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Ministry of Agriculture and Forests

Agriculture Research and Development Highlights 2020-2021

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ROYAL GOVERNMENT OF BHUTAN

Agriculture Research and Development Highlights

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Department of Agriculture
Ministry of Agriculture and Forests
Thimphu, Bhutan

FOREWORD

The Department of Agriculture is pleased to bring out its "Annual Research and Development Highlights" for the fiscal year 2020-21. 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 is an attempt to document the department's progress highlight for the reporting year while also addressing the challenges in pursuit of crop research and production, service delivery, infrastructure establishment and capacity building.

The reporting year also saw the department engage in and put forth a series of initiatives as part of the government's response to mitigate the fallout from the Covid19 pandemic.

This publication strives to collect reports from all agencies within the Department of Agriculture, collate the information, analyse and synthesize them into an abridged version that succinctly presents the progress for the past one year. The highlights are aggregated into different groups of approved programs, and therefore relay the cumulative figure of all major achievements by agencies within the department for the year. It however, is exclusive of the various programs and initiatives undertaken by respective dzongkhags.

The reporting format and the style allow for readers to browse through separate sections of interests to get a definitive overview of achievements thereof. Readers are however, encouraged to refer to annual reports of individual agencies for an exhaustive coverage. Individual agencies take out their own separate reports that provide comprehensive coverage of their respective progress.

I commend the Agriculture Research & Extension Division (ARED) and the editor for their diligence in meticulously going through every single report to analyse and take out this synthesized summary for the department.

With best regards,

Wangda Dukpa
OFFTG DIRECTOR

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SUMMARY

✓ In keeping with its efforts into research and technology development, the Department of Agriculture's 23rd Variety Release Committee (VRC) approved the release of several varieties of vegetables which include: three varieties of tomatoes, three radish varieties, two varieties of sweet potato and a variety of zucchini. At the same time, five hybrids vegetable varieties (tomatoes, radish and cauliflower) were notified and released based on their better yield performance and resistance to pests and diseases, and preferences by growers.

✓ Of the target production of 6,084 MT, the department's vegetable program produced 6,309 MT of vegetables, bringing more than 263 acres of fallow land into commercial cultivation engaging more than 212 youths and laid-off employees. Supported as part of the Economic Contingency Plan (ECP), the MoAF prioritized the cultivation of six important vegetables over 2004 acres of land that generated revenue of Nu 351 million.

✓ As part of the many responses to COVID-19 pandemic, the department implemented the Urban and Peri-urban Agriculture Farming Program's in collaboration with Thimphu Thromde and dzongkhag. The program for furloughed employees involved a total of 22 groups comprising 87 members who were provided with land development services, vegetable seeds/seedlings, organic manure, electric fencing and agriculture tools worth Nu.5,07,239.00. Further, the School Agriculture Program (SAP) also supported the initiative in Punakha, Bumthang and Sarpang dzongkhags where 277 youths produced a total of 96 MT of vegetables in a little over 77 acres of land that was hitherto left barren.

✓ The department also released two varieties of Arabica and Robusta coffee after four years of evaluation as well as a rice variety Bajo Kaap 3 for cultivation at altitudes below 1,500 masl. The rice variety is approved for release following its consistent performance in the mid-altitudes in terms of yield and blast resistance from several years of assessment.

✓ Based on research results on the efficacy of bio-pesticides and botanical extracts against major pests of cole crops the department's Technology Release Committee approved the release of Jholmal 3 – a bio-based formulation for pest management in cole crops.

✓ A total of 43 varieties of fruits are being evaluated for their performance across the department's research centres. These assessments are aimed at diversification of fruit crop varieties and also include morphological characterization of 44 cultivars/lines of different fruit crops for their distinctness, uniformity, and stability.

✓ To enhance mushroom production and diversify available options for growers, the department has initiated several research in mushroom like evaluation of alternate mushroom substrates, domestication of medicinal mushroom species like *Ganoderma* and *Hericium*, and evaluation of liquid spawns.

✓ The DoA officially released four Quinoa varieties in 2018. Thereon, the department has successfully assessed crop performance across varying agro-ecologies, post-harvest losses, milling options as well as value addition. To further evaluate available and alternate options as well as enhance the genetic base, the department has imported 186 new entries of quinoa germplasm and 74 amaranth genotypes which are being put under Multi-Environmental Trials (METs).

✓ In response to the growing popularity of sunflower farming in view of the various health benefits and high oil content, the department has been putting in efforts to diversify the standing sunflower gene pool with various accessions under performance evaluation.

✓ 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 a little more than 100 acres of upland paddy in 5 eastern dzongkhags and also helped bring around 128 acres of land under spring paddy. Additionally, amongst a series of other interventions, the department also promoted improved maize varieties through intensification program that covered 4,025 acres of dryland in 11 dzongkhags.

✓ Towards nutrition security and in enhancing household income, the department through its research and development centres established about 327 fruits orchards comprising around 13,000 fruit plants covering over 90 acres of land in selected areas across the country.

✓ For this reporting period, the National Organic Flagship Program added another 814.41 acres of land operated by 503 households as area under certified organic production. The total registered area under organic management stands at 10,095.29 acres comprising 1,265 households including farmers, farmer and youth groups, as well as commercial farms and institutional land. Twelve new products were also certified, and organic seeds production of selected crops were launched.

✓ As part of its mandate to ensure safety and quality of farm machines and implements, the Agriculture Machinery Centre (AMC) in collaboration with the Bhutan Standards Bureau (BSB) tested and certified 14 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 competed a number of training program for 884 participants that include farmers, private entrepreneurs and CNR students.

✓ Results from over four years of studies by the National Plant Protection Center (NPPC) to evaluate the inhibitory effect eight isolates of *Trichoderma sp.* on four different isolates of *P. capsici* since 2017 indicate that *Trichoderma* isolate Tc7a have potential inhibitory effects against *P. capsica,* and may be used as soil amendment in combination with other cultural practice rather than as a stan-alone control option in chilli farming.

✓ To help farmers improve their postharvest practices and enhance production the National Post Harvest Centre (NPHC) developed a low-cost environment- friendly onion curing and storage structure for commercial onion. The centre has amongst others, also devised an improved method to reduce the processing time in jaggery manufacture at cottage level.

✓ Contributing to increasing production for food security, the National Seed Centre (NSC) supplied a total of 474.15 MT seeds worth Nu. 154,998,783.41 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. The centre's gross revenue for the reporting year stood at Nu. 268.68 million from sale of seeds and seedlings and chemical fertilizers.

✓ The School Agriculture Program (SAP) presently supports 344 schools. For the reporting year, these schools produceded 80 MT of fresh vegetables, 18 MT of meat and 40 MT of eggs (118, 308 nos) as by-products of the learning process through the agricultural curriculum incorporated in the schools.

✓ In addition to completing soil investigation and soil surveys for various private and government agencies, the National Soil Service Centre (NSSC) successfully brought around 2,625 acres of land under several sustainable land management interventions. Additionally, about 698 acres of fallow land have been developed and brought into cultivation including those for laid-off employees and youth to provide economic relief in the wake of the Covid-19 pandemic.

✓ The department actively participated either as lead or as part of the national core group of experts engaged in preparation and review of a number of policy and strategy documents on climate change that include: Low Emission Development Strategy for Food Security, Second Nationally Determined Contribution, Third National Communication to the UNFCCC and the Sustainable Consumption and Production Strategy. These form the basis of the nation's commitment to international obligation while serving as policy and strategic guides for implementation of action plans.

✓ Several publications were brought out in the reporting period that include seed breeders' manual, a field guide on poisonous mushrooms of Bhutan, training manual on hydroponics farming technology, including a number of journal papers in internationally recognized high-impact journals.

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

1 RESEARCH HIGHLIGHTS

1.1 Field Crops

1.1.1 Rice

Rice research for the year 2020-21 reporting year include evaluation of a total of 131 rice lines including those at different stages of trial across all four the four Agriculture Research and Development Centers (ARDCs). Production evaluation trial (PET) is also being conducted on 14 rice lines.

Some of the important research include:

Evolutionary Plant Breeding Trial

Funded by the 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" initiated at the beginning of 2019 is aimed at evaluating and developing Evolutionary Population (EP) in rice that are expected to be climate resilient and adaptive to a particular micro-climate. The project will run for another two years.

Effect of AQUABIOTA Supplements on Rice Growth and Yield

As part of the assessment of the effect of Aquabiota on growth, yield and nutrient content of rice in Bhutan, a trial was established at Tsento-Shari rice research station in Paro. Aquabiota is a complex of microbiota selected amongst 200 strains known for their plant growth benefits. Microbiota is generally referred to the microbial com munities associated with plants and are profiled using marker genes to separately classify those that are suited to specific agriculture environments. They are shown to improve soil fertility, reduce diseases and pest, increase crop yield, reduce chemical fertilizer need, and increase concentrations of bioactive compounds in rice.

The preliminary research in Paro indicates that the application of Aquabiota in general positively affected growth and yield-related traits in rice, but these parameters were not statistically significant. The trial will be extended for another season.

Demonstration on Direct Seeding using Drum Seeder

Direct seeding as a potential means to reducing crop duration and labour and material costs is being tried at separate stations. The technology is widely adopted in other Asian countries, and avoids nursery raising and transplanting, and subsequently the crop duration can be shortened by 10-20 days. Substantiating earlier trials by the department, the demonstration trial conducted in this reporting year at the ARDSC

Menchuna (Tsirang) affirm that the crop matures 15-20 days earlier and the yield, recorded at 2,506.6 kg/acre, is at par with convention rice farming methods (see Table 1).

Table 1. Agronomic traits of direct seeded rice

Sl No	Plant height (cm)	Tillers/hill	Grains/panicle	Yield(kg/acre)
1	92.14	22	152	2900
2	109.20	20	155	3100
3	106.25	23	145	2205
4	115.00	25	135	2315
5	110.26	21	153	1998
Average	**88.80**	**22.2**	**148**	**2503.6**

1.1.2 Maize

Evaluation of Heat Tolerant Maize for Asia (HTMA) lines (Second phase)

After Bhutan joined the Heat Tolerant Maize for Asia (HTMA) project in 2014, the department received maize germplasms that were evaluated across the region where promising lines was identified and released as Bhutan's first climate resilient hybrid maize (Wengkhar hybrid maize-1) last year. In keeping with ongoing efforts into preparation against possible heat stress, the National Maize Program is continuing with the second phase of HTMA evaluation through the support of CIMMYT.

A total of 111 HTMA entries were evaluated across the country as nationally coordinated trials, both on-station and on-farms. All hybrids are found equally promising, with farmers preferring seven HTMA lines. Evaluations will continue with emphasis on addressing the impacts of climate change on agriculture through the development of climate resilient hybrid seeds.

Figure 1 Evaluation of HTMA entries

Maintenance of Basic Seeds

Out-crossing in maize is a hindrance in preserving true-to-type seeds for longer duration in farmers' field. 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 2. Basic seeds maintenance at research centres

Sl.no	Name of Agency	Maize variety	Quantity (kg)
1	ARDC-Wengkhar	Yangtsepa	50
		Chaskharpa	50
		Bhur Ashom 1	80
2	ARDC-Samtenling	Bhur Ashom 1	200
		Yangtsipa	400
		Arun-2	150
3	ARDC-Yusipang	Ganesh-II	60
4	ARDC-Bajo	Ganesh-II	210
		Yangtsipa	425
		Chaskharpa	136
		Total	**1,761**

Basic Seeds Production

Following the release of Bhutan's first Hybrid maize last year -Wengkhar Hybrid Maize-1 *(WHM-1),* ARDC-Wengkhar as the releasing agency, as required, started on-farm production of basic seeds of this variety in Yayung under Dremtse geog. The program involving 6 farmers takes up the production in an area of about 3 acres is supported through the CARLEP-IFAD funding. Meanwhile, basic maintenance of parental lines is ongoing with research centres.

Table 3. On-farm basic seeds production

Sl.no	Agency	WHM-1 activities	Qty (kg)	Remarks
1	ARDC-Wengkhar	Male parental line maintenance	147.5	On-going at ARDSC-Lingmethang
		Female parental line maintenance	78	
		F1 seed production	40	Initiated in 3 acres of land at Yayung
2	ARDC-Samtenling	Male parental line maintenance	0	On-going at Samtenling
		Female parental line maintenance	0	
		F1 seed production	0	
		Total	**265.5**	

1.1.3 Quinoa

Production Observation Trial

The department has completed first year of the production observation trials on 20 accessions received from International Centre for Bio-saline Agriculture (ICBA). Eight have turned out to be promising in terms of their performance in cool temperate agro ecological zone. The 2nd year trial has been expanded to three ARDCs – Bajo, Samtenling and Wengkhar to further assess their performance under different ago-ecological zones. The department has also successfully completed study into assessing the most suitable sowing time for second crop of quinoa after potato harvest in high altitude areas of Haa and Paro, the technical recommendations of which has been published in the fourth volume of the Bhutanese Journal of Agriculture (BJA).

Enhancing Genetic Base through Multi-Environmental Trials (MET)

Following establishment of formal linkage between the Department of Agriculture and the International Center for Biosaline Agriculture (ICBA) in Dubai, the department received 186 new entries of quinoa germplasm and 74 amaranth genotypes. These are being evaluated at NCOA, Yusipang. The Multi-Environmental Trials (MET) for quinoa for the 1st year has been completed in April 2021, while MET for amaranth the 1st year trial has been initiated – all as part of the effort to enhance genetic bases of quinoa germplasm.

Figure 2. Quinoa MET at ARDSC-Menchuna, Tsirang

1.1.4 Oilseeds

Evaluation of Sunflower Accessions

With various health benefits and high oil content sunflower farming is picking up in the country, particularly in Bumthang where farmers have taken it up for self-consumption

as well as for income generation. To diversify the standing sunflower gene pool, four existing sunflower cultivars (Thai sunflower, Dhaka sunflower, Bumthang local and Narang local) were identified and put under multi-location trial to assess its agronomic performance in varying agro-ecological zones. Results show significant variation in yield performance among the accessions except Dhaka sunflower with a marginally low yield at 0.60 MT/ac. The accession Thai sunflower exhibited maximum head diameter and number of achenes per head while lowest was observed in Bumthang local (see Table 4 for details).

Table 4. Sunflower accessions and characteristics

Variety	50% germ	Plant Height (cm)	Yield (MT)	1000 grain wt (g)	Head dia (cm)	No of grain/head	Achene weight/ head	Grain length (cm)	Grain width (cm)
Thai Sunflower	9.8[b]	167.8[c]	0.85[a]	60.25[c]	28.6	911.2	87.1	1.1[c]	0.5
Dakha Sunflower	9.2[b]	162.8[c]	0.60[b]	77.5b[c]	24	764.7	65.5	1.1[c]	0.7
Bumthang Local	11.8[a]	266.9[a]	0.90[a]	101.7[ab]	20.4	693.2	106.1	1.2[b]	0.6
Narang Local	12.0[a]	241.3[b]	0.61[b]	113.5[a]	22.1	774.2	91.4	1.3[a]	0.6
Mean	10.7	209.7	0.74	88.2	23.8	785.8	87.5	1.2	0.6
StdDev	1.4	48.7	0.23	26.1	4.6	174.8	29.3	0.1	0.1
p-value	0	0	0.02	0.01	0.09	0.3	0.3	0	0.2
CV%	6.67	6.3	19	21.27	17.3	19.5	35.3	3.2	13.9

1.1.5 Legumes & Other cereals

Chickpea and Soybean 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 263.87 kg/ac followed by NBeG at 2,258.30 kg/ac. The evaluation will now move on to farmers' field beginning next season.

Similarly, the department is evaluating five soybean varieties at different locations (Lingmethang, Samtenling, Yusipang, Bajo, Wengkhar, Tsirang, Tingtibi and Khangma). Although there were no significant differences in grain yields of different cultivars, TGX-1740F was found to be the most desirable as it matured earlier than the rest. However, since the other varieties also showed comparable yields, further evaluation at different agro-ecological zones will be carried out for definitive validation.

Introduction and Selection of HPYT CIMMYT Wheat Lines

The International Wheat and Maize Improvement Center (CIMMYT) in Mexico provided a total of 98 different wheat lines as part of the CIMMYT germplasm evaluation program. These were aimed at evaluating and selecting germplasms sets for

varietal development under our own ecological condition. From the entire population of these bread wheat lines, a total of 38 lines were selected based on plot uniformity, lodging incidence, agronomic score and spike observation. These lines are undergoing further observation trials.

Finger Millet (Eleusine corocana L.) performance Assessment

Field experiment on accessing two planting methods (direct seeded and transplanted) in finger millet was conducted at ARDC-Samtenling in 2020. The split plot design involved two finger millet varieties SM 1 and IE 4425. Results indicate that direct seeded method of planting yields higher than the transplanted method. Maturity period in the direct seeded crops was a week shorter when compared with the transplanted method. Additionally, economic returns for first method are much better with a lower cost of production (CoP).

Characterization of Rajma Beans and Pea Accessions

Phenotypic characterization of local rajma bean through Large Observation Plot (LOP) at ARDC-Wengkhar indicate that the variety exhibits determinate bush type growth with triangular shaped leaves, and faint purple stripes with white coloured winged flowers. The pods are observed normal green in vegetative phase, gradually turning yellow at its physiological maturity. Cross-sectionally, the pods are pear shaped, slightly curved with moderately stringy pod sutures and leathery pod wall fibre. The characterization work will be continuing in coming season

Similarly, characterization of 6 pea accession collected from NBC using UPOV guidelines on tests for distinctness, uniformity and stability were carried out. Morphological characteristic like seeds size, weight, shape, number of ovules and color, including plant growth and characteristic such leaf and stem were analysed. Among the nine accessions, accession BTNL 1390 (Bjee), 2262 (Bajo) and 2297 (Gomdar) were found to be high yielding. These will be further evaluated.

1.2 Horticultural Crops

1.2.1 Vegetables

Release of High Yielding Varieties

The department approved the release of nine open pollinated vegetable varieties. Good performing varieties are critical to meet the vegetable self-sufficiency. Open pollinated varieties play a crucial role for sustainability. ARDCs have tested several open pollinated vegetable varieties during 2019-2020 leading up to the release of these varieties through the 23rd Variety Release Committee (VRC) meeting in June 2021.

- ***Tomatoes:*** Three varieties of tomato; Srijana 1, Red Tommy Toe and Master under the name Wengkhar Lambenda 1, Bajo Lambenda 2, Bajo Lambenda 3 respectively were released. Tomato is one of the priority crops of the Department of Agriculture and this initiative is expected to supplement tomato shortage. These varieties have demonstrated superior quality in fruit and yield and resistance to blight diseases.

Figure 3. Bajo Lambenda 2, (2)Wengkhar Lambenda 1,(3) Bajo Lambenda 3

- ***Radish, Sweet Potato & Zucchini***: Three radish varieties: Akino Irodi as Bajo Lhaphu 2, Gensuke as Bajo Lhaphu 3, and Long Foot as Bajo Lhaphu 3, two varieties of sweet potato: Beni Azumi as Bajo Kewa Ngam 1 and Orange Flesh as Bajo Kewa Ngam 2) and one variety of Zucchini (Yellow Zucchini) sourced from Japan (IHPP-JICA project) and tested by ARDC Bajo were also released.

Notification of Hybrid Varieties

Five hybrids vegetable varieties were notified and released based on their better yield performance and resistance to pests and diseases and preferences by growers. They include two varieties of tomato: Cosmic (tested by NCOA - Yusipang) and Garv (tested by ARDC- Samtenling), two varieties of cauliflower (Suhasini and Candid Charm), and one radish variety: YR White spring (tested by NCOA). With their good market preference and extended shelf lives, these varieties offer wider choice to the growers.

Suhasini YR White spring Candid charm Cosmic Garv

Evaluation of Vegetable Varieties

A number of vegetable varieties being evaluated for performance across the four ARDCs are as summarized below:

- **Evaluation of Climate Resilient Tomato Varieties:** NCOA -Yusipang screened 28 open pollinated tomato lines received through the Asian Food & Agriculture Cooperation Initiative (AFACI) with the objectives to screen varieties for blight

resistance or disease resistance, yield and other desirable traits, and to develop suitable tomato varieties/hybrids best adapted to Bhutanese conditions.

- **Resistant Cultivars of Chilli:** Chilli production is constrained by, amongst others, chilli blight and other soil-borne diseases. To address these diseases, seeds of 30 multiple disease-resistant chili lines sourced from the Asian Vegetable Research and Development Centre, Taiwan are being evaluated at the four ARDCs.

- **Variety Improvement of Traditional/Indigenous Varieties**

  Traditional/indigenous vegetables are considered important for variety improvement for their adaptation to local climatic conditions and resilience to changing climate. A nationally coordinated trial on traditional beans and chilli lines are being conducted at Bajo, Samtenling and Yusipang to evaluate local lines that are climate proof and better performing. Other tests include those on traditional bean varieties too.

Evaluation of Crop Production Technologies

A number of crop production options are being evaluated to provide alternatives for improved and sustainable vegetable cultivation practices for our growers.

- **Chilli and Tomato Grafting Trial for Adaptation to Blight Disease**

  Chilli and tomato are susceptible to the blight disease. Dalle chilli, local cherry type tomato and brinjal are observed to exhibit some levels of tolerant to diseases. ARDC Wengkhar grafted local chilli cultivar Sha ema, Urkabangagla, and Pakshikha on Dalle chilli and brinjal. Additionally, tomato Srijana was grafted onto local cherry type tomato and brinjal. The success rate of chilli on Dalle was about 96%, and chilli on brinjal was 50 to 90% depending on the variety of brinjal rootstock used. Tomato on cherry type local tomato showed 80% success while tomato on brinjal had a success rate of 90 to 93%.

Figure 4. Field trials chilli grafted on brinjal (l), Grafting of local chilli on brinjal (c), and Srijana grafted on brinjal (r)

- **Demonstration Trials on Tomato Rain Shelter Production**

  Tomato research and development is being pursued in earnest as the crop is a mandatory one for the department. Production is hampered by incidences of blight diseases in open field. Two types of simple low-cost rain shelters using bamboos and polythene sheet have been designed and are being evaluated with preliminary results indicating rain shelters with dome shaped and sloping roofs as being very effective in reducing incidence of late blight and in enhancing high-quality tomato production. Rapid demonstration trials and promotion for both summer and winter production in the farmer's field have been initiated, and to date more than 100 such rain shelters have been constructed in Chukha, Thimphu and Paro. The production technology has proven to be very effective to reduce the incidence of late blight allowing production of high-quality tomatoes.

Figure 5. Rain shelter tomato production in farmer's field of Ngalachung, Dungna (Chukha), Geling (Chukha), Lokchina (Chukha) and Luni (Paro)

- **Evaluation of Bio-pesticide for Control of Pest in Cole Crops**

  Experiments on efficacy of bio-pesticides and botanical extracts against major pests of cole crops were conducted for two consecutive seasons in Yusipang. The treatments evaluated include: Neem oil (5ML/L of water), Jholmal (1 L Jholmal 1: 1 L water), Artemisia extract Jholmal 3 (1 L Artemisia; 1 L water), and All Bio. Based on field results the Third Technology Release Committee approved Jholmal 3 for released. This is in keeping with the importance and exigency in looking for viable options in organic plant protection technology.

- **Vegetables Crops Cultivation Trial in Soilless Media**

  Cultivation of vegetable crops in soilless media was initiated across the research centres including the NCOA in Yusipang. With limited land, especially in urban and peri-urban areas, there is a need to explore alternative methods of growing crops. Soilless media farming via hydroponics can be a feasible answer to this. Initial results demonstrate that vegetables crops like lettuce, sag, spinach and kale can be successfully raised on hydroponics while tomato and chilli can be grown on different substrates using the Dutch bucket system – a variant of hydroponics.

1.2.2 Potato

The main thrusts in 2020-2021 have been carrying out multi-location evaluation of potato clones in Bumthang, Khangma and Yusipang, followed by a series of technology demonstrations across the main potato growing districts. Climate resilient potato clones imported from the International Potato Centre in Peru and potato varieties imported from Nepal were put under multi-location evaluation. Further, 50 biofortified (tetraploid) clones were multiplied in greenhouses into mini-tubers for introduction into the open-field conditions. These are all geared towards addressing yield stagnation due to degeneration of seeds and varieties, so as to contribute to food and nutrition security. Highlights for the reporting year are as follow:

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.

Four multi-location/observation trials were completed in Yusipang, Khangma, Bumthang and Chapcha. Tuber sizes and yields of imported potato varieties from Nepal (Janak Dev and Khumal Rato-2) and two local varieties of Yusi Maap and Desiree were used as standard check. Further, four multi-location/ observation trials at four locations in Yusipang (both organic and conventional), Khangma, Bumthang on twenty heat-and-drought tolerant clones was conducted. Preliminary results indicate that average yield of potato clones under conventional management to be relatively higher.

Knowledge & Information Management

The National Potato Program published an article titled ‘Productivity and preferences of new potato varieties and their relationships in five districts of Bhutan’ in the Bhutanese Journal of Agriculture, Volume 4, Issue 1, encapsulating the findings of farmer preference of new potato varieties and their relationship with various varietal characteristics. Success story on Yusi Maap potato variety was also published in Sanam Drupdrey to disseminate and create awareness from farmers’ perspective. A package of practice on potato crop management has been developed and published.

The program also completed a vulnerability assessment survey in the seven dzongkhags of Tashigang, Mongar, Bumthang, Gasa, Wangdue, Chukha and Haa under FSAPP funding to map and understand households who are prone to risks and vulnerability in terms of their livelihood in the face of changing climate is being assessed.

1.2.3 Fruits and Nuts

Germplasm Evaluation & Morphological Characterization

A total of 43 varieties of fruits are being evaluated for their performance at ARDCs. They include varieties of loquat, avocado, dragon fruit, pecan nuts, pepino melon, watermelon, durian, watermelon, wine grapes and Sacha Inchi fruits. Besides, germplasm evaluation for diversification of fruit crop varieties, the department is also engaged in morphological characterization of 44 cultivars/lines of different fruit crops for their distinctness, uniformity, and stability. Presently, morphological characterization across the ARDCs include 3 guava, 4 passion fruits, 12 bananas, 3 papaya, and 22 avocados lines.

Organic Apple Management & Strawberry Mulch Studies

Strawberry is the only soft fruit that is being cultivated in the country. Given its importance, ARDC-Wengkhar is trying out 3 different system of strawberry cultivation (plasticulture, plastic mulch row cover and matted row) in addition to conventional methods to look into options at enhancing productivity. ARDC-Yusipang is currently trying out use of alternative organic inputs and their effect growth and yield is being in apple.

Strawberry in Hydroponics & Chilling Hours in Fruit Crops

Meeting required chilling hours is critical for fruit plants to break dormancy and continue their normal growth cycle, failing which fruit plants often fail to flower, or flower sporadically, thereby, affecting fruit sets. Proper understanding of chilling hours for each crop by their varieties is critical but till date no such study has been conducted in Bhutan. Hence, ARDC-Wengkhar is currently undertaking research to estimate chilling hours for 7 fruit crops.

Demand for strawberry is on the rise owing to its multiple use such as in yoghurt and in agro-processing as flavouring agent in addition to its table purpose. To promote cultivation on limited land resources, especially in peri-urban and urban areas, strawberry cultivation in hydroponics was tried out at ARDC- Wengkhar. Results show that strawberry can be successfully grown under hydroponics systems using our own nutrient formulation.

Wine Grapes Research

The department completed the second year on-station research on evaluation of wine grape varieties. The research, one of the first examples of private-public collaboration in R & D in the country is being implemented jointly with Fine Bhutan Wine Pvt Limited. Preliminary results indicate varieties Cabernet Franc, Cabernet Sauvignon and Sauvignon Blanc to be the most vigorous. Merlot, Cabernet Sauvignon and Sauvignon Blanc were least susceptible to downy and powdery mildews while Chardonnay, Pinot

Noir and Petit Manseng were highly susceptible. Of the 9 varieties being assessed, Cabernet Franc, Cabernet Sauvignon, Merlot and Syrah have already started to fruit in Lingmethang following which initial analysis were also carried out (see Table 5). In Paro, Merlot is also in fruiting. Additionally, the MoAF approved the extension of on-farm research, subsequent to which, new trial sites in Pinsa (Daga Geog, Wangdue) and Gor Tshalu (Mongar) were established.

Table 5. Preliminary results for four varieties harvested from Lingmethang trial

Variety	Bunch weight (grams)	Berry weight (grams)	Diameter (mm)	Height (mm)	TSS (%)
Merlot	78	2.0	12.2	14.4	15.4
Syrah	65.5	2.3	12.8	15.6	14.2
Cabernet Franc	79.3	1.8	12.2	12.8	13.7
Cabernet Sauvignon	49.9	1.7	11.4	11.8	14.6

1.2.4 Citrus

Protected Citriculture

Citrus cultivation under green house was initiated for the first time in the country in ARDC-Wengkhar. 22 released and potential citrus varieties were grafted onto C35 rootstock in the citriculture block. Based on their performance, the technology will be released for replication.

On-Station Evaluation of Citrus Varieties

Second year observation of new citrus variety being evaluated at ARDC-Samtenling recorded the highest plant height in variety Parson Brown and Taraku variety, while the largest canopy was recorded in Benyenda Valencia and Parson Brown. Incidence and severity of pest infestation was recorded the highest in Ryan variety. No incidence of disease is recorded in any of the varieties so far. Some varieties are in fruiting stage, and monitoring and assessment will continue for another three years.

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 one- acre demonstration-cum-citrus management trial at Punakha KhamsumYully Namgyel 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 new set of orange PAV Hayaka, Okisu and Mcmohan are under trials in Alay and Pasakha in Bongo Geog and Gaman in Darla Geog.

Clean Planting Material Production

With most mother plants in the country suspected to be infected with HLB and other diseases like CTV the department has provided added impetus on production of clean disease-free mother stocks from infected but superior lines. As part of the initiative to produce clean and high-health status mother trees, the National Citrus Repository (NCR) grafted Clementine, Taraku, Bearss lime, Ryan, Afourer, Hayaka, Okitsu Wase, Taracco ippolito, Parson Brown, Yushida ponkan, Kumquat, Pomelo, Otha ponkan, and Kabjisa local lime onto a total of 1000 trifoliate rootstocks seedlings.

The department also developed a standard operating procedure (SOP) for citrus nursery in Bhutan and a standard protocol for operation and management of the National Citrus Repository (NCR) at Tsirang.

Citrus Phenology study

As recommended by the Agriculture Research Coordination Meeting (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.

1.2.5 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 on-going and those in completions are as follows:

Evaluation of Mushroom Substrates

Conifer wood sawdust is a readily available material, and is often discarded as waste in the environment. On the other hand, mushroom growers have a limited choice of substrates to grow mushroom since hardwood sawdust is a rare commodity. A trial is being conducted at the NMC to explore options to cost-effectively utilize conifer wood sawdust as a substrate. If the results are promising, this would solve a major waste problem as well as address constraints in substrate availability.

Figure 6. One of the treatments involve fermenting the pine sawdust before spawning.

Cultivation & Domestication of Ganoderma & Hericium

Cultivation of Ganoderma is new to Bhutan and because of its medicinal and market value, a number growers have shown interest, thereby, necessitating the need to develop and disseminate cultivation technologies. Three different strains - Japan 542 and two wild strains collected from Chari base and Bjazam in Thimphu are being evaluated on *Quercus griffithii* wood logs.

Likewise, *Hericium erinaceus,* commonly referred to as lion's mane, is a wild medicinal mushroom species, also available in the forests of Bhutan. Efforts are being made to assess if the species can be domesticated. Specimen collected from the wild in Talo (Punakha) is under study and are at their incubation stages.

Figure 7. Incubation of *Hericium* species

Liquid Spawn & Wooden Dowel Spawn

The NMC embarked on its very first experiment in preparation of liquid spawn using 4% honey on distilled water with very successful results. The centre produced 62.5 liters or 222 bottles (shiitake-209, Oyster-5 and Ganoderma-8) of liquid spawn. The liquid spawn is observed to mature in a shorter time period compared to sawdust/grain substrates.

The centre also initiated studies on wooden dowel spawn for Shiitake mushroom for the first time. The dowels were made manually and inoculated with mother spawn. The mycelium run was found to be very good though it took longer duration. A total of 117

logs were inoculated and incubated for observation of mycelium run and fruiting. Results will be reported subsequently.

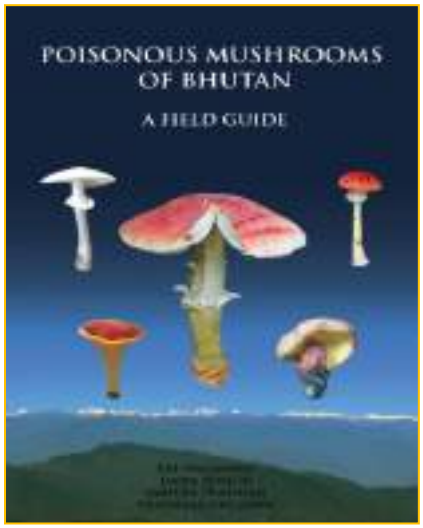
Mushroom Specimen and Herbarium

During the reporting year a total of 594 specimens were collected and processed for the centre's herbarium of which 274 specimens were collected from the garden and 320 were from other areas such as Punakha, Chhukha, Paro and Thimphu. Among the collection, ten species are new addition to the herbarium.

They include: 1) *Lichenomphalia cf. alpina; 2) Exidia glandulosa; 3) Tremella foliacea; 4) Polyporus alveolaris; 5) Isaria tenuipes; 6) Polyporus tuberaster; 7) Polyporus arcularius; 8)* Unknown species; 9) Unknown species; 10) *Pleurotus placentodes.* It is interesting to note that the species *Pleurotus placentodes* was never recorded in Bhutan to date and is also considered amongst the rare mushroom species elsewhere.

Book on Poisonous Mushrooms of Bhutan

A book titled "Poisonous mushrooms of Bhutan – a field guide" was published with fund supports from the National Organic Flagship Program (NoFP). With the publication the department hopes to educate the general mass on the species that are poisonous and hopefully prevent or reduce health hazards associated with accidental ingestion of such species.



1.2.6 MAPS

MAP Germplasm Establishment in Herb Garden

ARDC-Yusipang houses a repository or live herbarium of important medicinal plant species collected from within the country as well as species introduced from outside. The garden serves as a demo site for students, entrepreneurs and MAP enthusiasts besides doubling up as an on-station observation trial and source of mother plants for possible multiplication of species of interest. In the current reporting year, a total of 22 accessions of 13 different medicinal plants were collected from Chelela and Sagala under Haa Dzongkhag at altitudes ranging from 2,500 to 4,000 masl. Most of the wild medicinal plants collected are found to be growing in loamy soils and on rocky areas with a slightly acidic soil of pH 4.8 - 6.8.

1.2.7 Plantation Crops

Release of Coffee Accessions

The department released two varieties of Arabica and Robusta coffee. The 23rd Variety Release Committee (VRC) of the department recommended the release of the varieties Samtenling Coffee 1 and Samtenling Coffee 2 after four years of evaluation conducted by ARDC-Samtenling (Sarpang). The releasing ARDC is expected to take out the package of practices as required for the two released varieties soon.

2 DEVELOPMENT HIGHLIGHTS

2.1 Field Crops

2.1.1 Rice

Drought Tolerant Upland and Spring 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 a little more than 100 acres of upland paddy. This is an important intervention aimed at providing opportunities for households beyond 1,800 masl to diversify maize cropping system with rice and help enhance rice productivity and ensure rural self-sufficiency. An estimated production of 117 MT paddy is expected from target villages in 5 eastern dzongkhags of Lhuentse, Mongar, Trashigang, Tashiyangtse and Samdrup Jongkhar.

The department also supported in bringing 127.60 acres under spring paddy cultivation in the west central districts of Dagana and Wangdue alone.

Maintenance & Basic Seeds Production

The DoA at its four research and development centres produced around 12.266 MT of basic seeds of released and pipe line varieties as part of its regular maintenance and seed purification program. In addition to supporting the National Seeds Centre (NSC), these seeds were also used in promotion programs in needy dzongkhags.

2.1.2 Maize

Community Seed Production and Seed Replacement

As an important cereal crop, maize seeds continue to feature as a priority for farmers. Quality seeds play a crucial role and therefore the need to support farmers in producing and maintaining quality seeds. In the last season, six community-based seed production (CBSP) groups in eastern Bhutan produced over 59.56MT of quality maize seeds for

the National Seed Centre (NSC). At the given seed rate of 15kg/acre, the production would cover an area of 3970 acres, directly contributing towards seed replacement across the country.

Improved OPV Maize Intensification

The DoA is trying to inform maize growers of the susceptibility of local races to Gray Leaf Spot (GLS) disease to which farmers lost substantial parts of their crops in 2007, and is promoting improved varieties through intensification programs aimed at enhancing productivity, and thereby ensuring household food security. In this past reporting season, a total of 60.36 MT improved varieties namely - Shafangma ashom, Chaskharpa and Yangtsipa were promoted in 11 districts across the country covering 4,024 acres of dryland.

Table 6. Improved maize intensification

Variety	Dzongkhag	Quantity (kg)	Area (ac)
Shafangma Ashom	Samtse	680	45.33
Chaskharpa	Chukha	2600	173.33
	Pema Gatshel	1770	118
	Samtse	1930	128.67
	Sarpang	10	0.67
	Tashiyangtse	1640	109.33
Yangtsipa	ARDC-Wengkhar	1000	66.67
	Chukha	1700	113.33
	Dagana	900	60
	Mongar	1050	70
	Pema Gatshel	230	15.33
	Samtse	12900	860
	Sarpang	9000	600
	Tashigang	10180	678.67
	Tashiyangtse	1770	118
	Tsirang	10000	666.67
	Zhemgang	3000	200
	Total	**60360**	**4024**

2.1.3 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. The program still managed to produce a total of 34.8 MT quinoa for the reporting period in

selected areas in Samtse, Zhemgang, Samdrup Jongkhar, Tsirang, Dagana, Monagr, Trashigang, Chhukha, Thimphu and Paro.

Figure 8. Quinoa intensification program in Drujaygang Geog, Dagana

2.1.4 Oilseeds

Groundnut Intensification

As a part of groundnut intensification program, 288 households were supported with 4.15 MT groundnut seeds that helped them cultivate groundnut on around 51 acres of land. ARDC-Wengkhar implemented the activity as one of their research outreach programs with financial assistance from CARLEP-IFAD. The initiative expects to enhance oil seeds production in the region and make farmers self-sufficiency in cooking oil.

Promotion of High Yielding mustard varieties

Farmers widely grow locally available traditional mustard varieties where yield are comparable low compared to improved varieties. As a part of mustard enhancement program, 18 potential sites across the country were supported with a total of 7.96 MT improved mustard seeds covering 1,326 acres of land.

Table 7. Promotion of improved mustard varieties

Sl.no	Dzongkhag	Acre	Seed qty (kg)	Expected yield (MT)	Varieties
1	Lhuentse	16.7	100	3.8	M-27
2	Mongar	15.8	95	3.6	M-27
3	Mongar	83.3	500	19.2	Yusipeka-2
4	Paro	0.8	5	0.2	M-27
5	Pema Gatshel	67.5	405	15.5	M-27
6	Pema Gatshel	16.7	100	3.8	Yusipeka-2
7	Samdrup Jongkhar	283.3	1700	65.2	M-27
8	Samtse	84.8	509	19.5	M-27
9	Sarpang	127.5	765	29.3	M-27
10	Sarpang	91.7	550	21.1	Yusipeka-2
11	Tashigang	90.8	545	20.9	M-27
12	Tashigang	16.7	100	3.8	Yusipeka-2
13	Tashigang	50	300	11.5	Yusipeka-1
14	Tashiyantse	16.7	100	3.8	M-27
15	Thimphu	64.2	385	14.8	M-27
16	Trongsa	41.7	250	9.6	M-27
17	Wangdue	220.8	1325	50.8	M-27
18	Wangdue	37.5	225	8.6	Yusipeka -2
		1326.5	**7959**	**305.1**	

2.1.5 Legumes & Other Cereals

Upscaling Commercial Wheat Production in eastern Bhutan

In an effort to diversify rice-based cropping and also to help bring fallow lands into production, winter wheat is being promoted in the east where wheat crop is generally not popular. A total of 1.4 MT of wheat variety Gumasokaa was provided to 130 households in two geogs of Lhuentse and Mongar covering around 45 acres of land. The program was supported through CARLEP-IFAD funding as part of its wheat production enhancement program in the region.

Lentils Promotion through Economic Contingency Plan (ECP)

Cultivation of lentil cultivar WBL 58 was promoted in six dzongkhags of Lhuentse, Pemag Gatshel, Samdrup Jongkhar, Sarpang, Trashiyangtse, and Zhemgang as part of the Economic Contingency Plan (ECP). The initiative covered a little over 297 acres of lentil plantation.

Promotion and Intensification of Rajma Beans

Rajma bean is gaining popularity in the eastern dzongkhags, particularly due to its productivity, better market price and nutrition prospects. Over the years, the cultivation area and seed demand have increased, with communities venturing into commercial

cultivation. To help improve production resilience and diversification in the region, a total of 4.9 MT of Rajma bean seeds were provided to 22 potential sites that involved 480 households. The cultivated area covered around 226 acres of land with a production of more than 90.6 MT. Additionally, ARDC-Samtenling also ran a Rajma beans promotion program in Tsholingkhar and Semjong geogs of Tsriang which produced 2.35 MT of beans from a cultivated area of 10.9 acres.

2.2 Horticultural Crops

2.2.1 Vegetables

Winter Vegetable Upscaling Program

The government allocated Nu. 40.10 million to produce 6,084 MTs of winter vegetables under the Agriculture Economic Contingency Plan. The ministry prioritized six important vegetables (chilli, onion, tomato, brinjal, cauliflower and beans) and identified seven southern dzongkhags (Chhukha, Dagana, Samtse, Sarpang, Tsirang, Samdrup Jongkhar, Pema Gatshel) for the program. Further, the department also developed the "Food Security Strategy" with focus on winter vegetable production in response to COVID-19 pandemic. The strategy identified three mandatory crops (chili, onion, tomato), and signature crops, based on production potential of respective dzongkhags.

Of the target production of 6,084 MT, 6309 MT of vegetables were produced, accounting for an achievement of 104% of the overall plan target. Through this initiative, more than 263 acres of fallow land was brought under commercial cultivation engaging more than 212 youths and laid-off employees in various production activities.

Table 8. Winter Vegetable Production achievement against planned target

Dzongkhag	Planned target	Production MT	% Achieved
Chhukha	292.00	399.17	137%
Dagana	949.80	506.96	53%
Pema Gatshel	163.30	202.49	124%
Samdrup Jongkhar	459.50	295.00	64%
Samtse	224.50	361.43	161%
Sarpang	494.30	881.40	178%
Tsirang	3501.00	3662.98	105%
Total	**6084**	**6309.43**	**104%**

Farmers sold 6,115 MT of vegetables harvested from 2,004 acres of land as part of this initiative, and generated an income of Nu 351 million, helping enhance rural livelihood and household income (see Table 9).

Table 9. Production and income from winter vegetables

Dzongkhag	Chilli (MT)	Tomato (MT)	Onion (MT)	Others (MT)	Total (MT)	Income (Million Nu)
Chhukha	7.5	1.5	4.8	191.18	204.98	9.56
Dagana	23.26	5.3	146	332.4	506.96	14.2
Pema Gatshel	8.39	3.46	18	172.64	202.49	2.8
Samdrup Jongkhar	7.5	6.5	81	200	295	9.05
Samtse	16.1	16.25	5.5	323.58	361.43	96.405
Sarpang	248	65.4	0	568	881.4	21.8
Tsirang	379.33	75.81	121.5	3086.34	3662.98	197.475
Total	**690.08**	**174.22**	**376.8**	**4874.14**	**6115.24**	**351.29**

Production Input Support

In order to upscale production, various production inputs support was provided. Since vegetable are mostly cultivated under protected structures in winter, 342 numbers of pre-fabricated greenhouses and 599 numbers of rain shelters plastic were supplied along with 298 sets of drip irrigation and water storage tanks. Other supports include weed management options aimed at reducing labour requirement, crop protection from wild animals like plastic mulches and green nets, respectively.

Table 10. Production Input Support to Seven Dzongkhags

Production interventions	Unit	Chhukha	Dagana	Pema Gatshel	S/Jongkhar	Samtse	Sarpang	Tsirang	Total Qty
Seed	Pkts	-	4,914	8,924	15,850	7,422	8,773	8,000	**53,883**
Drip irrigation	Sets	-		64		69		64	**197**
Mulching plastic	Rolls	-	162	-	250	1,651	1,000	400	**3,463**
Green net fencing	Rolls	-	-	-	-	74	202	-	**276**
Greenhouse	Set	90	29	15	68	30	100	10	**342**
Low-cost greenhouse	Nos	87	-	28	30	69	315	70	**599**
Water tank	Nos	59	-	58		23	-	33	**173**
Shade Net	Rolls	86	23	49	40	132	266	-	**596**

Urban Agriculture Initiative

As part of the many responses to COVID-19 pandemic, the department in collaboration with Thimphu Thromde and Thimphu Dzongkhag initiated the Urban and Peri-urban Agriculture Farming Program in and around Thimphu for furloughed employees that mainly comprised those from the tourism sector. The program with additional fund from the Food and Agriculture Organization (FAO) involved a total of 22 groups comprising 87 members who were provided with land development services, vegetable seeds/seedlings, organic manure, electric fencing and agriculture tools worth Nu.5,07,239.00.

2.2.2 Potato

Promotion & Intensification of Late-blight Resistant & Nutrient-dense Varieties

Late-blight and nutrient-dense potato varieties of Yusi Maap and Nesephey Kewa Kaap (NKK) were promoted in Trongsa, Wangdue, Gasa, Thimphu, Paro, Haa, Chukha and Bumthang. Altogether, 12,400 kg of Yusi Maap and 950 kg of NKK were promoted.

Major support was also provided to Wobthang Organic Farm, Tang (Bumthang) to help improve and expand organic potato seed production system. The seeds were provided through a "seed back policy" where Wobthang Organic Farm would return the 10. 25 MT of Yusi Maap seeds to the department after the harvest in September or October 2021. Further, 1050 kg Yusi Maap seeds were supplied and planted at Ramthangkha Royal farm, Tshento, Paro.

Around 56 households of the organic village of Langpa Nobgang, in Samar Geog (Haa), were also provided with 2,800 kg of Yusi Maap seeds. This was aimed at replacing degenerated seeds. Besides, 8.952 MT of seeds were produced from the series of field demonstrations conducted in Haa, Paro, Thimphu, Tashigang, Mongar and Bumthang to disseminate varietal technology.

Farmers' Capacity Development

A total of 392 farmers were trained out of the planned target of 400 farmers. These programs were conducted as part of the collaborative annual workplan of the potato program, FSAP Project, and the NOFP funding. Farmers in Dungma, Metekha, Samar, Eusu and Katsho geogs trained in addition to those in Longpa Nobgang (Haa) and Laya (Gasa). Some programs were disrupted due to the COVID-19 pandemic.

2.2.3 Fruits and Nuts

Some of the primary development highlights for the Fruits & Nuts Program of the Department were:

a) **Demonstration Orchards & Crop Management:** A total of 327 orchards comprising 8,791 fruits plants covering more than 67 acres of land have been established. Additionally, 11 households in Kurtoe Geog in Lhuentse were trained on integrated fruit plants management while ARDC-Bajo helped top-work 665 local fruits trees with improved varieties benefitting 84 households in Bajo locality.

b) **Fruits Promotion for Nutritional Improvement:** A total of 4214 fruits plants were established over 23 acres to support nutritional improvement of 108 households.

2.2.4 Citrus

As in the previous reporting year, the department implemented a number of programs to support, develop and sustain the citrus industry.

Citrus Orchard Management & Technology Dissemination

- Eleven households in Lhuentse and 27 households in Mongar were trained on integrated citrus orchard management, including 6 youths who were provided hands-on training on canopy management. Mandarin growers in Bongo and Dungna (Chhukha) also attended similar capacity building programs.

- Forty-five farmers in Haa (Gakiling Geog) were trained on proper management of canopy including preparation and application of Bordeaux paste and Bordeaux mixture as an effective fungicide. Fertilizer applications in trenches to enhance soil nutrient content were also demonstrated.

- Three mandarin orchards were established in Chhukha to demonstrate improved management practices. ARDC-Yusipang in collaboration with Chukha Dzongkhag also supported the set-up of 19 mandarin orchards in Zamsa.

Climate Smart Water Management for Citrus

The National Citrus Program established climate smart irrigation facilities for citrus orchards and other dryland crops in five locations across the country. This initiative that includes 3 demonstration sites covers a command area of 264 acres, directly benefiting 124 households. Key facilities include the trapping of spring sources and drinking water over-flows, construction of reservoirs, distribution tanks and 25 cm pipe connections (see Table 11).

Table 11. Dry land Irrigation and low-cost water harvesting structures

Sl	Activity	Location	No. of beneficiaries	Fund allocated (Mn Nu)	Area Coverage (Acre)	Activity details
1	Dry land irrigation and drinking water	Zhemgang /Tama	26	0.45	1000	Constructed concrete tank at the source for water supply, earthen reservoir (3million liters) capacity with fencing to store water, distribution tank (2nos) at strategic location for irrigation of citrus, vegetables and for drinking. All the tanks are connected with HDPE pipes.
2	Low-cost water reservoir pond and smart irrigation system	Punakha/ Khamsum Yuley Namgyel Chorten		0.40	8	Constructed 2 low-cost water reservoir tanks of 27 thousand capacity each, 100 assorted fruit crops were connected with smart irrigation system
3	Low-cost water reservoir pond and smart irrigation system	Punakha/Ritsa		0.40	6	Constructed 2 low-cost water reservoir tanks of 2700 liters capacity each, A total of 1000 assorted fruit crops were connected with smart irrigation system

4	Low-cost water harvesting pond using silpauline sheet	Tarshigang/ Uzarong and Yangneer	98	1.00	150	62 nos of silpauline plastic of 300 GSM suplied for irrigation in citrus orchard, vegetables and other crops. 34 nos of silpaulin sheet were supplied to Yangneer and 29 nos to Uzarong. Each pond has a water holding capacity of 2700 liters.
5	Water reservoir tank	Tashigang/ Uzarong		1.18		Constructed 6 concrete water tanks at source for storing water for irrigation in citrus, vegetables, and as drinking water. All the tanks are connected with HDPE pipes from the reservoir tank.

2.2.5 MAPS

Demonstration & Multiplication of Cape Gooseberry

Cape gooseberry (*Physalis peruviana)*, also referred to as golden berry belongs to the Solanaceae family, and is native to the Andean Region. It is cultivated currently in South American countries, especially Colombia, Peru and Ecuador. Consumption of fruits and vegetables is reported to reduce the risk of cardiovascular (CVD), respiratory and digestive diseases and certain cancers. Anti-tumor, anti-diabetic, anti-inflammatory, anti-hypertension activities and cardio-protective effects have also been reported from berry fruits such as strawberries, blueberries, blackberries, raspberries and cranberries.

The germplasm was introduced into Bhutan from Thailand by the researchers in Yusipang. However, a scientific adaptation research to document its adaptability and generation of package of practices could not be initiated as the crop failed to bear fruits in the previous reporting year (2019-2020). The MAP section at NCOA-Yusipang has recovered the germplasm from National Biodiversity Centre, Serbithang and has started on-station observation evaluation trial beginning January 2020.

Capacity Building and Knowledge Management

Growers of the Bama Sanam Chithuen Detshen in Thimphu were provided with hands-on training on cultivation, management and post-harvest practices of culinary herbs. The farmer capacity development program was conducted in collaboration with the Dzongkhag administration, Thimphu. They were also familiarized with the provisions and requirements of the Local Organic Assurance System.

Several publications were also taken out on spices and medicinal plants as per the program's annual work plan as follows:

Table 12. List of publications taken out on MAPs in the FY 2020-21

Sl. No.	Topic
1	Assessment of Nursery Methods and Manures for Cultivation of Chirayita (*Swertia chirayita* Buch-Ham.) in Lauri Geog, Bhutan
2	Lauri farmers successfully domesticates *Swertia chirayita*
3	Culinary herbs cultivation package of practices
4	Package of practices for Goned (*Carum carvi* Linn.)
5	Package of practices for Manupatra (*Inula racemosa* Hook. f.)
6	Package of practices for Ruta (*Saussurea lappa* Clarke)
7	Package of Practices for Ti-yangkhu (*Dracocephalum tanguticum*)
8	Seed production manual for ginger
9	Seed production manual for turmeric
10	Seed production manual for large cardamom
11	GAP Standard for ginger and turmeric

2.2.6 Plantation Crops

Multiplication of Plantation Crops

ARDC-Samtenling produced more than 6,140 healthy seedlings for establishment of demo-orchards of released varieties as well as for on-farms evaluation of plantation crops across the country. The seedlings were multiplied in keeping with the requirements for ultra-high density orchard set-up.

Table 13 Multiplication of plantation crops seedlings (2019-2020)

Sl	Crops	Seedling No.
1	Arecanut (*Areca catechu)*	3,700
2	Coffee (*Coffea arabica & robusta)*	1,200
3	Tea *(Camellia sinensis var. sinensis & assamica)*	500
4	Cocoa (*Theobroma cacao)*	700
5	Sacha inchi (*Plukenetia volubilis)*	40
	Total seedlings	**6,140**

2.3 Organic

Subsequent to the government's approval of the National Organic Flagship Program (NoFP) in 2019, a series of activities have been launched to take forward the initiatives of the National Organic Program (NOP). Some of the highlights for the reporting year including regular organic agriculture programs by the NOP are summarized as below:

Area under Organic Management

In the FY 2020-21, total of 691 households operating a total area of 2,090.26 acres have registered for organic agriculture production. with NOP (see Table 14). Maximum agriculture area registered during the reporting period is from Samtse, Sarpang, Samdrup Jongkhar, Zhemgang, Paro and Tsirang. The total registered area to date stands at 10,095.29 acres comprising 1,265 households that include individual as well as farmer groups, youth groups cultivating state land with LUC, commercial farms and institutional land.

Area under Certified Organic Production

A total of 814.41 acres of land operated by 503 households has been certified through the Local Organic Assurance System (LOAS) in the 2020-21 reporting year. Chhukha, Sarpang and Tsirang recorded the highest acreage in terms of the area certified organic production (see Table 14).

Table 14. Total area under certified organic management (2020-21)

Sl	Dzongkhag	Registered area (Ac)	Registered HH	Area certified (Ac)	Certified HH
1	Thimphu	35.89	49	46.00	46
2	Chhukha	208.98	62	186.32	62
3	Haa	23.76	23	60.77	79
4	Paro	828.31	36	36.38	35
5	Samtse	300.09	137		
6	Sarpang	17.55	16	239.80	186
7	Samdrup Jongkhar	193.75	141		
8	Zhemgang	147.02	58		
9	Tsirang	126.11	98	136.23	76
10	Punakha	23.84	10	29.04	10
11	Mongar	21.00	27		
12	Trashigang	0.70	5		
	Lhuentse	4.00	13		
13	LUC	10.00	5		
14	Commercial farms	79.87	9	79.87	9
15	Institutions (NCOA 68.12+NSC 1.4)	69.40	2		
	Total FY 20-21	**2,090.26**	**691**	**814.41**	**503**
	Cumulative achievement	**10,095.295**	**1,265**	**3,167.38**	**788**

Organic Products Certified

Twelve new products were certified under LOAS. They are rice, mustard green, radish, coriander, cauliflower, cabbage, dry chilli, bunching onion, buckwheat flour, wheat flour, garlic and potato. Rice was certified from Chimakha organic farm in Paro and all other products were certified from model organic village, Lull under Kazhi Geog,

Wangdue. Both Lull Model Organic Village and Chimakha farm were certified under LOAS in 2020. With the certification of 12 new products, cumulative number of organic commodities certified under LOAS is 38.

Figure 9. LOAS certified products at their launch

Production of Organic Commodities

A total of 1,820.50 MT of selected commodities (quinoa, buckwheat, ginger, turmeric, mushroom, cardamom, cauliflower, beans and chili) were produced as part of the National Organic Flagship Program. The department provided support in the form of the production materials like irrigation equipment, seeds and seedling, technical inputs, farm tools, etc. These productions are spread across the country and are being implemented adopting integrated landscape approach.

Organic Manure Production

There are ten commercial organic manure production units in the country, the largest being the Bhutan Organic Fertilizers in Pasakha with a production capacity of 876 MT/year and the Greenure located at Darla and operated by Bhutan Board Private Limited with production capacity of 1440 MT/year. The units have not yet achieved their full production capacities. There are also mid-scale and small manure production unit located at various places. Altogether, a total of 477 MT of organic fertilizers were produced in the reporting year comprising chicken manure, vermi-compost, bio-slurry compost and compost.

TOT and Farmers' Capacity Building

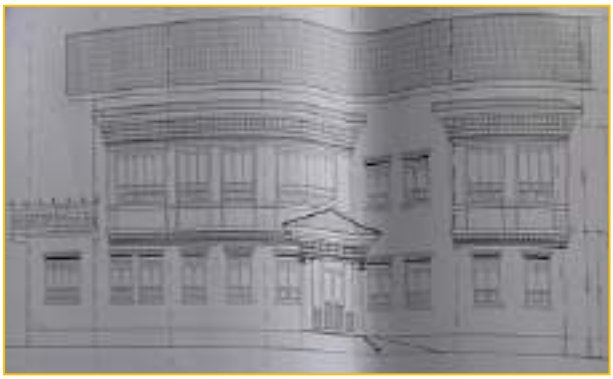
The NOP conducted a series of farmers training and TOT to promote organic farming and facilitate registration and certification. The programs largely focused on building capacity of farmers and extension officials on organic principles and practices, Bhutan Organic Guarantee System (BOGS) and Bhutan Organic Standards (BOS). Stakeholders were also trained on instituting Internal Control System (ICS) in the group which would facilitate faster and cost-effective certification. Sensitization was also carried out on the benefits of organic products, preparation of healthy food and gender empowerment (see table below for details).

Table 15 ToT and Farmers' capacity building program

Sl	Topic	Location	No. of participant
1	ToT on BOGS and ICS for organic focal persons and researchers	NCOA, Yusipang; ARDC, Bajo and ARDC Wengkhar	54
2	Instituting Internal Control System (ICS) for farmers group	Gasa, Tsirang and Sarpang	168
3	Farmers training on organic principles and practices, crop production	Paro, Sarpang,	86
4	Enhancing soil fertility, plant protection and crop diversity	Lull, Kazi, Wangdue	25
5	Vegetable nursery management	Langpa- Nobgang, Haa	60
6	Awareness training on safe and nutritional food diversity (including gender)	Langpa- Nobgang, Haa	25
7	Organic farming and enterprise development	Punakha	4
8	ICS implementation	Goongring, Sarpang	50
9	Hands on Training on Bhutan Agri Microbial Solution (BAMS)	NSSC, Semtokha	15
10	Training on organic crop production	Zhemgang, Trongsa, Sarpang, Trashigang, Lhuentse	282
11	ToT on electric fencing for extension staff	Lhuentse	21
	Total		**790**

Infrastructure Development

To strengthen the institution for development of organic agriculture, three laboratories are being constructed. The construction of two storied conference hall and laboratory building at NCOA-Yusipang has started and is on schedule. The department has also started construction of microbiology laboratory at NSSC, Semtokha and bio-control laboratory at NPPC, Semtokha. The laboratories will facilitate production of biofertilizers and biopesticides.



Model Organic Villages

With financial support from the GEF-LDCF project, two additional model villages, one each in Lhuentse and Thimphu dzongkhags have been identified and supported. Support to existing model farms in Chudzom under Sarpang and Lull under Wangdue dzongkhag has also been strengthened. Model organic villages are established as an approach to promote organic farming

3 SUPPORT SERVICES

3.1 Farm Mechanisation

3.1.1 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.

Design, Fabrication & Demonstration of Bed & Mulching Machines

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.

Figure 10. Bed-making and mulch laying

Design & Fabrication of buckwheat de-husking machine

Buckwheat is becoming popular because of its considerable health benefits. Normally buckwheat is milled directly which is not attractive for commercial purposes and consumption. AMC is in the process of testing and evaluating existing AMC made buckwheat de-husking machine and Japanese impeller type rice mill for de-husking buckwheat.

Testing for Standard and Certification

As in the previous FY, the AMC continued with the 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 centres tested 14 machines in the fiscal year 2020-21. Additionally, standard for portable brush-cutter has been endorsed.

Figure 11. Lab test (l), field test (c) and certificate of compliance (r)

3.1.2 Developments

Capacity Building

The AMC's Training Section completed capacity development programs for various stakeholders to help them enhance their technical knowledge as well as encourage individuals in taking up mechanized farming. A series of training programs were conducted for 884 participants that include farmers, private entrepreneurs and CNR students (see Figure 12).

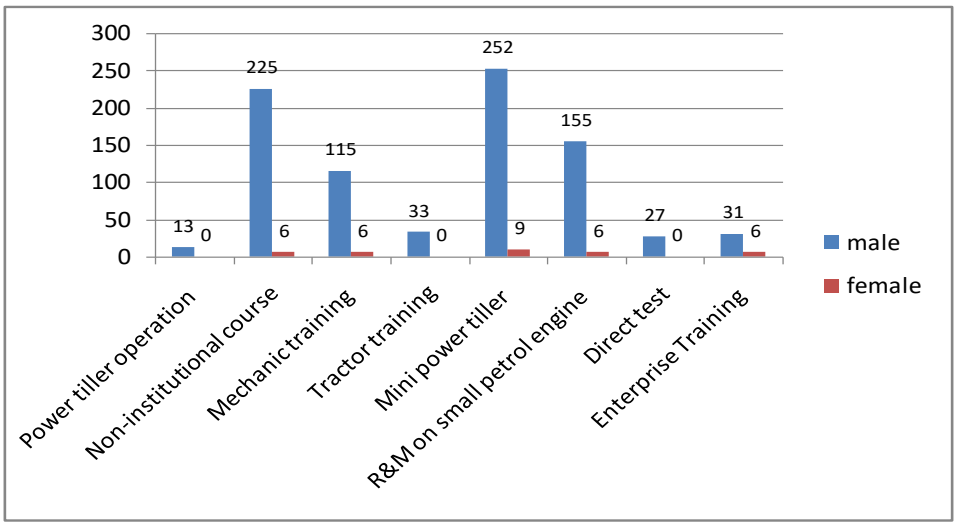


Figure 12. Training of various stakeholders in farm machinery

3.2 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:

3.2.1 Research

Inventory of Botanicals with Pesticidal Properties

The centre conducted surveys to identify botanical plants with pesticidal properties in the country for organic agriculture and also to document spatial and temporal distribution of botanical plant species in the country. An a-priori list of botanical plants with the pesticidal properties were used when conducting field surveys in randomly selected survey sites in Dagana, Tsirang, Chhukha with the last batch for Wangdue, Gasa and Punakha. The field survey recorded and inventoried 21 species of botanicals, belonging to 13 different families. Species belonging to *Asteraceae* (*Compositae*) recorded the highest entries with six species followed by three species in the Lamiaceae (mint) family.

Trial on Portable Electric Fencing

The NPPC in collaboration with the Bumthang Dzongkhag Agriculture Sector, the National Highland Research and Development Center (NHRDC), the National Research and Development Center for Animal Nutrition (NRCAN), the Phrumsengla National Park and the Wangchuck Centennial National Park with fund support of the National Organic Flagship Program established two pilot portable electric fences in Tsakorthang, Choekhor Geog earlier this year. The two pilot sites were established to study the appropriateness (design) and feasibility of installing portable electric fence where round the year crop guarding is not required; to evaluate the shelf life of poly wires and Mild Steel (MS) flat posts and ring insulators; and to examine the efficacy of LX-6122 energizer which is smaller in size and cheaper in price than the ones currently used. Farming paddocks of the Green Commercial Farm and Tsakorthang Tshesay Duetshen were selected for the study. Bye-laws/agreement with the beneficiary farmers were developed to ensure accountability in managing and maintaining the electric fence. Observational data will be collected and due inferences made in the ensuing year.

Figure 13. Portable electric fence installed at the pilot site in Bumthang

Bioacoustics Trial against Wild Animals

As a part of technology development for crop protection, the centre in collaboration with ARDC-Wengkhar, trialed two locally modified bioacoustics devices to protect crops from primates. The device contained pre-recorded unspecified sound of different preys and predators to repel primates from cultivated fields, with provisions for auto and manual control modes. The auto mode has on-off preset schedule that can be connected through its WiFi system to a smart phone for operation based on the likelihood of primate's visits for foraging crops. These trial sites in two locations: Wokuna, Kabesa Geog, Punakha and Arikha, Chapcha Geog, Chhukha were selected during the National Electric Fence Impact Assessment Survey 2020 when primates - Assam maquac (*Macacaassamensis*) and Gray Langur (*Semnopithecus entellus)* were reported as very serious pests in Wokuna and Ari areas respectively.

Figure 14. Bioacoustics device (Left) and scheduled time for the bioacoustics system (Right)

Farmers reported that the device is not effective against monkeys, but repelled sambar deer from damaging chili, vegetables, paddy seedlings and winter wheat. Further work to improve the prerecorded sound has to be explored in the next season. After the installation of bioacoustics device, farmers observed that Grey langurs were avoiding the area, but were foraging in nearby fields located about 200 metres away.

Evaluation of Bio pesticides and Botanical Extracts against major Insect Pests of Cole crops

As part of the study undertaken since 2019-2020 at the National Centre for Organic Agriculture (NCOA), effectiveness of a range of bio pesticides and botanicals against major insect pests of cabbage, cauliflower and broccoli were evaluated. Five treatments (neem oil, Jholmol, artemisia extract, *Bacillus thuringiensis* and a control) were assessed in addition to data collection on population dynamics of insect pests and beneficial insects as a comparison between organic and conventional farms located in Yusipang and Bjimina. Preliminary results on population dynamics of insects pests from the study are highlighted below.

- **Cauliflower**

In Bjimina (66%) as well as Yusipang (88), the major insect pests observed in cauliflower were aphids. The second major insect pest was looper in Yusipang comprising 20.7% of the total samples observed while DBM was the second largest pest comprising 6.6% of the total insect samples observed in Bjimina. In Yusipang, major beneficial insects observed in cauliflower were spiders followed by a range of hymenopteran parasitoids. In contrast, mostly syrphids were observed as the primary predators in Bjimina. Unlike in Yusipang, no coccinellid activities were observed in Bjimina.

- **Cabbage**

Aphids were observed to be the major insect pest in Yusipang as well as in Bjimina on cabbage. This was followed by semi-looper in Yusipang. Syrphids were the major natural enemies found in cabbage followed by spiders. Higher populations of syrphids and spider were observed in Bjimina as compared to Yusipang, but the number of parasitoids and coccinellids were found to be higher in Yusipang.

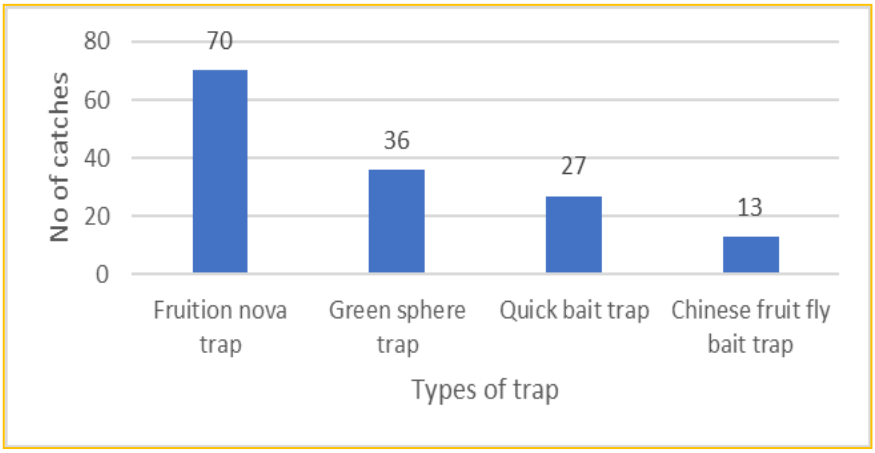
- **Broccoli**

Aphids were the major insect pest observed in broccoli in Bjimina as well as in Yusipang, followed by semilooper. Higher level of aphid infestation was observed in Yusipang than in Bjimina. Syrphids were observed to be the major beneficial insect in broccoli with higher population in Yusipang. The second most abundant natural enemies were observed to be spiders. Coccinellids were only observed in Yusipang

Evaluation of efficacy of different traps against Chinese citrus fruit fly (Bactrocera minax)

A trial is underway to evaluate the effectiveness of fruition nova traps, a female fruit fly trap manufactured by AgNova Technologies Pvt Ltd, a company based in Australia. Such traps have not hitherto been evaluated against *B. minax*. Other visual and

olfactory traps such as the use of green spheres that mimic citrus fruits and a locally made food lure along with a commercially available Chinese fruit fly bait are also being evaluated. The trial is being conducted in a large block of citrus orchards at Rimchhu, Goenshari Geog (Punakha). Preliminary results show highest number of *B. minax* being trapped on fruition nova traps followed by green sphere traps. The Chinese fruit flies bait trap ensnared the lowest number of flies.



Bio-assays on Trichoderma sp. against Phytophthora capsici

In the previous years, the NPPC has isolated eight native isolates of *Trichoderma sp.* The current study evaluated the efficacy of *Trichoderma* isolate Tc7a against *P. capsici* and compared its efficacy to that of *Trichoderma viride* obtained from Pest Control India (PCI) and Thailand under laboratory and greenhouse conditions.Isolates of *P. capsici* and isolates of *Trichoderma* sp. collected from Thimphu were used for both laboratory and greenhouse study along with isolates of *Trichoderma* from PCI and Thailand, and the fungicide, Ridomil. Laboratory assessment showed that all isolates of *Trichoderma* sp. had inhibitory effect on the growth of *P. capsici* regardless of their place of origin. However, fungicide maintained 100% inhibition against growth of the pathogen. Both the laboratory and greenhouse studies indicate suppression of *P. capsici*. Yet, growth inhibition rarely exceeded 70% in the laboratory, and disease severity reduction was rarely observed below 20% under greenhouse condition at 28 DAT. The results indicate that the isolate Tc7a and the imported *Trichoderma sp.* have potential against *P. capsici* isolate T12Aa and may be used as soil amendment in combination with other cultural

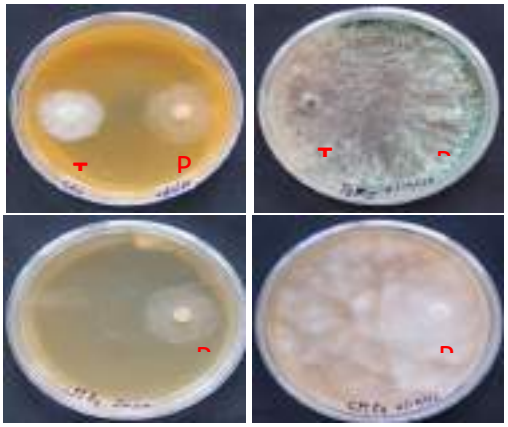


Figure 15. Effect of *Trichoderma* sp. on radial growth of *P. capsici* in the laboratory: dual culture of *Trichoderma* (T) and *P. capsici* (P), and *P. capsici* alone (P) at 1 day (below)

practices rather than as a stand-alone control option

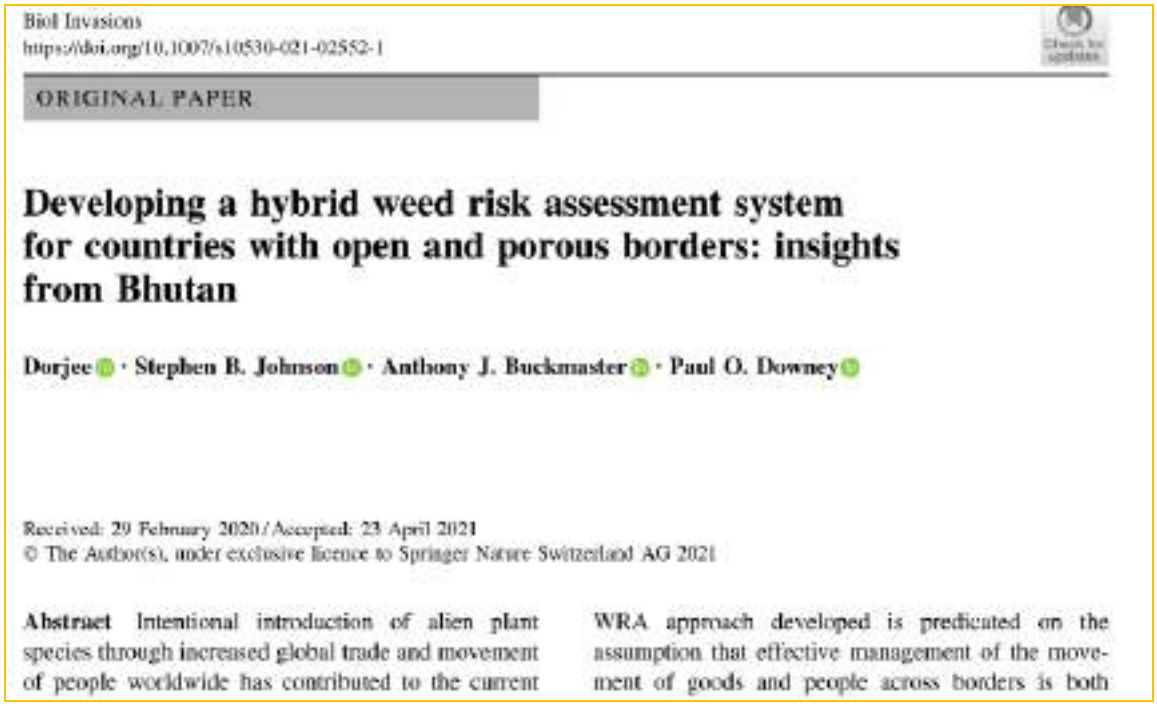
Figure 16. Evaluation of isolates of *Trichoderma* sp. against *P. capsici* under greenhouse condition: Plant inoculated with *Trichoderma* alone (left), *Trichoderma* with pathogen (middle) and with *P. capsici* alone (right) at 7 weeks of inoculation

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. Since then, the NPPC has tested four batches of samples comprising different varieties. The 5th batch test conducted in 2020-2021 cleared 28 varieties for mass propagation, making the cumulative count of samples tested to date as 653.

Knowledge Management – International Publication

The department takes immense pride in acknowledging the publication of two journal articles from the NPPC in highly accredited Biological Invasions journal in this reporting period. The first paper titled "*Weeds in the land of Gross National Happiness: knowing what to manage by creating a baseline alien plant inventory for Bhutan*" is the most comprehensive to date and sets the initial pre- and post-modern economic development baseline of alien plants in the country. This foundational database is the basis on which other important aspects of alien plant distribution, movement pathways, research and management can be gradually built upon. It helps identify the rising global threat from introduced alien plants, as well as set a benchmark for biodiversity conservation in this Eastern Himalayan biological hotspot.



Biol Invasions
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ORIGINAL PAPER

Developing a hybrid weed risk assessment system for countries with open and porous borders: insights from Bhutan

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Abstract Intentional introduction of alien plant species through increased global trade and movement of people worldwide has contributed to the current

WRA approach developed is predicated on the assumption that effective management of the movement of goods and people across borders is both

The second paper, "*Developing a hybrid weed risk assessment system for countries with open and porous borders: insights from Bhutan*," provides guidance for the development and adoption of risk-based management of alien plant species in countries with open and porous borders. The outcome of this should significantly improve alien species management outcomes and addresses shortcomings of the current systems. The development and evaluation of this formalised hybrid approach using Bhutan as a case study will ensure that this approach can be applied in other countries with open and porous borders.

Fall Armyworm (FAW) Monitoring

Fall armyworm was detected and identified for the first time in 2019 from Punakha. Since then, the pest has been reported from other parts of the country, mostly in maize. Being a new pest in the country its activity and population dynamics in different agro-ecological zones and crops in the country has to be monitored. Pheromone lures and traps in 19 different sites across the country were used to collect data which suggest that the strain present in Bhutan largely prefers to feed on maize as no FAW have so far been detected from traps deployed in paddy – thus aligning with the report that molecularly characterized the species detected in the country as 'maize strain'. Trapping data suggest that FAW population in the warmer belts of central and southern regions such as Wangdue and Sarpang might fluctuate and correlate with the availability of suitable host crop species. FAW is a native to the tropics and current data also indicate their propensity in warmer belts across Bhutan. No FAW were detected across cooler-temperate regions to date.

Figure 17. Monitoring FAW in paddy and maize

3.2.2 Developments

Pest Surveillance

As part of its regular annual services, the NPPC carried out pest surveys and surveillance across the country on major crops to record and help farmers' make appropriate and timely decision on management of important insect pests and diseases. Some of them, in gist, include:

a) Leaf Hoppers in Paddy

There is a dearth of information on hopper species complex infesting paddy and their population dynamics in the country. Therefore, major hopper species infesting rice crops are being identified and their population dynamics being studied in rice growing areas located in Chuzergang and ARDC Samtenling in Sarpang. Light traps were designed and deployed.

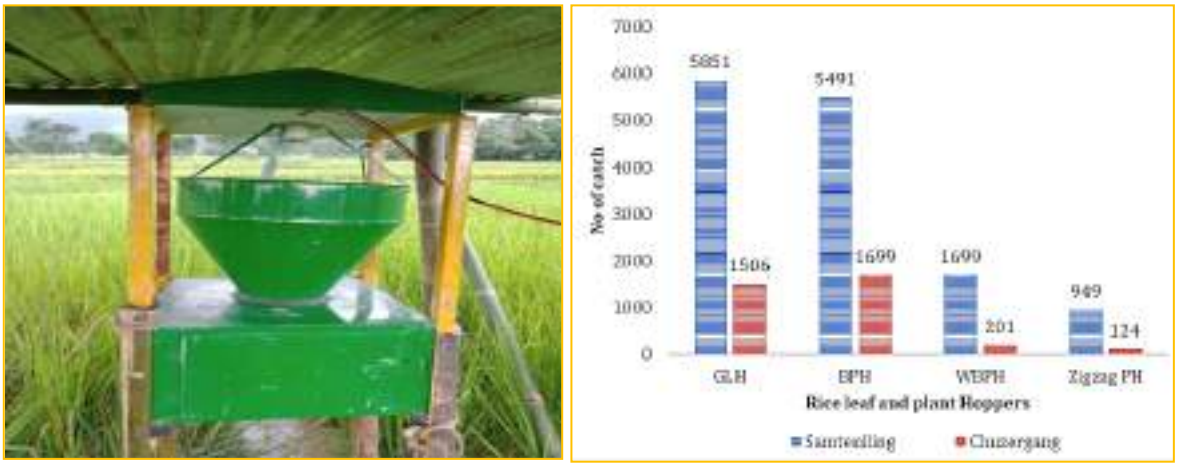

Figure 18. Light trap used for trapping rice leaf and plant hoppers in rice fields in Samtenling, Sarpang (L), and major hopper species observed in the ARDC Samtenling and Chuzergang (R)

Green leaf hoppers (GLH) and the brown plant hoppers (BPH) were observed to be the major hopper pest species in both Chuzergang and ARDC, Samtenling. In ARDC Samtenling green leafhoppers was the major pest species observed followed by brown plant hoppers. In Chuzergang BPH was the major hopper species observed followed by GLH.The Hopper population was higher in Samtenling compared to Chuzergang. Very low population of white back planthopper (WBPH) and zigzag plant hopper was observed in both the study sites. The results obtained in this study suggests that the hopper population build up and activity can greatly vary between location and hopper species

b) Rust in Wheat

Wheat rust survey as a regular activity is conducted every year by the NPPC in collaboration with the ARDCs and the extension agents. The activity is also a part of the global wheat rust monitoring system wherein rust outbreaks and possible development of new rust races are monitored. Monitoring survey was conducted in the selected geogs of Trongsa, Punakha, Thimphu and Paro dzongkhag.

Overall, the rust disease (both yellow rust and brown rust) is recorded from all the regions in Trongsa, Paro, Thimphu and Punakha visited during the survey. However, the incidence and severity varied among the regions. While only yellow rust as recorded in Thimphu regions, the barberry plant which is suspected to be the alternate host of the wheat rust is abundantly present in almost all the sites where the wheat crops are cultivated. Yet, the rust pustules (aciospores) were not observed from any of the sites.

Development of Bylaws for Electric Fencing Management

It was observed during the National Electric Fencing Impact Assessment survey (2020) that community vis-à-vis beneficiaries were not taking ownership and accountability to manage electric fencing supported by the government and projects. Farmer's apathy towards free support and the negligence of electric fences have resulted in damage of GI wires, fence posts, energisers and earth systems. Although section 5.10 in the EF implementation guideline under Roles and Responsibilities recommends establishing by-laws by beneficiaries, only about 25% electric fencing groups had bylaws and they too were mostly non-functional. With funs support from Bhutan for Life eight groups were formed in Bumthang and Gasa dzongkhags covering 141 households where 22 bylaws were developed. Salient features incorporated in the bylaws include taking ownership and accountability of electric fencing management and maintenance by the group; provisions to resolve conflicts among group members; sanctions for the failure to abide by bylaws; terms of references of key posts in the group; membership fee collection for maintenance and repair of electric fence.

Capacity Development – Training of Trainers & Establishment of New Electric Fences

The plant protection focal officials based at the Agriculture Research and Development Centre, Wengkhar through the financial support of the National Organic Flagship Programme conducted a three-day Training of Trainers (ToT) on electric fencing in Lhuentse Dzongkhag. A total of 21 participants including geog and forestry officials as well as a focal from the Tarayana Foundation attended the program. The training included both the theory as well as hands-on practical session to identify and rectify EF line defaults.

The centre also trained with 27 households in Chokhor, Bumthang on EF installation and management as well as trouble shooting, diagnostic and repair of electric fence components. They are now expected to be able to repair and resolve minor faults in the fences themselves. The EF was established with help from the department and covers around 27 acres of land.

National Electric Fencing Data Management & Electric Fencing Monitoring

The Department of Agriculture is required to maintain data on electric fencing and regularly collects the annual data on electric fences installed in dzongkhags. In the 2020-21 financial year, a total of 765.63 km electric fence was installed in the country, which is expected to protect 5,223.77 acres of agricultural fields from wild animals.

The DoA alone supported the installation of 32-kilometer electric fencing (EF) in five dzongkhags of Bumthang, Chhukha, Punakha, Wangdue and Sarpang through the support of the National Organic Flagship Program (NOFP). This support in these five dzongkhags is expected to minimize crop loss and motivate farmers to increase the area under organic crop and vegetable production.

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 insecticide, fungicide, herbicides, nontoxic PP products and rodenticides. About 4.2 MT of PP products and more than 400 MT of Butachlor 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 diseases issues. It also includes laboratory diagnostics.

3.3 Post-Harvest Program

3.3.1 Research

Evaluation of Curing & Storage Method and Quality Changes in Areca nut

Since there are no proper curing and storage methods for areca nuts in Bhutan, a study was initiated to determine appropriate methods to cure and store areca nuts and assess their effects on nut quality. From the different treatments assessed, areca nuts buried in pit enclosed in polyethylene bags had the least weight loss during the curing and storage period. This method also recorded the lowest rate of rotting and sprouting in nuts compared nuts compared to other treatment samples. Areca nuts enclosed in polyethylene bags and buried in pits of 1.5 m deep and 1 m wide is found to be the best method to cure and store areca nuts among the treatments evaluated based on its ability to retain the best quality, and prevent spoilage and sprouting.

Clarification of Apple Juice Using Enzymes

One of the key challenges in processing apple juice is obtaining good juice yield and attaining stable clarification after juice extraction. Enzyme effects were studied on juice extraction yield and clarification stability. Maceration enzyme pectinase at 0.02%, amylase at 0.02% and combination of both at 0.01% each were added to crushed apple juice prior to juice extraction. Incubation parameters such as temperature and time of incubation were also studied. Results show that juice recovery percentage of crushed apples treated with the combination of enzymes incubated at 40^0C for 24 hours were highest followed by ones treated with amylase and pectinase while control had the lowest yield recovery. All the sample treated with enzymes gave higher clarity measurements except for that treated with amylase. One of the recommendations would

be to add the mix of enzymes prior to juice pressing and incubate at higher temperature and longer duration to obtain the best clarification result.

Efficiency assessment of NPHC designed onion curing-cum-storage Structure.

The National Post Harvest Centre (NPHC) has developed a low-cost environment-friendly onion curing and storage structure essential for small-scale farmers taking up commercial onion farming. Storage losses in these structures were assessed for two years in two sites in Pema Gatshel across different altitude. Onions were cured for a month and stored for five months in the structure. Results indicate that onions could be stored up to 5 months with minimal damages excluding a one month required for curing. Temperatures inside the structure were recorded between 28°C to 31°C which was ±1°C lower than the recorded ambient temperature.

Reducing Jaggery Processing Time

Processing of jaggery from sugarcane syrup usually takes 8 hours – a time consuming process. A study was conducted in Pema Gatshel to look into options in reducing the processing time by replacing the traditional processing method. The improved method includes boiling of sugarcane using steam jacketed heater for processing of jaggery. It is found that jaggery processing in steam jacketed heater reduces the time to 4 hours.

Product Development

A number of products have been developed by the National Post Harvest Centre (NPHC) to help value-add and diversify farm products. In the past year, the centre, along with its food processing plants in Dagapela, Goling, Lingmethang and Shumar developed several products on trial. Some of the processed products developed include candy, pickles, powders, wine, tea, starches, flour, cookies, cakes, doughnuts, sweets, biscotti, noodles, sauce, dehydrated products, kimchi, breakfast cereals, etc.

3.3.2 Developments

Transfer of Post-production Technologies

Simple and effective postproduction technologies developed by the centre were disseminated in different parts of the country on need basis. The following technologies were established in collaboration with various stakeholder and funding agencies:

Table 16.Post-production technologies disseminated

Technology	Place	No	Remarks
Onion curing & storage shed	Chukha, Dagana, Gasa, Mongar, Pema Gatshel, Punakha, Samtse, Sarpang, Tashigang, Tashi Yangste, Tsirang, Trongsa, Wangdue, Zhemgang	64	RGOB and projects in collaborations with Dzongkhag
Electric dryer	Bumthang, Dagana, Mongar, Paro, Samtse, Sarpang, Tashi Yangste, Thimphu, Zhemgang	35	NOFP, RDCCP and Dzongkhags
Cardamom dryer	Nangkor, Zhemgang	1	In collaboration with Dzongkhag

3.4 Seeds and Plants Development Program

3.4.1 Developments

Amidst the constraints posed by the Covid 19 pandemic, the National Seed Centre (NSC) was able to achieve most of its target for the reporting year 2020-21. Sales volumes saw an increase as a direct result of the Department of Agriculture's mass vegetable production drive initiated as part of the nation's response to the Covid- 19 pandemic. Gross revenue for the reporting year stood at Nu. 268.68 million – inclusive of revenue generated from sale of seeds and seedlings and chemical fertilizers.

Seeds Production and Supply

Contributing to increasing production for food security, the NSC supplied a total of 474.15 MT seeds worth Nu. 154,998,783.41 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 (see Table 17).

Table 17. Seeds supplied and revenue generated from the sales in 2020-21

Sl. No	Commodity	Type/Variety	Annual Targets (Kgs)	Annual Achievement (Kgs)	Amount (Nu.)
1	VEGETABLE SEEDS	All types	15,000	18,740.82	128,975,605.59
2	CEREALS SEEDS	Paddy, Maize, Wheat	160,000	174,348.90	16,338,020.10
3	OILSEEDS	Mustard, Soybean	8,000	14,930.00	1,518,471.18
4	SEED POTATOES	Desiree, NKK, YM	236,000	266,136.00	8,166,686.54
		Total	419,000	474,155.72	154,998,783.41

Seedling production & Supply

A total of 267,127 numbers (Nu. 8,894,580 worth) of assorted high quality and released varieties of temperate, sub-tropical fruit plants, Citrus, asparagus and strawberry seedlings were produced and supplied to the farmers as per the annual demand towards enhancing horticulture production. The supply quantity as compared to the past year has decreased mainly due to low demand of asparagus seedlings. The supply trend for other fruit plants has remained the same. The centre supplied around 35,928 citrus seedlings from Jachedphu farm.

Figure 19. Citrus seedling production (Jachedphu farm)

Table 18. Seedlings supplied and revenue generated from the sales in 2020-21

Commodities	Type/variety	Annual Targets (Nos)	Annual Achievement (Nos)	Amount (Nu.)
TEMPERATE FRUIT PLANTS	All types	26,000	28,350	2,795,932.00
SUB-TROPICAL FRUIT PLANTS	All types	48,000	52,419	3,683,353.00
CITRUS SEEDLINGS	Dorokha Local Selection	36,000	35,928	1,796,400.00
ASPARAGUS SEEDLINGS	Merry Washington	10,000	146,995	587,980.00
STRAWBERRY SEEDLINGS	Sweet Charlie/Chandler	2600	3,435	30,915.00
	Sub-total	**122,600**	**267,127**	**8,894,580.00**

Service Delivery Facilities

With fund support from the EU-RDCCRP and the NOFP the centre carried out a number of important infrastructure development activities aimed at enhancing service delivery. These include infrastructure development at the NSC in Paro as well as its regional centres like automated polycarbonate greenhouse constructed at Jachedphu, land development work at Phobjikha to mechanize farming and to serve as a model farm, amongst many. A gist of these development is reflected in Table 19.

Table 19 Infrastructure development for service delivery

Sl.No	Activities	Fund	Approved budget (Nu in million)	Location	Status
1	Smart irrigation	RDCCRP/NOFP	10.728 (RDCCRP), 3.00 (NOFP)	RSC Chundudingkha and Bondey Farm	Completed
2	Revamp vegetables seed store (10MT) and cereal seed store (200 MT) at HQ	RDCCRP	3.45	NSC HQ Paro	Completed
3	Revamp 25 MT seed store at RSC Bajo	RDCCRP	1.22	RSC Bajo	Completed
4	Establishment of 60 MT cold room at RSC Samtenling	RDCCRP	3.14	RSC Samtenling	Completed
5	Fully automated polycarbonate greenhouse	RDDCRP	6.33	RSC Jachedphu	Completed
6	Land development	NSC	2.17	Phobjikha Farm B	22 acres

7	Construction of Wooden (Bacal) house	NSC	0.76	Nangsiphel Farm	Completed
	Grand Total		**30.80**		

Initiation of Organic Seed Production

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, 7.74 MT of organic seeds have been produced in the above RSGs areas and supplied to the dzongkhags, and another 6.80 MT organic seeds of beans, quinoa, buckwheat, chili, ginger and turmeric are certified under LOAS and packed as per organic standard exclusively for the launch program and supplied to designated organic sites. In order to enhance organic seed production of other crops as well as adopt a landscape model, seeds of other potential commodities like cauliflower, broccoli and beans be promoted in new areas and as per the interest of the growers.

Figure 20. Launch of organic seeds production (L) and organic seeds (R)

Capacity Development

In view of the increasing vulnerability of agriculture system to the effects of climate change, it is important to promote and safeguard traditional crops that are more tolerant to changing climate. The National Seed Centre (NSC) through the fund support from the Green Climate Fund (GCF) project promoted community seed production system for traditional seeds to diversify climate resilient crops. The 6-year project support began in 2020. For this reporting period the centre trained 535 farmers in six dzongkhags (Punakha, Wangdue, Trongsa, Dagana, Tsirang and Sarpang) on seed production technology of paddy, wheat, beans, cauliflower, broccoli, ginger, turmeric

and mustard with emphasis on organic methods. A first of its kind, such programs will greatly benefit seed growers in upgrading their skills and knowledge on seed production as well as help drive home the importance of traditional varieties, their conservation and their significance in promoting food self-sufficiency and security.

Figure 21. Farmers training on community seed multiplication and management in Wangdue

The trained communities are registered with NSC and will produce seeds of the above commodities and supply to NSC on a buy back mode. This mechanism will build up good linkage and a sustained seed production scheme.

3.5 Soil Services Program

3.5.1 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:

Evaluation of microbial nutrient management in rice production

The aquabiota which contains microbe selected amongst 200 strains specific for the benefit of the plant growth were evaluated in high and mid altitude rice varieties. Five treatments including control, aquabiota, EM solution, Biochar and bio-fertilizer (*Azotobacter spp.*) were used in the study. The first-year result revealed that the aquabiota treatment had a consistent high value of grain yield to biological yield ratio regardless of plant height, flag leaf length, number of tillers per hill, and panicle length. The grain yield was significantly higher in high altitude rice but non-significant in mid altitude rice. The research was carried out in collaboration with ARDC-Yusipang, Bajo and Wengkhar. The study will be repeated for another year.

Figure 22. Aquabiota application in research plots

Evaluation of silicon fillers in rice production

Silicon (Si) fillers are natural element and silicon-based fertilizers are often used by farmers to reduce the excessive use of chemical fertilizers. A study was conducted to evaluate the use of silicon fillers in rice production in different treatment combination with NPK fertilizers viz. control (0), NPK + silicon (100 +0), NPK + silicon (50 +50), NPK + silicon (25 +75) and NPK + silicon (0 +100). The first-year study revealed that the 75% Si treatment recorded the maximum grain yield followed by NPK fertilizers (refer Table 20). The study was carried out in collaboration with the ARDCs-Yusipang, Bajo and Wengkhar. The study will be repeated for another year.

Table 20. Comparison of grain yield between NPK fertilizers, combined doses of NPK fertilizer with Si fillers on grain yield of rice

Treatments	Grain yield (kg/ha)	Difference
NPK	3680.43	
50% NPK + 50% Si	3288.91	- 391.5167
25% NPK + 75% Si	4829.61	+1149.183
Si fillers	2983.40	- 697.033

Soil Survey and Land Evaluation

The Soil Survey Program (SSP) carried out soil survey of reconnaissance scale in Haa, Mongar, Paro, Pema Gatshel, Tashigang, Thimphu and Tsirang Dzongkhags. The survey collected baseline soil data from the cultivated areas through systematic soil descriptions and classifications covering a total of 296 profile points (see Figure 23).

With the above seven dzongkhags, the centre has now completed reconnaissance soil survey in 13 dzongkhags. The overall target is to produce Bhutan Soil Map and Information for cultivated land by the year 2023.

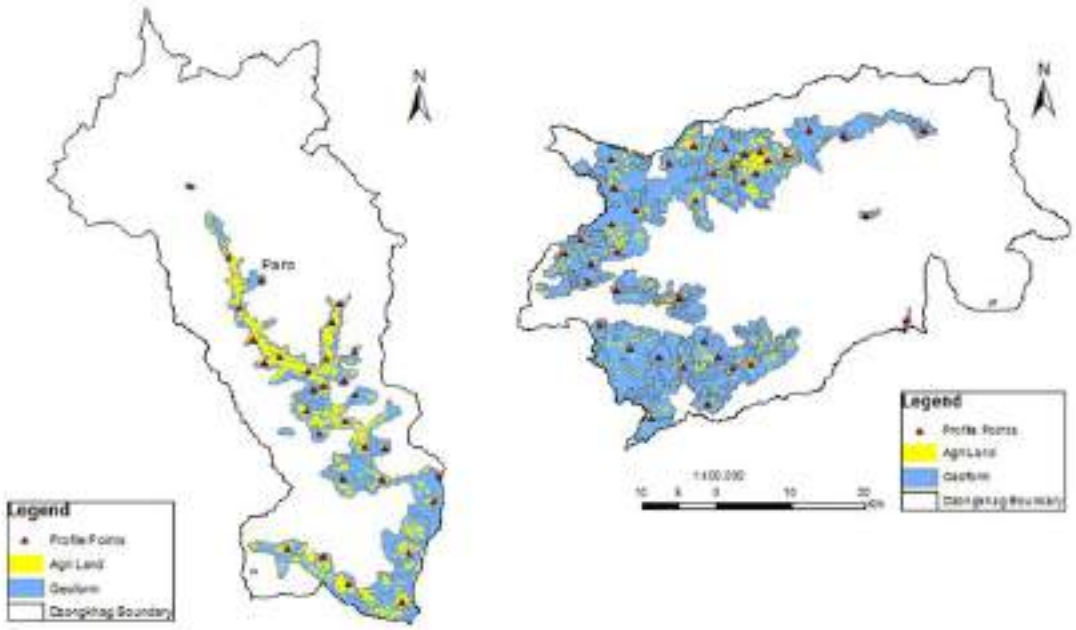

Figure 23. Profile points in two Dzongkhags – Paro (L) and Trashigang (R)

Similarly, a detailed soil survey was conducted at Gyalsuung site at Puili and Deklai under Pemathang Geog, Samdrup Jongkhar Dzongkhag and Rural Development Training Centre (RDTC) site in Zhemgang to map the soil and assess the potential of the sites for agriculture farming by using Land Capability Classification - a rational and systematic method of determining the ability of the land to sustain a range of specified uses without causing significant long-term degradation. A total of 13 sites were examined through profile pits in Samdrup Jongkhar and 10 sites in Zhemgang.

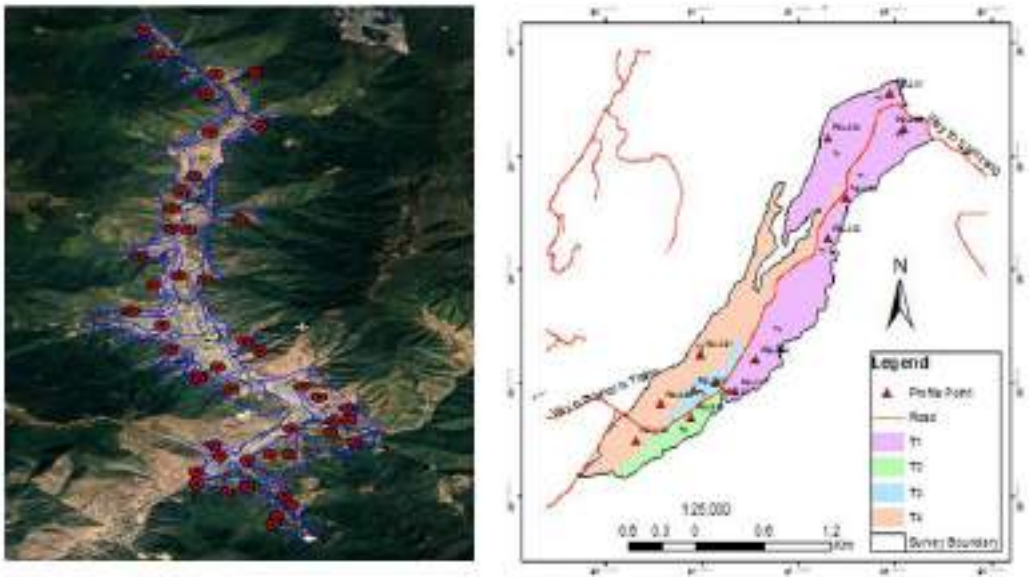

Figure 24. Location of soil profile distributions in Thimphu Thromde (Left) and at Gyalsuung site in Samdrup Jongkhar Dzongkhag

Furthermore, the Centre in collaboration with the Ministry of Work and Human Settlement (MoWHS) carried out a detailed soil survey in Thimphu Thromde and its peripheral areas with an attempt to generate soil information and map for use in the revision of Thimphu Structure Plan (2002-2027). In total 46 soil profiles were examined and soil samples were collected to determine soil chemical properties.

3.5.2 Developments

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

Soil Investigation

Following the request from the Military Training Centre (MTC), Tencholing in Wangdue, the NSSC undertook land degradation assessment along the road leading to Desuung Training Centre above the MTC. Similarly, based on the request from the Department of Culture, Ministry of Home and Cultural Affairs (MoHCA), the centre performed a study on varved silt and clay deposits site at Sona Gasa in Punakha (see Figure 25).

The soil investigation at Tencholing focused on assessment of the land degradation and coming up with recommendation to protect the exposed slopes while at Sona Gasa the study looked at uneven distribution of featured red-colored clay, discontinuous layers of manganese stains, irregular iron pan, silt deposits in certain pockets of the area, decayed wood, charcoal and fragments of varve deposits embedded within the exposed substratum. The findings showed that the massive structure of buried soil materials without stratification and their mixed occurrence with blocks and fragments of varved deposits, the genesis of the massive deposits of red clay and white silt at Sona Gasa could be due to glaciation events.

Figure 25. a) Red clay and white silt deposits; b) Scapolite without stratification with blocks and fragments of varved deposits; c)Remnants of GLOF sediments

Other soil investigation activities for the reporting year include assessment of potential impact of mining activities on apple orchard in upper Gidaphu (Thimphu) and study into suitability of paddy cultivation on marshy land parcel in Nyamji village, Tsento Geog, Paro in collaboration with the Land Management section of the DoA.

Soil and Plant Analytical Services

Analysis of some 2,465 samples for testing of soil chemicals, soil physical, and plant, irrigation water, including compost samples were completed between 1 July 2020 and 2 May 2021 (Figure 26). 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 and the academia.

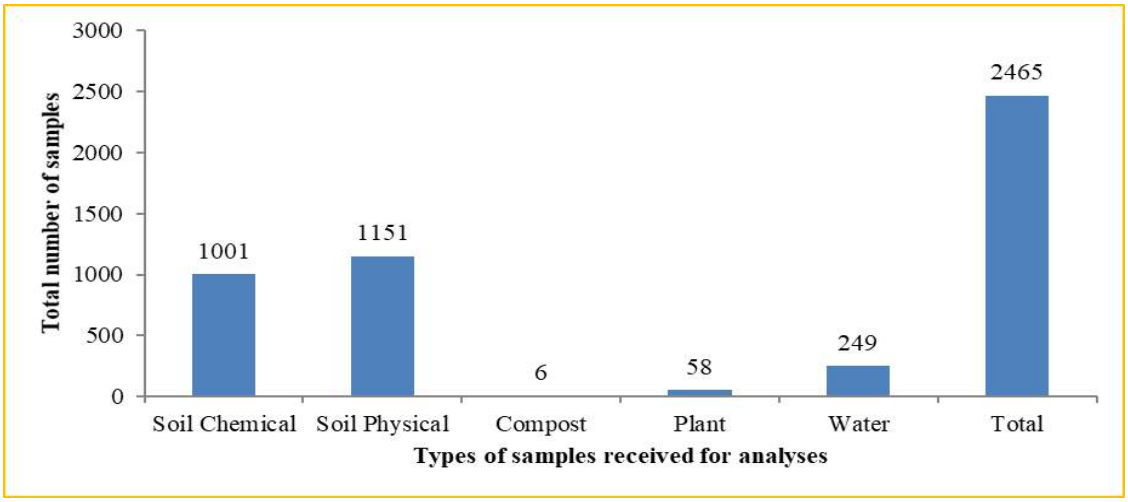

Figure 26. Types and number of samples received and analyzed

Organic Inputs & EM Solution Production, and Employment Generation

To support the National Organic Flagship Program (NOFP), the centre has been putting in efforts to increase organic inputs production and its promotion. To date the centre has engaged and supported 11 individuals in the production of vermi compost and EM compost and make them available to organic growers (refer Table 4 for details). These are in addition to the existing 10 commercial composting units being supported by the flagship program. In the reporting period the centre procured about 58 metric tons of locally available organic fertilizers worth Nu. 1.5 million, and distributed to Trongsa, Sarpang, Zhemgang, Wangdue, Gasa, Samtse, Chukha, Punakha and Thimphu dzongkhags. As targeted in the NOFP, to date 14 individuals are employed in various organic fertilizers production units.

About 5,500 litres of effective micro-organism (EM) solution and Bhutan Agri-Microbial Solution (BAMS) were supplied to farmers and schools across the country. The production of BAMS started at NSSC following hands-on training provided by the experts from ARDC Bajo. BAMS is similar to EM solution except that the inoculants used for EM are imported whereas for BAMS the inoculants are native.

Sustainable Land Management

With fund support from GCF, GEF-LDCF, CARLEP, FSAPP, NOFP, ECP 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. During the reporting period (FY 2020-21), about 1940 acres of agriculture land has been brought under ALD through terracing, terrace consolidation, orchard terracing and surface stone removal (see Table 21 and Figure 27 for details). Similarly, about 685 acres of vulnerable and degraded agriculture land has been brought under SLM through various interventions (see Table 22).

Table 21. Agriculture land development initiatives

Sl. No.	Agriculture land Development (ALD)	Progress FY 2020-2021 (Acre)	Remarks
1	Terracing (bench/dry-land)	1378.55	Carried out in all 20 Dzongkhags through different funding supports
2	Terrace consolidation	515.67	
3	Orchard terracing	16.35	
4	Surface stone removal	29.81	
	Total ALD progress	**1940.38**	

Table 22. SLM Initiatives

Sl. No.	Sustainable Land Management (SLM)	Area (acres)	Remarks
1	Contour hedgerow	497.62	
2	Contour stone bund		
3	Check dams	1	
4	Orchard establishment	4.5	
5	Landslide stabilization (plantation)	2	
6	Soil fertility improvement through legume seed support.	156.33	S/Jongkhar, Tashi Yangtsi, Dagana
7	Water source protection	23.9	
	Total area under SLM	**685.35**	

Figure 27. Dryland terracing at Namlaythang, Dagana (L) and Wangling, Trongsa (R)

Fallow Land Reversion

Although no separate budget has been allocated for fallow land reversion, since this is a priority activity in the 12FYP (2018-2023), efforts are being made to bring fallow land back to cultivation through various incentive packages supported by different projects. During the reporting period, about 698 acres of fallow land has been brought back to cultivation. The details of dzongkhag wise fallow land reversion, ALD and SLM for the reporting period (July 2020-June 2021) are summarized in Figure 28.

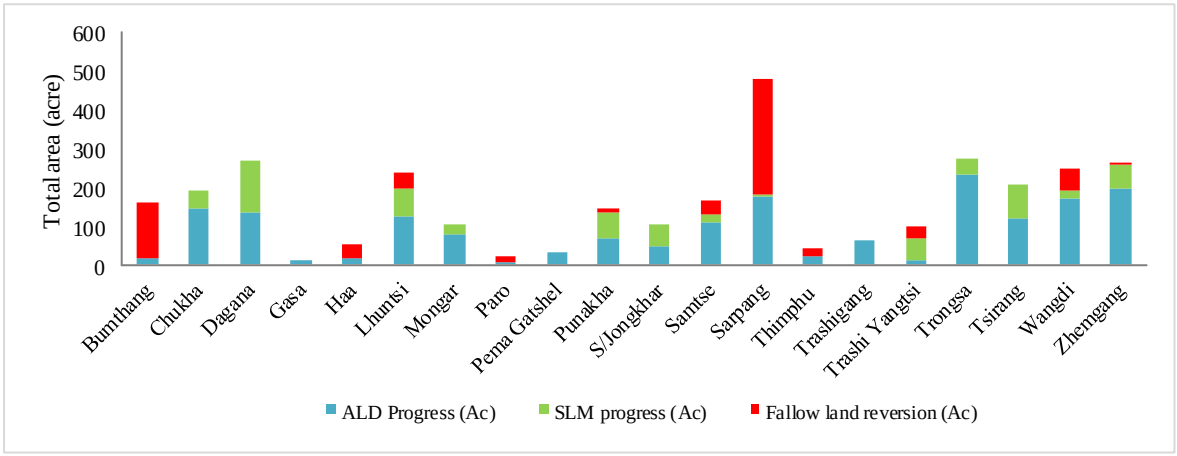

Figure 28. Dzongkhag wise fallow land reversion, ALD and SLM progress (FY2020-21)

Participatory SLM Action Planning

As part of the GCF Project, the centre carried out Participatory SLM Action Planning (AP) exercises at targeted SLM sites in eight project dzongkhags 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 i) to create awareness on GCF project, ii) to sensitize about the importance of SLM and ALD including different technologies, and iii) 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. The main output from this planning exercise is the SLM action plan that gives detailed SLM interventions to be carried out during the project period.


Land Conversion

Field analyses for the 34th batch of land conversion applicants were carried out in Dagana, Punakha, Tsirang, Trongsa, and Wangdue Phodrang dzongkhags in collaboration with the Land Management Section of the department. Of the 75 registered cass for land conversion from Chhuzhing to Kamzhing, only 61 cases were investigated. 14 cases were rejected on grounds of non-compliance with the land conversion guidelines and 15 cases were admitted for further review for conversion based on soil analytical perspective. The report is being forwarded to the land management committee meeting for further review and endorsement. A total of 212 cases (25 from Chhukha, 6 from Samdrup Jongkhar, 126 from Samtse and 65 from Sarpang Dzongkhags) were suspended due to COVID 19 pandemic situation.

3.6 Agromet Services Program

3.6.1 Development

Launch of ADSS

The Department of Agriculture formally launched the agromet decision support system (ADSS) on March 16, 2021. The ADSS which is a web portal to disseminate agro-advisories based on the weather forecast from the National Center for Hydrology and Meteorology (NCHM) was developed by the Regional Integrated Multi-Hazard Early Warning System (RIMES). The machine learning

platform will henceforth be operationalized to disseminate farm advisories not only in the pilot areas but across the country. The fund support for the system development including the ToT was supported by the Hydromet Services and Disaster Resilience Regional Project funded by the World Bank. A sensitization program on climate and weather services was also conducted for farmers in Shaba and Lungnyi geogs in Paro.

4 SCHOOL AGRICULTURE PROGRAM

The School Agriculture Program (SAP) is a collaboration between the Department of School Education, Ministry of Education (MoE) and the Ministry of Agriculture & Forests, and has been functional since 2000. The Ministry of Agriculture and Forests is the lead agency. The program now focuses on supplementing food and nutrition in school feeding program to help address shifting priorities.

Program Expansion and Production

The past year has been a very challenging year for the program with the closure of many schools due to the COVID19 pandemic. Several activities could not be taken up. Still, despite the constraints, eight new schools have been identified for expansion of SAP activities as follows.

Table 23. New addition of schools for SAP expansion

Sl	School	Dzongkhag
1	Chapcha PS	Chhukha
2	Pachu PS	Chhukha
3	Norbugang PS	Pema Gatshel
4	Khengzore PS	Pema Gatshel
5	Shali PS	Pema Gatshel
6	Garpawoong MSS	Samdrup Jongkhar
7	Tshaluna PS	Thimphu
8	ELC High School	Thimphu Thromde

Contribution to Food & Nutrition Security

The SAP currently supports 344 schools, contributing substantially to food production and nutrition security as well as the school revenue. In spite of the challenges posed by the pandemic, SAP supported schools still managed to produce 80 MT of fresh vegetables, 18 MT of meat and 40 MT of eggs (118, 308 nos). These productions come about as by-products of the learning process through the agricultural curriculum incorporated in the schools. However, schools are seeing a dip in the production with a decrease in financial support both from the government and the development partners. A growing attachment to religious views amongst students has also led to a decrease in the livestock production in schools.

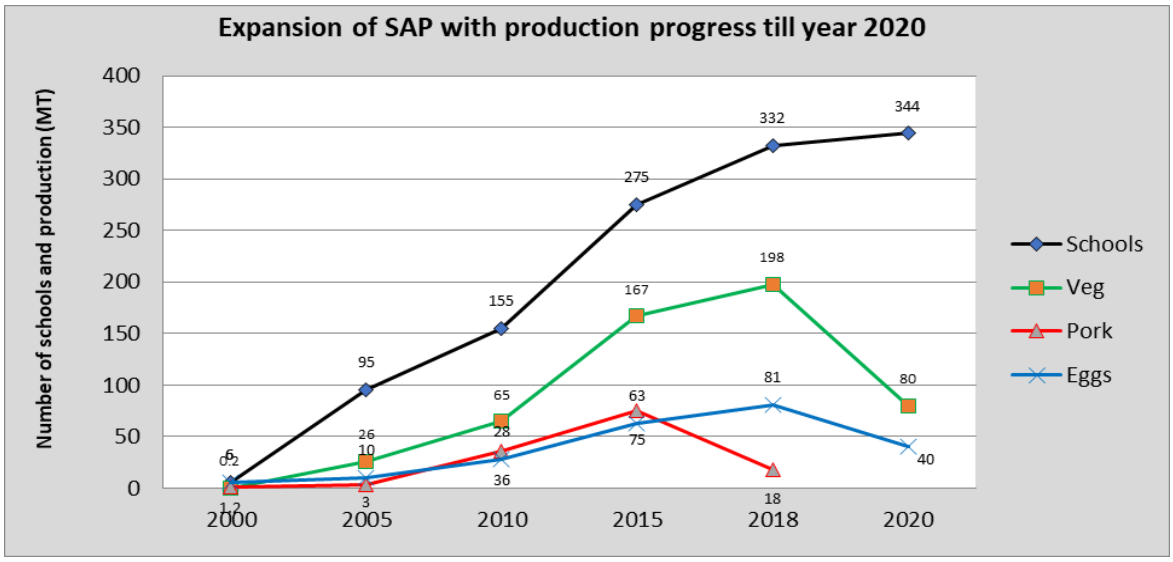

Figure 29. Food production by SAP schools (2020 – 21)

Focal Agriculture Teachers' Capacity Development

Bhutan joined 150 other UN nations on 16 October 2020 to observe the World Food Day with global theme "***"Grow, Nourish, Sustain Together. Our Actions are our Future".*** In keeping with existing Covid19 protocols, the program convened virtually from the Conference Hall of Ministry of Information and Communication (MoIC), and was graced Hon'ble Sanam Lyanpo as Chief Guest. Officials from UN House-Bhutan, MoAF, MoE and MoH attended the program .

As part of the celebration, and as is the annual feature of the day, the Annual SAP Award was announced for middle, higher and model schools. The program did not cover lower level of schools as they remained closed due to the pandemic. The cash prizes for the Best SAP Farm Award (see Table 24) were sponsored by World Food Programme (WFP)-Bhutan.

Table 24. Winners of the Best SAP Farm Award 2020

Category	Position	School	Dzongkhag	Cash Prize (Nu.)
1. Middle Secondary School Level	First	Yebilaptse Central School	Zhemgang	25,000
	Second	Yurung Central School	Pema Gatshel	15,000
	Third	Gesarling Central School	Dagana	10,000
2. Higher Secondary School Level	First	Bajo Higher Sec.School	Wangdue	25,000
	Second	Norbuling Central School	Sarpang	15,000
	Third	Yelchen Central School	Pema Gatshel	10,000
3. Model School Level	First	Zangkhar Primary School	Lhuentse	25,000
	Second	Damphu Central School	Tsirang	15,000
	Third	Genekha Lower Sec.School	Thimphu	10,000

Urban Agriculture

As part of the responses to COVID-19 pandemic, the SAP coordinated the implementation of the Urban and Peri Urban Agriculture programme laid off youths from the tourism and hospitality sectors with the financial assistance of FAO. The program was initiated in Thimphu, Punakha, Bumthang and Sarpang dzongkhags. A total of 493 youths were engaged in cultivating a little over 191 acres of vegetables that produced around 95 MT of fresh and organic vegetables. The initiative spent around Nu 3.171 million from the National Organic Flagship Programme (NOFP) and the WFP. JICA-Bhutan experts also provided technical support including inputs like organic fertilizer, viz, Bokashi and liquid fertilizers.

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Rice Fortification

The SAP has been coordinating the rice fortification initiative amongst relevant stakeholders like MOE, MoH, BAFRA, GNHC, FCBL, Bhutan Standard Bureau (BSB) and WFP since 2017. During the reporting period, 3 standards on plain rice (PR), fortified rice kernals (FRK) and fortified rice (FR) targeted for rice fortification have been drafted and approved by BSB as national standards. A rice fortification blending unit has been procured by FCBL for establishment at FCBL Phuentsholing.

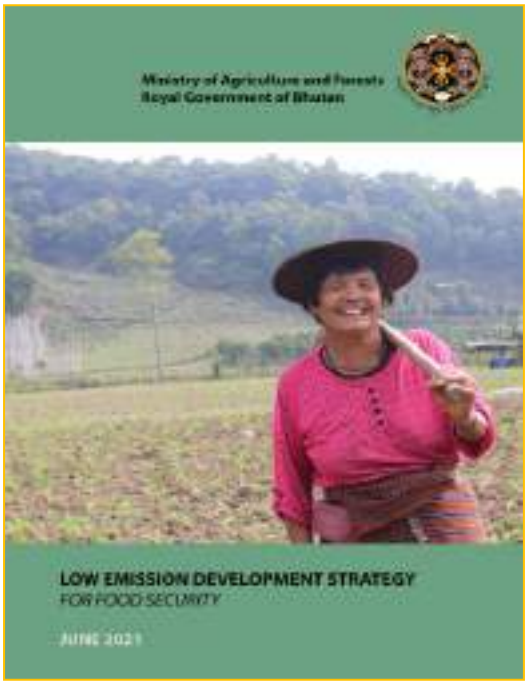
5 POLICY, STRATEGY AND KNOWLEDGE & INFO MANAGEMENT

5.1 Policies and Strategies

On a national and international level, the department actively participated either as lead or as part of the national core group of experts engaged in preparation and review of a number of policy and strategy documents. These documents form the basis of the nation's commitment to international obligation as well as serve as policy and strategic guides for implementation of action plans in various disciplines.

Low Emission Development Strategy

While GHG emissions from the agriculture and livestock sector is a significant contributor to the country's total national greenhouse gas emissions, the sector still remains the backbone of rural livelihood as well as an integral element in achieving food self-sufficiency and national self-reliance. In cognizance of the need to enhance food production while adhering to the country's carbon neutral commitment, the MoAF through the UNDP Climate Promise Program developed the "LEDS for Food Security." The DoA and the DoL formed the core expert groups who worked alongside international experts and the UNDP Bhutan team to put together priority action plans to



mitigate GHC emissions from the sector through short, medium and long-term targets.

Second Nationally Determined Contribution

Following the ratification of the Paris Agreement in September 2017, the Intended Nationally Determined Contribution (INDC) that Bhutan submitted back in 2015 became Bhutan's first Nationally Determined Contribution (NDC) that reaffirmed Bhutan's pledge to remain carbon neutral which was first made in 2009.

The department actively worked with other government agencies, stakeholder groups and private sector with support of the UNDP's Climate Promise in preparing the Second Nationally Determined Contribution (NDC) which was successfully completed in June 2021. The 2nd NDC maps Bhutan's continued pursuit of a low emission development strategy in keeping with the obligations of the Paris Agreement whilst taking forward our national development agenda.

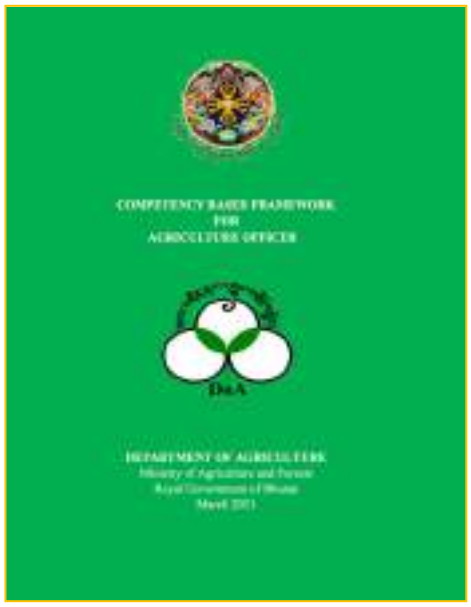
Additionally, in order to support the implementation of NDC, the Climate, Land, Energy and Water System (CLEWS) modeling on projection of resource utilization vis-à-vis sustainable production for self-sufficiency has been completed with preliminary findings. This will help examine the country's feasibility and potential in terms of implementations of programs committed as part of Bhutan's obligations to global climate actions.

Third National Communication

Along with other various working agencies – both governmental and civil society organizations – the DoA actively participated in developing the "Third National Communication to the UNFCCC". The document reports on the action taken by Bhutan to address adverse impacts on climate change, and is submitted to the United Nations Framework Convention on Climate Change (UNFCCC) as a requirement in addition to emission mitigation strategies.

Competency Based Framework for Agriculture Officer

As per the directives of the Royal Civil Service Commission (RCSC) the DoA developed the Competency Based Framework for Agriculture Officers. The framework that is developed following a series of consultation with stakeholders in addition to online surveys identify a total of 3 key roles, 9 competency areas, 27 key competencies and 81 behavioural indicators for agriculture officers – all programmed to improve leadership qualities and enhance workplace and behavioural competencies.



5.2 Knowledge & Information Management

Bhutanese Journal of Agriculture

The Department launched the fourth 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

Research Capacity Building

Ever since the department started the initiative in 2018, more than 110 researchers and agriculture officials have been trained on experimental design, data analyses and scientific paper writing. This is expected to equip agriculture professionals with the requisite knowledge and skills in designing, implementing and analysing research trials and in effectively communication their findings in peer-reviewed scientific journals.

Hydroponics Training Manuals and Desuung Skilling Program

To enhance skills of youth and interested entrepreneurs, a training manual on "Hydroponics Farming Technology- A Skilling Program" was developed by the department in coordination with ARDCs and Central Programs. Further, based on the MoU signed between the Desuung Skilling Office, the DoA trained the first batch of 31 Desuups for 15 days on hydroponics farming technology followed by 45 days post-training field engagement program on hydroponics at ARDC Bajo and ARDC Wengkhar.

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