# ROYAL GOVERNMENT OF BHUTAN

# Agriculture Highlights 2022-2023

**Department of Agriculture**
**Ministry of Agriculture and Livestock**

**June 2023**

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Department of Agriculture
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# FOREWORD

The Department of Agriculture is pleased to bring out its **"Agriculture Highlights"** for the fiscal year 2022-23. This annual publication is a concise summary of all major achievements made in research and development by Agriculture Research and Development Centres (ARDCs), Central Programs, Commodity Programs and Support Services within the department. It serves as a comprehensive record of our progress during the reporting year, addressing the challenges encountered in crop research and production, service delivery, infrastructure establishment, and capacity building.

The publication strives to collect reports from all agencies within the Department of Agriculture, compile the information, analyze it, and synthesize it into a condensed version that effectively highlights the progress made over the past year. The highlights are organized into various approved program groups, providing an overview of the cumulative achievements by agencies within the department. It however, is exclusive of the various programs and initiatives undertaken by respective dzongkhags.

The reporting format and style enable readers to navigate through specific sections of interest, providing a comprehensive overview of the achievements therein. Readers are encouraged to refer to the annual reports of individual agencies for a more extensive coverage of their respective progress. Each agency produces separate reports that offer a comprehensive account of their accomplishments.

I applaud the diligent efforts of the Agriculture Research & Development Centres (ARDCs), Central programs, Agriculture Production Division (APD), Agriculture Research & Innovation Division (ARID) and the Dzongkhag Agriculture Sectors in successfully fulfilling and accomplishing the department's goals.

**(Yonten Gyamtsho)**

**DIRECTOR**

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## SUMMARY


- The Ministry in collaboration with the Desuung National Services completed the 2nd phase of the Million Fruit Tree Plantation with high-value fruit trees to enhance food and nutrition security as well as for household income generation and employment opportunities.

- Under the Water Flagship Program, the department successfully implemented 35 irrigation schemes, spanning a length of 164 km and covering an area of 6785 acres during FY 2022-23. These schemes have greatly contributed to improving the lives of 3455 households. The Desuung National Services played a significant role in constructing 8 out of the 35 schemes.

- In keeping with its efforts in research and technology development, the Department of Agriculture's 25th Variety Release Committee (VRC) and 9th National Seed Board (NSB) approved the release of 28 crop varieties based on their better yield performance and resistance to pests and diseases, and growers' preferences. In addition, four technologies were released during the 6th Technology Release Committee (TRC) viz. Bentonite clay water harvesting pond, Smart irrigation systems, Mulch laying attached to a tractor, and Walipini (sunken greenhouse).

- The department also released three turmeric varieties, two ginger, one black pepper, and two betel leaves based on their high productivity and high market potential after a fast-track on-station and on-farm evaluation.

- To enhance mushroom production and diversify available options for growers, the department has initiated several research in mushrooms like evaluation of alternate mushroom substrates, domestication of medicinal mushroom species like *Hericium*, and evaluation of Shitake mushroom and *Pholiota microspora*.

- For this reporting period, the National Organic Flagship Program added another 111.77 acres of land operated by 25 households as an area under certified organic production. The total registered area under organic management stands at 14,099.54 acres comprising farmers, farmer groups, youth groups, as well as commercial farms and institutional land. Eight new products were also certified making the total organic certified product 65.

- As part of its mandate to ensure the safety and quality of farm machines and implements, the Agriculture Machinery and Technology Centre (AMTC) in collaboration with the Bhutan Standards Bureau (BSB) tested and certified 11 farm machinery. These certifications constitute an integral part of formal procedures for availing credit services and subsidies by private entrepreneurs whilst operating their firms. The centre also conducted various research on technologies such as IoT-based animal repellent, automation in greenhouse, and vertical hydroponic system.

- Several research studies were conducted by the National Plant Protection Centre (NPPC) on the control and management of Fall Armyworm (FAW) at different locations using the new generation insecticides–with low toxicity, sex pheromones, and FAW resistant crop varieties.

- Contributing to increasing production for food security, the National Seed Centre (NSC) supplied 474.73 MT seeds worth Nu. 62 million that were produced on farms, imported from India, and produced by Registered Seed Growers (RSGs). These include cereals seeds of improved varieties, high-quality vegetable seeds, oilseeds, and potato seeds. The centre's gross revenue for the reporting year stood at Nu. 233.50 million from the sale of seeds and seedlings and chemical fertilizers.

- In addition to completing soil investigations and soil surveys for various private and government agencies, the National Soil Service Centre (NSSC) successfully brought around 1060 acres of land under sustainable land management interventions. Additionally, about 90.45 acres of fallow land have been developed and brought under crop cultivation.

- Following the comprehensive data collection from various regions of Bhutan, a soil map with a resolution of 250 meters was generated using random forest modelling by NSSC. Through this modeling approach, the generated soil map exhibits seven distinct classes – Dystric Cambisols; Anthraquic Cambisols; Eutric Cambisols; Skeletic Cambisols; Haplic Acrisols; Haplic Allisols, and Haplic Lixisols–providing valuable insights into the spatial distribution and classification of soils across the country.

- Several publications/policies were brought out in the reporting period that includes the Food and Nutrition Security Policy of Bhutan 2023, Cost of Production 2023, and a number of journal papers in internationally recognized high-impact journals.

- The Department launched the sixth volume of the Bhutanese Journal of Agriculture (BJA) to help promote a vibrant culture of research and scientific communication among its employees.

# 1 Million Fruit Tree Plantation Project

Upon the Royal Command of His Majesty the King, the Ministry of Agriculture and Livestock implemented Million Fruit Tree Plantation Project in partnership with the Desuung National Service covering all 20 dzongkhags. The project not only enhances the nutrition and income of our rural communities but also contributes to creating employment opportunities in the fruit sector. The engagement of thousands of De-Suups has also provided them with an opportunity to appreciate our rural heartlands and reciprocate our farmers for the invaluable role they play in our lives. The seedlings were distributed to all the households across the country as Royal *Soelra* with great symbolism and economic value.

During the first phase, **1,019,785** fruit plants including 5000 Bodhi trees were planted in households and institutes all across the country through the engagement of 2,118 Desuups for the duration of a little less than three months (April-June 2022).

***Temperate Region:*** Almond, kiwi, pecan nut, apple, apricot, walnut, peach, pear, plum, persimmon, cherry and chestnut
***Sub-tropical Region:*** Avocado, citrus, dragon fruit, passion fruit, mango, guava, litchi, papaya, pomegranate, banana and bodhi tree. These high-value commodities were prioritized considering the potentiality in terms of climate, soil, land type, market availability and need for crop diversification.

**Figure 1. Launching of Million Fruit Tree Plantation at Yusipang, Thimphu on 15th March 2022**

The second phase of MFTP is ongoing and planted 2,59,210 nos. of high value temperate fruit trees (Almond, Walnut, Pecan nut, Kiwi) and 665,058 nos. of sub-tropical fruits (Avocado, Dragon fruits, Irwin Mango, Mandarin, Macadamia nut, Seedless lime, Coconut, Prickly Custard Apple -Soursop, Agarwood) as of 15 July 2023.

The department also carried out the first phase replacement of the dead and injured plants with quality seedlings. In the temperate region, about 169,800 nos. of fruits were replaced in the month of February-March, 2023 and about 171,679 nos. fruits were replaced in the sub-tropical region in May-June 2023.

## 2 Royal Bhutan Flower Exhibition (RBFE)

The annual Royal Bhutan Flower Exhibition (RBFE) was scheduled for the first week of June 2023 in Thimphu City. A total of 350,000 ornamental plants were produced for the exhibition. Six agencies (*ARDC, Bajo; NCOA, Yusipang; Dechhencholing Royal Project; Chimipang Royal Project; Nezerkha Royal Project; National Biodiversity Centre*) under the Ministry of Agriculture and Livestock, Tashichhodzong Garden Project, and Desuup Skilling Programme participated in plant production. To encourage the private sector and provide them with business opportunities, three private nurseries were also engaged in raising the flowers. However, the exhibition was rescheduled, and thus the plan to plant and display ornamental plants was shelved.

To reduce waste and recover some of the costs, the plants were put up for sale and distributed to interested institutions for beautification purposes. As of 29 June 2023, Nu. 695,162 worth of ornamental plants were sold. Some 34000 plants were distributed free of cost to support beautification initiatives by organizations. The remainder were used for decoration in various important events.

*Coleus* *Dianthus* *Petunia* *Marigold*

## 3 Greenhouse and Chain-link fencing

***Greenhouse Progress Update 2022-2023***

The department initiated one greenhouse for every household to enable farmers to produce crops during the off-season and in areas with relatively extreme climatic conditions where crop production is not feasible in the open field. In FY 2022-23, the 2535 greenhouses have been distributed covering all dzongkhag. The total budget for the supply of Greenhouse was Nu. 88.40 million from RGoB and FSAPP project with additional funding from GCF and Dzongkhag grants.

**Table 1. Greenhouse target and distribution**

| Source | Target (nos.) | Achieved (nos.) |
|---|---|---|
| RGoB | 1200 | 1351 |
| FSAPP | 800 | 1126 |
| GCF | | 36 |
| Dzongkhag grants | | 22 |
| Total | **2000** | **2535** |

***Chain-link fencing Progress Update 2022-2023***

Human wildlife conflict is one of the serious issues faced by farming communities. To mitigate crop damage by wildlife, the department initiated to establish chain-link in all agriculture farms across all dzongkhag.

In the first phase of chain-link establishment, the department protected more than 3000 acres of farmland stretching across 111.5 kms and directly benefiting 991 households with the budget of Nu.178.80 Million. The details of schemes are given in Table 2.

**Table 2. Chain-link fencing details**

| Dzongkhag | Geog | Length (Km) | Total command area | Beneficiary HHS | Fallow land acres | Budget |
|---|---|---|---|---|---|---|
| Bumthang | Chumig | 4 | 103 | 50 | 0 | 6.240 |
| Chhukha | Darla | 5.5 | 300 | 63 | 10 | 4.680 |
| Dagana | Karna | 6 | 100 | 30 | 0 | 9.360 |
| Gasa | Goenkhamaed | 6 | 19 | 21 | 1 | 9.360 |
| Haa | Eusu | 5 | 50 | 20 | 20 | 7.800 |
| Lhuentse | Minjay | 8.0 | 120 | 45 | 40 | 12.480 |
| Mongar | Ngatshang | 5 | 100 | 140 | 30 | 7.800 |
| Paro | Lungnyi | 4 | 170 | 45 | 7 | 6.240 |
| Pema Gatshel | Nanong | 6 | 98.7 | 22 | 2 | 9.360 |
| Punakha | Chhubu | 8 | 82 | 51 | 0 | 12.480 |
| Samdrup Jongkhar | Pemathang | 2 | 18 | 6 | 0 | 3.120 |
| Samtse | Sangangcholing | 3 | 100 | 54 | 0 | 8.424 |
| Sarpang | Senggey | 7 | 523 | 55 | 0 | 10.920 |
| Thimphu | Kawang | 1.9 | 30 | 41 | 0 | 2.964 |
| Trashi Yangtse | Boomdeling | 1.5 | 20 | 15 | 0 | 2.340 |
| Trashigang | Samkhar | 5 | 120 | 26 | 5 | 7.800 |
| Trongsa | Tangsibji | 7 | 400 | 101 | 0.5 | 10.920 |
| Tsirang | Semjong | 4.5 | 201.45 | 72 | 40.29 | 7.020 |
| Wangdue Phodrang | Gasetshogom | 12 | 250 | 76 | 0 | 18.720 |
| Zhemgang | Shingkar | 10.11 | 389 | 58 | 0.5 | 15.772 |
| Grand Total | | **111.51** | **3194.15** | **991** | **156.29** | **173.80** |

# 4 Land Conversion and land exchange

The Department verified 91 cases of land conversion cases from three Dzongkhags (Chhukha, Samtse and Sarpang). Out of 91 cases, 55 cases was recommended for conversion based on technical assessment on soil conditions, availability of water for irrigation, surrounding land use status etc. and 36 cases were rejected since they didn't meet the technical criteria. In addition, 212 land exchange cases were coordinated in collaboration with National Land Commission Secretariat.

# 5 Assuring Irrigation Water and infrastructures

The Agriculture Engineering Division (AED) under the Department of Agriculture oversees all the construction works related to agriculture infrastructure developments under the Ministry of Agriculture and Livestock. This involves building new irrigation systems, rehabilitating the old ones, support to Farm road bridges survey, design, and other RNR civil construction works. However, its primary focus is on irrigation and in improving crop productivity and production. Here are some of the activities carried out in collaboration with other stakeholders:

***Infrastructure Construction and maintenance***

Catered to the construction and maintenance needs of all RNR construction works under the Ministry of Agriculture and Livestock including design, estimation, tendering, supervising, and monitoring during the execution of the works. A Few large-scale projects were outsourced to private firms, particularly those funded by donors.

- Completed Construction of Laboratory building at NMC, NSSC, NPPC and NCOA-Yusipang
- Constructed drying shed at NBC, Serbithang
- Constructed Yak Wool processing plant at Haa,
- Internal irrigation aquaduct at NRDCA, gelephu
- Constructed solar powered Lift irrigation system at Gangri, Paro
- Pop-up irrigation system at Changzamtog park, irrigation system at Nangkhag, Jamkhar geog

***Construction of Farm Road Bridges***

AED conducted feasibility studies, comprehensive surveys, and designed 20 Farm road bridges across Sarpang, Punakha, Wangdue phodrang, Zhemgang, Chukha, Haa, and Trongsa. Currently, most of these bridges are in the construction phase, while a few have already been completed. The construction of these farm road bridges has significantly improved the accessibility of farm roads throughout the year, enabling farmers to easily reach their farms and transport their agricultural products to nearby markets. Therefore, prioritizing the construction and maintenance of farm roads and connecting them with farm road bridges remains crucial for the nation's economic development, particularly for individual households.

***Irrigation systems***

One of the core mandates of the department is the construction of irrigation facilities/systems to enhance crop production, food and nutrition security of rural communities and RNR sector growth. AED carries out the preliminary and detailed survey, designing, estimation, and overall monitoring of the irrigation system including the capacity building on the operation and maintenance of the irrigation system and formation of water user associations/groups (WUA).

During this FY, 35 irrigation schemes were completed, out of which, 27 irrigation schemes were completed under the Water Flagship Program and 8 schemes were completed under

Desuung Water Partnership. In total, the irrigation schemes of 164 km covering an area of 6785 acres benefited 3455 households (Table 3).

**Table 3. Irrigation schemes completed during FY 2022-23**

| SN | Name of Irrigation Channel | Location | Length (Km) | Command Area (Ac) | Beneficiary (HH) | Approved Budget (Nu. in Mn) | End Date |
|---|---|---|---|---|---|---|---|
| 1 | Langjaru Irri. Scheme | Sangbaykha, Haa | 4.50 | 39.00 | 12 | 10.60 | 30/09/2022 |
| 2 | Khangdari-Godari Irri. Scheme | Jamkhar, Yangner, Trashiyangtse | 2.45 | 136.54 | 154 | 35.28 | 30/09/2022 |
| 3 | Chukarpo Irri. Scheme | Langchenphu, Jomotshangkha | 6.50 | 384.00 | 113 | 42.76 | 30/09/2022 |
| 4 | Longorchhu Irri. Scheme | Zham, Lhuntse | 5.50 | 361.00 | 28 | 35.00 | 31/10/2022 |
| 5 | Wangringmu Irri. Scheme | Wangringmo, Trashiyangtse | 6.90 | 170.00 | 333 | 13.70 | 15/08/2022 |
| 6 | Rawadrang_Manchhu Irri. Scheme | Tokaphu, Tomijangsa | 8.00 | 180.00 | 90.00 | 35.22 | 31/12/2022 |
| 7 | Sibjana Irri. Scheme | Damji, Maedtsho, Gasa | 3.02 | 120.00 | 58 | 22.53 | 12/04/2023 |
| 8 | Omshari Integrated Scheme | Pemathang, Samdrupcholing | 6.84 | 1050.00 | 384 | 95.00 | 04/06/2023 |
| 9 | Tashipang & Pemashong Irri. Scheme | Mendrelgang, Tsirang | 2.00 | 54.96 | 88 | 6.55 | 15/03/2023 |
| 10 | Hokatsho Irri. Scheme | Kabjisa, Punakha | 8.00 | 190.20 | 57 | 30.15 | 01/05/2023 |
| 11 | Ngawang Sechuyuwa Irri. Scheme | Rubesa and Bjena, Wangdue | 11.40 | 384.54 | 288 | 37.47 | 27/10/2023 |
| 12 | Phendey Yuwa Irri. Scheme | Talo and Toepisa, Punakha | 5.20 | 433.66 | 265 | 55.04 | 30/10/2023 |
| 13 | Takabi Irri. Scheme | Trong, Zhemgang | 4.00 | 52.00 | 55 | 9.09 | 13/07/2023 |
| 14 | Tagmochhu Irri. Scheme | Tagmochhu, Maenbi, Lhuntse | 10.00 | 404.55 | 150.00 | 3.28 | 05/09/2023 |
| 15 | Dowachen Irri. Sscheme | Dowachen, Medtsho, Lhuntse | 1.00 | 20.00 | 8.00 | 3.31 | 27/02/2023 |
| 16 | Tsuenduegang Irri. Scheme | Tsuendugang, Naja, Paro | 6.17 | 250.31 | 83.00 | 18.40 | 19/06/2023 |
| 17 | Solar powered Lift irrigation | Gangri & Tilli, Shaba, Paro | 2.30 | 36.00 | 21.00 | 6.46 | 15/12/2022 |
| 18 | Kulung Integrated Scheme | Kulung, Nanong, Pemagatshel | 16.00 | 0.00 | 0.00 | 8.88 | 20/11/2022 |
| 19 | Zab-Rangrekha Irri. Scheme | Zab-Rangrekha, Kabisa, Punakha | 2.50 | 60.20 | 27.00 | 1.00 | 29/05/2023 |
| 20 | Serigang Irri. Scheme | Serigang, Kabisa, Punakha | 3.00 | 55.00 | 130.00 | 1.00 | 06/08/2023 |
| 21 | Nevana Irri. Scheme | Nevena, Kabisa, Punakha | 1.00 | 39.00 | 25.00 | 2.95 | 30/05/2023 |
| 22 | Penzolum to Temkha Irri. Scheme | Temkha, Toebisa, Punakha | 2.00 | 15.00 | 10.00 | 2.50 | 28/05/2023 |
| 23 | Tokha and Wangchen Irri. Scheme | Tokha, Toebisa, Punakha | 2.00 | 36.50 | 28.00 | 1.50 | 06/10/2023 |
| 24 | Lumtsawa and Toktokha Irri. Scheme | Toktokha, Toebisa, Punakha | 4.00 | 103.00 | 34.00 | 1.80 | 06/10/2023 |
| 25 | Bemsisi Irri. Scheme | Bemsisi, Toebisa, Punakha | 4.00 | 12.00 | 20.00 | 1.60 | 22/05/2023 |
| 26 | Burchuthang Irri. Scheme | Burchuthang, Chudzom, Sarpang | 2.00 | 18.00 | 14.00 | 9.61 | 07/02/2023 |
| 27 | Taklai Irri. Scheme | Taklai, Chhuzergang, Sarpang | 17.00 | 1022.00 | 611.00 | 24.65 | 13/06/2023 |
| 28 | Dawathang-Shawapang Irri. Scheme | Dawathang, Shawapang, Chhuzergang, Sarpang | 2.00 | 100.00 | 100.00 | 6.44 | 06/03/2023 |
| 29 | Karbeythang Irri. Scheme | Karbeythang, Chhuzergang, Sarpang | 2.00 | 100.00 | 100.00 | 3.27 | 04/07/2023 |
| 30 | Sep Irri. Scheme | Bayling, Trashiyangtse | 2.50 | 740.00 | 17.00 | 6.00 | 16/06/2023 |
| 31 | Phawangphu to Nachi Irri. Scheme | Phangwangphu, Jamkhar, Trashiyangtse | 2.60 | 30.00 | 11.00 | 8.40 | 17/03/2023 |
| 32 | Braktsa and Tokshing Irri. Scheme | Braktsa and Tokshing, Toedtsho, Trashiyangtse | 3.00 | 55.00 | 32.00 | 7.50 | 17/03/2023 |
| 33 | Rollam-Thragom Irri. Scheme | Rollam-Thragom, Yallang, Trashiyangtse | 0.80 | 65.00 | 50.00 | 1.20 | 18/12/2022 |
| 34 | Yarphel Irri. Scheme | Yarphel, Yallang, Trashiyangtse | 1.50 | 35.00 | 31.00 | 2.60 | 30/09/2022 |
| 35 | Melongkhar irrigation scheme | Melongkhar, Yallang, Trashiyangtse | 1.70 | 32.00 | 28.00 | 2.80 | 30/09/2022 |
| | | **Total** | **163.38** | **6784.46** | **3455.00** | **553.54** | |

***Omshari Landmark irrigation project***

Coinciding with the 33rd birth anniversary of Her Majesty the Queen, Ashi Jetsuen Pema Wangchuck, the Omshari Landmark Irrigation was formal handing-over by His Excellency Lyonpo Yeshey Penjor, MoAL, signifying a significant milestone for the local communities.


The Omshari Landmark Irrigation Project, located in Pemathang Gewog, Samdrup Jongkhar, was launched on November 11, 2022, at a cost of Nu. 95.00 million and implemented by the Desuung National Service. With the completion of this project, 384 households with a command area of 1050 acres were benefitted from improved access to irrigation facilities. The Irrigation system will address the water needs of farmers, allowing them to cultivate their lands throughout the year and enhance agricultural production. It will also contribute to poverty alleviation and food security in the region.

The Agriculture Engineering Division (AED) conducted the feasibility studies including the design, cost estimation, and monitored the overall project.

# 6 Research Highlights

The agriculture sector is significantly impacted by climate change and climate-induced disasters. To enhance the resilience of the agriculture sector to these challenges, various climate-smart farming technologies are being implemented. These include drip irrigation and other piped irrigation methods to combat droughts, the adoption and innovation of new management practices, organic farming techniques, the development of pest/disease and stress-tolerant crop varieties, and improvements in soil fertility through nutrient management. These technologies ensures increase in productivity even in the face of severe droughts, erratic rainfall patterns, and the emergence of new pests and diseases. The Agriculture Research and Development Centres (ARDCs) and Central program have been actively conducting various research to bring forth innovative technologies that enhance the crop productive and mitigate the impact of climate change.

Every year, the department organizes the Agriculture Research Coordination Meeting (ARCM) with participants from ARDCs, Central Programs, and Department HQ chaired by the Director. The ARCM serves as the technical forum where annual agriculture research work plans are planned, reviewed, and harmonized. It also aims to identify emerging research needs and priorities, as well as finalize and endorse nationally coordinated trials and collaborative work plans. Additionally, the ARCM provides a platform for presenting completed research results, highlighting significant findings for knowledge sharing, increasing visibility, and enabling publication in peer-reviewed journals.

The ARDCs and the central programs successfully completed 93 different research topics comprising of 121 activities during the FY 2022-23 as shown in Annexure 1. Here is a commodity wise breakdown, providing a concise overview of both ongoing and completed research activities:

## 6.1 Field Crops

### 6.1.1 Rice

Rice research for the year 2022-23 reporting year includes evaluation of a total of 109 rice lines including those at different stages of trial across all the four ARDCs. Production evaluation trial (PET) is also being conducted on 15 rice lines. Some of the important research include:

***Evolutionary Plant Breeding Trial***

Funded by Bio-diversity International and coordinated by the National Biodiversity Centre (NBC) in partnership with the four ARDCs and Geog Agriculture Extension Supervisors of respective regions, the “Evolutionary Plant Breeding Project” was initiated in 2019. Its main objective is to assess and develop Evolutionary Population (EP) in rice that can withstand specific micro-climatic conditions and exhibit climate resilience. The findings from the project indicate a significant variation in yield, with the highest yield recorded for the variety Yusiray Maap 1 (1.83 t/acre), and the lowest yield observed for the Jakar ray Naab variety (1.44 t/acre) as presented in Table 4.

**Table 4. Agronomic traits and yield of rice treatments at Tsento, Paro**

| Treatments | Mean PH (cm) | Mean Tiller (no) | Mean Panicle length (cm) | Mean filled grains (no) | Mean unfilled grain (no) | 1000 grain weight | Plot yield (t/ac) |
|---|---|---|---|---|---|---|---|
| Yusiray Kaap 3 | 85.87$^{e}$ | 6.33$^{b}$ | 19.67$^{b}$ | 110.07$^{ab}$ | 6.60$^{b}$ | 28.13$^{abc}$ | 1.71$^{ab}$ |
| Yusiray Maap 1 | 105.4$^{c}$ | 9.13$^{ab}$ | 20.87$^{b}$ | 84.60$^{bc}$ | 16.20$^{ab}$ | 32.80$^{ab}$ | 1.83$^{a}$ |
| Mixture | 116.07$^{b}$ | 11.20$^{a}$ | 21.47$^{b}$ | 118.07$^{ab}$ | 11.80$^{ab}$ | 20.80$^{c}$ | 1.67$^{ab}$ |
| Jakaray Naab | 84.93$^{e}$ | 12.40$^{a}$ | 15.73$^{c}$ | 51.47$^{c}$ | 1.80$^{b}$ | 26.80$^{abc}$ | 1.44$^{b}$ |
| Dumbja | 126.07$^{a}$ | 6.60$^{b}$ | 24.40$^{a}$ | 142.87$^{a}$ | 25.73$^{a}$ | 26.13$^{bc}$ | 1.64$^{ab}$ |
| Khangma Maap | 97$^{d}$ | 10.73$^{a}$ | 19.47$^{b}$ | 69.33$^{bc}$ | 2.53$^{b}$ | 34.80$^{a}$ | 1.77$^{a}$ |
| CV% | 2.59 | 15.37 | 3.52 | 18.02 | 47.63 | 10.15 | 6.08 |
| SE | 2.17 | 1.18 | 0.58 | 14.12 | 4.19 | 2.34 | 0.08 |
| P value | 0.001 | 0.001 | 0.001 | 0.0007 | 0.001 | 0.002 | 0.013 |

### *Efficacy of Nano-fertilizer on Rice Growth and Yield*

Multi-location trials were conducted to evaluate yield response of rice growth and yield to Nano-Urea in 2022, covering major rice growing regions in the country by Agriculture Research and Development Centres (ARDCs). The preliminary research indicates that the application of nano-urea have 14% higher yield than the control plots in the on station trials, but didn't show significant yield difference. The trial will be extended for another season.

## 6.1.2 Maize

### *Fast Track Evaluation of Hybrid Baby Corn (R-62)*

Baby corn cultivation provides an opportunity for crop diversification, value addition, and revenue generation and is becoming increasingly significant in improving the livelihood of farmers. So far, there is no record of baby corn accession in the country.

**Figure 2. Hybrid Baby corn R-62 harvested at 57 DAS (a) Cobs with husk and (b) dehusked cob**

Evaluation was carried out on an agronomic performance and adaptability evaluation of hybrid baby corn R-62 in varying agro ecological zones (Samtenling, Lingmethang, and Tsirang).

The results show that the ideal time for harvesting was between 55-65 days after sowing. The average yield of baby corn was 3.9 MT/ac. An economic analysis for baby corn production for one acre was carried out and revealed a net profit of Nu. 23,120 and a cost benefit ratio of 1.49.

This indicates that baby corn cultivation has the potential to be a profitable business, leading to improved livelihoods for farmers through increased income generation. The variety was released and endorsed by 25th Variety Release Committee (VRC) and the 9th National Seed Board (NSB).

### *Evaluation of Heat Tolerant Maize (Second phase)*

A total of eight sets of Climate Resilient hybrid lines from CIMMYT were evaluated with two sets at ARDC, Samtenling, and six sets at Waichur in Mongar and Muktangkhar in Trashigang. Data on physiological characteristics were collected from sowing to harvesting. The trials aimed to identify the best climate resilient lines, raise awareness among farmers and extension services about hybrid maize production, showcase the performance and benefits of hybrid maize varieties, and gather farmers' feedback for future adoption of the technology. Some of the preferred hybrids by farmers from the field day.


**Figure 3. The hybrids preferred by farmers during the field day**

### *Evaluation of Efficacy of Nano urea on Growth and Yield of Maize*

The evaluation of Nano-urea effectiveness on the growth and yield of maize was carried out in ARDSC Samtenling in collaboration with National Soil Service Centre. The study aimed to investigate the impact of innovative nano nitrogen fertilizer on maize growth and yield, with a secondary goal of reducing imbalanced urea fertilizer usage. Five treatments were evaluated on maize variety Bhur ashom 1 and the treatments include: (T1) Control 0_0 (T2) Chemical fertilizer 100_0, (T3) Chemical fertilizer+ Nano urea (50% CF+N) 100_0, (T4) Chemical Fertilizer + Nano Urea (25% CF + 75% N) 25_75 and T (5) Nano urea 0_100. The findings from the study show that the T2 (100% CF) achieved the highest yield (645.3 kg/acre), followed by T4 (25% CF + 75% N). Treatments 1 and 5 (Control and 100% NU) had the lowest yields. Treatment 4 (25% CF + 75% N) exhibited the tallest plant and ear height, followed by treatment 3 (50% CF + N) and treatment 5 (100% N).

However, the yield differences between the treatments were not statistically significant ($p$ =0.252). Generally, the potential yield of maize variety Bhur Ashom 1 is 1-1.3 t/ac. On the contrary, the study recorded a much lower maize yield even with the recommended rate of chemical fertilizers. The low yield could be explained by low soil pH and poor soil nutrient content. Therefore, improving soil pH to an optimal level of 6.5 can enhance soil health and promote better absorption of phosphorus, calcium, and manganese, which are typically limited in acidic soils with pH levels below 5.0.

### *Crossing of improved Maize with local landrace*

The development of inbred parents for future crossbreeding was started this year at ARDC Samtenling. The two varieties used were (Tsiksumpa and Yangtsepa) to ensure controlled pollination, manual self-pollination of each parent was carried out at flowering stage. Pollen was collected from the tassel and carefully applied to newly emerged silks in the morning. Silk bags were utilized to prevent unintended cross-pollination. During harvesting and de-husking, a meticulous seed selection process was conducted, discarding diseased, deformed, and small seeds. For future replication, 1.5 kg of high-quality seeds were collected for Tsiksumpa, and 2 kg for Yangtsepa.

### *Evolutionary Breeding/Bulking of improved, local and OPV for selection of elite lines*

Evolutionary plant breeding (EPB) is an approach that utilizes natural selection to enhance crop diversity and stability in a specific environment. A total of 17 maize varieties, including local and hybrid such as Bhur Ashom-1, Yangtsepa, Baipo Ashom (Orong), Tsiksumpa, Goshing local (yellow), Goshing local (white), Baby corn, Wengkhar HM-1, Wengkhar HM-1 parental line (Male), Wengkhar HM-1 parental line (Female), Dekhalb 9144, Dekhalb 9149, PPS4525, PPS4111, P3377, P3502, Z829-344, Kanglung local, and Wengkhar local was carried out at ARDC Samtenling. The main objective of the program is to create a new variety through the mass selection method. This breeding activity is in its second year and will continue for several years until a promising variety is obtained.

### *Maintenance of Basic Seeds*

Out-crossing in maize is a hindrance in preserving true-to-type seeds for longer duration in farmers' fields. Basic seed production and maintenance is one of the most important activities carried out at ARDCs to help provide growers and agencies with viable and true-to-type planting materials.

**Table 5. Basic seed production of maize in three ARDCs**

| SN | Location | Variety | Qty (kg) |
|---|---|---|---|
| 1 | ARDC Wengkhar | Yangtsepa | 76 |
| | | Bhur ashom-1 | 26 |
| | | Wengkhar hybrid-1 | 105 |
| 2 | ARDC Samtenling | Bhur ashom-1 | 70 |
| 3 | ARDSC Tsirang | Yangtsepa | 224 |
| | | Chaskarpa | 98 |
| | | Ganesh-2 | 212 |
| | | Sweet corn | 27 |
| | | **Total** | **838** |

### 6.1.3 Quinoa

***One Country One Priority Product (OCOP) Initiative***

Bhutan has identified quinoa as the priority commodity under the FAOs' initiative of One Country One Priority Product (OCOP) program. Through OCOP, the quinoa commodity will receive technical and financial support to upscale the cultivation and utilization of quinoa. The OCOP program will be helpful in increasing productivity and ensuring the market for quinoa

***Enhancing Genetic Base through Multi-Environmental Trials (MET)***

Following the establishment of formal linkage between the Department of Agriculture and the International Center for Biosaline Agriculture (ICBA) in Dubai, the department received 180 new entries of quinoa germplasm. Following the evaluation of these lines, 39 lines have been selected for further evaluation. Through the MET trial program with ICBA, new coloured varieties of quinoa will be selected and released in the coming years.

### 6.1.4 Other cereals

***Introduction and Selection of Harvest plus Yield Trial (HPYT) CIMMYT Wheat Lines***

The International Wheat and Maize Improvement Center (CIMMYT) in Mexico provided 98 different wheat lines as part of the CIMMYT germplasm evaluation program. These were aimed at evaluating and selecting germplasm sets for varietal development under our own ecological conditions. From the entire population of these bread wheat lines, 38 lines were selected based on plot uniformity, lodging incidence, agronomic score, and spike observation. These lines are undergoing further observation trials.

***Evaluation of spring wheat line NL-1073***

NL-1073 is an advanced wheat line from CIMMYT, Mexico. It was introduced from Nepal to ARDC, Bajo in 2014. Performance evaluation was carried out for NL-1073 under rice-based system. The line was compared with the existing wheat varieties in ARDC, Bajo field. The results of the trial are presented in the Table 6.

**Table 6. Agronomic traits of NL-1073 wheat line with the released varieties**

| Variety | Plant Height (cm) | Maturity Range (Days) | Maturity Group | Panicle Length (cm) | Presence of awn | 1000 grain weight (gm) | Yield (MT/ac) |
|---|---|---|---|---|---|---|---|
| NL-1073 | 80-85 | 130-135 | Early | 8.5 | Yes | 35-40 | 1.46 |
| Bumthangkaadrukchu | 90-95 | 150-160 | Medium | 11 | Yes | 40-45 | 1.38 |
| Bajosokha kaa | 90 | 155-160 | Medium | 10 | Yes | 40-45 | 1.46 |
| Gumasokha kaa | 90-95 | 150-160 | Medium | 10 | Yes | 40-45 | 1.34 |

Due to its high grain yield potential and good agronomic traits: early maturity, it was released and endorsed as Bajo Kaa 3 by the 25$^{th}$ VRC and 9$^{th}$ NSB.

***Production Evaluation Trials (PET) of Wheat lines***

Six bio-fortified wheat lines were evaluated at ARDC Bajo and ARDSC, Tsirang under rice-based and maize-based systems respectively. At maturity, data on different agronomic traits were gathered and grain yield was estimated from a 6 $m^2$ crop cut area. Amongst the tested bio fortified wheat lines at ARDC, Bajo, BF412 yielded the highest with 2.1 MT/ac followed by BF450 with 2.02 MT/ac. In ARDSC, Menchunna, BF447 yielded the highest 0.73 MT/ac followed by BF415 with 0.69 MT/ac. These lines will be further evaluated in farmer's field.

Similarly, PET of five wheat lines from SAARC blast nursery were conducted at ARDC Samtenling to find out which lines are promising and resistant to blast disease under sub-tropical conditions. Agronomic characteristics and yield data were recorded. Out of five, three lines were selected and will be evaluated in the next season.

***Implementation of Neglected and Underutilised Species (NUS) Project: Millet***

National Centre for Organic Agriculture (NCOA) along with National Biodiversity Centre (NBC) has been closely working with the farmers of Zamsa and Phasuma village under Chukha Dzongkhag in conserving the millets. Farmers of these two villages cultivate two varieties of millets (finger and foxtail). Apart from the conservation work, NCOA has also selected three farmers and established an observation trial on foxtail millet intercropped with quinoa with the objective to enhance nutrition security. NCOA has also supported the farmers with vermicompost to continue conserve and promote neglected and underutilised crop species.

### 6.1.5 Legumes

***Initial Evaluation of Lentil (Lens culinaris ssp. Culinaris)***

Initial evaluation trial of four lentil lines, received from Uttar Banga Krishi Vishwavidyalaya (UBKV) West Bengal, were evaluated at station and the finding shows that all the treatment perform better compared to standard check (WBL 58) and will continue to evaluate in coming season.

***Chickpea, Soybean and Adzuki bean Performance Evaluation***

Preliminary results from evaluation of two new lines of chickpea - JG 14 (ICCV 92944) and NBeG 3 - introduced from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) India show that both lines are resistant to fusarium wilt and adaptable to tropical zones. The line JG14 yielded the highest at 2263.87 kg/ac followed by NBeG at 2,258.30 kg/ac. The evaluation will now move on to farmers' fields beginning next season. More research with new lines and improved management practices to be adopted to increase the productivity of chickpea in our condition. Similarly, evaluation of six soybean varieties (Khangma Libi 1, Local Libi, Khangma Libi 2, Enrei, Japanese white and Tashigang Local) was conducted. Among the entries, Enrei and Japanese white have highest yield of 850 kg/ac, followed by 825 kg of Japanese white. The seed production will be continued at NCOA Yusipang in the coming season.

Evaluation trial on adzuki bean (*Vigna angularis)* was carried out at ARDSC, Panbang, Zhemgang in 2022 and showed that the potentiality of adzuki beans to grow in the subtropical region like Zhemgang mainly due to its adaptability and high yielding.

## 6.2 Horticultural Crops

### 6.2.1 Vegetables

***Release of high-yielding varieties***

The Department released twelve new vegetable varieties that are high yielding and critical to meet vegetable self-sufficiency through the 25th VRC and the 9th NSB. The released and notified vegetable varieties include as follows:

- **Three cauliflower varieties**: "*Valentena"* and "*Carotena"* cauliflower varieties have market potential in Singapore and the "*Monsoon Queen*" variety is suitable for subtropical zones,
- **One broccoli variety:** "*Green Magic*" which has a compact head and greenish color has been released.
- **One pakchoi variety:** "*Tasty Green*" released for commercial production.
- **Five tomato varieties:** Yusi Lambenda 1, Yusi Lambenda 2, Yusi Lambenda 3, Samtenling Lambenda 1 & Samtenling Lambenda 2, which are suitable for growing at altitude ranges from 200 to 2700 masl.
- **Two chilli varieties:** Samtenling Ema 1 & Samtenling Ema 2 are suitable for growing at altitude ranges from 200 to 1800 masl.

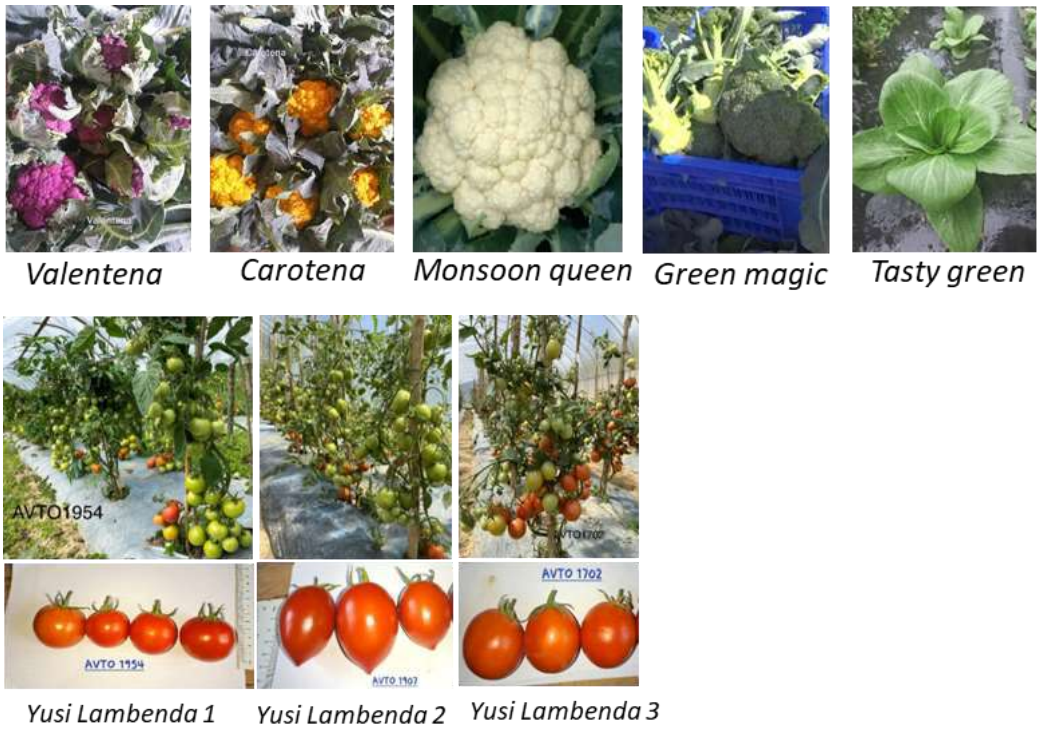


**Figure 4. Vegetable varieties released through 25th VRC and 9th NSB**

***Evaluation of improved open-pollinated tomato varieties***

More than 45 tomato open-pollinated lines were provided by the World Vegetable Centre (WVC) - AFACI, South Korea with the objective to improve the income of Bhutanese farming communities and make the best varieties available to Bhutanese communities. The study revealed that tomato varieties introduced by the WVC, Taiwan are superior in terms of marketable yield, fruit quality, and disease resistance compared to the standard check (Roma). Three of the lines, ***AVTO1954, AVTO1702, and AVTO1907*** were released for promotion and commercial production.

***Evaluation of World Vegetable Chilli Lines***

NCT of WVC chilli was conducted at NCOA, Yusipang, ARDC Bajo, ARDC Samtenling and ARDC Wengkhar at an altitude range of 100-2,600 masl during normal chilli growing season in the open field. The preliminary result of the 20 AVPP lines indicated the highest in AVPP 1510 kg/acre with a yield of 7,157 kg/acre followed by AVPP 1107 with 5,477 kg/acre and AVPP 1324 and AVPP 1108 with 5,137 kg/acre and 5,014 kg/acre respectively.

***Breeding of chili for development of Phytophthora wilt-resistant cultivar***

The chilli varieties resistant to *Phytophthora* blight with fruit quality acceptable to the consumers are currently not available in the country. In this study, two moderately resistant cultivars (AVPP 1337 and Mongar Local) were used as parents to develop a *Phytophthora* wilt-resistant variety of chilli with high pungency by applying the backcrossing method of breeding. In the initial crossing, F1 plants obtained had fruit characteristics intermediate to both parents. This F1 progeny will be backcrossed with the recurrent parent (Mongar Local) in the coming season to increase the pungency in AVPP 1337.

***Additional vegetable research activities:***

In addition to the above four research activities, the following research activities were conducted:

- Evaluation of off-season production of onion.
- Fast-track evaluation of hybrid cabbage and cauliflower.
- Chilli grafting trial for cold tolerance.
- Comparison study of chili production in open and protected conditions.
- Hydroponics trial in Deep Water Culture Technique- Nutrient comparison trial.
- Study on staggered cultivation of cauliflower in Southern Bhutan.
- Evaluation of exotic chilli varieties for their tolerance to cold weather (winter production) in open fields in southern Bhutan.
- Cost-benefit analysis of tomato in open and protected cultivation
- Performance evaluation trial of sweet potato (Purple flesh)
- Broccoli varietal trial
- Watermelon varietal trial
- Tomato production in Sunken Garden (protected cultivation)

### 6.2.2 Potato

The Department through the National Potato Program has carried out the following potato research and promotional activities in the FY 2022-2023:

***Release of high-yielding varieties***

Upon endorsement by the Ministry**,** Potato clone no: CIP398180.292 was released as Yusi chip 1, the new potato chipping variety with 20-23% dry matter, extreme resistance to Late-blight and Potato virus-X, Heat and drought tolerant, yielding 12 MT/ac.

***Multi-location trials***

Climate-resilient clones (CIP398180.289, CIP398180.292, CIP398192.213, CIP398208.219) were evaluated with Desiree as the standard check. Four multi-location trials were conducted in Khangma, Bumthang and Yusipang. In Yusipang, both organic and conventional trials were undertaken. Analysis completed for four different heat and drought (climate resilient) potato clones and will proposed for the release next year.

Multi location trial on biofortified potato clones ongoing at Bumthang, Khangma and Yusipang. This is aim to contribute to addressing the nutrient deficiency in the country.

To augment spring potato production in the country, observation trial for mass potato cultivation at Samtse, Chukha and Sarpang was initiated. It is found to be successful and hence, first ever spring potato cultivation on a commercial scale in Sarpang Dzongkhag will take place in upcoming years.

### 6.2.3 Fruits and Nuts

***Germplasm maintenance and evaluation***

There are almost 50 varieties of fruits and nuts germplasm being maintained in the ARDCs which include varieties of pear, peach, plum, kiwi, persimmon, loquat, mango, avocado, sacha inchi, walnut, grapes and dragon fruits. Some of the high-value fruits such as soursop and Irwin mango are under evaluation at ARDC Samtenling and ARDSC Lingmethang. This germplasm serves as a repository for fruit species and a source of planting material for further propagation.

***Establishment and research on high-density mango trials under protected conditions***

Research on high-density mango plantations in the mega greenhouse has been initiated at ARDC Samteling and Wengkhar. A total of 22 high-value mango varieties namely, Irwin mango, Duncan, Chinwang, Dashehari, Langra, and Alphonso have been planted at a spacing of 2.5*2.5m and 4*4m in Samteling and Bhur, respectively. The main objective of this research is to evaluate the performance and economic viability of mango production using high-density planting under protected structures.

***Promote netting in orchards to protect against fruit flies***

ARDC Wengkhar with fund support from CARLEP_IFAD promoted insect-proof nets in 10 pear orchards in Lhuentse and Pemagatshel dzongkhag. The nets were provided to 10 pear growers, with 8 located at Minjey geog and 2 at Chongshing geog. The objective of this initiative was to assess the effectiveness of these nets in controlling fruit flies, which have emerged as a significant threat to pear production, causing a complete fruit drop and impacting farmers' income. The nets were installed when the fruits reached marble size. To evaluate the effectiveness of the nets in preventing fruit fly damage, a comparison will be made between the quality of fruits and the level of fruit fly infestation inside and outside the nets at the end of the pear season. This research aims to reduce fruit fly damage and subsequently increase farmers' income by enabling the sale of high-quality pear fruits.

**Figure 5. Demonstration of netting in pear orchard**

***Evaluate small-sized watermelon trial***

In recent years, watermelon production is gaining importance among growers. It is in high demand, particularly during the summer season. However, currently, only large-sized watermelon varieties are available in the market. This poses challenges for transportation and does not cater to the needs of small families. Therefore, there is a need to introduce smaller-sized watermelon varieties that are more convenient for transportation and suitable for smaller families.

The multi-location trial has been initiated in Lingmethang, Bajo, and Bhur using Randomized complete block design (RCBD) to evaluate the small-sized watermelon varieties. The trial included six treatment varieties namely, PPS 315, PPS 142, PPS 313, PPS 304, PPS 317, and sugar baby (control) and two replications. The study revealed significant differences in the weight, height, and diameter of the watermelons among the six tested varieties. Particularly, PPS 315 was found to produce small-sized fruits, which weighed an average of 2.4 kg. All varieties exhibited a dark green color, and the crops were harvested approximately 83 days after transplanting.

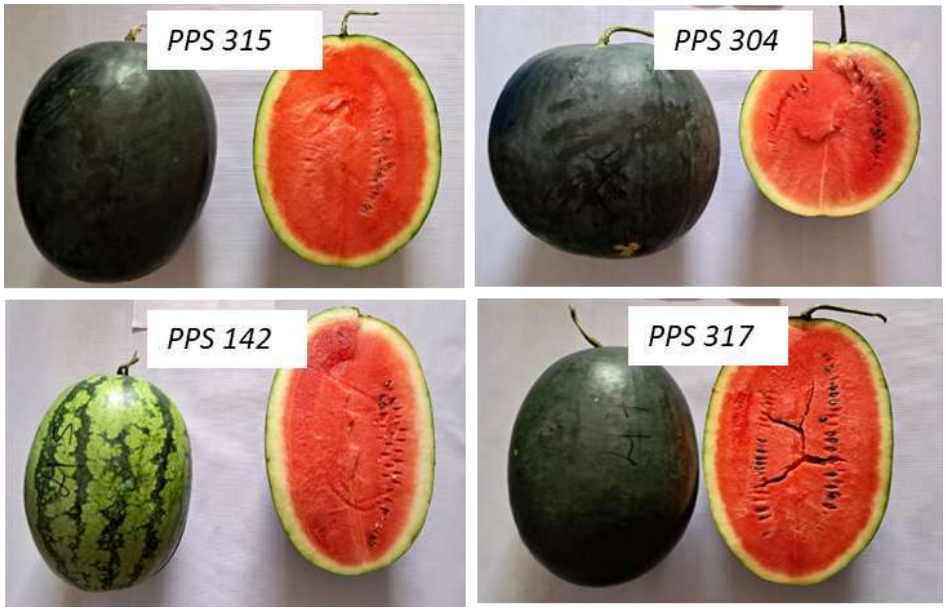


**Figure 6. New varieties of watermelon under evaluation**

### *Fabrication of hot callusing for grafting walnut and persimmon*

Unlike other fruit crops, walnuts are more difficult to propagate with less grafting success rate. To address this issue, ARDC-Wengkhar, with support from LDCF-GEF, conducted research trials on developing a functional hot callusing structure with easily accessible materials with an aim to develop a practical hot callusing device and to assess its success rate in walnut propagation through grafting. Hot callus grafting is a grafting technique that involves subjecting grafted trees to controlled, elevated temperature and humidity.

The hot-callusing method focuses heat specifically on the graft union area (at 27°C) to accelerate callusing between the stock and scion. This promotes rapid callus formation while leaving other parts of the plant, such as buds and roots, unaffected by the heat. The study reported that out of 140 grafted walnut seedlings in the hot callusing devices for a duration of four weeks, there was a graft success rate of approximately 75% as compared to the normal grafting method which has about 30-40% success rate. This research demonstrates the potential of hot callusing as a viable method for walnut propagation in Bhutan.

By developing a cost-effective and locally accessible hot callusing device, farmers can enhance their walnut production and contribute to the expansion of walnut orchards in the country.

**Figure 7. Fabricated hot callusing technology for walnut propagation**

### *Evaluation trial on passion fruit*

Passion fruit, scientifically known as *Passiflora edulis*, is a plant that belongs to the Passifloraceae family. Generally, there are three types of passion fruit: yellow, purple, and hybrid varieties. Yellow types thrive best in lower elevations but are sensitive to low temperatures. They produce larger fruits compared to the purple types. On the other hand, purple types grow well in higher elevations and their fruits turn purple when ripe. However, these fruits are generally smaller than the yellow ones.

In Bhutan, we have limited varieties of passion fruit though demand for it is increasing with the establishment of agro-industry in Lingmethang. The only existing variety released so far is the local one, which unfortunately falls short in terms of fruit size and quality. To address this, a new passion fruit variety called Summer Queen has been introduced from Japan. The Summer Queen variety offers larger fruit size, improved taste, vibrant color, and delightful fragrance.

**Figure 8. Establishment of evaluation trial at ARDC Wengkhar**

A multi-location trial has been established in Wengkhar, Bajo, and Bhur to assess the performance of the summer Queen watermelon variety. The aim is to release this variety for commercial cultivation, particularly for juice processing purposes. The seedlings were planted using a Complete Randomized Design (CRD) with 5 replications (Figure 5.1). The plants are

expected to produce fruit in the coming year. The evaluation of the fruits will involve considering various parameters, including weight, height, diameter, pulp weight, and juice content.

***Evaluation of organic strawberries under different organic mulch***

A study on the effect of different types of mulch (transparent plastic mulch, black plastic mulch, straw mulch, pine needle mulch) on yield and quality of organically managed strawberries (Sweet Charlie variety) was conducted at NCOA, Yusipang. The result showed that there is no significant differences among the treatments on the fruit quality.

### 6.2.4 Citrus

***Efficacy of cow urine on growth and development of Poncirus trifoliate***

A study on the impact of using fermented cow urine at varying on the growth of *Poncirus trifoliate*, a commonly utilized rootstock for citrus mass production was initiated. The objective was to achieve the desired size and height for successful grafting in a shorter time frame. There is no major significant difference in all the parameters, however the plant treated with 30% cow urine shows maximum plant height as shown in Figure 9.

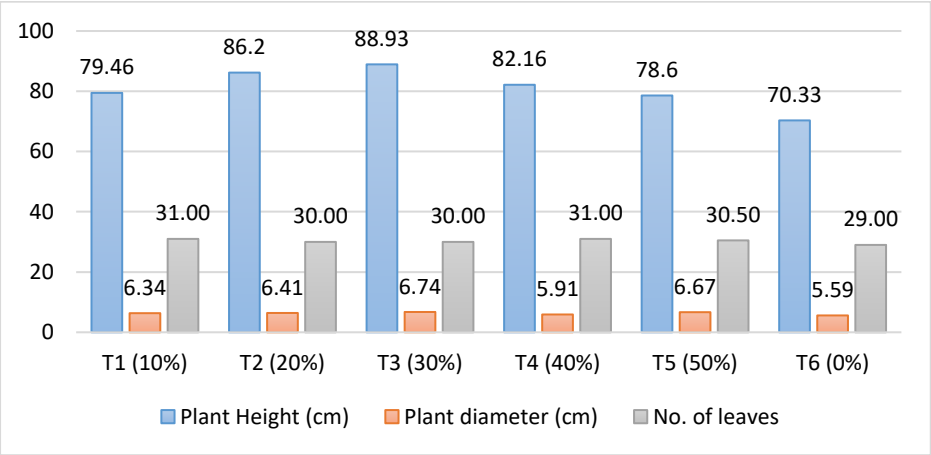


**Figure 9. Growth of citrus rootstock with use of cow urine**

***On-farm Evaluation of Citrus Varieties***

The department is continuing with a series of on-farm trial and demonstration programs in citrus in various locations. They include:

- A demonstration cum citrus management trial consisting of the varieties such as Hamlin, Afourer, Okitsu wase, Fortunella, and Fingered citron at Nebesa, Rangthangling geog, Tsirang located at an altitude of 1666 masl.
- An acre of demonstration cum citrus management trial at Punakha, Khamsum Yully Chorten consisting of the varieties Clementine, Taraku, Otsu, Otha ponkan, Teishu ponkan and Bearss lime.

- A new citrus variety evaluation trial consisting of three varieties, Hayaka, Mc.Mohan and Okitsu Wase at Baychu Royal Orchard for identification, multiplication and further replication of best performing lines.
- A citrus processing variety trial on both on-station and on-farm for 16 varieties imported from Australia at ARDC-Wengkhar. The preliminary research shows that the varieties such as Cara Cara, Ryan, Salustiana, and Torocco Ippolite are found to be potential processing varieties.

***Citrus Phenology study***

As recommended by the ARCM, ARDC- Bajo prepared and circulated procedures for data collection using citrus phenology monitoring template. The procedures cover required sample plots per dzongkhags according to their altitude ranges (from <800 masl up to 1,600 masl). All ARDCs are in the process of data collection, following which analysis will be carried out to update the current citrus phenology cycle.

### 6.2.5 Mushroom

A series of research on mushroom is being conducted at the National Mushroom Centre (NMC) in an effort to enhance mushroom production and diversify available options for growers. A gist of the studies currently ongoing and those in completion are as follows:

***Cultivation & Domestication of Hericium and other mushrooms***

*Hericium erinaceus*, commonly referred to as lion's mane, is a wild medicinal mushroom species, also available in the forests of Bhutan. With success in domestication, production trial on sawdust medium was conducted for wild/local strain and exotic (Thai) strain, which was imported in 2022. The result shows that average yield of the local strain and exotic strain was 2.13 kg and 1.65 kg per bag respectively.

Similarly, performance evaluation of Lion's Mane was also conducted on *Quercus griffithii* wood logs with technical assistance provided by the Senior JICA Volunteer, Mr. Atsushi Kumata. The performance trial of wild *Flammulina populicola* and *Flammulina velutipes* (exotic) imported from Thailand was also conducted at the centre. The production could not be compared since the exotic strain did not fruit well (Figure 10).


**Figure 10. Exotic/Thai strain *Flammulina velutipes* (A & B) & wild/local strain *Flammulina populicola* (C & D) fruit body**

The performance trial was conducted on two strains of *Pholiota microspora* (N217 and N405) introduced from Japan and seven wild indigenous strains *Pholiota microspora* collected from different places in the country. The trial is ongoing and the result is yet to be compiled.

***Organic control of fungus gnat on Oyster mushroom cultivation***

A trial was conducted to explore organic control measures for managing fungus gnat infestation in Oyster mushroom cultivation. Fungus gnats pose a significant threat to mushroom crops, leading to production losses in terms of both quality and quantity. The trial involved four treatments: T1 (Neem oil 5%), T2 (Onion bulb extract 4%), T3 (Garlic bulb extract 4%), and T4 (Untreated control). The trial is still ongoing, but initial observations indicate that the emergence of fungus gnats is relatively lower in treatments T1, T2, and T3 compared to the control treatment (T4). The average yield of the first harvest was highest in T1 and T3 with 498g, and 465g respectively. Some fruiting bags in all treatments showed green mold infection. Further data on yield will be collected for an additional flush/harvest.

***Shiitake Mushroom***

A study was conducted to evaluate the morphological characterization and yield performance of six hybridized strains of shiitake mushrooms. During the experiment, the billets were induced for fruiting. However, no fruiting occurred during the first soaking, and only 14 billets fruited during the second soaking. The study is currently ongoing, and further observations and data collection are in progress.

***Evaluation of Pine Sawdust as Substrate for Mushroom cultivation***

The study aimed to explore various pretreatment methods for pine sawdust to utilize it as a viable substrate for cultivating oyster and shiitake mushrooms, considering the significant amount of sawmill waste generated. However, in a previous trial conducted last year, the fruiting results were unsatisfactory due to infestation by mushroom flies. To further investigate the findings of the initial experiment, a cultivation trial was initiated using solely fermented sawdust. The sawdust underwent fermentation for one year before being used. The results showed that the average yield per 850 ml bottle was 66.25g, with the highest yield recorded at 125g and the lowest yield at 17g. The average biological efficiency was 17.9%, with the highest and lowest biological efficiencies being 25% and 45% respectively.

Considering the low yield of 66.25g from 1kg of substrate and a biological efficiency of 17%, it can be concluded that pine sawdust is not suitable as a substrate for mushroom cultivation.

***Mushroom Specimen and Herbarium***

NMC has collected and preserved 99 specimens at the herbarium. Truffle specimen was found and recorded for the first time in Bhutan. The specimen was identified as *Tuber* cf. *borchii* and found in Oak forest. A total of 107 specimens were identified and data is uploaded in the biodiversity portal.


**Figure 11. Truffle specimens found in Oak forests**

### 6.2.6 Plantation Crops

***Physio-morphological Study of different Cocoa accessions***

The research evaluation on Cocoa crop (*Theobroma cacao* L.), a tropical crop, was initiated by ARDC-Samtenling. This study examined the vegetative and reproductive morphological traits and their adaptation in sub-tropical region of Bhutan. Currently, three varieties have been identified from the germplasm such as Forastero, Criollo and Trinitario based on their inherited traits. The study on cocoa morphological characterization have been performed on both vegetative and reproductive characters (leaves, flowers, fruits and seeds) in line with international descriptors (IPGRI, 1995).

**Trinitario** **Forastero** **Criollo**

**Figure 12. Morphological characteristics of three different cocoa accessions**

***Performance of three exotic Areca nut accessions***

The on-station research on Areca nut (*Areca catechu*) was carried out in Samtenling, Sarpang, to evaluate the performance of three exotic cultivars of areca nut. The study revealed that the vegetative growth parameters varied significantly among the accessions. Further evaluation on inflorescence and fruits is yet to be determined once the crop attains full maturity stage. The research is ongoing and expected to complete in a few years.

**Figure 13. On-station experimental trial at ARDC, Samtenling**

### *Morphological characterization of two different accessions of betel leaf*

Similarly, ARDC-Samtenling carried out a research to evaluate the adaptability and performance of on-station and on-farm betel leaf accessions under subtropical AEZ. Betel leaf production holds great economic significance in the country, as it generates income for farmers and reduces the dependency on import. Two cultivar of betel leaf (Bangla and Kali Bangla) were released as Samtenling Pani 1 and Samtenling Pani 2 respectively yielding 1.9 – 2.3 MT/ac. The economic return of these varieties ranges from Nu. 0.35 – 0.4 million per acre in a year.

**Figure 14. Betel leaf plants data collection in on-station and on-farm trials under closed system**

### *Characterization and performance evaluation of Sacha inchi*

Sacha inchi (*Plukenetia volubilis* L.) is a native plant of Amazon basin in South America. Sacha inchi, roughly translated as false peanut, is a perennial vine. The study was intended to assess the morphological characteristics and phenology, yield and oil recovery of Sacha inchi in Bhutanese conditions. Quantitative and qualitative morphological data together with leaf samples were assessed from four plants selected randomly as per the plant descriptors (IPGRI,

1995). The oil recovery from sacha inchi kernel was 47.80 percent which is higher than mustard seed oil which is about 35 percent. The study will be completed by April, 2024.

**Figure 15. Sachi inchi plant, fruit, kernel, oil extract**

### 6.2.7 Spices

***Evaluation of three accessions of local turmeric***

Evaluation of three accessions of local turmeric was initiated to identify and notify potential varieties that are best suited to different agroecological zones after instruction and resolution of 3rd ARCM. Due to the economic and commercial importance of the crop in the 13th FYP, there was an urgent need to formally notify the cultivars for the export market (both raw and processed form) and to streamline the seed supply system. Thus, evaluation was carried out in both on-station and on-farm fields of ARDC Samtenling, ARDSC Panbang (Zhemgang), Tsholingkhar (Tsirang) and Dungna geog, Chhukha Dzongkhag. Three accessions of turmeric with high potential for commercial production and economic importance were evaluated and released through 25th VRC and 9th NSB.


**Figure 16. Three turmeric varieties released during 25th VRC and 9th NSB**

***Evaluation of ten accessions of local ginger***

Evaluations of ten ginger accessions were initiated following the resolution of 3rd ARCM. Initially, 24 indigenous ginger accessions were collected from ginger-growing areas of Bhutan. After the initial evaluation trial, 10 accessions of ginger were selected for multi-location trials at Tsirang, Chukha and ARDSC Panbang for performance evaluation. After the assessment, two accessions of ginger with high productivity, high market potential, and processing requirements were proposed and released through 25th VRC and 9th NSB.

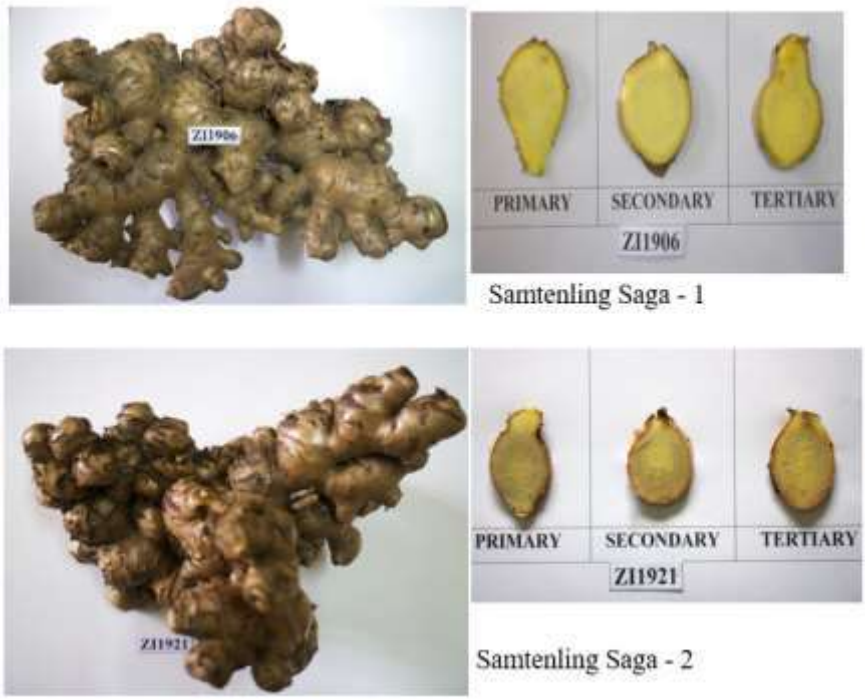


**Figure 17. Two ginger varieties released during 25th VRC and 9th NSB**

### *Evaluation and morphological characterization of two cultivars of black pepper accessions*

Morphological characterization and evaluation of two accessions of local black pepper were conducted at on-station research field (ARDC Samtenling) and on-farm field at Chaskar village, Sershong geog, under Sarpang Dzongkhag. The morphological characterization and evaluation was done using the Guidelines of International Plant Genetic Resources (IPGR), 1995. The proposed cultivar was found to be tolerant to adverse climatic conditions of the warm and wet agro-ecological, suitable for regular production and processing, good adaptation and has good market potential both within and outside the country due to its spicy flavour. Thus, it was proposed and released as ***Samtenling Na-le-Sham 1.***

**Figure 18. Released variety of black pepper**

***Performance evaluation and morphological characterization of small cardamom***

The Department imported seven varieties of small cardamom from India and initiated evaluation in all AEZ. The multi-location on-station trials were established at ARDC Samtenling, ARDSC Tsirang, ARDSC Lingmethang and on-farm trials were established at Kabji, Meritsemo, Bongo geog, Chhukha, Jangchubling, Chhudzom geog, Sarpang, and Gomphu, Trong geog, Zhemgang. The trials were implemented from May 2023 and it will be completed in December 2027.

# 7 Development Highlights

## 7.1 Field Crops

### 7.1.1 Rice

***Drought Tolerant Upland Paddy Intensification***

In continuation of the initiatives from the previous years in improving farming households' resilience against climate change impacts, the department directly supported the cultivation of 176 acres of upland paddy. This is an important intervention aimed at providing opportunities for households beyond 1800 masl to diversify maize cropping system with rice and help enhance rice productivity and ensure rural self-sufficiency. An estimated production of 3520 kg upland paddy was distributed covering 176 acres in Lhuentse and Bumthang Dzongkhags.

### 7.1.2 Maize

***Improved Maize Intensification***

Three released open pollinated maize varieties, Chaskarpa, Shaphangma ashom, and Yangtsepa, were used to intensify maize production. A total of 99.9 MT improved maize seeds was procured from the National Seed Centre and distributed in 12 maize growing districts covering 6658 acres. The program involved use of 5.6 MT of Chaskarpa maize, 0.6 MT Shaphangma ashom and 93.6 MT of Yangtsepa.

**Table 7. Improved maize intensification**

| Variety | Dzongkhag | Qty (MT) | Area (acre) |
|---|---|---|---|
| Chaskarpa | Mongar | 0.0 | 0.7 |
| | Pemagatsel | 2.1 | 141.3 |
| | Samtse | 3.5 | 233.3 |
| Shaphangma ashom | Pemagatsel | 0.1 | 9.3 |
| | Samtse | 0.5 | 33.2 |
| Yangtsepa | Dagana | 1.5 | 101.3 |
| | Mongar | 18.0 | 1199.3 |
| | Sarpang | 18.4 | 1228.0 |
| | Tsirang | 10.0 | 666.7 |
| | Chukha | 4.2 | 280.0 |
| | Samtse | 22.6 | 1506.7 |
| | Pemagatsel | 9.7 | 643.3 |
| | Wangdue | 1.2 | 80.3 |
| | Paro | 0.9 | 61.9 |
| | Thimphu | 0.0 | 0.2 |
| | Tashigang | 7.0 | 466.7 |
| | Tashiyangtse | 0.1 | 6.0 |
| | Total | **99.9** | **6658.3** |

### *Hybrid maize intensification*

An intensification of Wengkhar hybrid maize-1(WHM 1) was for the first time carried out in Tsakaling and Waichur under Mongar districts covering six acres. During the harvest, ARDSC Khangma conducted yield monitoring and found that the newly released hybrid yielded 2.3t ha-$^{1}$. A total of 13 MT was harvested from six acres. The hybrid outperformed other released maize varieties such as Yangtsepa, Shafangma, and Chaskharpa. Farmers in these areas expressed their admiration for the performance of WHM 1, which exhibited desirable traits like shorter and uniform plant height and fully covered kernels.

**Figure 19. Crop cut during the harvest and harvested cobs of WHM-1**

## 7.1.3 Wheat

### *Wheat and minor cereals breeder seed maintenance*

In order to augment the National Seed Centre's production of wheat and minor cereals seeds, the department also produced seeds of various promising wheat and minor cereals seeds for multiplication and on-farm testing as well as seeds of released wheat and minor cereals varieties for maintenance lines.

**Table 8. Wheat & minor cereals seeds produced**

| Variety/line | Quantity (kg) |
|---|---|
| Bajosoka kaa | 290 |
| Gumasoka kaa | 1220 |
| Bumthangkaadrukchu | 2540 |
| NL-1073 (Bajokaa-3) | 260 |
| NBC Millet 830 | 5 |
| Samtenling Memja | 44 |
| Buckwheat | 92 |
| Total | 4451 |

### *Implementation of Neglected and Underutilised Species (NUS) Project: Millet*

National Centre for Organic Agriculture (NCOA) along with National Biodiversity Centre (NBC) has been working with the farmers of Zamsa and Phasuma village under Chukha Dzongkhag in conserving the millets. Farmers of these two villages cultivate two varieties of millets (finger and foxtail). Apart from the conservation work, NCOA has also selected three

farmers and established observation trial on foxtail millet intercropped with quinoa with the objective to enhance nutrition security. NCOA has also supported the farmers with vermicompost to continue conserve and promote neglected and underutilised crop species.

### 7.1.4 Quinoa

***Quinoa Intensification***

Quinoa production took a dip in the reporting year due to major constraints like absence of proper value chain and marketing system which largely discourage farmers from venturing into its cultivation. Nevertheless, regional ARDCs have put in efforts to sustain production in their respective regions through intensification programs. In 2022-2023, 30 MT quinoa was produced from two geogs; Barthasm and Shongphu in Tashigang where it involved more than 150 households.

**Figure 20. Quinoa in farmer's field**

### 7.1.5 Legumes

***Adzuki bean promotion and intensification***

A total of 468 kg of Adzuki seeds were distributed in three Eastern Dzongkhags (Mongar, Trashigang and Lhuentse) covering nine geogs (Tsakaling, Yagneer, Dremetse, Chaskhar, Udzorong, Chali, Jarey, Medtsho & Narang). Over 220 households cultivated these seeds on more than 70 acres of land. To ensure a reliable market for the farmers, a buyback system for Adzuki beans has been initiated, with support from the CARLEP project.

Similarly, NCOA-Yusipang supplied 594.5 kg of adzuki bean seeds to Chhukha, Dagana, Paro, Punakha, Tsirang, and Zhemgang. With these seeds, farmers produced 5283 kg of adzuki beans, which were bought back from the farmers and stored at NCOA.

***Promotion and Intensification of Rajma Beans***

A total of 2140 kg of rajma seeds were procured through CARLEP project, ahead of the cropping season, which were subsequently distributed to farmers in the eastern region. With the supplied seeds, farmers were able to produce seven MT of rajma, resulting in significant cash income for the farmers.

## 7.2 Horticultural Crops

### 7.2.1 Vegetables

The vegetable program has taken up several developmental activities including training and demonstrations to contribute to the national self-sufficiency of vegetables.

- Promoted newly released chilli variety: Sitara Gold and HPH 1069 through demonstrations and training, supply of chilli seedlings, seeds, and technical advice in Samphelling (Purbaling and Sonamthang) Phuentshogling (Dophulakha) covering 5 acres.
- Promoted tomato cultivation in protected cultivation by providing 20mx5m greenhouses (Yusipang-2, Dagala-1, Ramthangkha-1, Ramtokto-1), 22mx44m Mega greenhouses (Pangbang, Zhemgang) and plastics for rain shelters (Yusipang and Hongtsho).
- Demonstration of World vegetable Centre's tomatoes in Model Organic Villages (MOV). Yusipang. Hongtsho, Khachadrapchu (Thimphu), Dophulakha (Chhukha) Chuzom (Sarpang), Ramthangkha (Paro) covering 0.5 acres.
- Provided support to 37 farmers and organic group in Bongo, Geling and Phuntsholing of Chhukha Dzongkhag Khateod of Gasa, Jadingkha and Genekha of Thimphu, Patshaling of Tsirang and Lull and Nahi of Wangdue on Organic broccoli and cauliflower production targeted for Singapore market.
- Provided both technical and input support in winter vegetable production covering 3 acres in Mongar Dzongkhag.
- Developed of modified agriculture model and trellising belonging to 9 households.
- High yielding and nutria dense vegetable seed production, promotion, and technical support to farmers in West Central Region.
- 37 desuups trained on Horticulture (Highland Vegetable Production) for 3 months through 7 Dessung Skilling Program (DSP).

### 7.2.2 Fruits and Nuts

***Fruit Intensification***

Fruit intensification in the Eastern region, funded by the CARLEP and Bhutan Ecological Society (BES) is primarily carried out via the establishment of focus villages and contract farms. Fruit intensification in the financial year 2022-23 had a total of 542 beneficiaries for 26,112 seedlings. The implementation site includes nine temperate fruit villages, one subtropical village and 25 contract farms under CARLEP support while there was a total of six temperate fruit villages, nine subtropical villages and 25 demo-orchards under BES support covering total of 88 acres of land.

**Figure 21. Fruit seedlings distribution to the beneficiaries in the east**

### *Promotion of Efficient Orchard Irrigation*

Promotion of efficient orchard irrigation through the installation of automated drip irrigation aims to encourage sustainable water management in farmer's fields. As of 15/06/2023, ARDC Wengkhar completed the installation at two sites. One site is a four-acre mango orchard at Rashingbee, Lhuentse while another site is a one-acre mixed fruit orchard of avocado, citrus and mango at Jumery, Mongar. Both the farmers received financial support for material cost from CARLEP on a cost-sharing basis. Wherein, out of the total of Nu. 0.23 Million, both the beneficiaries together contributed Nu. 0.07 Million as a cost sharing amount. Drip irrigation promotes efficient irrigation by delivering water directly to plant roots and minimizing water loss through evaporation and runoff hence it reduces water waste by up to 70% in comparison to conventional methods.

**Figure 22. Installation of drip irrigation in on-farm mango and pear orchard**

## 7.2.3 Mushroom

### *Mushroom Laboratory*

The construction of mushroom laboratory was completed and inaugurated by EU Delegation on 23 September 2022.

### *Mushroom production*

The total mushroom production for this FY is 286MT (Shiitake- 91 MT & Oyster-195MT).

### *Spawn production and supply*

The spawn production and supply of different mushroom species for the financial year are given in Table 9-Table 12.

**Table 9. Sawdust media inoculated by mushroom type**

| SN | Type of mushroom | Unit | Qty | Remarks |
|---|---|---|---|---|
| 1 | Shiitake | Bottle | 13,126 | Japanese strains |
| 2 | Nameko | Bottle | 101 | Two commercial strains of Japan, wild |
| 3 | Hericuim | Bag | 71 | Thai strains & wild isolates |
| 4 | Needle mushroom | Bottle | 105 | Thai strain & wild isolates |
| 5 | Ganoderma | Bottles | 200 | Japanese strain, wild isolates |
| 6 | King Oyster | Bottle | 133 | Indian strain |
| 7 | Oyster mushroom | Bottle | 18 | Hungarian strain |
| 8 | Changmashamu | Bottle | 18 | Wild isolate from Semtokha |
| 9 | Exidiasp | Bottle | 5 | Wild isolate from Chamgang |
| 10 | Golden oyster | Bottle | 4 | Wild isolate from Daga Uma, Wangdue |
| | | **Total** | **13,781** | |

**Table 10. Shiitake mushroom spawn supply by dzongkhag**

| SN | Dzongkhag | Qty. of Spawn Supplied (bottle) | | Total Qty. Supplied (bottle) |
|---|---|---|---|---|
| | | NMC | ARDC Khangma | |
| 1 | Chhukha | 672 | 0 | 672 |
| 2 | Haa | 0 | 0 | 0 |
| 3 | Lhuentse | 0 | 232 | 232 |
| 4 | Mongar | 0 | 540 | 540 |
| 5 | Paro | 787 | 0 | 787 |
| 6 | Punakha | 176 | 0 | 176 |
| 7 | Samdrupjongkhar | 0 | 140 | 140 |
| 8 | Sarpang | 384 | 0 | 384 |
| 9 | Thimphu | 2533 | 0 | 2533 |
| 10 | Trashigang | 0 | 290 | 290 |
| 11 | Trashiyangtse | 0 | 563 | 563 |
| 12 | Trongsa | 1926 | 0 | 1926 |
| 13 | Tsirang | 0 | 0 | 0 |
| 14 | Wangdue | 1824 | 0 | 1824 |
| 15 | Zhemgang | 840 | 0 | 840 |
| | **Total** | **9,142** | **1,831** | **10,973** |

**Table 11. Shiitake mushroom cultivation**

| SN | Dzongkhag | No. of HH | No. of logs inoculated |
|---|---|---|---|
| 1 | Chukha | 3 | 3200 |
| 2 | Lhuentse | 1 | 1162 |
| 3 | Mongar | 4 | 2700 |
| 4 | Paro | 5 | 4000 |

| | | | |
|---|---|---|---|
| 5 | Pemagatshel | 1 | 350 |
| 6 | Punakha | 3 | 5254 |
| 7 | Samdrupjongkhar | 1 | 700 |
| 8 | Sarpang | 21 | 2088 |
| 9 | Thimphu | 12 | 12000 |
| 10 | Trashigang | 3 | 1300 |
| 11 | Trashiyangtse | 5 | 2550 |
| 12 | Trongsa | 13 | 14800 |
| 13 | Wangduephodrang | 28 | 18620 |
| 14 | Zhemgang | 23 | 8450 |
| | **Total** | **123** | **77174** |

**Table 12. Oyster mushroom spawn supply by Dzongkhag**

| SN | Dzongkhag | Qty. of Spawn Supplied (packet) | | | | Total Qty. (packet) |
|---|---|---|---|---|---|---|
| | | NMC | ARDC Khangma | ARDC Bajo | Private Spawn Producers | |
| 1 | Bumthang | 0 | 0 | 0 | 790 | 790 |
| 2 | Chukha | 63 | 0 | 0 | 6,069 | 6,132 |
| 3 | Dagana | 19 | 0 | 35 | 1,074 | 1,128 |
| 4 | Gasa | 15 | 0 | 0 | 2,524 | 2,524 |
| 5 | Haa | 0 | 0 | 0 | 610 | 610 |
| 6 | Lhuentse | 5 | 540 | 25 | 2,690 | 3,235 |
| 7 | Mongar | 10 | 600 | 0 | 2,955 | 3,565 |
| 8 | Paro | 221 | 0 | 0 | 19,265 | 19,486 |
| 9 | Pemagatshel | 7 | 540 | 0 | 860 | 1407 |
| 10 | Punakha | 38 | 0 | 868 | 4,966 | 5,872 |
| 11 | SamdrupJongkhar | 0 | 0 | 0 | 1.756 | 1,756 |
| 12 | Samtse | 200 | 0 | 0 | 2,589 | 2,789 |
| 13 | Sarpang | 12 | 0 | 0 | 19,550 | 19,562 |
| 14 | Thimphu | 847 | 0 | 20 | 9,050 | 9,897 |
| 15 | Trashigang | 0 | 3,573 | 0 | 75 | 3648 |
| 16 | Trashiyangtse | 0 | 653 | 0 | 335 | 988 |
| 17 | Trongsa | 18 | 0 | 20 | 2,955 | 2,993 |
| 18 | Tsirang | 21 | 0 | 15 | 6,351 | 6,387 |
| 19 | Wangdue | 1,708 | 0 | 844 | 1,846 | 4,398 |
| 20 | Zhemgang | 11 | 0 | 450 | 0 | 461 |
| | **Total** | **3,103** | **5,906** | **2,277** | **8,6184** | **97,470** |

### *Capacity building*

The Centre facilitated the establishment of a private spawn production unit (Oyster) in Punakha dzongkhag and trained the entrepreneur on spawn production. The centre provided training to 89 youth and Desuups and farmers on spawn production. The main objective of the training was to equip participants with the skills and knowledge necessary for spawn production, with the ultimate goal of facilitating its privatization and transfer to the private sector.

The centre also provided training to a diverse group of individuals, including 426 Desuups, youths, mushroom collectors, and growers to enhance their knowledge in mushroom cultivation technology, wild mushroom identification and sustainable harvesting practices. These training programs were conducted under the Desuung Skilling Program and other initiatives.

***Awareness and advocacy***

Every year, the Centre conducts an awareness program on wild mushroom poisoning prior to the start of the mushroom season. This program utilizes television, social media, and print media to disseminate information. The community of Geney (126 individuals), focal persons of BFL (42 individuals), and four batches of Desuups from the Desuung Skilling Programme (76 individuals) received awareness sessions on mushroom poisoning. The participants were educated about the edibility of mushrooms and the potential risks of mistakenly consuming poisonous mushrooms that resemble edible ones.

## 7.3 Organic Agriculture

The department supported and facilitated new registration and Local Organic Assurance System (LOAS) certification mainly to expedite the third party certification for vegetable export to Singapore. Some of the highlights for the reporting year are summarized as below:

***Area under Organic Agriculture***

In the FY 2022-23, total of 79.5 acres under Sarpang, Thimphu, Chhukha, Wangdue, Pemagatshel, Mongar, Bumthang and Paro Dzongkhags have registered with NCOA for organic agriculture production. The total registered area to date stands at 14099.54 acres. The registered area belongs to farmers operating individually or in groups cultivating own land or state land with Land User Certificate (LUC).

***Area under Certified Organic Production***

A total of 111.77 acres of land operated by 25 households under Thimphu, Paro, Chhukha, Wangdue and Sarpang dzongkhags has been certified through the Local Organic Assurance System (LOAS) making the cumulative 7520.33 acres.

***Organic Products Certified***

Eight new products were certified under LOAS. They are rice, broccoli, cauliflower, big chilli, small chilli, mushroom, maize and turmeric. With the certification of these products, cumulative number of organic commodities certified under LOAS is 65.

***Organic vegetable Production for Export***

The organic vegetable production plan was developed for a period of one-year with effect from June, 2023 to May, 2024 whereby the exporter (Sibjam) has to supply 250 kgs of broccoli and 50 kgs of cauliflower fortnightly to the importer based in Singapore at a continuous stretch. Considering the accessibility to the Paro airport and highly perishable produce, the potential

LOAS certified organic operators were identified in the western and west central dzongkhags i.e.Chhukha, Paro, Haa, Thimphu, Tsirang, Wangdue, Punakha and Gasa.

***Facilitation of Bhutan Food and Drug Authority (BFDA) Certification***

The department facilitated the BFDA third party certification for expediting the certification process for export of vegetables (broccoli, cauliflower, asparagus and chilli) to Singapore. Altogether, 175.40 acres belonging to 68 households from Paro, Thimphu, Chhukha, Haa, Wangdue and Tsirang dzongkhags have processed for the third-party certification.

***Registration of Bhutan Natural Mark and LOAS Mark***

A distinct certification mark for LOAS was developed (Figure 23). This mark will help to distinguish between commodities certified by BFDA and those certified under LOAS. To ensure the appropriate use and prevent misuse, the registration process for these marks has been initiated with the Department of Media, Creative Industry, and Intellectual Property. These marks will remain the property of the Ministry of Agriculture and Livestock (MoAL).


**Figure 23. LOAS certification mark and Bhutan Natural Mark**

***Laboratory cum Multi-purpose hall***

The construction of two storied building (Laboratory cum Multi-purpose hall) of worth Nu. 34 million was completed and inaugurated on 13th April 2023. The ground floor of the new building has laboratories including tissue culture lab and library while the upper floor of the building has provision for conference halls. The National Organic Flagship Project (NOFP) supported the construction of the building.


***Awareness and capacity building***

A total of 360 farmers and extension officials were trained in instituting Internal Control System (ICS) to facilitate faster and cost-effective certification. Farmers were also sensitized on the use of farm diary, benefits of consuming organic products, preparing healthy food and gender empowerment, hands-on training on vermicomposting technology, plant protection and soil fertility techniques.

The ‘Organic Day’ was organized at the NCOA-Yusipang; 23 delegates from the Asian Food and Agriculture Cooperation Initiative (AFACI), officials from the Department of Agriculture the event. The event was organized to promote organic agriculture and enhance collaboration and partnership with AFACI for future endeavors.


A village organic fair was organized at Chhudzom Geog, Sarpang from 27-28 May 2023. The main objectives were to bring together organic farmers of the Geog, showcase and share experiences and to provide market avenue for organic products. Nine registered organic groups from Chhudzom Geog displayed their organic products (fresh and processed) along with traditional farming tools and crafts.


# 8 Support Services

## 8.1 Farm Mechanization and Agriculture Technology

### 8.1.1 Research

The Department continued its effort into innovations in farm mechanization in its drive to improve existing farming practices and adapt modern technologies into Bhutanese farming context and make farming attractive and drudgery-free.

***IoT based Animal Repellent to mitigate Human-Wildlife Conflict***

To protect crops from wild animal, an IoT based technology was developed. By leveraging IoT, sensor-based systems and GSM technology, farmers can remotely control and monitor the crop using their mobile phones providing flexibility and convenience without needing to be physically present in the field. The system was implemented in various locations (Zhemgang, Trongsa, Punakha, and Sarpang), with positive feedbacks from farmers affirming its effectiveness in safeguarding their crops.

**Figure 24. Automated animal repellant installed in field**

### *Tractor attached multipurpose lifter*

To upscale the cultivation of vegetables by speeding up land preparation that which entails bed making and mulch laying on the raised bed and reduce farm labour and drudgery, the centre has designed and fabricated bed-making and mulching machines. Demonstration of these tractor-attached machines was made to farmers covering an area of 20 acres.

### *Active heating and cooling system in greenhouse in extreme temperature*

For 10x5m greenhouse, a 24kW heater in winter and 2600 CFM fans in summer or evaporative cooling can be used. The estimated cost of using a 24 kW heater for 8 hours per day is Nu 510.72 per day (Nu 15,321 per month). Using a 152W exhaust fan would cost Nu 97 per month. The study will help farmers choose suitable and cost-effective temperature control methods for their greenhouses.

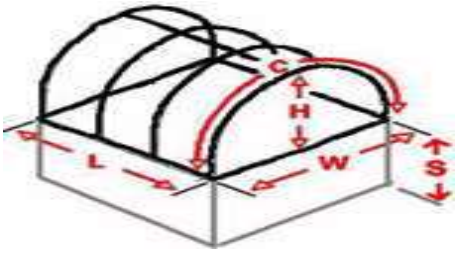


**Figure 25. Design of the green house used to determine heating and cooling**

### *Vertical hydroponic systems*

A vertical hydroponic system was developed that can accommodate 160 plants in the same space as a NFT system designed in the last fiscal year, which only accommodates 64 plants. This innovative approach optimizes space utilization and has the potential to significantly increase yields in hydroponic farming.

**Figure 26. NFT hydroponic system (L) & Multi-layered vertical hydroponic system (R)**

### *IoT based automation in greenhouse*

The focus on improving the IoT-based greenhouse monitoring system resulted in significant advancements. The introduction of a Printed Circuit Board enhanced system reliability and reduced potential failure. Push-button control enables precise atmospheric conditions for optimized plant growth. The roll-up mechanism for side ventilation accommodates both AC

and DC motors, offering flexibility and cost-effectiveness. The improved prototype was successfully installed for evaluation. The smart irrigation system was implemented in various locations (Nahi in wangdue, Dagana, Thimphu and Sarpang).

**Figure 27. Automated Roll up motor for ventilation (L) & Printed Circuit Board (R)**

### *Alternative Seedling Raising Materials for Rice Transplanting*

To address the scarcity of red soil for cultivating rice seedlings in Bhutan, an experiment was conducted to explore alternative growing mediums. The study examined the impact of different soil mixtures on seedling growth parameters and field performance. It was discovered that field soil can serve as a viable alternative. The objective is to provide region-specific recommendations for efficiently raising nurseries that are suitable for machine transplanting.

**Figure 28. Seedlings raised in field soil for machine transplanting**

### *Dehusking machine for oats*

The AMTC designed a de-husking machine for buckwheat, which has a de-husking efficiency of 88%. This machine was tested and found to have a 71.4% de-husking efficiency for oats as well. This offers a solution to the laborious manual process used in the oat de-husking. The AMTC's efforts in developing oat de-husking machinery aim to enhance efficiency and productivity in Bhutan's oat production as oats is gaining its popularity owing to its nutritional value. As part of the expansion program de-husking machine sample was provided to a young farmer who owns an oat processing unit and cultivates oats on a 9-acre land.

**Figure 29. Testing of oats de-husking and handing over of machine**

### *Testing for Standard and Certification*

As in the previous FY, the AMTC continued to develop standards and testing of a number of farm machinery in collaboration with the Bhutan Standards Bureau (BSB) as part of its mandate to ensure safety and quality of farm machines and implements in the country. These certifications have now become the basis for approval of financial loans with subsidy components for procurement of machinery. The centre developed 4 standards and tested 11 machines in the fiscal year 2022-23.

**Table 13. Standards developed for farm machines**

| SN | Particulars | Level | Remarks |
|---|---|---|---|
| 1 | Polyethylene GH | National level | Deliberated at TC-08, BSB and endorsed. |
| 2 | Power Sprayer | National level | Deliberated at TC-08, BSB and endorsed. |
| 3 | Electric Motor | National Level | Deliberated at AMTC-TC endorsed, draft completed |
| 4 | Electric Fence Wire | Ministry level | Deliberated at AMTC-TC endorsed, draft completed |

**Table 14. Farm machines tested for certification**

| SN | Farm Machine/Model | Private Firms |
|---|---|---|
| 1 | Mini tiller, FT550 | Jamtsho Trader Pvt Limited |
| 2 | Mini tiller, FT750 | Jamtsho Trader Pvt Limited |
| 3 | Mini tiller, RT65 VST SHAKTT | Jamtsho Trader Pvt Limited |
| 4 | Mni tiller, XPW1150D | Agri Mart Pvt Limited |
| 5 | Mini tiller, XPW 750D0 Gold | Agri Mart Pvt Limited |
| 6 | Mini tiller, XPW 1050 | Agri Mart Pvt Limited |
| 7 | Brush cutter, R-B436 | Jamtsho Trader Pvt Limited |
| 8 | Combine Rice Mill, 6N2018-9FC2/G | De-pel Agritect Pvt Limited |
| 9 | Combine Rice Mill, 6N2020 – 9FC2/A | De-pel Agritect Pvt Limited |
| 10 | Mini tiller (FWMT250D), | Tsirang Implements and supply |
| 11 | Mini tiller (FWMT310D), | Tsirang Implements and supply |

### 8.1.2 Developments

***In-house re-skilling program***

In-house training enhanced staff skills in IoT-based automation and 3D drawing using Inventor software. The programs aimed to re-skill participants and empower them to utilize these technologies effectively. It included lectures, demos, and practical sessions, resulting in successful project presentations and IoT-based initiatives. A month-long training on workshop machines is currently ongoing.

**Figure 30. In-house re-skilling and certification program**

***Effective Water Management***

ARDC-Bajo has constructed Bentonite clay water harvesting pond at Drukjaygang geog of capacity 236,000 litres with dimension of 1.5 m height, 24.5 m top length, 9 m top breadth, 20.6 m base length and 5.2 m base breadth (Figure 31).

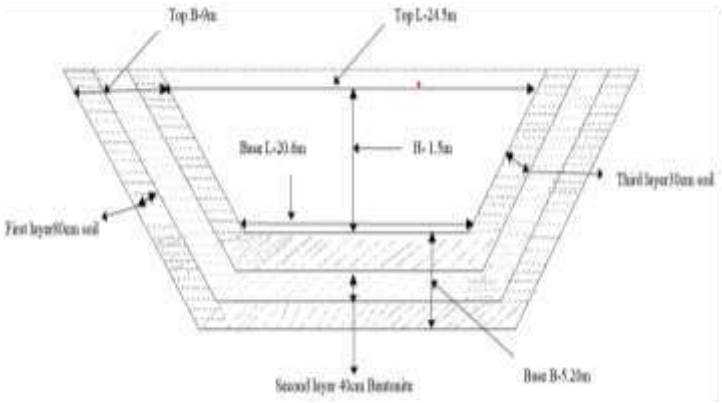


**Figure 31. Design and dimension of Bentonite clay water pond**

This initiative aims to provide effective water management solutions for communities residing in areas with limited water resources. This technology was released during 6$^{th}$ Technology Release Committee in June 2023.

## 8.2 Plant Protection Services

Highlights of the plant protection services for the past fiscal year by the Department's National Plant Protection Centre (NPPC), Semtokha, besides the general functions like distribution of plant protection chemicals, include:

### 8.2.1 Research

***Study on Fall Armyworm (FAW)***

Three research activities aimed at identifying strategies to manage Fall Armyworm (FAW) were conducted. The first study was aimed to identify the resistant maize varieties among four Bhutanese varieties and three African FAW tolerant hybrids against FAW. Preliminary findings indicate that all Bhutanese varieties are susceptible to FAW damage.

The second study was currently underway at Dzomlingthang Punakha, to assess the efficacy of new-generation insecticides with low toxicity against FAW. The expected outcome of this research is to identify the most effective insecticide to control this invasive pest.

The third study was underway in Chukha (Khempaithang and Sonamthang, Samphelling Geog), Punakha (Dabchegang, Guma Geog), Sarpang (Singye and Gakidling Geogs), and Lhuentse aimed to evaluate seven different sex pheromone lures against FAW. Preliminary finding shows the Dutch lure SF2113 to be the most effective, as it resulted in the highest number of trapped moths.

***Effectiveness of a Sonic Impact Ultrasonic Monkey Repellent Device***


A study was conducted to evaluate the effectiveness of an ultrasonic monkey repellent device with sonic impact. The device aims to create a distressful environment using sonic and ultrasound frequencies, preventing immunity development. Three regions (Gasa- Damji, Punakha- Wokuna, Thimphu-Khariphu) were selected for installation and data on deterrence distance, avoidance duration, proximity time, and approach frequency were collected. Preliminary findings indicate the device's ineffectiveness in deterring monkeys from entering farm fields.

***Comparative Study of Earth Electrode Resistance for Effective Electric Fencing***

The G.I rod was found to exhibit the highest resistance from three different electrodes (GI, Copper, and earth slab) based on the study conducted to investigate the earth resistivity of different electrodes and evaluate the shelf-life of the different earthing electrodes in Thimphu (Khariphu) and Gasa (Damji). However, the current flow through the fence line was observed to be nearly identical, and there was no significant difference in the voltage recorded across all the earthing.

**Figure 32. Data collection on the earth resistance (L) and fence voltage of different earthing types (R)**

### *Farmers' Perception of Butachlor Resistance against Paddy Weeds*

In order to assess the development of Butachlor resistance in paddy weeds and gather farmers' perceptions of its effectiveness, a baseline survey was conducted in Bhutan's major rice-growing regions, including Wangdue, Punakha, Paro, and Thimphu. The survey involved random sampling and interviewing 190 farmers. The findings of the survey revealed that 87% of the interviewed farmers reported a decline in the effectiveness of Butachlor over time while 11% stated that there was no change in its effectiveness, and 2% were uncertain about the effectiveness of Butachlor.

**Figure 33. Conducting interview with farmers on Butachlor resistance**

### *Effectiveness of Bio-Weedicide in Weed Control*

Evaluation trials undertaken in Khariphu, Phobjikha and ARDC Samtenling to assess the effectiveness of Niramoy Natural Weedicide (non- selective) showed consistent effectiveness of the weedicide. The weed densities significantly decreased overtime, reaching zero counts within 15-20 days after application across all the treatments except for the control (no spray). Overall, the Niramoy Natural Weedicide demonstrated promising results in effectively controlling agricultural weeds across the evaluated sites.

**Figure 34. Potato field before (L) and after (R) application of Niramol**

### *Inventory of Invasive Plant Species and Agricultural Weed*

Inventory survey was conducted in Sarpang, Chhukha, Lhuentse, Mongar, Trashi Yangtse, and Trashigang Dzongkhags, covering 40 geogs to locate, document, and map invasive plant species and agricultural weeds. The survey documented 162 species belonging to 39 different families, including approximately 30 invasive plants that pose a threat to agricultural land and the surrounding environment.

**Figure 35. Data recording (L) and herbarium collection (R)**

### *PCR Analysis of Citrus Samples for HLB Pathogen*

The NPPC has been screening citrus plants for huanglongbing (HLB) pathogen from the National Citrus Repository at the ARDSC-Maenchuna, Tsirang since it first started the program in 2017. In 2022-23, twenty varieties were cleared for mass propagation, and one variety was recommended to be destroyed.

### *Knowledge Management – International Publication*

The department takes immense pride in acknowledging the publication of two journal articles from the NPPC in this reporting period. The first article, titled *"The Fruit Flies (Diptera, Tephritidae) in Bhutan: New Faunistic Records and Compendium of Fauna"*, provides valuable insights into the fruit fly species found in Bhutan, presenting new faunistic records and a comprehensive compilation of the fauna. The second article, titled "Assessment of

exposure to pesticides and the knowledge, attitude, and practice among farmers of western Bhutan," explores the topic of pesticide exposure among farmers in western Bhutan, analysing their knowledge, attitudes, and practices related to pesticide use. These publications signify our dedication to advancing scientific knowledge and contributing to the understanding of relevant issues in Bhutan's agricultural and ecological contexts.

### 8.2.2 Developments

***Pest Surveillance***

NPPC conducted a survey in Haa and Paro Dzongkhags to monitor wheat rust outbreaks and the potential development of new rust races in the region. The survey results indicated a low incidence of rust, specifically yellow rust, with no cases of brown rust observed in the surveyed fields. However, in Tsento geog, a high incidence of loose smut was found in the local Yue Kaa wheat variety. In Naja geog, Paro Dzongkhag, both Yue Kaa and Bhoe Kaa wheat varieties showed a moderate incidence of powdery mildew.

Further, a study was conducted to assess the development and severity of rice blast disease in IR-64 rice variety sourced from ARDC Bajo, which is grown by farmers and maintained by research centres. The study revealed that the IR-64 seeds exhibited susceptibility to rice blast disease throughout all stages of crop growth. Numerous susceptible lesions were observed on the leaves of the plants compared to the local seeds. However, this susceptibility did not adversely affect the yield, as it did not cause any damage to the panicles or nodes of the plants.

**Figure 36. Monitoring of rust at Bji, Haa (L) and monitoring of rice blast at Baap, Punakha (R)**

***National Plant Protection Referral Laboratory***

On the 19th June 2023, the Hon'ble Secretary of the Ministry of Agriculture and Livestock inaugurated the National Plant Protection Referral Laboratory, a newly constructed laboratory facility funded by the National Organic Flagship Program (NOFP) at an estimated cost of Nu. 35.499 million. This new laboratory stands as a remarkable achievement and will play a crucial role in advancing plant protection studies, research, and diagnostics. It aims to address the emerging challenges in plant health and mitigate the risks posed by pests. The laboratory provides a dedicated space and facilities for conducting research in these crucial areas of plant

protection (Entomology, pathology and weeds science). By bringing together these important disciplines under one roof, the laboratory aims to foster collaboration and innovation in addressing plant protection challenges and promoting Integrated Pest Management (IPM) practices.


**Figure 37. Inauguration of the new laboratory by Hon'ble Secretary, MoAL and His Eminence Truelku Jampel Tenpai Khorlo**

***Plant Protection Services***

The NPPC supplied a series of different types of plant protection (PP) products to help manage crop pests and diseases. These PP products are broadly categorized into insecticides, fungicides, herbicides, nontoxic PP products and rodenticides. About 324.24 MT of Butachlor and 75.77 MT of other PP products were supplied from July 2020 to June 2021. The centre also provided a range of diagnostic and advisory services to farmers and other growers across the country on a number of pest and disease issues. It also includes laboratory diagnostics.

## 8.3 Seeds and Plants Development Program

### 8.3.1 Developments

The National Seed Centre mobilized adequate seeds, seedlings and fertilizers and supplied to the dzongkhags, geogs and individual clients meeting their demands. The centre also managed to acquire adequate NPK fertilizers (2496 MT) free of cost from Yara international, Norway through the support of foreign ministry and goodwill and bilateral relationship. A total of Nu. 37.7 m was spent on transhipment of the fertilizer stock from Norway to Phuentsholing, Bhutan.

The Gross revenue for the reporting year stood at Nu. 233.5 million – inclusive of revenue generated from the sale of seeds and seedlings and chemical fertilizers.

### *Seeds Production and Supply*

Contributing to increasing production for food security, the NSC supplied 474.73 MT seeds worth Nu. 61.54 million that were either produced in farms or imported from India, or produced by Registered Seed Growers (RSGs). These include cereals seeds of improved varieties, high quality vegetable seeds, oilseeds, and potato seeds (Table 15).


Wheat seed production at Bajo farm

**Table 15. Seeds supplied and revenue generated from the sales in 2022-23**

| SN | Commodity | Type/Variety | Annual Targets (Kg) | Annual Achievement (Kg) | Amount (Nu.) |
|---|---|---|---|---|---|
| 1 | Vegetables | All types | 10,000 | 8,935.84 | 43,950,095.10 |
| 2 | Cereals Seeds | Paddy | 40,500 | 40,596.00 | 2,169,856.00 |
| | | Maize | 76,000 | 101776.00 | 3,256,832.00 |
| | | Wheat | 25,000 | 33,855.00 | 2,054,395.00 |
| 3 | Oilseeds | M-27/YP 1, YP 2 | 8,000 | 15,386.50 | 1,728,986.99 |
| 4 | Seed Potatoes | Desiree, NKK, YM | 260,000 | 274185.00 | 8,380,758.60 |
| | | **Total** | **413500** | **474,734.34** | **61,540,923.70** |

### *Seedling Production & Supply*

A total of 425,501 temperate fruits plants and 7,03,417 sub-tropical fruit plants of assorted high quality and released varieties were supplied for the Million Fruit Tree Plantation (MFTP)) Phase II, mortality replacement of MFTP phase I and other regular demands. High quality temperate fruit plants almonds, pecan nuts, kiwi and walnuts were supplied in the MFTP Phase II and for subtropical fruit plants like Shiranui mandarin, macadamia nuts, seedless lime, Irwin mango, soursop, dragon fruits type C and avocado were supplied to the farmers. The centre also supplied around 36,204 citrus seedlings from Jachedphu farm, Tashiyangtse.


Fruit Plants at Samtenling Farm

Table 16. Seedlings supplied for normal sale and MFTP Phase II and replacement of MFTP Phase I

| SN | Commodity | Qty (nos.) | Amount (Nu) | Remarks |
|---|---|---|---|---|
| 1 | Temperate fruit plants | 429355 | 29,870,880.00 | Includes MFTP supply |
| | *NSC farms* | 24908 | 2,397139.00 | |
| | *Private Nursery* | 25589 | 3,178,298.00 | |
| | *Imported from India* | 378858 | 24,295,443.00 | |
| 2. | Sub-tropical fruit plants | 703417 | | Still supply ongoing |

## Fertilizer supply


Despite the challenges of sourcing fertilizers due to a global shortage caused by the Ukraine-Russia conflict, the Royal Government of Bhutan (RGoB) successfully obtained 2496 MT of NPK fertilizers from Yara International, Norway. This valuable donation was possible through the bilateral relationship and the diligent efforts of the Ministry of Foreign Affairs. However, the RGoB had to cover the transhipment cost of Nu.37.70 million from Norway to Kolkata to Phuentsholing. Overall, various types of fertilizers including Urea, Suphala (NPK), Single Superphosphate (SSP), Muriate of Potash (MOP), and Borax, totalling 2424.36 MT valued at Nu.112 million were supplied to farmers.

**Table 17. Fertilizer supplied details**

| SN | Fertilizers | Unit | Target 2022-2023 | Achievement (sold till June 16, 2023) | Selling Price/MT | Amount (Nu.) | Closing stock |
|---|---|---|---|---|---|---|---|
| 1 | NPK,18:11:13 (Yara Int brand) | MT | 1315.00 | 1054.65 | 60320.00 | 63,616,488.00 | 1441.35 |
| 2 | Suphala, NPK, 16:16:16 | MT | | 80.95 | 60320.00 | 4,882,904.00 | Nil |
| 3 | Urea (46% N) | MT | 400.00 | 965.585 | 33528.00 | 32,374,133.88 | 43.495 |
| 4 | SSP (16% $P_2O$) | MT | 500.00 | 318.6 | 34800.00 | 11,087,280.00 | 270.4 |
| 5 | MoP (60% $K_2O$) | MT | 9.50 | 4.5 | 42640.00 | 191,880.00 | Nil |
| 6 | Borax (20% boron minimum) | MT | 0.50 | 0.075 | 187600.00 | 14,070.00 | Nil |
| | **Sub- Total** | | **2225.00** | **2424.36** | | **112,166,755.88** | |

### *Service Delivery Facilities*

With fund support from the EU-RDCCRP and CARLEP, the centre carried out a number of important infrastructure development activities aimed at enhancing service delivery. These include infrastructure development at RSC, Jachedphu. The vegetable seed-processing house under CARLEP fund support was successfully completed and for citrus propagation, laying of sub and top soil in citrus trays was completed under the RDCCRP fund support (Table 18)

**Table 18. Infrastructure development for service delivery**

| SN | Activity | Quantity | Amount (Nu.) | Source of fund |
|---|---|---|---|---|
| 1 | Vegetable seed processing house | 1 | 1,995.348.43 | NSC revenue |
| 2 | Laying of Sub-Soil & Topsoil in the Concrete Trays | 1 | 400,000.00 | NSC revenue |

### *Organic Seed Production and Supply*

With the support from National Organic Flagship Program, the National Seed Centre initiated production of organic seeds of buckwheat, quinoa, beans, chili, ginger and turmeric. More than

100 acres of farm land have been registered for organic seed production in Samdrup Jongkhar, Tashigang, Tashi Yangtse, Mongar, Lhuentse, Sarpang, Wangduephodrang and Paro.

For the reporting year alone, 7.39 MT of organic seeds have been produced in the above RSGs areas and supplied to the dzongkhags. While progress has been made in harnessing the potential of organic seed production through capacity development and support for organic inputs, the demand for organic seeds within the country remains limited. This hampers the production potential of farmers. Factors such as restricted markets, inadequate availability of plant protection products, and a lack of organic fertilizers and pesticides pose challenges to the growth of organic seeds in the country. However, the centre will continue to produce organic seeds on the registered land, based on the annual demand with support from NCOA Yusipang and explore external markets.

## 8.5 Soil Services Program

### 8.5.1 Research

The National Soil Services Centre (NSSC) carried out a number of activities intended to build research capacity of the Soil Services Program as well as help better understand and build knowledge and information on soil and nutrient management. Key research activities include:

***Efficacy of novel nana urea***

Evaluation of the efficacy of Nana (Nitrogen) on the performance of paddy, potato and maize were conducted at different sites. The basal dose of nitrogen from urea was applied at a half dose, while maintaining a constant rate of phosphorous and potassium in all treatments. Nano (Urea) was applied as a top dressing. Across the trial sites, there was variation in grain yield among the treatments in the on-station trials. The treatments that used chemical fertilizers (CF) had the highest grain yield. Generally, the use of NU resulted in lower crop yield compared to chemical fertilizers, although this difference was not statistically significant. The maximum yield was recorded in 100 % CF followed by 100 % CF + 75% NU, respectively. The 100 % CF + 50 and 100 % NU recorded the lowest yields.

***Hydroponic nutrient evaluation***

The NSSC-formulated nutrients were evaluated in strawberries using three hydroponic systems: Dutch bucket system, Deep water culture, and Nutrient film technique (Figure 38 (L)). Initially, the growth of strawberries was satisfactory in both treatments. However, in the later stages, the plants grown with NSSC formulated nutrients exhibited symptoms such as yellowing leaves, root rot, and fruit decay as shown in Figure 38 (R). To address these issues, hydrogen peroxide and chelated iron were applied as remedial measures. Additionally, due to high temperatures inside the poly-house (reaching approximately 40 degrees Celsius), a shed net was installed to control excessive heat caused by a hot and dry spell. These remedial measures led to improvements in plant growth and morphology as shown in Figure 38 (R).

Unfortunately, data collection from the treatments was not possible as the fruits were damaged due to iron and oxygen depletion.

Similarly, ARDC-Wengkhar conducted tests using the same nutrient formulation on lettuce and strawberries, and observed similar results, which were reported during the 6th ARCM.

**Figure 38. Strawberry plant under hydroponic system at the NSSC (L) & Strawberry plant before and after remedial measures at NSSC**

However, the NSSC formulated nutrient showed good result in substrate-based tomato production at ARDC- Wengkhar and the results are as provided in Table 19.

**Table 19. Performance of tomatoes on different substrate using NSSC formulated nutrients**

| Treatment/media | Fruit weight(g) | Fruit width(mm) | Fruit height(mm) |
|---|---|---|---|
| Moss+cocopeat | 51.4 | 43.2 | 44.5 |
| Cocopeat | 49.8 | 42.4 | 41.5 |
| Sawdust | 25.5 | 33.2 | 33.9 |
| Soil | 48.8 | 42 | 41.7 |
| **P-value** | 0.001 | 0.002 | 0.012 |

**Source: ARDC-Wengkhar, 6th ARCM*

### *Evaluation of microbial nutrient management in rice production*

Aquabiota is a complex of microbiota selected amongst 200 strains for their properties to benefit plant growth. A second-year experiment was conducted to validate the research findings of the first year. Five treatments - control, aquabiota, EM, vermicompost and biochar were compared, and the results show that the yield and yield parameters of all the treatments did not differ significantly. The findings of the research are presented in Table 20.

**Table 20. Effects of five treatments on growth and yield of rice in experiment**

| Trt | Plant height (cm) | No of tillers per hill | No of fertile tillers per hill | No. of spikelet per panicle | No. of hollow spikelet per panicle | No of panicle per $m^2$ | Grain yield/ha (kg) | Biological yield/ha (kg) |
|---|---|---|---|---|---|---|---|---|
| 1 | 95.1958 | 7.2916 | 7.2500 | 107.2917 | 8.1250 | 217.3300 | 4940.733 | 13170.0000 |
| 2 | 95.7208 | 6.7083 | 6.6667 | 114.7083 | 9.1250 | 206.6700 | 4404.363 | 13167.0000 |
| 3 | 93.4833 | 6.8333 | 6.6250 | 107.0000 | 8.7916 | 206.3333 | 4904.743 | 13300.0000 |
| 4 | 96.0750 | 7.2083 | 7.0416 | 109.6667 | 8.5000 | 203.3333 | 4908.547 | 13167.0000 |
| 5 | 97.6041 | 7.0416 | 6.9583 | 117.0000 | 13.5000 | 188.6700 | 4080.613 | 14300.0000 |
| **F value** | **0.494** | **0.480** | **0.286** | **0.229** | **3.263** | **0.344** | **0.783** | **0.278** |
| **P value** | **> 0.05** | **> 0.05** | **> 0.05** | **> 0.05** | **> 0.05** | **> 0.05** | **> 0.05** | **> 0.05** |
| **Sig** | **ns** | **ns** | **ns** | **ns** | **ns** | **ns** | **ns** | **ns** |

### *Earthworm profiling*

An increased population of earthworms promotes greater mineral availability through nutrient cycling, organic matter decomposition, and the improvement of soil's physical, chemical, and biological properties. This, in turn, contributes to enhanced soil fertility, indirectly leading to higher crop productivity.

A study was conducted to examine the impact of various factors on the earthworm population in a specific area, as well as the relationship between the earthworm population and different physicochemical parameters of the soil. The earthworm sampling was carried out in three different land use types: organic fields, conventional fields, and natural vegetation, within three study locations at varying altitudes: Sephu (3000-3300masl), Chapcha (2300-2700masl), and Tsendagang (1200-1600masl). The sampling was conducted at three different soil depths: 0-10 cm, 10-20 cm, and 20-30 cm in May 2022.

In case of land use, the highest earthworm population was observed in organic fields, followed by natural vegetation and conventional fields. In terms of altitude range, the highest earthworm population was found in the high-altitude range, followed by the low and mid-altitude ranges. The majority of earthworm populations were concentrated in the 0-10 cm soil depth. Additionally, higher levels of organic carbon and organic matter were identified as significant determinants of the earthworm population. Moreover, a positive and highly significant correlation was observed between the earthworm population and total nitrogen, suggesting that a higher earthworm population promotes increased mineral availability through enhanced nutrient cycling.

### *Efficacy of EM, BAMS and biofertilizer on the decomposition rate of compost*

The centre initiated a trial to compare the efficacy of Effective Microorganism (EM), Bhutan Agri-microbial solution (BAMS) and bio-fertilizer on the decomposition rate and nutrient content of compost. This trial is a collaborative activity between the NSSC and NCOA Yusipang, ARDC Bajo and Wengkhar. The trial is expected to be complete by the end of September 2023.

**Figure 39. BAMS activation (L) and trial implementation (R)**

### *Efficacy of different organic fertilizers on Potato and Chilli*

As agreed during the 5th ARCM, the centre initiated a trial to compare the effectiveness of various organic fertilizers on the growth and yield of chilli and potatoes, which are commercially cultivated crops in the country. The chilli trial was established at three different sites: NCOA-Yusipang, ARDC Bajo, and Samtenling. Similarly, the potato trial was set up at Chapcha, NCOA-Yusipang, and Gangtey. Both trials are currently in progress and will complete by October 2023.

**Figure 40. Chilli trial at Bajo (L) and Potato trial at Chapcha (R)**

### *Soil Survey and Land Evaluation*

The Soil Survey Program (SSP) carried out soil survey of reconnaissance scale in Chukha, Mongar and Samdrup Jongkhar Dzongkhags and Nganglam Dungkhag. The survey collected baseline soil data from the cultivated areas through systematic soil descriptions and classifications covering a total of 78 profile points. With the above dzongkhags, the centre has now completed reconnaissance soil survey in 20 dzongkhags. The overall target is to produce Bhutan Soil Map and Information for cultivated land by the year 2023.

Following the comprehensive data collection from various regions of Bhutan, a soil map with a resolution of 250 meters was generated using random forest modeling. The process involved utilizing approximately 1882 sample points (Figure 41) and around 67 environmental covariates within the R environment. Through this modeling approach, the generated soil map exhibits seven distinct classes – Dystric Cambisols; Anthraquic Cambisols; Eutric Cambisols; Skeletic Cambisols; Haplic Acrisols; Haplic Allisols and Haplic Lixisols, providing valuable insights into the spatial distribution and classification of soils across the country (Figure 41).

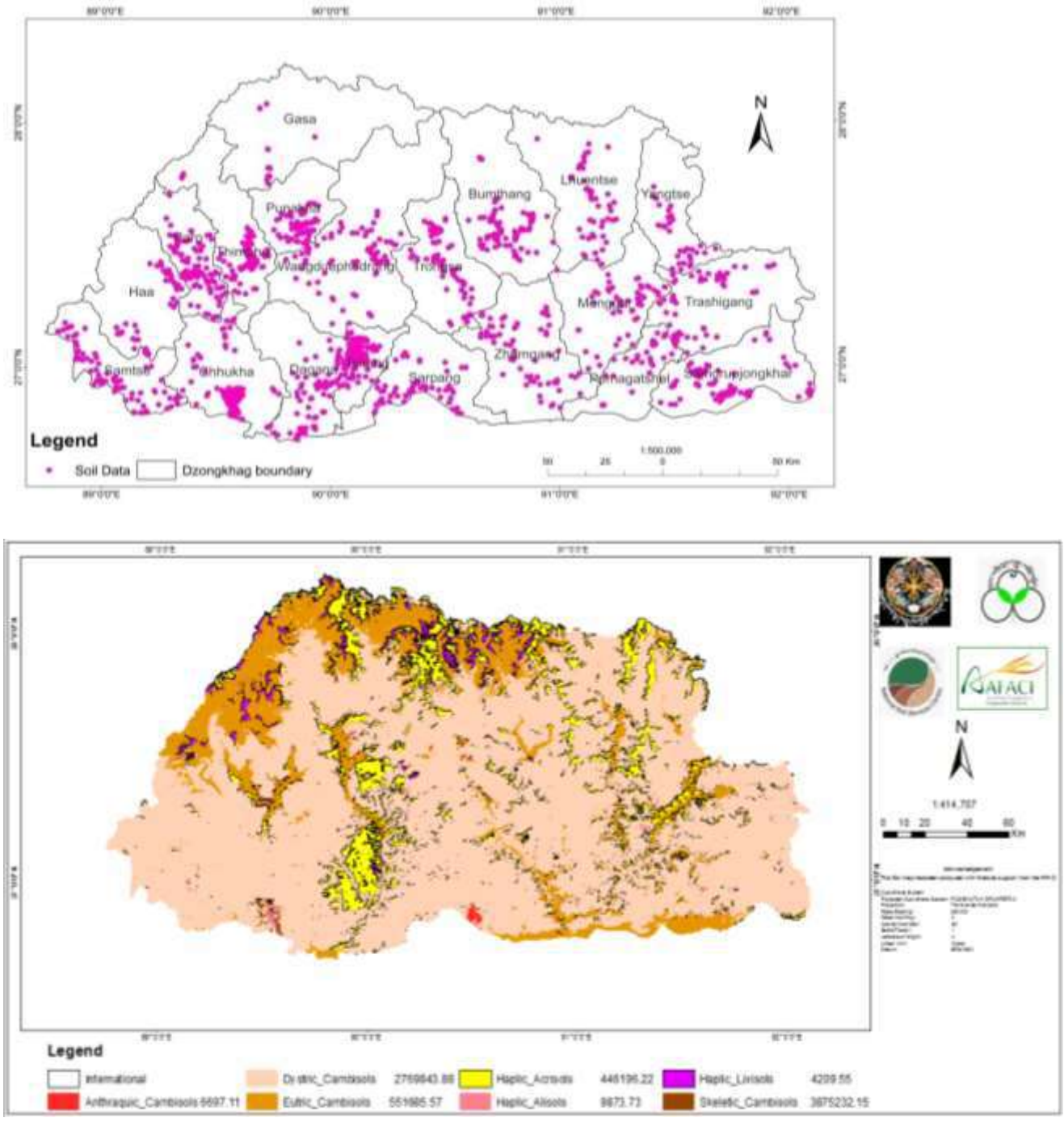


**Figure 41. Distribution of soil observation sites (top) and national reconnaissance soil map (below)**

### 8.5.2 Developments

In delivering effective soil and nutrient, and land management services to growers and other stakeholders around the country, the centre implemented various soil and land management activities during the reporting period. Some of the major activities include:

***Soil and Plant Analytical Services***

Analysis of some 4141 samples for testing of soil chemicals, soil physical, and plant, irrigation water, including compost samples were completed (Figure 42). Chemical analyses and analysis for soil bulk density were the two main components. Samples analyzed come from a range of clients that include farmers, agriculture extension, research centres, department of Forests and Park Services and the academia.

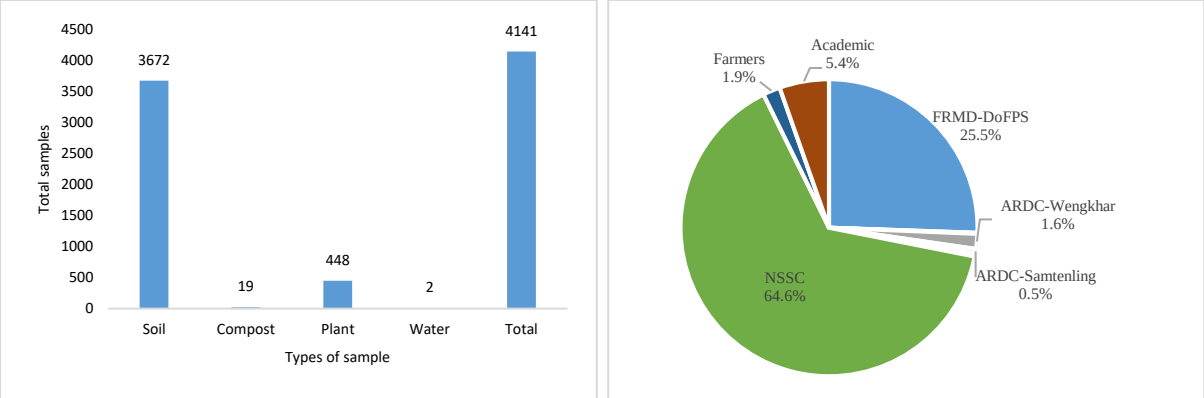


**Figure 42. Type and number of samples analyzed (L) and different clients availing laboratory services (R)**

***Soil Investigation***

A detailed soil investigation was conducted for Tareythang Gyalsung Project Site under Sarpang Dzongkhag covering 2028.31 acres. A total of 22 profile pits were excavated and described using a standardized proforma developed by the centre.

Based on the agricultural suitability assessment of the project site using the Land Capability Classification (LCC) system developed by the centre, most of the soils were classified under class S2 (moderately suitable), S3 (marginally suitable), and SC3 (conditionally suitable) for farming. This classification was primarily due to factors such as low soil pH, coarse soil texture, shallow rooting depth, and high content of surface and subsurface stones, boulders, and gravel, which acted as the main limiting factors (Figure 43).

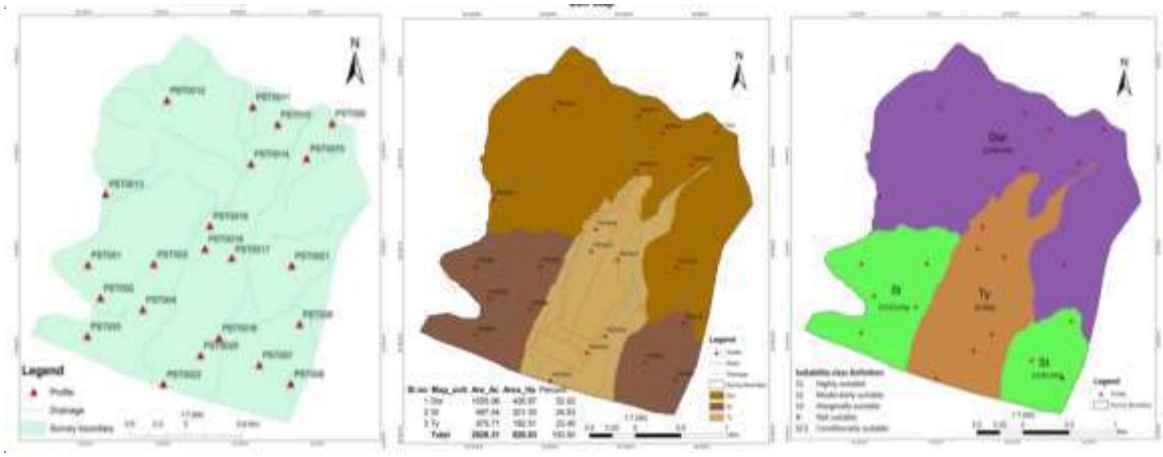

**Figure 43. Location of profile sites, soil map and land suitability map**

### *Feasibility studies of alienable land in Samdrup Jongkhar and Tsirang Dzongkhags*

A team from the Centre in collaboration with the National Land Commission Secretariat carried out the feasibility study of alienable land under Samdrup Jongkhar and Tsirang Dzongkhag for agricultural suitability. The feasibility study was carried out from 24 May to 6 June 2023. In Samdrup Jongkhar, nine sites covering about 934 acres were assessed while in Tsirang, six sites covering about 834 acres were assessed (Table 21). All these sites were technically found to be feasible for agricultural purposes.

**Table 21. Alienable land sites feasible for agricultural farming at Samdrup Jongkhar and Tsirang Dzongkhag**

| Samdrup Jongkhar Dzongkhag | | | | |
|---|---|---|---|---|
| **Site Name** | **Geog** | **Area (Acres)** | **Altitude (masl)** | **Suitability** |
| **Ngangtshothang** | Samrang | 57.40 | 360 | Suitable |
| **Samrang** | | 181.26 | 400 | Suitable |
| **Samrang** | | 321.406 | 370 | Suitable |
| **Dradueltang** | Phuntshothang | 110 | 180 | Suitable |
| **Raling** | Pemathang | 89.20 | 500 | Suitable |
| **Pirung** | | 61 | 500 | Suitable |
| **Amshingzor** | | 42 | 600 | Suitable |
| **Tshotsalo** | Martsala | 41.715 | 1600 | Suitable |
| **Gerwa** | Doethang | 29.6 | 550 | Suitable |
| **Total** | | **933.58** | | |

| Tsirang Dzongkhag | | | | |
|---|---|---|---|---|
| **Site Name** | **Geog** | **Area (Acres)** | **Altitude (masl)** | **Suitability** |
| **Norjangsa** | Doonlagang | 52.48 | 1800-1900 | Suitable |
| **Sershong** | Phuntenchu | 111.43 | 1000-1300 | Suitable |
| **Thamdara** | Barshong | 50.71 | 1400 -1600 | Suitable |
| **Kobchey** | Sergithang | 50.05 | 1000-1200 | Suitable |
| **Katley** | Patsaling | 30.1 | 1000-1200 | Suitable |
| **Danashey** | | 539.63 | 600-700 | Suitable |
| **Total area** | | **834.4** | | |

### *Soil Microbiology Laboratory*

The construction of a multi-storey laboratory building at the NSSC complex in Semtokha has been successfully completed and inaugurated on 21 June 2023. The process of furnishing the laboratory with essential equipment and furniture will be finalized by the end of June 2023. Once fully operational, the laboratory will focus on isolating, identifying, and preserving beneficial native soil microorganisms to produce mother cultures for the commercial production of biofertilizers in the country.

The laboratory will also conduct efficacy trials and quality control tests for both domestically produced and imported biofertilizers. Looking ahead, the laboratory aims to explore the potential of bioprospecting, leveraging Bhutan's huge opportunities in producing microbiome-based ingredients for healthy foods and high-quality health products in collaboration with relevant national and international agencies.

Furthermore, the laboratory will serve as a soil museum and Gene Bank, preserving below-ground biodiversity for future reference and research purposes. Its comprehensive facilities and resources will contribute to the advancement of soil science and microbiology in Bhutan.

### *Organic Fertilizers*

Approximately 464 MT of organic fertilizers, including Bhutan Agri-Microbial Solutions (BAMS), were produced according to records (Table 22). However, the producers encountered difficulties in marketing their products. Therefore, the centre procured approximately 36 MT of organic fertilizers which were distributed to certified organic growers in Chukha, Wangdue, Tsirang, Thimphu, Paro, and Gasa, aiming to assist them in their agricultural activities.

**Table 22. Production units and the quantity produced**

| SN | Production Unit | Fertilizer type | Quantity (MT) |
|---|---|---|---|
| 1 | Greenure (BBPL) | Compost | 78.56 |
| 2 | Sonam Gaki fertilizer manufacturing unit (Jigmeling) | Compost | 225 |
| 3 | BOF (Pasakha) | Compost | 10 |
| 4 | BHU ORG FARM | Chicken Manure | 100 |
| 5 | Diana nursery | Vermicompost | 10 |
| 6 | Bio-slurry compost | Bio-slurry compost | 10 |
| 7 | Betini vermicompost | Vermicompost | 5.5 |
| 8 | Sergithang vermicompost | Vermicompost | 3.5 |
| 9 | Relangthang vermicompost | Vermicompost | 6.5 |
| 10 | Mendralgang vermicompost | Vermicompost | 1.2 |
| 11 | Flora Bhutan | Vermicompost | 12 |
| 12 | BAM solution | BAM solution | 2 |
| | **Total** | | **464.26** |

### *Sustainable Land Management*

With fund support from GCF, GEF-LDCF, CARLEP, FSAPP, NOFP, and other RGoB grants and in collaboration with ARDCs, dzongkhags and geogs, various agriculture land development (ALD) interventions, sustainable land management (SLM) technologies and fallow land reversion have been implemented in all the dzongkhags.

**Table 23. Details of Agriculture Land Development (ALD)**

| Agriculture land Development (ALD) | Area (Acre) | Sustainable Land Management (SLM) | Area (Acre) |
|---|---|---|---|
| Terracing (Dry land terracing, wet land consolidation and surface stone removal) | 662.82 | Contour hedgerow & stone bunds construction | 377 |
| Fallow land revived | 90.45 | Orchard establishment | 6 |
| | | Landslide stabilization (plantation) | 15 |
| **Total** | **753.27** | **Total** | **398** |

During the reporting period (FY 2021-23), about 662.82 acres of agriculture land has been brought under Agriculture Land Development ALD through bench terracing, terrace consolidation, and surface stone removal (Table 23). Similarly, about 398 acres of vulnerable and degraded agriculture land has been brought under SLM through various interventions. In addition, about 91 acres of fallow land has been revived and brought back to cultivation.

***Participatory SLM Action Planning***

The NSSC carried out Participatory SLM Action Planning (AP) exercises in 26 sites of five GCF project Dzongkhags namely: Zhemgang, Wangdue, Samtse, Tsirang and Dagana to identify SLM interventions to better protect vulnerable agriculture land from degradation caused by climate change induced soil erosion and landslides. The Participatory SLM AP was aimed to sensitize about the importance of SLM and ALD including different technologies, and to provide opportunity for the community to diagnose their own land based livelihood problems, issues and constraints and come up with appropriate land based solutions to address those problems. In total 1612 farmers (M:1126 & F:486) were sensitized on SLM and 26 SLM action plans were developed.


**Figure 44. Sensitization meeting on SLM and ALD to farmers**

***Awareness and Capacity Building***

The centre carried out awareness program on Organic Fertilizers Production and Marketing' and developed an animated video on the benefits of integrated use of organic and chemical fertilizer.

Trained and provided hands-on-training to 22 agriculture officials and GT members of GCF project Dzongkhags on SLM activities such as construction of dry land terraces using machines, hedgerows establishment, contour stone bunds construction, check dam construction and soil sampling procedures.

**Figure 45. Hands-on-training on SLM activities**

***National Reporting 2022 to the UNCCD***

As the National Focal Point for the United Nations Convention to Combat Desertification (UNCCD), the NSSC is entrusted with the responsibility of implementing the Convention and fulfilling all obligations as a Party to the Convention. One crucial obligation among many others is the submission of National Reports to the UNCCD. Bhutan submitted its most recent National Report in 2018, and the next report was due in 2022. With the assistance of national experts and experts from the World Overview of Conservation Approaches and Technologies (WOCAT) based at the University of Bern in Switzerland, Bhutan submitted its National Report in February 2023.

## 8.6 Knowledge & Information Management

***Food and Nutrition Security Policy of Bhutan 2023***

The Food and Nutrition Security Policy 2014 (FNS) has been the basis for steering the development of the agriculture and livestock sector thus far. Nevertheless, the implementation of 2014 policy has revealed certain inadequacies in holistically capturing critical aspects of food safety, health and nutrition, and livestock development amongst others. The conventional challenges faced by the sector such as human wildlife conflict, increasing fallow land, farm workforce shortages, subsistence farming have been further compounded by increasing

incidence of climate related agricultural challenges such as floods, landslides, pests and diseases. Therefore, keeping in view the above challenges, the FNS Policy was revised with 11 strategy policy interventions by the Ministry and was endorsed formally by the Cabinet.

***Bhutanese Journal of Agriculture***

The Department launched the sixth volume of the Bhutanese Journal of Agriculture (BJA) to help promote a vibrant culture of research and scientific communication amongst its employees. The journal is an effort into collectively seeking new and relevant technologies through data-driven research and effectively communicate them through a peer-reviewed platform.

Following our successful registration as a member with an authorized Digital Object Identifier (DOI) provider, our journal papers hereon will carry their own unique identifiers with required metadata. This will enable easy indexing and accessibility of our papers online while ensuring their long-term storage in the digital space as well as enhance our journal's credibility. The articles of volumes 4, 5 and 6 (31 papers) were assigned with individual DOI.

***Cost of Production***

The Department has recently released the third edition of the *"Cost of Production of Major Agricultural Commodities in Bhutan"*. This updated publication builds upon the previous document titled "Cost of Production of Field and Horticulture Crops Grown in Bhutan 2020". The primary objective of this publication is to facilitate evidence-based decision-making for producers, planners, policymakers, financial institutions, and agriculture entrepreneurs. Moreover, the information on production costs provided in this report will serve as a fundamental reference for young individuals interested in agriculture and agro-based enterprises, enabling them to develop investment proposals.

***Agro meteorology Services***

The department coordinates and provides early warning services for extreme weather events and farm advisories to make effective use of weather patterns and climate phenomena. Through the Adaptation Fund Support, agrometeorological products in identified commodities were disseminated in Paro, Tsirang and Dagana Dzongkhags.

In addition, the enhancement of the Agromet Decision Support System (ADSS) was outsourced to Regional Integrated Multi-Hazard Early Warning System (RIMES) including the enhancement of the pest panel. The agromet focal officers from ARDCs and Central programs were trained in data incorporation in ADSS and crop weather calendar was developed through the strengthening risk information for disaster resilience project and Green Climate Fund.

## Annexure 1: Stocktaking of Research activities under 4 ARDCs, 5 Central agencies during FY 2022-23

| SN | Technology | Nos. | Agency |
|---|---|---|---|
| 1 | Performance Evaluation Trial of black rice: two (2) cultivars | 2 | Bajo |
| 2 | Evaluation of IRRI advance rice lines: three (3) lines | 3 | Bajo |
| 3 | Participatory Evaluation Trials of bio fortified wheat: six (6) lines | 6 | Bajo |
| 4 | Evaluation of promising wheat line NL-1073 in Punakha and Wangdue Phodrang | 1 | Bajo |
| 5 | Varietal evaluation of pecan nut trees: Mahan, Burket, Nellie, Desirable, Cheyenne, and Kiowa | 5 | Bajo |
| 6 | Efficacy of different organic fertilizer on growth and yield of chilli | 1 | Bajo |
| 7 | Protected cultivation (sunken greenhouse) | 1 | Bajo |
| 8 | Hydroponic farming types: Nutrient Film Technique, Dutch Bucket System, Drip Substrate Culture in Pot, Drip Substrate Culture in Trough, Vertical Tower System, and Deep Water Culture | 6 | Bajo |
| 9 | Demonstrated and rolled out six basic automated greenhouses and six smart irrigation | 1 | Bajo |
| 10 | Constructed bentonite pond | 1 | Samtenling |
| 11 | Evaluation Paddy IRRI and BRRI under irrigated condition | 1 | Samtenling |
| 12 | Evaluation Paddy (DQ-11 & Mahsuri) | 1 | Samtenling |
| 13 | Evaluation PET on two chickpea lines from ICRISAT (JG-14: ICCV 92944) | 1 | Samtenling |
| 14 | Initial evaluation of 4 lentil lines (WBL 77, L4717, L4727 and IPL 220) | 1 | Samtenling |
| 15 | Evaluation Seed purification of local paddy varieties | 1 | Samtenling |
| 16 | PET on two promising Finger millet lines (GPU 28 and HR911) | 1 | Samtenling |
| 17 | Evaluation of grapes & arecanut accession | 1 | Samtenling |
| 18 | Performance of tomato on potato grafting | 1 | Samtenling |
| 19 | Breeding of chili for Phytophthora wilt resistance | 1 | Samtenling |
| 20 | Screening of chili varieties (7 varieties) for Phytophthora wilt | 7 | Samtenling |
| 21 | Performance evaluation of broccoli variety (Besty) from Syngenta | 1 | Samtenling |
| 22 | Evaluation of short duration, heat and rain tolerant hybrid cauliflower (7 varieties) | 1 | Samtenling |
| 23 | Evaluation of bacterial wilt resistant/tolerant tomato varieties (11 OP lines from AVRDC) | 1 | Samtenling |
| 24 | Management of Phytophthora wilt of chili by grafting on brinjal rootstock (NCT) | 1 | Samtenling |
| 25 | Staggered cultivation trial on cauliflower | 1 | Samtenling |
| 26 | Management of powdery mildew disease in chili | 1 | Samtenling |
| 27 | Evaluation of synthetic and organic pesticides on management of broad mites in winter chili | 1 | Samtenling |
| 28 | Isolation and identification of pathogens causing swollen shoot in arecanut trees | 1 | Samtenling |
| 29 | Screening of common pest and diseases in IRRI lines in collaboration with Field crops | 1 | Samtenling |
| 30 | Evaluation of efficacy of bio-weedicides (Niramoy natural weedicides) in managing agricultural weeds | 1 | Samtenling |
| 31 | Effect of Nobel Nano nitrogen fertilizer on growth and yield on maize | 1 | Samtenling |
| 32 | Efficacy of feeding materials on yield, quality of vermi-compost and reproduction/multiplication of earthworm (*Esienia foetidi*) | 1 | Samtenling |
| 33 | Study on economic analysis of multi-tier cropping system | 1 | Samtenling |
| 34 | Economics on high density and ultra-high density mango cultivation (Samtenling Aumchukuli-1, 2, 3 & 4) | 1 | Samtenling |
| 35 | Performance evaluation of two varieties of Rice (Zangthi and Chandanath) | 2 | Wengkhar |
| 36 | Research on fabrication of hot callusing for grafting walnut | 1 | Wengkhar |
| 37 | Desk study on production trend of fruit trees in Bhutan | 1 | Wengkhar |
| 38 | Research on clean citrus nursery production | 1 | Wengkhar |
| 39 | Comparison study of tomato and chilli production in open and protected condition | 1 | Wengkhar |
| 40 | Production trial on strawberry with NSSC formulated nutrients under NFT and sprinker based VTS | 1 | Wengkhar |
| 41 | Carry out production trial of lettuce with NSSC and premixed nutrient in DWC | 1 | Wengkhar |

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|---|---|---|---|
| 42 | Evaluate drought tolerant potato varieties | 1 | Wengkhar |
| 43 | Engage youth in commercial farming through mentoring skilling and engagement on Spawn Enterprise | 1 | Wengkhar |
| 44 | Evaluation of oyster mushroom production using sawdust substrate | 1 | Wengkhar |
| 45 | Collection and identification wild edible mushrooms | 1 | Wengkhar |
| 46 | Modify plastic streamer to metallic drum | 1 | Wengkhar |
| 47 | Produce spawn for mushroom promotion | 1 | Wengkhar |
| 48 | Mushroom Enterprise skilling and post skilling | 1 | Wengkhar |
| 49 | Conduct capacity development for the youth commercial mushroom producers | 1 | Wengkhar |
| 50 | Evaluation of HTMA lines (Phase II) | 1 | Wengkhar |
| 51 | Evaluation of quality protein maize (QPM) hybrids | 1 | Wengkhar |
| 52 | Fast track evaluation of hybrid baby corn | 1 | Wengkhar |
| 53 | MET trial on Quinoa | 1 | Wengkhar |
| 54 | MET trial on Amaranthus | 1 | Wengkhar |
| 55 | Evaluation of Chickpea (NCT) | 1 | Wengkhar |
| 56 | Basic seed production of released & local varieties | 3 | Wengkhar |
| 57 | One High altitude climate resilient Rice variety – released during 25$^{th}$ VRC & 9$^{th}$ NSB | 1 | Yusipang |
| 58 | Three potential high yielding tomato varieties identified for Bhutanese condition and released during 25$^{th}$ VRC & 9$^{th}$ NSB | 3 | Yusipang |
| 59 | Development of cost effective climate resilient technology Rain Shelter evaluated and released during 25$^{th}$ VRC & 9$^{th}$ NSB | 1 | Yusipang |
| 60 | Fast track evaluation of cabbage, cauliflower and Broccoli | 1 | Yusipang |
| 61 | One variety of Broccoli – Green Magic evaluated and released during 25$^{th}$ VRC & 9$^{th}$ NSB | 1 | Yusipang |
| 62 | Evaluation of colored cabbage and cauliflower varieties for export market | 1 | Yusipang |
| 63 | Evaluation of short duration cabbage and cauliflower varieties | 1 | Yusipang |
| 64 | Evaluation of cabbage varieties for resistance to club root | 1 | Yusipang |
| 65 | Pak Choi - One variety- Tasty Green evaluated and released during 25$^{th}$ VRC & 9$^{th}$ NSB | 1 | Yusipang |
| 66 | One Culinary Herb (Dil) released during 25$^{th}$ VRC & 9$^{th}$ NSB | 1 | Yusipang |
| 67 | Diversification of potato cultivation during winter months in low altitude areas | 1 | Yusipang |
| 68 | Evaluation of Sweet Potato varieties | 1 | Yusipang |
| 69 | Improvement of traditional climate resilient potato storage technology | 1 | Yusipang |
| 70 | One Chipping variety proposed for release in the upcoming VRC | 1 | Yusipang |
| 71 | AMTC made Buckwheat DE huller | 1 | AMTC |
| 72 | Bed Making Implements | 1 | AMTC |
| 73 | Tractor attached Mulch Laying Implement | 1 | AMTC |
| 74 | Mega Greenhouse | 1 | AMTC |
| 75 | Portable Greenhouse | 1 | AMTC |
| 76 | Passive Greenhouse | 1 | AMTC |
| 77 | Automation of Greenhouse | 1 | AMTC |
| 78 | Quinoa Polishing in available Rice mill | 1 | AMTC |
| 79 | Expansion of direct seeding in warmer regions and research in colder regions | 1 | AMTC |
| 80 | Hydroponic | 1 | AMTC |
| 81 | Tractor Attached Lifter | 1 | AMTC |
| 82 | Animal Repellent | 1 | AMTC |
| 83 | Research on raising nursery for transplanting | 1 | AMTC |
| 84 | Research on AI-based animal repellent | 1 | AMTC |
| 85 | Evaluation of Pine Sawdust as Substrate for Mushroom cultivation | 1 | NMC |
| 86 | Effectiveness of lime for paddy straw sterilization on growth and yield performance of oyster mushroom (*Pleurotus ostreatus*) | 1 | NMC |
| 87 | Domestication of wild *Hericium erinaceus* on sawdust medium | 1 | NMC |

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|---|---|---|---|
| 88 | Domestication of wild *Flammulina populicola* on sawdust medium | 1 | NMC |
| 89 | Domestication of wild strains of NAMEKO *Pholiota microspora* in saw dust media | 1 | NMC |
| 90 | Evaluate insecticides to control Fall armyworm (FAW) | 1 | NPPC |
| 91 | Evaluation of FAW Pheromone (sex) Lures | 1 | NPPC |
| 92 | Huanglongbing (HLB) disease detection; laboratory analysis | 1 | NPPC |
| 93 | Evaluate Trichoderma spp., to manage Phytophthora blight in Chilli | 1 | NPPC |
| | **Total** | **121** | |

# Department of Agriculture

# Ministry of Agriculture & Livestock