area was 366.57 and 366.57 acres, respectively, while the total renewed and certified households were 306 and 306 respectively.

Table 4. 2. Renewal of area and household

Sl. No.	Dzongkhag	Area Registered (acre)	Area certified (acre)	Households Registered	Households Certified
1	Punakha	9	9	1	1
2	Wangdue	86	86	36	36
3	Mongar	26.276	26.276	25	25
4	Bumthang	10	10	1	1
5	Zhemgang	3	3	5	5
6	Sarpang	117	117	75	75
7	Tsirang	56.3	56.3	42	42
8	Chhukha	59	59	121	121
Total		**366.576**	**366.576**	**306**	**306**

4.2.2. Awareness Program on Bhutan Organic Standard (BOS 02:2022) for the staff of the National Centre for Organic Agriculture (NCOA).

Capacity building for a day on the Bhutan Organic Standards (BOS) 02:2022 was provided to the staff of the NCOA, in the centre on August 30, 2024, by the Policy Regulation and Coordination Programme (PRCP). The PRCP is one of the five programmes under the NCOA that oversee organic regulation, capacity building, policy research, registration, and certification.

Figure 4. 3. Awareness of BOS 02:2022 for the staff of NCOA

The important objectives of the training were to prepare and build the capacity and knowledge of the staff on the BOS 02:2022 and facilitate the third-party organic certification of the centre later. Currently, as the first stage, the NCOA campus is certified organic under the Local Organic Assurance System (LOAS), monitored and issued by the PRCP. However, to avoid a conflict of interest and self-certification, the centre looks forward to certifying under the Bhutan Food and Drug Authority's (BFDA) third-party organic certification. The BOS 02:2022 was recently listed as a family of standards under the International Federation of Organic Agriculture Movement (IFOAM).

The training was attended by the staff from the Field Crops, Horticulture sector, National Potato Programme, and Technical Support Sector of the centre. The broad agenda covered during the training was as follows:

- Introduction, Organic Agriculture (OA), and Ecosystem Management and General Requirements for Organic Production.
- Organic Crop Production Standards, Appendices 2 and 3.
- Mushroom Production, Processing, Handling, and Storage, and Social Welfare.

4.2.3. Capacity Building of Organic Operators/Farmers on BOS 02:2022, Internal Control System (ICS), and Organic Management and Practices.

The Bhutan Organic Standard (BOS) version 02: 2022 is a document officially listed under the International Federation of Organic Agriculture Movement (IFOAM) Family of Standards to strengthen the overall organic regulation and certification system in Bhutan. The main objectives of the Bhutan Organic Standard are to provide a set of rules and regulations that need to be complied with while doing organic farming, and to provide a basis for the certification of organic products in Bhutan. The organic farmers must undergo training on BOS 02:2022, as it is a prerequisite for organic certification.

The training for most of the Dzongkhags was covered during the erstwhile National Organic Flagship Program (NOFP). However, organic farmers/operators in a few Eastern Bhutan were left uncovered due to the COVID-19 pandemic. Thus, in the FY 2024-2025, the focus was laid upon to those organic operators and organic groups who were not trained on BOS 02:2022, Internal Control System (ICS) institution, and Farm Diary maintenance during the NOFP.

In FY 2024-2025, a total of 391 individuals were trained on BOS 02:2022, ICS, Farm Diary maintenance, organic management practices, and soil fertility and plant protection technologies. Out of 391 farmers trained, 30 farmers of four vegetable groups (Phosorung, Wangling, and Kelikhar vegetable groups) from Mongar Dzongkhag were also trained on organic standards, organic certification system, and Organic technologies as per the request and budgetary support from *Druk Nyo* Foundation.

Table 4. 3. Individual organic operators

Dzongkhag	Gewog	Village	No. of Participants
Bumthang	Tang	Tandingang, Langmalung (Chutoe), Mesithang.	33
	Chhokhor	Jalikhar, Lusbee, Dhur, Nasphel, Ngalhakhang, and Changwa	55
	Ura	Trabe	35
Total			**123**

Table 4. 4. Organic group operators

Sl. No.	Name of organic group	Location	No. of Participants
1.	Organic Asparagus Seedling Production Group, Rezor Lemongrass Group, and Beypam Tsesay Tshongdrel Detshen	Udzurung Gewog, Trashigang	38
2.	Threlphug Organic Group	Kangpar Gewog, Trashigang	23
3.	Kalong Sonam Gongphel Detshen and Khalong Rolong Women's Group	Narang Gewog, Mongar	17
4.	Bikar Thramlo Farm, Lemi Women's Group, and Woongkhar Women's Group	Drametse Gewog, Mongar	31
5.	Naropungtang Pineapple Grower's Group	Thangrong Gewog, Mongar	22
6.	Changkala Organic Production Group and Nganyee Model Organic Village	Jarey Gewog, Lhuentse	31
7.	Ngar Vegetable and Marketing Group and Amtse Ginger Group	Gangzur Gewog, Lhuentse	23
8.	Yangbari Pineapple Growers' Group	Gongdue Gewog, Mongar	40
9.	Drachukha Flowers' Group	Goenshari Gewog, Punakha	13
Total			**238**

Figure 4. 4. The participants of Bumthang Chhokhor Gewog (L) and Ura Gewog (R) during the BOS 02:2022 and ICS training

4.2.4. Capacity Building of Organic Asparagus and Broccoli growers on BOS 02:2022, ICS Institution, Farm Diary Maintenance, and Management Practices for Organic Production.

From 3rd to 27th March 2025, the PRCP of the NCOA successfully conducted an intensive training program on organic Broccoli and Asparagus production across six western Dzongkhags. This initiative was strategically designed to enhance the cultivation and productivity of these high-value crops, which have been identified as priority commodities under the 13th Five-Year Plan (FYP).

The objectives of the training were to equip farmers with knowledge of Bhutan Organic Standards, Internal Control System (ICS), and Farm Diary Maintenance while providing practical training on the production of organic broccoli and asparagus. The training was attended by 176 farmers from different gewogs across six western Dzongkhags. The Dzongkhag Agriculture Officer (DAO), Dzongkhag Organic Focal, and the Gewog Extension Agents of the respective Dzongkhags and Gewogs played a vital role in the rollout of this training program. The details of the training location and participants' attendance are detailed below.

Table 4. 5. The details of the training for organic asparagus and broccoli

Sl. No	Dzongkhag	Gewog	Attendance
1	Tsirang	Thakorling	36
2	Wangdue	Daga	13
		Nahi	17
3	Haa	Samar	14
4	Paro	Luni	11
5	Chhukha	Geling	17
		Bongo	16
		Chapcha& Bjabcho	14
		Dungna	15
6	Thimphu	Mewang & Genekha	8
		Kawang & Dagala	15
Total			**176**

The training was conducted for two days; the first day was dedicated to familiarizing participants with the Bhutan Organic Standard, the Internal Control System (ICS), and the detailed maintenance of farm diaries, which is a fundamental prerequisite for securing Local Organic Assurance System (LOAS) certification. Furthermore, farmers underwent comprehensive training on the Bhutan Organic Guarantee System (BOGS), which explains the foundational principles governing organic production and certification in the country. Participants were also well-versed in the diverse organic registration and certification frameworks, including LOAS and third-party certification, while emphasizing the importance of keeping accurate and organized farm records.

On the second day of the training, both theoretical and practical sessions were conducted on organic asparagus and broccoli production. The practical session focused on transplanting asparagus crowns and seedlings, emphasizing trench depth and width, row-to-row and plant-to-plant spacing, proper planting techniques, and the ideal harvesting time. Additionally, farmers participated in a hands-on session on raising a broccoli nursery in the polytunnel, equipping them with the necessary skills to establish their nurseries. This training provided them with practical knowledge to enhance their organic farming practices on broccoli and asparagus.

Figure 4. 5. Theory and practical session on organic Asparagus and Broccoli production management practices for Domsar Organic Group of Daga Gewog, Wangdi Phodrang

4.2.5. Advocacy and Awareness Program on Organic Agriculture to Peri-Urban Farmers of Thimphu.

The National Centre for Organic Agriculture (NCOA), Yusipang, conducted an advocacy and awareness program for a day on 13th May, 2025, on organic agriculture to 40 peri-urban farmers from Bjimina village, under Mewang Gewog, Thimphu Dzongkhag. The program was funded through the depository work of the Department of Agriculture (DoA). The main objectives of the program were to 1) Raise awareness about organic farming practices and benefits 2) Sensitize on the Bhutan Organic Standards 02: 2022, maintenance of farm diary and organic certification system 3) Advocacy on organic asparagus and broccoli production and 3) Build capacity among peri-urban farmers to adopt organic methods, thereby contributing to a more sustainable and healthy farming ecosystem. Bjimina village was strategically chosen in consultation with the Gewog Agriculture Extension Officer due to its proximity to the highway and easy access to the Thimphu city vegetable market. The village also cultivates different kinds of vegetables, making it a promising location for organic farming with good market potential.

4.2.6. ToT on Organic agriculture in GMC

A comprehensive training of trainers (TOT) on Organic Agriculture was conducted by the National Centre for Organic Agriculture's (NCOA) officials, Yusipang, from 18th to 20th December, 2024, at the ARDC-Samtenling, Gelephu Mindfulness City (GMC). There was a total of 40 participants, including Gewog agriculture extension officials, *Sanam Jabchorpas*, and progressive farmers. The

fund for the training was sourced by the Dzongkhag Agriculture Sector from the Green Environment Fund (GEF) project. The training was held as a follow-up to the previous visit of the NCOA's officials with the Dzongkhag Agriculture Officials. One of the important objectives of this training was to build the capacity of Extension Officials and other stakeholders in the latest trends in organic farming, to prepare them for 100% conversion of GMC to organic farming.

The participants were trained on the Bhutan Organic Guarantee System (BOGS), which provides guidelines on organic production and confirmatory assessment/organic certification in the country. The Bhutan Organic Standards (BOS), one of the documents under the BOGS provides a comprehensive framework for organic farming, outlining principles, objectives, and requirements for certification. It emphasizes health, ecology, fairness, and care, and emphasizes the importance of maintaining ecological balance while producing safe and nutritious food. It outlines specific requirements for organic production, including the prohibition of synthetic chemicals, the use of high-quality seeds, and a conversion period. They were also informed on different organic registration and certification systems in the country such as the Local Organic Assurance System (LOAS) and third-party certification. The LOAS Manual in Bhutan provides a framework for organic certification, aligning with BOS. It details the certification process, including the submission of application, mandatory farmer training, registration, signing the organic pledge, and field inspections.

Figure 4. 6. Training of Trainers (ToT) on Organic Agriculture at the GMC

4.2.7. Exhibition at Bhutan Innovation Forum (BIF), Pangbisa, Paro.

The Bhutan Innovation Forum (BIF), held at Pangbisa Dungkar Dzong, which was envisioned by His Majesty the King, is an initiative aimed at fostering creativity, innovation, and entrepreneurship within Bhutan. The BIF was an exciting event that took place from October 1-3, 2024, wherein global thought leaders, innovators, entrepreneurs, artists, philosophers, scientists, and investors gathered to explore pathways for creating impact and promoting innovation in the country.

The forum focused on mindfulness, innovation, entrepreneurship, and sustainability, serving as an incubator for advancements in digital technology, ecology, education, health, urban planning, and

economic transformation. A key theme on Gelephu Mindfulness City, a visionary project announced by His Majesty the King to create a sustainable and conscious business hub inspired by Bhutanese identity and Buddhist heritage.The Ministry of Agriculture and Livestock showcased traditional farming technologies at the Bhutan Innovation Forum as part of an exhibition highlighting climate-resilient agriculture practices and innovative farming technologies.

The exhibition focused on sustainable farming methods, including organic agriculture, water-efficient irrigation systems, and drone technology for crop monitoring. The initiative aligns with Bhutan's broader Agri-Tech Revolution, which aims to integrate modern technology with traditional farming to enhance food security and agricultural productivity.

4.2.8. Bhutan Natural Mark

With the approval of the 21st Technical Working Group (TWG) meeting for Organic Agriculture held on 26th November, 2024, in Thimphu, the meeting has endorsed the use and design for the Bhutan Natural Mark (BNM). The mark will be exclusively used to facilitate the export of Bhutanese food and agricultural products, where Bhutanese organic certifications are not accepted. However, the BNM will be issued only for food and agricultural products certified under the Local Organic Assurance System (LOAS) or Third-Party organic certification issued by the Bhutan Food and Drug Authority (BFDA). By providing a recognizable and trusted branding for Bhutanese food and agricultural products, the mark could open up new export market opportunities.

This mark will remain as a property of the Ministry of Agriculture and Livestock (MoAL), nevertheless, there is a possibility of misuse of the mark in the market. Therefore, to address the issue, we have registered the mark for Intellectual Property (IP) right with the Department of Media, Creative, Industry and Intellectual Property (DoMCIIP) under the Ministry of Industry, Commerce and Employment (MoICE).

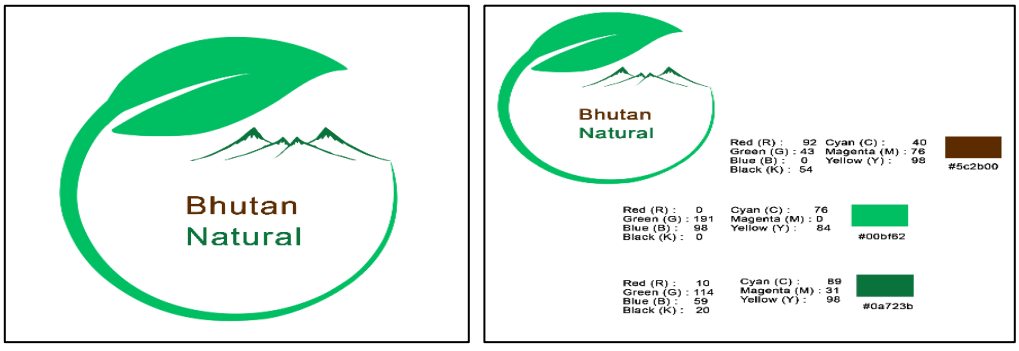

Figure 4. 7. Bhutan Natural Mark with colour specifications

Eligibility criteria for Bhutan Natural Mark

i. It will be authorized exclusively for Bhutanese organic Food and Agricultural products to be exported.

ii. The NCOA will authorize the use of "Bhutan Natural Mark" to the Bhutanese Food and Agricultural products that are LOAS or BFDA Third-Party certified and have obtained "Bhutan Organic Mark" but are not certified by any International Certifying Body.
iii. The "Bhutan Natural Mark" shall be exclusively used for export.
iv. Exporters or any business firms who wish to access the "Bhutan Natural Mark" should be registered with NCOA as per BOS 02:2022.
v. Exporters or any business firms who wish to access the "Bhutan Natural Mark" should give a legally binding commitment that the products using "Bhutan Natural Mark" are accepted in the importing country and that a premium price shall be paid to the Bhutanese farmers/producers.

4.2.9. Coordinated TWG to address cross-sectoral issues

The PRCP, NCOA, conducted a Technical Working Group (TWG) Meeting to address Cross-sectoral Issues. The 21st TWG meeting was conducted by NCOA on 26th November, 2024, at the National Plant Protection Centre's (NPPC) conference hall. The meeting was attended by the Department of Agriculture (DoA), Department of Agriculture Marketing and Cooperatives (DAMC), Bhutan Food and Drug Authority (BFDA), and the various Centres under DoA, including National Seed Centre (NSC), National Soil Service Centre (NSSC), National Mushroom Centre (NMC), Agriculture Machinery and Technology Centre (AMTC), and National Plant Protection Centre (NPPC).

The TWG meeting is conducted biannually to discuss and resolve cross-sectoral issues on organic development in the country. It is seen as important to have TWG members from various sectors/agencies as they play a vital role in taking forward organic development in their respective sectors/agencies, besides the sole effort of NCOA, Yusipang. The TWG provides a platform for movers and shakers of organic from different sectors/agencies to come together and work closely.

The 21st TWG meeting was chaired by Programme Director of NOCA. During the meeting, some of the agenda items discussed were;

- Accreditation of Bhutan Organic Guarantee System (BOGS).
- Extension of Local Organic Assurance System (LOAS).
- Information Sharing on Organic Agriculture Development in GMC.
- Finalization of Organic Strategy for 13th FYP and beyond.
- Finalization of the Bhutan Natural Logo.
- Update on Organic Activities in the 13th FYP by respective sectors.
- Discussion on collaboration with CertAll, opening of organic sales outlet in Paro, Bhutan Foods Closing, and export trial reports from the NOFP project.

5. TECHNICAL SUPPORT SERVICE RESEARCH AND DEVELOPMENT PROGRAM

5.1. TECHNICAL SUPPORT SERVICE RESEARCH ACTIVITIES

5.1.1. NCT on wood vinegar as fungicide on tomato and prepare a comprehensive report

The study was conducted at the NCOA in the open field. Ratan tomato variety was used for the study purpose. The research trial layout was Randomized Complete Block Design (RCBD) having five treatments consisting of treatment (t1) Control, (t2-0.1% vv) 2 ml in 2000ml water, (t3-0.5% vv) 10ml in 2000ml water, (t4-1% vv) 20ml in 2000ml and (t5-2% vv) 40ml in 2000ml water. There were three replications for each treatment. During the field preparation 4 kg of well decomposed Farm Yard Manure (FYM) has been used in each plot as a basal dose application. Later while planting the potted seedlings basal dose application was repeated with 300 gm/hill. In addition to that 300 gm of FYM has been applied to each plant in two split applications at 30 days and 60 days after transplanting. Weeding was done frequently throughout the growing season to reduce the competition with plant on water, nutrients, air, space and light. To keep the soil moisture at field capacity to encourage good vegetative growth, irrigation was done frequently and as it matures irrigation was done when ever needed.

Figure 5. 1. Staking, harvesting and recording of tomato weight

Following the appearance of the first symptoms of disease, treatments were applied and data were collected from five plants/plot which were seventy-five plants in total. Three sprays were applied to each treatment at an interval of ten days between each one. Data were collected for three times prior to treatment application. The parameters for data collection were disease severity, effect on fruit, plant height and stem diameter.

Generally, the mean difference across the treatment for disease severity shows no significant difference between the treatments over time as shown in figure 3. However, 2nd data shows fairly consistent disease severity across treatments, with most treatments around a severity of 2.0, except for T5, which shows a lower level at 1.7. But 3rd data shows increase in disease severity with

Treatment 1 (t1) showing the highest severity at 2.47, followed closely by Treatment 5 (t5) at 2.4, while Treatments 2 (t2) and 3 (t3) show the lowest severity (1.67). This trend suggests that disease resistance decreases for most treatments over successive application, especially for Treatment 1, while Treatments 2 and 3 may provide relatively more stable disease control over time.

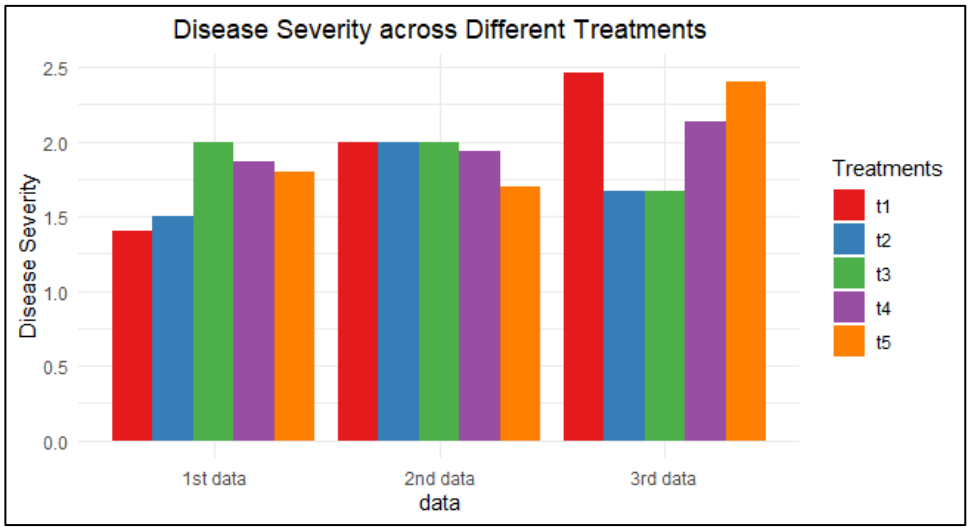

Figure 5. 2. Disease severity across different treatments

The mean data shows that there is no significant difference between the treatments on the effects on fruits however, in the first data, treatment 2 (t2) and treatment 3(t3) has considerably the same effect on fruits with value 10. The treatment 1 (t1) shows the lowest effect. With concessive application of treatments, in 2nd data, treatment 2 (t2) and treatment 4 (t4) shows the same effect on fruits at value 10 followed by treatment 3 (t3) at 11 while treatment (t5) seems to have the highest effect at 7 on fruits among all the treatments in both 1st and 2nd data.

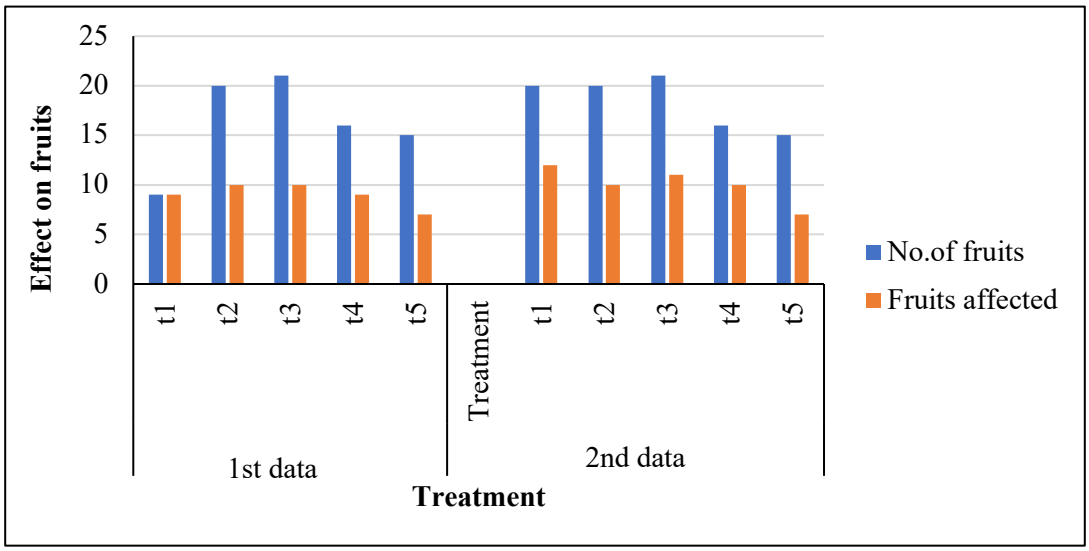

Figure 5. 3. Effect on fruits across different treatments

There was no significant difference on the effect on stem diameter across the treatments and have considerably the same diameter in treatment (t1, t2, t3, t4, t5) at 4 in 2nd data. However, treatment (t4) has smallest diameter in 1st and 3rd data. It also shows that the tallest height is with the treatment (t5) at 38 followed by treatment (t1) in 1st data but in 2nd and 3rd data there is fairly consistent in height across all the treatments (t1, t2, t3, t5) except for treatment (t4) which has the height at 79 in 3rd data.

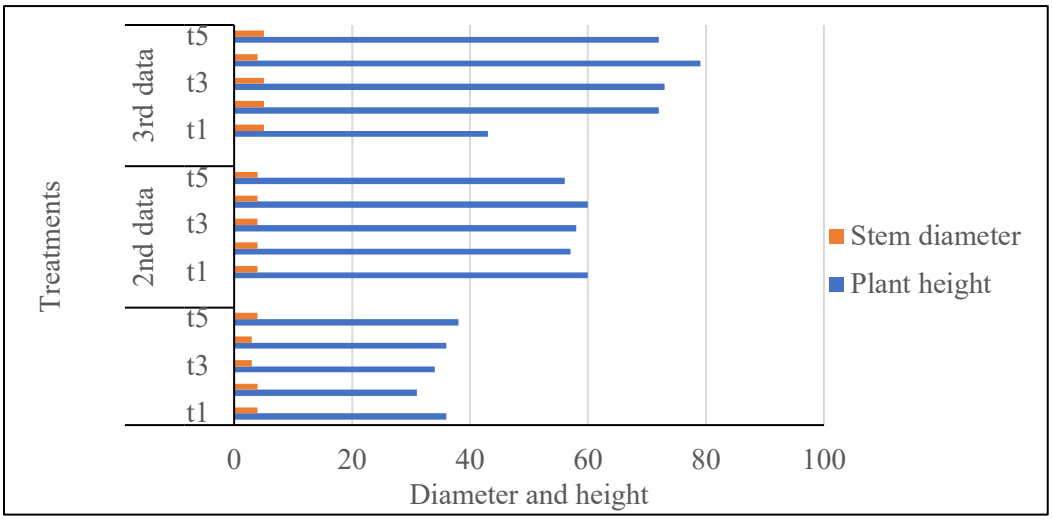

Figure 5. 4. Effect on plant height and stem diameter across different treatments

Five treatments of wood vinegar consisting of treatment (T1) Control, (T2-0.1% vv) 2 ml in 2000ml water, (T3-0.5% vv) 10ml in 2000ml water, (T4-1% vv) 20ml in 2000ml and (T5-2% vv) 40ml in 2000ml water is used as fungicides against early blight of tomato. The study found out that there is no significant difference in disease severity across all the treatments. However, treatment (t2) and (t3) may provide more control over disease severity. The more effect on fruit with treatment (t5) may be due to the high concentration of wood vinegar as compared to other treatments. Therefore, there is a need to further carry out NCT research on wood vinegar and prove it as a fungicide against early blight on tomato and as well as increase the yield.

5.1.2. Conduct research trial on the efficacy of different bio-pesticides in controlling cutworms in cole crops

Cutworms (Agrotis spp.) are among the most significant pests affecting cole crops (Brassica spp.) such as cabbage, cauliflower, and broccoli in Bhutan. The larvae of the cutworm are known for their destructive feeding habits, particularly in the seedling and early growth stages of the cole crops, causing significant yield loss. Inorganic pesticides having environmental impact and gradual development of resistance by pests is becoming a concern. Moreover, consumers are getting highly concerned of their health consuming chemically treated vegetables, switching their preference to chemical free vegetables. Environmentalist are encouraging farmers to adopt environmentally sustainable cultivation practices. This has led to increased interest in the use of bio-pesticides, which are generally considered safer and more sustainable alternatives. Bio-pesticides are derived from natural materials such as animals, plants, bacteria, or minerals. In recent years, several bio-

pesticides have shown promise in controlling various agricultural pests, including cutworms. In addition to that, ginger and garlic extract has also shown to be effective in controlling insect pests due to its pungent aroma. Therefore, the research is conducted to evaluate the effectiveness of five bio-pesticides (Beauveria bassiana, Azadirachtin, Metarhizium anisopliae, Bacillus thuringiensis, Rangzhing Bupmen) and one local bio- extract (ginger and garlic) in controlling cutworm infestations in cole crops.

The study was conducted at the field of National Centre of Organic Agriculture, Yusipang (NCOA). Golden cross variety was used for the study purpose where the nursery was raised on 15/3/2025 and the initial germination was observed on 22/3/2025. Following the germination, potting for individual seedlings were done on 9/4/2025 for better growth and well establishment of roots.

Figure 5. 5. Germination and potting of cabbage seedlings

On 6/5/2025 transplantation of potted seedlings was done in the randomized complete block design (RCBD) with 7 treatments having 3 replications for each. The total plots are 21 in number with each measuring 2 m^2. Neither FYM nor compost is not used during the field preparation however, while planting the potted seedlings 300 gm of compost per seedling is applied.

Figure 5. 6. Transplantation of potted seedlings in RCBD

5.1.3. Research trial on the assessment on application of dolomite on change in pH of acidic soils, growth and yield parameters of cabbage and broccoli

Bhutanese soils are predominantly acidic which is further intensified by frequent leaching and soil erosion caused by mountainous farming, which washes away alkaline elements such as calcium, magnesium, sodium, and potassium. The acidity of the soil affects plant growth by reducing the availability of major plant nutrients, making them insufficient for crops. Acidic soils also increase the solubility of elements such as aluminum, manganese, and iron, which can become toxic to plants in excessive amounts. Additionally, acidic soils have a higher incidence of fungal diseases. It is essential to note that pH levels above 5.5 are favorable for plant growth, with a soil pH of 6.5 considered optimal for nutrient availability.

Dolomite, is rich in magnesium and calcium, elements that are typically deficient in Bhutanese soils. It is also documented to be widely used in Japan as a soil amendment to stabilize acidic soil and supplement essential nutrients. Therefore, this study aims to evaluate the effect of various rates of dolomite application on changes in soil pH, crop production and productivity.

The experimental design was a Randomized Complete Block Design (RCBD) with four treatments *i.e.,* Control, Dolomite (6.7 kg/m^2), Vermicompost (3 kg/m^2) and Dolomite + Vermicompost (6.27 kg/m^2+3 kg/m^2) and four replications. The total experimental field of 43.75 m^2 with acidic soil was identified and subdivided into 16 plots, each measuring 1 m x 1 m.

Plant growth parameters, including height, width, circumference, weight (fresh and dry), leaf number, leaf length, and leaf color index (SPAD), will also be measured. In addition, we will observe and document any reduction in the incidence of pests and diseases in the plots treated with dolomite.

Figure 5. 7. Field preparation and application of treatments

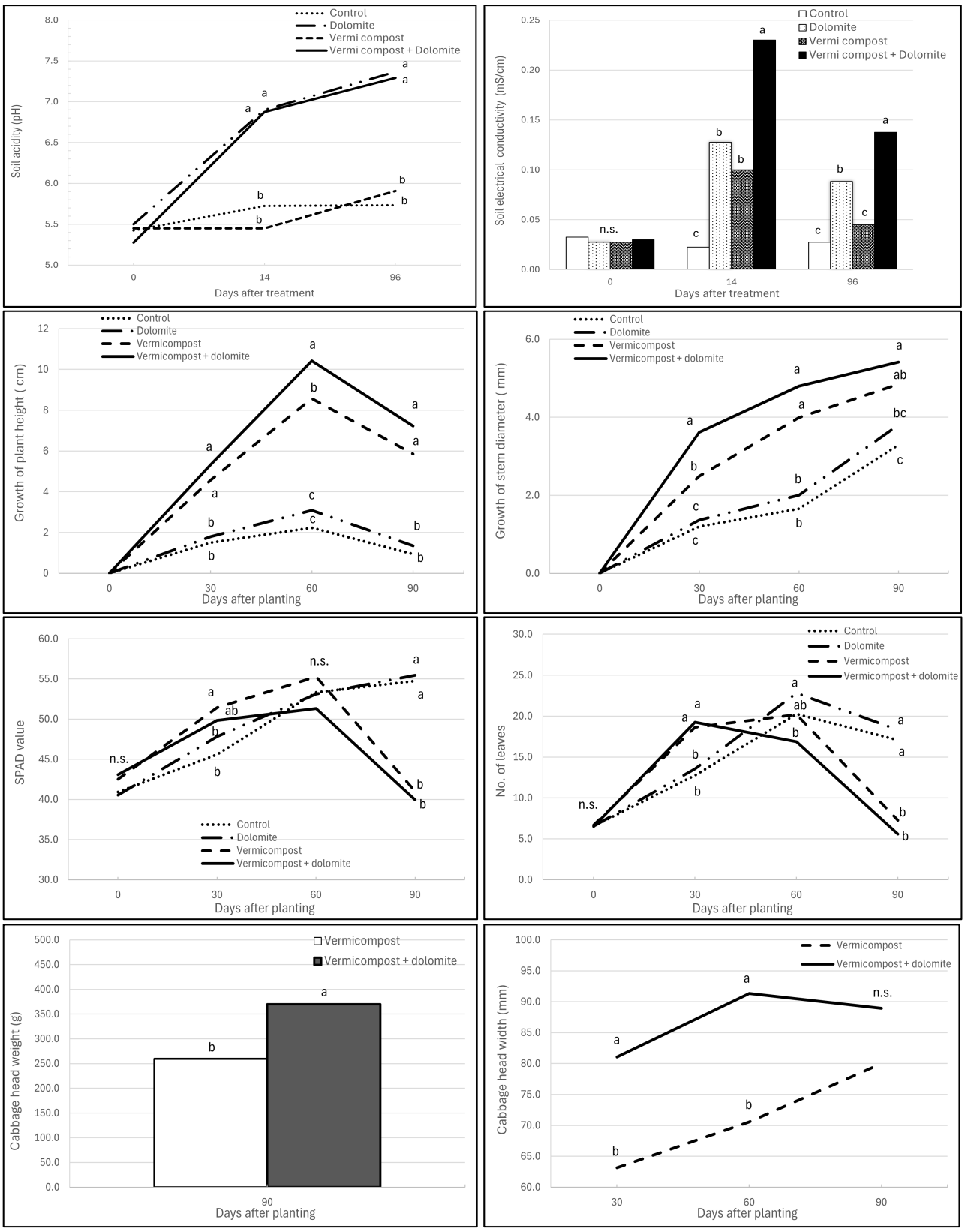

Figure 5. 8. Result of the effect of treatment on soil, growth and yield of cabbage

The results from the figures collectively indicate that the application of vermicompost, both alone and in combination with dolomite, significantly enhances plant growth and physiological performance compared to the control and dolomite-only treatments. Specifically, treatments with vermicompost (with or without dolomite) resulted in higher soil pH, increased chlorophyll content, greater shoot and root lengths, improved dry matter accumulation, and higher marketable yield. The combined application of vermicompost and dolomite often produced the highest values, suggesting a synergistic effect, although in some cases (e.g., chlorophyll content and fruit yield), the differences between vermicompost alone and the combined treatment were not statistically significant (n.s.). In contrast, dolomite alone showed minimal or no improvements across most parameters. This suggests that while dolomite may contribute to soil pH correction, vermicompost plays a more dominant role in enhancing plant growth and productivity.

Figure 5. 9. Nursery raising of potted cabbage and broccoli seedlings

Additionally, similar kind of research trial has been established in a split plot design with two crops (cabbage and broccoli), four treatments and five replications (blocks). The total experimental field of 100 sq. m with acidic soil was identified and subdivided into 20 plots. The research field was established on 12/05/2025 followed by the application of treatments.

5.1.4. Fabrication and testing of compost sieving machine

Sieving process is the process to separate larger particles from a mixture (Adedipe et al., 2021). A sifter/sieving machine is a device for separating wanted elements from unwanted material or for characterizing the particle size distribution of a sample, typically using a woven screen such as a mesh or net or metal. It is widely used for screening, grading and filtering, separating and classifying and sieving of powders, pellets, granule, and paste particles. The devices run on vibration or rotational motion, which lets grains of varying sizes to pass through the mesh to be collected and observed on top of the device. Sieving contributes to product quality, uniformity and processing efficiency. The sieves/ screens are the oldest and most widely used working elements for the separation of solid particles by size (Liu, 2009).

Basically, this machine was developed for vermicompost sieving to separate the fine particles to be use for agriculture purposes. Vermicompost is nothing but compost produced by intensive decomposition of organic wastes by earthworms (Vermicompost significantly affects plant growth.

A meta-analysis). Vermicomposting is the process in which organic waste is decomposed using earth worms resulting in a mixture called vermicompost.

The screening system toggles the switch and satisfies this need, with much higher capacity rate to compete with manual screening. It's usually a vibration with reciprocating screen (or) with openings of perforated sheet material, and let the fine compost go through the screen. The machine is Alternating current (AC) motor driven with gear reducer attached to it.

General objective

The general objective of this work was to develop mechanized motorized sieving machine

Specific objectives

(i) To reduce drudgery and human effort for sieving
(ii) To evaluate the machine performance for sieving vermicompost

Description of the machine

The machine was particularly design and fabricated for sieving vermicompost from impurities and clogged soil. The perforated sheet allows the fine soil particles to pass through the holes of the sieve plate while the bigger impurities are unable to pass through it and remain on the sieve. This method of separation of particles from a mixture based on the difference in size of particles is known as sieving. Sieve plates have 2.5 mm perforated bottoms which allow only particles of a specific size to pass through it. The size of mesh can vary from one place to another depending upon its application. The sieving/separating machine is made up of the following components;

Mesh assembly: High surface finish mild metal perforated sheets size of 2.5 mm were used as mesh to allow the passage of materials. The mesh is tightly enclosed by mild steel angle to hold soil within the sieve during operation. The assembly also content chute as a way for collection of un-sieved soils and foreign materials.

Motor and gear reducer: AC motor is one of the main prime movers that gives power source for sieving machine to operate. The motor is connected with gear reducer mainly use to reduce the RPM of motor and vibration during operation. To change the rotational movement of motor to and for direction, the link is centrifugally fixed on top of gear reducer shaft.

Main frame: Is the part of the machine that gives shape, supports and encloses the machine. The total weights carried by the main frame are: Weight of the electric motor, weight of the perforated sheet, weight of the gear reducer. The two design factors considered in determining the material required for the frame are weight and strength; angle mild steel bar was used to give the required rigidity.

Principle of operation

Operation of the machine is easy and requires only one individual to operate it easily. Separation by sieving mechanically is accomplished by powering the electric motor which is attached with gear reducer; on top a gear reducer shaft the link is fixed centrifugally which makes up the drive mechanism that goes to and fro along the frame that hold perforated sheet. The motion of the fixed link to and fro subjects the mesh assembly to the same, thereby unsettling the materials on the mesh. The constant random motion of these materials and the effect of gravity forces smaller particles that can pass through the mesh to fall through to the outlet. The particles with the smallest sizes end up at the bottom and collected manually, while those with the largest particle sizes remain on top of mesh and run through chute. **Figure 5.10** below is the pictorial view of the fabricated machine.

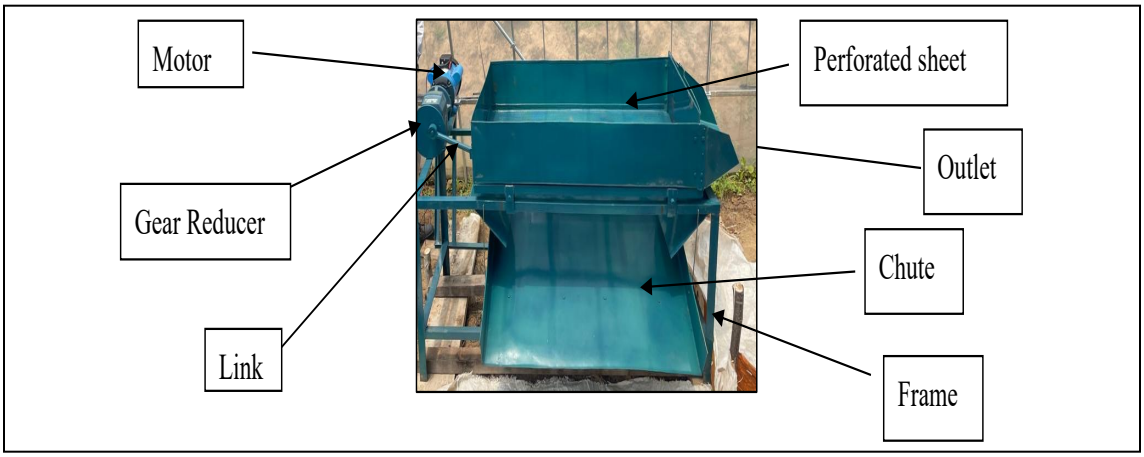

Figure 5. 10. Isometric view of sieving machine

Performance test

A performance test was carried out in the National Centre of Organic (NCOA), Yusipang Thimphu. The electrical sieving machine was used to carry out separation operations on vermicompost, and other soil types sample with excessive coarse particles. For this study, a vermicompost was separated from other impurities. These mixed materials were poured in the layer of the mesh (perforated sheet) assembly and sieved. The time to completely separate the mixture into the sieve was recorded and the respective weight of each layer was finally measured. Similarly, the compost sample was weighed before sieving and each collection from chute and others from outlet were weighed after sieving with the machine. Similarly, manual data were also recorded with same parameters.

Result and Discussion

Effect of compost moisture content on efficiency of machine

Moisture content significantly affects the efficiency of a sieving machine, as higher moisture levels cause soil or material particles to clump together, reducing their ability to pass through the sieve openings. This results in lower separation accuracy, increased material retention on the sieve, and reduced throughput. In contrast, drier materials flow more freely and are more easily separated, leading to higher sieving efficiency. Therefore, controlling the moisture content is crucial for achieving optimal performance and accurate classification during the sieving process. To find out the effect of moisture content on the efficiency of sieving machine, regression analysis was carried and found out it has moderate negative correlation where increase in moisture directly reduce the efficiency. The regression statistics give 51 % and 71%, the proportion of the efficiency affected that is explain by moisture content for machine and manual respectively. The result is significance where p value is ($p<0.05$).

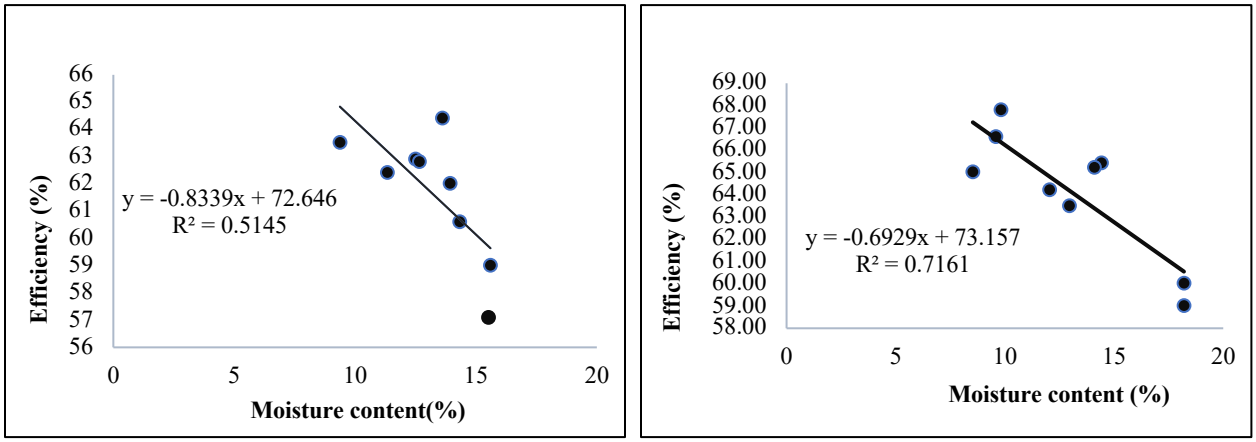

Figure 5. 11. Effect of moisture content to efficiency – Machine (L) and manual (R)

Comparing sieving machine capacity and manual sieving

On an average, a three man took 1 minutes 55 seconds to sieve 5kg of vermi compost without a rest until fine soil particles are separated and covering 124.01 kg/h. While the manual sieving capacity was 139.21 kg/h under 1425 RPM of motor. The sieving machine is 1.2 times more efficient than manual labor. The efficiency of machine and manual sieving was 61.63 % and 64.08 respectively. The losses percentage due to human error and vibration of machine was 0.9% for machine and 1.88% for manual.

The sieving machine plays a crucial role in improving the efficiency and accuracy of separating fine particles from vermicompost. The finding of this study states that the moisture of soil has major impact on the efficiency performance of sieving. It significantly reduces manual labor, saves time by 1.2 time compare to manual sieving. By utilizing vibration or rotary motion, the machine enhances the screening process, especially in agricultural. Overall, the sieving machine is an effective, reliable, and user-friendly solution for achieving uniform size of product. The site test

was successfully completed and the findings that sieving machine powered by motor was faster and human effort require is less.

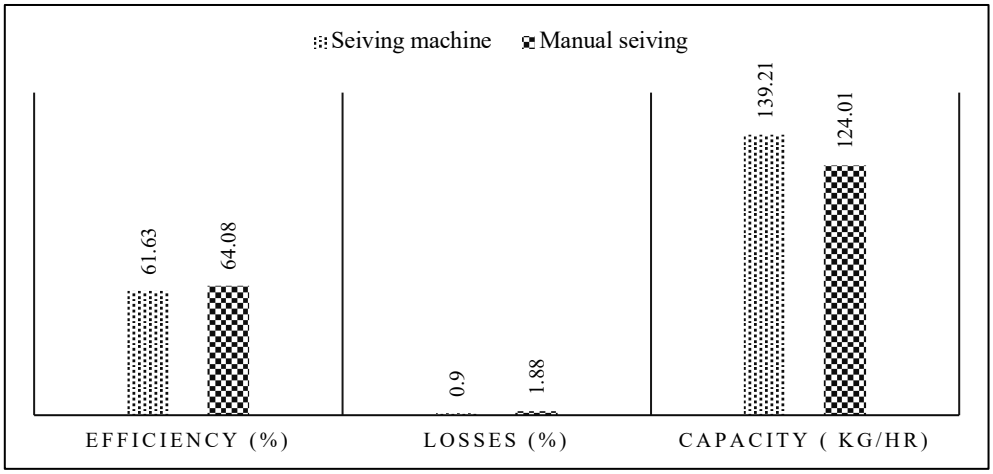

Figure 5. 12. Performance comparison of sieving machine vs manual

5.2.TECHNICAL SUPPORT SERVICE DEVELOPMENT ACTIVITIES

5.2.1. Production of wood vinegar

Wood vinegar also knowns as Pyroligneous acid is a dark liquid produced through natural act of carbonization, which occurs when a biomass is heated in an airless container during charcoal/ biochar production. Wood vinegar having benefit in controlling pests and diseases in agriculture, the sector as produced around 30 liters of bamboo wood vinegar to be used in the NCOA farm.

Figure 5. 13. Extraction of wood vinegar

5.2.2. Production of lupin seed for green manuring

As part of our ongoing efforts to improve soil fertility at the National Center for Organic Agriculture, TSS has initiated lupin production since last year, which is one of the soil fertility improvement technologies especially for the organic farming having poor soil.

Having the advantages of lupin on soil fertility improvement, TSS has produced around 37 kg of lupin seeds this year to cultivate as green manuring crop during the upcoming season in the NCOA farm as well as for distribution to the organic farmers and encourage them to take up lupin cultivation as a green manuring and incorporate them adding organic matter to the soil.

Figure 5. 14. Production of lupin seeds

5.2.3. Production of liquid bio- inputs (Jholmol, Jeevamrut and plant extracts)

Among the several type of technologies for plant nutrients management that has been practicing by TSS in National Center for Organic Agriculture, liquid bio- input (Jholmol-I, Jholmol-II, Jholmol-III and Jeevamrut) is one technology among them. Liquid being in nature, it provides nutrients to the plants faster and more efficiently. For Jholmol-I, ingredients required were cow dung, cow urine and water. For Jholmol-II, cow urine and water. For Jholmol-III, cow urine, water and locally available materials having bitter, sour or pungent smell and for Jeevamruth ingredients required were cow dung/cow urine, jaggery/besan, buttermilk and water. This year the sector has produced more than 4000 liters of bio- input and used for various commodities production by different programs within the farm.

Figure 5. 15. Application of liquid bio- fertilizers

5.2.4. Green manuring of research plots in core area of NCOA

The soil of the NCOA farm is depleted due to the continuous use of the land, despite adding manures which has been produced with in the centre. To replenish the soil nutrients, the sector has come up with an idea of sowing pea as a cover crop/ green manuring during the lean season which is one of the sectors goals for improving the soil. The sector has done the green manuring of 3 acres within the core area of the centre.

5.2.5. Seed production of pea

Pea being leguminous crop in nature, sowing of pea continuously in the NCOA farm increases the soil nutrients. To keep the continuity of sowing of peas as a cover crop during the lean season. The sector aimed to produce the pea seeds for the upcoming season as the seed production plays the vital role for the continued sowing of pea. However, the status of peas at this time are at their flowering stage in the field.

Figure 5. 16. Status of peas in the field

5.2.6. Research Outreach Program (ROP) on improved organic soil nutrient management and plant protection technologies

A Research Outreach Program to train 25 farmers each from Lango, Paro and Kawang, Thimphu with focus on preparation of bio inputs for improved soil nutrient management and plant protection was carried out from 21st to 24th April, 2025. The program activities included theory session where farmers were given a theoretical session covering the background, benefits, and importance of organic agriculture, organic soil nutrient management strategies focusing on composting, cover cropping, crop rotation, and green manuring, soil amendments and bio fertilizers. Organic plant protection strategies emphasizing on encouraging beneficial insects, using trap crops, companion planting, bio pesticides and implementing integrated pest management approaches. Following the theory session a hands-on Bio-Input Production Training was conducted where farmers were demonstrated step by step on how to make the bio inputs (Bokashi, Jholmol 1, 2 & 3, Jeevamrut, Biochar, garlic chilli concoction, and Takakura compost). The usage, benefits, and limitations of each bio-input were also explained. The ROP was well-received by the farmers.

Given that agriculture in Paro is predominantly paddy cultivation, the farmers expressed significant interest in learning how to utilize rice husk, rice bran, and straws which are materials often considered waste. They were pleased to learn that these readily available resources could be transformed into valuable bio-inputs, offering a sustainable alternative to burning agricultural waste. The hands-on training sessions were particularly engaging, with farmers expressing confidence in their ability to produce bio-inputs on their farms.

Figure 5. 17. Demonstration of on preparation of bio inputs to the farmers

5.2.7. Organic training on soil fertility and plant protection at Goenshari, Punakha

An organic soil fertility and plant protection training was conducted from 25th–27th February 2025 at Goen Shari, Punakha by NCOA officials. Thirteen farmers participated. The training covered Bhutan Organic Standards (BOS) 02:2022, organic soil fertility practices, plant protection, and technologies developed by ARDC Bajo and NCOA.

On the second day, the Internal Control System (ICS) Manual under the National Organic Programme was introduced, highlighting roles, documentation, inspections, and group certification to support smallholders. Participants also learned about nursery raising, cutting preparation for Sichuan pepper, and organic nutrient management. Emphasis was placed on compost, manure, green manures, crop rotation, and intercropping to enhance soil health and sustainability.

Later, a session on organic plant protection introduced eco-friendly methods to control pests and diseases, promoting ecosystem balance and reducing chemical use. Techniques like intercropping, use of biopesticides, and companion planting were emphasized for healthier, resilient crops. On the final day, participants engaged in hands-on training to prepare biofertilizers and biopesticides. This empowered farmers to adopt organic practices and produce their own inputs, enhancing sustainability and crop performance.

Figure 5. 18. Demonstration and hand-on-training on preparation of bio inputs to the farmers

2.2.8. Report on Takakura seed compost making

Takakura Seed Composting is a low-cost and eco-friendly method of managing organic waste, developed by Professor Koji Takakura in Japan. This composting technique uses a "seed" culture made from fermented kitchen waste and natural microorganisms, which accelerates the decomposition process. Unlike traditional composting systems that may require large spaces or sophisticated infrastructure.

Takakura method is suitable for urban and household settings, making it an ideal solution for sustainable waste management in densely populated areas. Its fast-processing time, minimal odor, and ease of maintenance have made it popular in various parts of Asia and beyond, promoting both environmental stewardship and community participation in reducing landfill waste.

2.2.9. Seed Compost Preparation

Seed compost is created by mixing fermentation liquids with natural materials (e.g., rice bran, hulls, leaves, wood shavings). The mixture is inoculated with microorganisms collected from fermented foods and forest soil to initiate microbial activity.

In a recent development, two Japanese experts conducted a two-day hands-on compost training at NCOA. The training focused on creating a base called Takakura seed compost by mixing various edible items, including brown sugar, yeast, yogurt, rice husk, and water. This mixture is kept for a few days to reach over 60 degrees Celsius, with its moisture content dropping to 40 percent, turning into a black color. Wet waste is then added daily, with the composting continuing until complete decomposition. To ensure proper aeration, the compost is prepared on bamboo platforms with holes. This method significantly reduces leachate—a hazardous liquid from wet waste—and minimizes its environmental impact.

Figure 5. 19. Takakura seed compost

Benefits and Use of Compost

- Soil Improvement: Enhances physical, chemical, and biological properties.
- Fertilization: Supplies nitrogen, phosphorus, and potassium (NPK) to crops.
- Compost promotes formation of soil aggregates, improving structure and fertility.

The Takakura Method is a low-cost, high-efficiency composting system that empowers households and communities to manage organic waste sustainably. By leveraging natural fermentation processes and simple techniques, it promotes environmental health and soil fertility.

2.2.10. Establishment of large-scale compost production facilities

The National Centre for Organic Agriculture (NCOA), with financial support of Nu. 1.2 million from the AFACI-RATES program, has established large-scale compost production facilities to boost organic input supply, improve soil health, and enhance overall farm productivity. The initiative aims to develop sustainable infrastructure for composting, integrate cattle rearing with compost production, and promote Bhutan's national goal of organic farming.

The facilities include a compost shed for processing, a utility shed for tools and equipment, and a cattle shed for generating raw materials like dung and urine. Cattle integration plays a vital role in creating a sustainable and cost-effective bio-input system, offering ecological, economic, and agronomic benefits.

Additionally, a greenhouse measuring 5 m x 20 m has been set up for large-scale vermicomposting using earthworms and local organic waste. These efforts collectively support farmer training, reduce chemical input dependency, improve soil fertility, and contribute to Bhutan's food security and environmental goals.

Figure 5. 20. Compost Shed and Cattle shed and Utility shed

2.2.11. GIES certification of quinoa from Bartsham, Tashigang

Quinoa (*Chenopodium quinoa*) has been identified as one of the priority crops under Bhutan's "One Country, One Product" initiative due to its nutritional value, climate resilience, and potential for commercialization. To support its promotion and protection, the Department of Agriculture (DoA), in collaboration with the National Centre for Organic Agriculture (NCOA), National Soil Services Centre (NSSC), and FAO-Bhutan conducted a study in Bartsham village, Trashigang Dzongkhag to come up with GIES data set. GIES, Geographical Indication and Environmental Sustainability ensures that products are linked to their environment, culture, and traditional knowledge, while meeting standards of sustainability and quality. If successfully certified, Bartsham Quinoa will gain a distinct identity tied to its unique origin, and unlock opportunities for premium markets, including international recognition. This would not only boost the local economy but also strengthen the community's pride in sustainable farming.

Figure 5. 21. GIES study team in Bartsham

The study team conducted a comprehensive data collection exercise focused on Bartsham village in Bhutan. Key demographic variables such as population, culture, tradition, agronomic practices, and soil characteristics were gathered to understand the community's socio-economic and agricultural profile. In addition, metrological and spatial datasets were used to map the study area, identify suitable zones for crop cultivation, and analyze rainfall and temperature patterns critical to sustainable farming.

GIES Case Dataset on Quinoa (*Chenopodium quinoa* Willd.) from Bartsham *Gewog*, Trashigang Dzongkhag, Bhutan

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Keywords: Bhutan, Bartsham, Quinoa, Geographical Indication Environment and Sustainability, One Country One Priority Product, Food and Nutrition Security, Household Income

Abstract

Bhutan is known to the outside world as a Gross National Happiness (GNH) country. It is a small Buddhist country nestled in the eastern Himalayas sandwiched between India and China. It is the first carbon negative in the world. The constitution mandates to ensure 60% of its areas under forest cover for all times to come. Bhutan is largely an agrarian country with a diverse agri-food system engaging 41.7% of its employed population in agriculture, forestry and fishery. Bhutan introduced Quinoa (*Chenopodium quinoa* Willd.) in 2015 as a nutrient dense cereal to enhance its food and nutritional security. It has successfully adapted its cultivation under the six different agro-ecological zones and mainstreamed as a priority commodity in the current 13th Five Year Plan. Quinoa has been nominated as Bhutan's One Country One Priority Product (OCOP) under the Food and Agriculture Organizations' (FAO) global flagship initiative to strengthen the value chain of Special Agricultural Products (SAP).

Figure 5. 22. Snapshot of the manuscript

Based on the findings, a detailed manuscript was developed and submitted to FAO Bhutan. To complement the written report, a video documentary was also produced. This visual piece highlights the unique lifestyle, agricultural practices, and cultural richness of the Bartsham community, effectively capturing the village's socio-economic realities and its evolving relationship with emerging crops like quinoa.

2.2.12. Regional Agriculture Database for the west central Region

As per the directives of the Agriculture Research and Coordination Meeting, regional research centers were tasked with developing a robust database or data inventory system. A well-structured database is essential for effective research planning, monitoring, and decision-making. It enables systematic storage, retrieval, and analysis of key agricultural data, including crop performance, trends, agriculture facilities and farmer practices. Such a system not only enhances data accessibility and transparency but also supports evidence-based interventions, facilitates collaboration among research institutions, and ensures that valuable research outputs are preserved and utilized for long-term agricultural development. In response to the directive from the Agriculture Research and

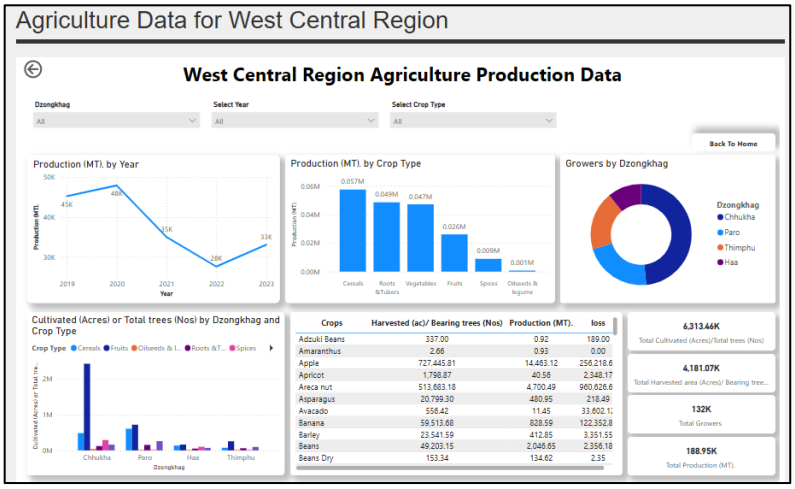

Figure 5. 23. Snapshot of the West central database

Coordination Meeting, the socio-economic sector successfully developed and launched a comprehensive agricultural database system. The system is designed to enhance the management, accessibility, and use of agricultural research data for the West-Central region of Bhutan.

The database integrates three core components: agricultural production, agricultural technologies released, and agricultural infrastructure. It serves as a centralized repository to store, retrieve, and analyze critical data related to farming systems, innovations, and resource distribution. To ensure relevance and accuracy, various statistical methods and data modeling tools were employed in the development process. These tools allow for structured data categorization, trend analysis, and spatial mapping.

To promote transparency and public access, the database has been hosted online and is accessible through the NCOA's official website at https://ncoa.gov.bt/agriculture-data-for-west-central-regiontest/. This platform supports evidence-based planning and policy formulation while encouraging collaboration among researchers, extension agents, and decision-makers.

2.2.13. Training on office automation using Google Tools and Audio-Visual Communication at GMC

A five-day training program on data management and documentation of success stories was conducted in Sarpang Dzongkhag from December 9 to 13, 2024. The training was designed to build the capacity of administrative officers and Extension Officers in using digital tools for recording agricultural success stories and managing field data effectively.

Figure 5. 24. Training on office automation

The program was conducted in two main modules: (i) Audio-visual documentation through basic videography and vlogging, and (ii) Digital data management using tools like google forms, sheets, excel, and tableau. The training aimed to support improved agricultural planning and communication through better data systems and storytelling.

Participants acquired hands-on skills in producing visual stories using video editing and interviewing techniques, improving their ability to capture and share impactful narratives from the field. They also learned to design digital surveys, manage and clean data, and visualize datasets for decision-making. Following the training, a practical agriculture database was developed for Sarpang Dzongkhag, consolidating and standardizing collected data into a user-friendly format. This database serves as a resource to support planning and monitoring of agricultural programs.

2.2.14. FAO Director Generals Visit

The Director-General of the Food and Agriculture Organization (FAO) of the United Nations, Dr. Qu Dongyu, along with his delegation, visited the National Centre for Organic Agriculture (NCOA) in Yusipang on 5 February 2025. The visit aimed to observe the role of research and innovation in driving Bhutan's sustainable agriculture agenda.

Figure 5. 25. FAO Director General visit to Bhutan

NCOA, which has been at the forefront of promoting organic farming in Bhutan for over five decades, showcased its key initiatives and milestones during the visit. With technical and financial support from FAO, projects such as the One Country One Priority Product (OCOP) - with quinoa as Bhutan's nominated crop - and value chain studies for cardamom and ginger have been instrumental in enhancing agricultural resilience, food security, and sustainability.

A highlight of the visit was the official handover of quinoa production machinery by Dr. Qu Dongyu to farmers and research centers through their respective representatives. This gesture reflects FAO's continued support for Bhutan's commitment to organic and sustainable farming systems.

2.2.15. Training of Desuups for Geocoding and Technical support to MFTP Geocoding

The Socio-Economic Sector served as the technical consultant for the geocoding of the Million Fruit Tree Plantation Project (MFTP) in 2025. Initiated by His Majesty the 5th King Jigme Khesar Namgyel Wangchuk, the MFTP aims to enhance rural household nutrition security, provide employment opportunities for youth through Desuups (guardians of peace), and foster a connection between youth and rural communities.

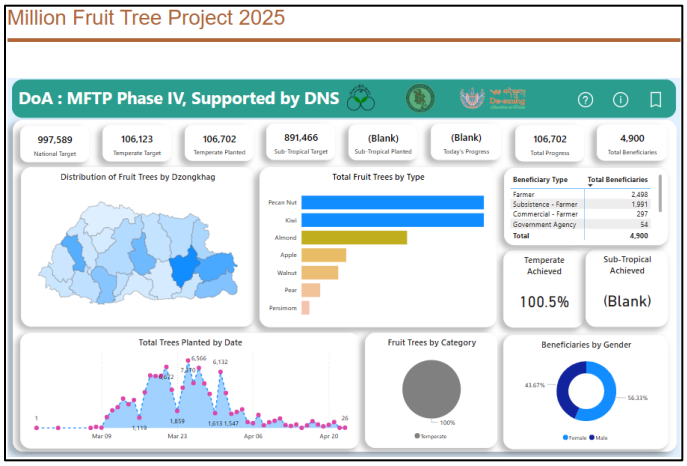

Figure 5. 26. Snapshot of MFT Dashboard

To support the initiative, the Socio-Economic Sector facilitated numerous virtual training sessions for Desuups on digital data

collection and geospatial mapping. These sessions were complemented with continuous technical backstopping to ensure accuracy and consistency in the data-gathering process.

As of now, 106,702 temperate fruit trees have been successfully planted across Bhutan, directly benefiting 4,900 individuals. All planted trees are geocoded using GIS technology via the KoboCollect data collection platform. This geospatial data is updated in real-time and publicly accessible through the Department of Agriculture's online dashboard, ensuring transparency and effective monitoring.

The project targets the plantation of approximately 997,589 fruit trees by mid-August 2024, with continued emphasis on digital monitoring, spatial accuracy, and youth engagement through technology-enabled solutions.