ROYAL GOVERNMENT OF BHUTAN

Agriculture Research and Development Highlights 2018-2019

2019

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 2018-19. 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.

It is a result of concerted effort put in 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. The reporting format and the style of reporting allows 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 single synthesized summary for the department.

With best regards,

Kinlay Tshering (Ms)
DIRECTOR

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SUMMARY

- ✓ The Department continued its efforts in minimizing vegetable imports through its winter vegetable commercialization programs. In its second year, the winter chilli production program, covered a total of 1,317 households with cultivated area of 364.34 acres, and as of May 2019, the production is recorded at 2019.17 MT. Comparisons indicate an increase by 13.03% in the area under cultivation with a corresponding increase of 55.84% in total production in the 2018-19 seasons as against 2017-18.

- ✓ Continuing with its efforts into research and technology development, the Department of Agriculture released four heat tolerant cabbage (Asha and Bengal King) and cauliflower (White Express 50 and Pragati 40) varieties. This marks a significant outcome in the department's concerted effort in providing alternatives to conventional cabbage and cauliflower varieties as one of the adaptation strategies in response to rising temperature and demand for year-round consumption.

- ✓ The DoA also released a variety of ground apple (*Smallanthus sonchifolius*) under the local name "Yusi Yacon-1" based on the evaluations to date, as well as formally notified red kiwi "Enza Red" and green kiwi Hayward. Two pine apple varieties Kiew and Queen were also approved for formal notification.

- ✓ Following its introduction in 2015, and the official release of four varieties last year, the department has been aggressively promoting quinoa in all 20 dzongkhags, including processing and packaging options. From a production of 9 MT in 2017, the estimated quinoa production for 2018-19 stands at 37.16 MT. Over 683 teachers and 5,082 students in 19 schools and colleges also took part in awareness programs that sensitized on the nutritional benefits of quinoa.

- ✓ In keeping with emerging technologies and their significance in response to the climate change adaptation, enterprise development and youth farming, the department has started investing into research in intensive protected agriculture by setting up infrastructures like hydroponics. This is expected to facilitate research and demonstration on hi-tech resource effective farming system.

- ✓ Citrus mandarin still is one of the highest incomes earning horticultural produce for Bhutanese farmers with a revenue generation of Nu 355 million in the 2018-19 season. The department continued with a number of interventions to improve mandarin farming. More than 1,908 orchards in 7 dzongkhags were brought under improved canopy and orchard management approaches which also saw a total of 1,073 farmers being trained on improved orchard management practices.

- ✓ The government approved the department's National Organic Flagship Programme (NOFP), themed "Sustained livelihood through the commercialization of organic farming in the 12 FYP". The program with an outlay of Nu 1.0 billion shall focus on

commercialization of selected commodities as well as production of in-country bio inputs for enhanced organic farming.

- ✓ Providing impetus on legumes and oil crops, the DoA with support from the Bhutan Care Credits Limited (BCCL) under His Majesty's Secretariat and other partners brought about 30 acres in two rehabilitation communities in Lhuentse and Pemagatshel under soya bean production. The community in Pemagatshel also cultivated 20 acres of groundnuts. Additionally, a total of 70 acres in six eastern dzongkhags were brought under soya bean cultivation with an estimated production of 31.5 MT.

- ✓ The School Agriculture Program (SAP) presently supports 327 schools with coverage of 70%, contributing 23% of fresh vegetables and over 53% of livestock produce to the school feeding program. In the academic year 2018, 332 member schools produced a total of 198 MT of fresh green vegetables and potatoes while 24 schools running poultry programs produced a total of 14, 71,862 eggs, contributing to the school feeding program as well as generating funds to sustain their SAPs.

- ✓ The DoA was engaged in a total of 400 km farm roads construction and maintenance in FY 2018-19. Around 600 acres of farm land have been developed and rendered cultivable employing the department's farm machinery stationed at various locations across the country.

- ✓ In addressing unavailability of irrigation water for agricultural development, the DoA, in addition to technical backstopping completed five major irrigation schemes totaling 45.50 km in length, providing assured irrigation water to over 1,200 households covering a little over 1700 acres of paddy fields.

- ✓ The National Soil Service Centre (NSSC) successfully brought around 439 acres of land under several sustainable land management and stabilization interventions. The NSSC also analyzed some 4,056 soil, plant and water samples for a range of clients.

- ✓ Placing added emphasis on the primary importance of uniformity, safety, and validation, the Department launched the Bhutan Organic Guarantee System (BOS) including testing and successful development of standards for four farm machineries.

- ✓ The 5th Royal Bhutan Flower Exhibition (RBFE) was held at Samdrup Jongkhar from 21 to 27 February 2019. The DoA as the technical member of the RBFE is involved in the planning and development of the exhibition. The event this time produced and showcased over 40,000 ornamental plants of 16 different species.

- ✓ Several publications were brought out in the reporting period that include citrus canopy management guide, standard operating procedure for citrus nursery, chiraita cultivation manual, version 2 of the guide to fertilizer recommendation for major crops, five separate booklets of the "Bhutan Organic Guarantee Systems" series, and two separate technical

guides for mushroom spawn production and mushroom diseases in Bhutan. It also formulated and developed a strategic blue print for agriculture research in Bhutan - “Agriculture Research Strategy 2018-28”. The Department launched the second 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

Production Evaluation Trials

Production evaluation trials (PETs) of 97 lines of rice germplasm are on at ARDC-Bajo and ARDC-Tsirang to identify elite lines best suitable cultivars for specific agro-ecological zones. These lines are at various stages of their evaluation – observation nursery, initial and advance stages. Advanced evaluation trials were also carried out on two entries, YP/K-Y/B-20 and Chandannath 1 by ARDC-Yusipang with local check Janaam. The varieties differed significantly only in plant heights and shall be promoted for on-farm testing from next season.

Two local rice varieties popular and established in west Bhutan, *Tan Tshering* and *Nabja* were evaluated to provide additional choice for farmers in the eastern region. The evaluation trials in three districts of Lhuentse, Pemagatsel and Tashigang returned above national average yield of 1.6 MT per acre, with *Tan Tshering* recording the highest yield at 3.1 MT/acre in Tashigang. *Nabja* production was found highest in Lhuentse at 2.3 MT/acre. Farmer preference differed in the three districts. Tashigang farmers favoured *Tan Tshering* while Nabja was preferred in Pemagatshel. However, in Lhuentse farmers preferred both the varieties for better performance in terms of yield and disease resistance.

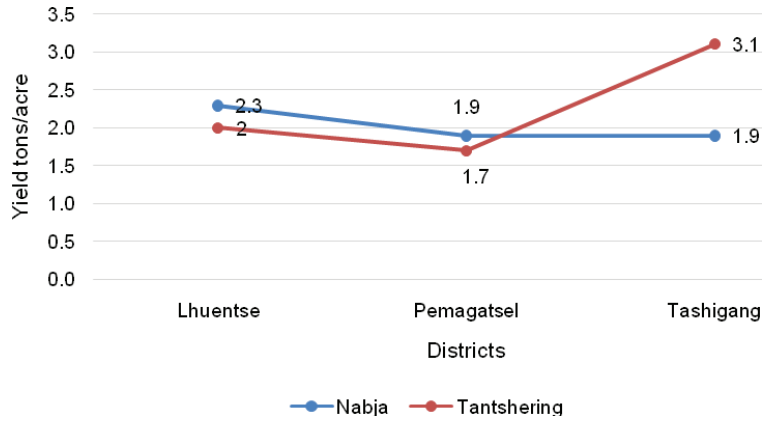

Figure 1 Production of two local paddy varieties at three different districts

High Altitude Rice

Packages of practices (POP) were developed for the two high altitude rice varieties released by the department in the last reporting year. The packages for the two released varieties Yusiray Kathramathra and Yusiray Kaap 3 will serve as an important technical guide, particularly for agriculture extension personnel. Both varieties are recommended for high altitude areas above 1800 masl.

On-farm Evaluation of New Advanced Rice Lines

On-farm evaluation of promising rice varieties to test their wider adaptability was organized in four gewogs each in Punakha and Wangdue dzongkhags. Three promising rice varieties were tested involving a total of 24 households/sites. The lines were entirely raised under farmers' agronomic management conditions from nursery till maturity. Field day was organized at harvest to jointly assess yield potential of the new lines and gather farmers' feedback (See Table 1).

Table 1 On farm evaluation

Sl No	Gewog/ Dzongkhag	Variety	Till/hill	Yield (Kg/acre)
1.	Kabesa, Punakha	TME-50518	7	2254.26
			9	3231.78
2.	Kabesa, Punakha	Ceres	8	2686.04
			7	2226.97
3.	Kabesa, Punakha	Zhanghan	8	2418.60
			10	2306.51
4.	Baarp, Punakha	Zhanghan	12	3282.94
			12	2830.93
5.	Baarp, Punakha	TME-50518	10	2878.29
			12	2403.10
6.	Baarp, Punakha	Ceres	11	2790.69
			9	2464.65
7.	Bjena, Wangdue	TME-50518	19	3970.54
			15	4177.44
8.	Bjena, Wangdue	Zhanghan	16	3665.11
9.	Bjena, Wangdue	Ceres	13	3103.87
			10	3046.35
10.	Daga, Wangdue	Ceres	11	940.93
			12	990.69
			12	1085.27
11.	Daga, Wangdue	Zhanghan	12	818.60
			14	933.02
			13	1085.27
12.	Daga, Wangdue	TME-50518	14	845.34
			15	897.98
			12	1100.77
13.	Kabesa, Punakha	TME-50518	7	2254.26
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			14	897.98
			14	1100.77

Research into Direct Seeding in Rice

Assessment into direct seeding as a potential option in mitigating farm labour constraint show that drum seeding require significantly lower labour requirement as against conventional methods. No significant yield differences were observed. However, the crop matures 15-20 days earlier than normal transplanted rice with a significantly low seed rate of 7kg/acre as compared to 25-30 kg/acre for normal transplanted rice.

Conservation of Traditional Rice Varieties

On-station selection and maintenance of six high altitude rice varieties have been initiated. Seed selection and maintenance breeding are implemented to obtain pure seed which are then supplied to interested farmers keen in growing their traditional varieties.

Table 2 Seed production of traditional varieties

Variety	Seed Produced (kgs)	Yield (kg/ac)	Original Source of the Variety
Dumja	35	657.82	Paro
Themja	118	891.39	Paro
Zhuchum	70	782.95	Gyenakha
Shabja Kuchum	110	626.63	Trongsa
Janaam	20	884.31	Thimphu
Hungrel Maap	30	1077.7	Paro
Total	**383**		

Maintenance & Basic Seeds Production

The Fields Crops Program also produced a total of over 3,000 kgs of seeds of 7 rice varieties as part of its regular maintenance and seed purification program including a little over 530 kgs of 5 rice varieties for seed increase program of potential pipeline and released varieties.

1.1.2 Maize

Identification of Climate Resilient Hybrid Maize Lines

After Bhutan joined the Heat Tolerant Maize for Asia (HTMA) project, a total of 153 maize lines were evaluated under Bhutanese condition to prepare against possible heat stress on maize crop in the future, leading to the identification of five climate resilient hybrid maize lines (ZH1619, ZH138098, ZH111755, and ZH15286 & ZH15390). Field adaptation trial are being held at three locations in Mongar, Sarpang and Tashigang, through which one best line is expected to be identified for release and maintenance in 2020.

1.1.3 Quinoa

Quinoa (*Chenopodium quinoa* Wild) research and development has marked four years since it was first introduced in the country in 2015. It has now spread into all 20 dzongkhag covering all agro-ecological zones an estimated area of about 600 acres in 2018-2019. The total estimated production from dzongkhags, ARDCs, Euglena Co. Limited (of Japan) and Land Use Certificate (LUC) user groups for the reporting year is 37.16 MT. The figures do not include proportions that farmers have now started consuming or selling in local markets. The DoA aims to upscale quinoa cultivation to enhance household food and nutritional security as well as diversify farmers' cropping systems to adapt this versatile climate resilient crop. The consolidated total 12th FYP target for quinoa is 630 acres with an expected production of 310.50 MT.

Production Observation Trial

The DoA continued with the production observation trials at ARDC Yusipang and also expanded to ARDC Samtenling (Sarpang) to assess the feasibility of Quinoa cultivation after rice harvest in wet-subtropical zone. The most suitable sowing time for second crop of Quinoa after potato harvest in high altitude areas of Haa and Paro is also being assessed through collaborative on-farm trials in Haa.

Enhancing Genetic Base

The Department of Agriculture established formal linkage with the International Center for Biosaline Agriculture (ICBA) in Dubai as part of its effort to enhance genetic bases of Quinoa germplasm. The ICBA has generously supplied 20 new Quinoa germplasm which are currently under trial.

Knowledge and information Management

One scientific paper titled "Adaptation of Quinoa in the Bhutanese Cropping Systems" has been published in Bhutan Journal of Agriculture (Volume II, Issue 1, 2019). A second paper titled "First Adaptation of Quinoa in the Bhutanese Mountain Agriculture Systems" has been submitted to an international journal and is currently under peer review. These represent our efforts in synthesizing and reporting results of our work on Quinoa to a wider professional audience.

1.1.4 Oilseeds

The Department of Agriculture aims to increase oilseeds production from 1,332 MT to 2,000 MT by the end of the plan period. The current total production stands at 1,536 MT and there are numerous challenges.

Major highlight in oil seeds research for the 2018-19 reporting period include:

Evaluation of Local Groundnut Varieties

Groundnut is produced in small pockets over the country and consumed unprocessed, and has negligible contribution to domestic cooking oil share. Groundnut varieties native to various communities in eastern Bhutan has the potential to contribute to domestic cooking oil production. As part of the efforts to diversity oil seed crops in the country, ARDC Wengkhar is evaluating 5 popular groundnut varieties collected from different communities for their adaptation in various parts of the country. The varieties are being tried at ARDC Bajo, Yusipang, Wengkhar, Samtenling, Tsirang, Tingtibi, Lingmethang and Khenedrang to study their performance and adaptability.

1.1.5 Legumes & Other cereals

Evaluation of Mung Bean Varieties

Five mungbean (*Vigna radiata*) varieties (Yellow dal, Kalo dal, Phushro dal, Bari mung and Massam) were evaluated to compare yield on-station. Significant differences were observed among the varieties. Bari mung recorded the highest productivity at 367 kg/ac, and Phusro Dhal had the lowest yield of 67 kg/ac.

Lentils Research

Study on assessment of grain quality and production in lentils (*Lens culinaris*) showed very low productivity under Samtenling conditions with extrapolated yield of only 34.6 kgs/acre. The average flowering date of evaluated lentil was 67 days and it took 129 days to maturity. Average recorded plant height was 25 cm.

Figure 2 Lentils at vegetative and flowering stages

Advance Evaluation of Wheat Lines

Three popular wheat lines received from Nepal and another from India are being tested for production performance to provide additional growing options from the limited number of improved varieties in wheat. Preliminary results are summarized in Table 3.

Table 3 Wheat lines in evaluation

Sl	Treatments	Days to Heading	Days to Maturity	Plant height (cm)	Disease score (0-5)	Yield (ton/ha)
1	Munal (Nepal)	95	151	90	0	3.32
2	Chyakhuru (Nepal)	94	151	90	0	3.08
3	Swargadwar (Nepal)	98	151	89	0	3.15
4	BHU 35 (Indian)	96	151	91	0	3.3
5	Bumthangkadrukchu(Local check)	94	151	96	0	2.88

Wheat Breeder Seed Maintenance

In order to augment the National Seed Centre's production of wheat seeds, the department also produced seeds of various promising wheat lines for multiplication and on-farm testing as well as seeds of released wheat varieties for maintenance (see Table 4).

Table 4 Wheat seed production by ARDCs (2018-19)

Line/variety	Quantity (kg)
Bumthangkaa Drukchu	2250
Bajosokha kaa	200
Gumasokha kaa	180
Total	**2630 kgs**

1.2 Horticultural Crops

1.2.1 Vegetables

Release of Heat Tolerant Varieties

The department approved the release of four heat tolerant cabbage (Asha and Bengal King) and cauliflower (White Express 50 and Pragati 40) varieties following their on-station evaluation at ARDC-Wengkhar. This marks a significant outcome in the DoA's concerted effort in providing alternatives to conventional cabbage and cauliflower varieties already grown in the country that do not tolerate high temperature. Evaluation of heat tolerant varieties is one of the adaptation strategies in response to rising temperature and demand for year-round consumption.

Figure 3 Cabbage Bengal King and Asha, and cauliflower Express White 50

Evaluation of tomato variety "Red Tommy Toe" against local cherry tomato showed its fruit weight of 20.99 gm as highly significant from the local check (11.4gm). However, the number of fruit/plant was 77.23 and 177.15 for Tommy Toe and local cherry respectively. Both are indeterminate varieties.

On-farm adaptive research on Red Tommy Toe and another variety "Master" at three different locations in Dagana also show promising results, and farmers have already started saving seeds of the variety Tommy Toe to continue production from the coming seasons as the preference for the variety in the market is also good. Master variety is better preferred by hoteliers.

Observation trial on GARV variety at ARDC-Samteling (Sarpang) indicates that the variety can be recommended for notification to enable cultivation on a commercial scale in view of its high recorded yield at 12.5MT per acre.

Evaluation of Hybrid Radish

YR White Spring F1 hybrid radish was evaluated for summer production which showed promising results. The hybrid was found to possess desirable traits like lack of pubescences and forkedness, uniformity in shape and size, and good taste and also demonstrated suitability for year round production.

Evaluation of Hybrid Radish

Evaluation of hybrid cucumber variety Sarika in Saprang showed promising results with yields as high as 32 kg/acre, with very low incidence of pests and diseases. The variety also matured for harvest in 49 days after transplanting, with three harvests possible during the entire trail period.

Observation trial on cost of production

Preliminary observation trial on comparing the cost of production for greenhouse (20m x 5m) tomato under different mulching treatments was conducted in ARDC-Yusipang. Cost of production under plastic mulch was found to be the lowest, while no mulch treatment returned the highest cost of production (see Table 5). The study will be repeated next season with replications for statistical validation of the results.

Table 5 Cost of production amongst mulch treatment in greenhouse tomato

Materials	Expenses (Nu.)	Production (kg)	CoP/kg (Nu.)	Profit (Nu.)
Plastic mulch	7603.75	642	12	30916
Artemisia Mulch	8060.5	445.47	18	18668
No mulch	8660.5	381.81	23	14248

Note: Cop – Cost of production

Hydroponics Research

With the fast-paced development and progress in all spheres, the department has increasingly felt the need to set-up its own infrastructure to facilitate research into hi-tech and intensive farming, particularly in response to addressing emerging interests and concerns expressed by progressive private sectors. With fund support from the FSAP Project, three hydroponics structures of size 10m x12m covering an area of 120 m^2 are being constructed at the research centres in Yusipang, Bajo and Samtenling. At an estimated total cost of Nu. 6,491,369.28, the structure will facilitate research and demonstration in hi-tech and resource effective farming system.

1.2.2 Potato

The department's National Potato Program's thrusts areas enhancing potato production through off-season farming, technology transfer (demonstration of new varieties), farmers' capacity development and evaluation of potato germplasm for variety development. These activities also attempt to address the decline or stagnation in yield due to degeneration of seed and varieties. The program targets to release 4 new high-yielding, late-blight resistant and climate-resilient varieties in the 12th FYP.

Evaluation of New Clones

The National Potato Program continued with the evaluation of 20 new climate resilient CIP potato varieties (clones) in different agro-ecological zones in Yusipang, Khangma, Phobjikha and Bumthang. These new clones are being multiplied from micro-tubers in addition to 45 new clones/ varieties on evaluation trials in various agro climatic zones.

Table 6 Micro-tubers in greenhouse (Yusipang) planted out from tissue culture

S/L	CIN (Clone Identification No)	S/L	CIN (Clone Identification No)
1	Clone No:309103.85	11	Clone No: 398180.292
2	Clone No:309028.56	12	Clone No: 309074.129
3	Clone No: 309017.101	13	Clone No: 398180.289
4	Clone No: 309003.11	14	Clone No: 309077.116
5	Clone no: 398098.203	15	Clone No: 309036.2
6	Clone no: 398208.219	16	Clone No: 309041.1
7	Clone No: 398190.605	17	Clone No: 398192.592
8	Clone No: 309087.23	18	Clone No: 304079.1O
9	Clone No: 398192.213	19	Clone No: 302535.3
10	Clone No: 309121.6	20	Clone No: 598192.553

Multiplication of Biofortified (tetraploid) Clones

A total number of 50 biofortified (tetraploid) potato clones were imported from the International Potato Centre (CIP) in Peru in the 2018-19 FY. These were imported to build on the existing germplasm to help develop high-yielding, late-blight resistant and high nutrition varieties in the 12th Five Year Plan and beyond. This will also address seeds degeneration and yield stagnation. The clones are being currently multiplied at tissue culture laboratory of National Seed Centre (Paro).

All in all, the highlights for the program can be summarized as hereunder.

Table 7 Summary achievement (2018-19) for the Potato Program

Success indicators	Units	Target	Achieve-ment	Achievement (%)	Remarks
Winter (off-season) potato production promoted/ intensified through seed support	kg	20,000	20,000	100	Samtse, Sarpang & Samdrup Jongkhar
New varieties demonstrated and promoted	kg	2000	3875	194	21 gewogs in 13 Dzongkhags
New improved potato clones evaluated/multiplied for research	No	45	46	102	26 evaluated & 20 climate resilient clones multiplied in Khangma, Bumthang, Phobjikha & Yusipnag
Farmers capacity developed	No	300	343	114%	FSAPP & ITPGRFA in Haa, Chukha, Dagana, Tashigang & Bumthang

1.2.3 Fruits and Nuts

Characterization of Local Pineapple Accessions

In Bhutan pineapple (*Ananas comosus)* is mostly grown on a small scale in scattered pockets, and is usually intercropped with other subtropical fruit trees like areca nut, litchi and mango. There are no researches conducted or varieties released in the country.

Therefore, to characterize local pineapple accessions, pineapple germplasm was established with three local accessions (PV1, PV2, PV3) and evaluated over a year. Studies on the physical (weight, size, shape, texture and colour), physico-chemical (TSS, pH, titratable acidity and soluble solids) characteristics of the accessions reveal that PV1 is late-maturing amongst three accessions with an average fruit weight 1.3 kg - significantly higher *(P*=0.00) than that of PV2 (0.97Kg) and PV3 (0.5Kg). Significant difference (PV=0.05) were found in plant height, peduncle length, peduncle diameter, number of peduncle slips, suckers and aerial suckers amongst the three accessions. TSS was found significantly higher (*P*=0.00) in PV1 (14.34) compared to PV2 (9.64) and PV3 (13.42).

Economics of Arecanut (Areca catechu L.) Multi-tier Cropping

An areca nut-based multitier cropping system with coffee and banana as understory and pinto peanut (*Arachis pintoi)* as ground cover is under evaluation at ARDC – Samtenling (Sarpang). The Bhutanese areca nut industry at present is mono-cropping based where returns per unit area of land is low with high risk associated with market fluctuation and unexpected losses due to pests and diseases, and other natural calamities. Multi-tier cropping system in areca nut has the potential to provide substantial increase in income per unit area through diversification and better utilization of resources (land, space, light and nutrients). This approach can significantly boost the income of small and marginal farmers.

Ground Apple Varieties Released

The department released a variety of ground apple (*Smallanthus sonchifolius*) under the local name “Yusi Yacon-1” based on the evaluations to date. Yield differences under different cultivation practices are being evaluated at ARDC-Yusipang, and a “Package of Practices for Production of Ground Apple” has been put together and is under review for publication.

Kiwi and Pineapple Varieties Notified

Red kiwi “Enza Red” and green kiwi “Hayward” were formally notified for cultivation based on the data collected from their cultivation in Tsirang and Chukha respectively. The National Seed Board also approved the formal notification of two pine apple varieties Kiew and Queen.

Germination Studies in Kiwi & Persimon

Poor germination of seeds is a limiting factor in kiwi and persimmon for rootstock production. Rootstock germination trial using four treatments for persimmon and 16 treatments for kiwi at the ARDC-Wengkhar found out sodium hypochloride treatment followed by stratification in sand gave the best result (69%) followed by fresh seeds treated with sodium hypochloride (30%) in persimom. For kiwi, seeds stratified for 8 weeks and treated with GA3 at 1500 ppm and sown in cocopeat gave the highest germination rate of 77.3%

Production Manual for Apple Rootstocks

ARDC-Yusipang produced a manual on propagation of apple (Var. Maruba - *Malus prunifolia)* through stem cuttings. The manual is expected to help nursery growers as well as the NSC in effective multiplication of clones for rootstock production.

1.2.4 Citrus

Evaluation of Citrus Varieties for Processing

The Citrus Program started on-farm evaluation of a total of 13 citrus promising citrus varieties which also include a few varieties introduced from Australia through ACIAR project. These varieties (Dorokha local,Clementine,otsu-4, salustinia, cara cara, Yushida ponkan, tarku, okitsu wase, otha ponkan, teishu ponkan, Zhemgang lime, Shemjong lime, and local 27) were planted along a triangular system of layout with spacing of 5m (plant to plant and row to row) with 3 seedlings per variety. The trial aims to evaluate their performance under different agro-ecological zones (800-1800 masl) so as to diversify commercial citrus enterprises in the country.

Policy Guidelines and Manuals

i. **Citrus production strategy for 12 FY** had been prepared in line with the department's 12 FYP to guide implementation of the citrus program. The key components of the strategy document are drawn from the Citrus Development Master Plan.
ii. **Citrus Canopy Management Guide:** This will provide practical guidance to extensions and farmers on citrus canopy management. The guide also includes planning and evaluation sections.
iii. **Standard Operation Procedure (SOP) for Citrus Nursery** is expected to help to standardize production of citrus nursery so as to adopt advanced technology and phyto-sanitory requirements as part of the measures to safeguard the industry from citrus HLB and other graft and vector transmissible diseases.
iv. **Plastic Lined Water Harvesting Guide:** A leaflet guide on water harvesting technique was prepared to guide extension and farmers in setting up plastic-lined water harvesting structure for irrigation in citrus.

1.2.5 Mushroom

The National Mushroom Centre also conducts research into mushroom in an effort to enhance mushroom production and diversify available options for growers. In this reporting period, the centre has initiated a series of study. These studies are currently on-going and results expected to be reported in the coming year.
Brief gists of the study, however, are:

Re-inoculation studies in Shitake Mushroom

Re-inoculation experiments are being conducted at different locations in Thimphu and Paro with the objectives of assessing if Shiitake mycelia can colonize old billets cultivated in the previous year where mycelium run is not good due to poor management. Results, if positive, would provide growers with a second shot at raising Shiitake on previous year billets.

Studies on Fruiting Ability of Hybridized Shiitake Strains

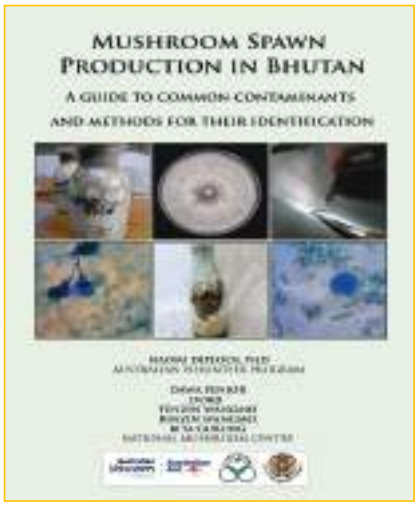
Seven hybridized shiitake strains including Japanese wild shiitake and Bhutanese shiitake are being assessed for their mycelia colonization rate, fruiting ability, productivity, and disease tolerance. The study expects to screen at least 3 best performing strains for further evaluation, and subsequently for release for commercial cultivation.

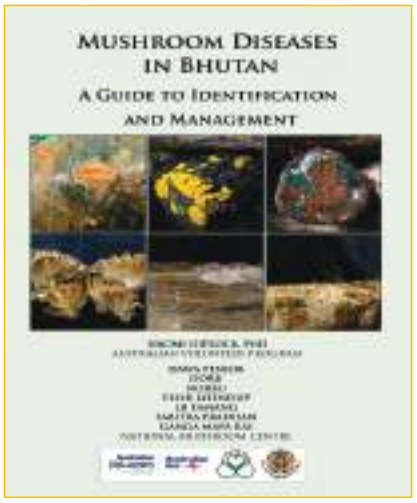
Oyster Mushroom Variety Evaluation Trial

The NMC has 10 varieties of Oyster mushroom maintained in its gene bank. However, details on morphological characteristics, growth and yield performance of each variety are not available. Trials are hence being conducted to evaluate these cultivars and obtain comprehensive datasets on these cultivars, and eventually select best performing cultivars for summer crop.

Guide to Mushroom Pest and Disease

Realizing the importance of identification of contaminants in mushroom spawn labs to aid spawn producers, both private and government to identify and manage commonly observed across Bhutan, the NMC produced a guide to common contaminants and their identification procedures for spawn cultivation. It also took out a guide on mushroom diseases in Bhutan. Based on survey data and observations made over two and half years, the publications are expected to help mushroom growers identify and manage common diseases in Shiitake and Oyster mushroom, and thereby improve their yield and quality.





1.2.6 MAPS

Evaluation of Water Wasabi

Water Wasabi {*Eutrema japonicum* (Miq.) Koidz} research was initiated in collaboration with Mac & Me. Co. Ltd., based in Bangkok, Thailand and ARDC-Yusipang at Tendrelgang Community Forest, in Yusipang, Thimphu. The research aims to evaluate the performance of Wasabi (variety Ozawa) in order to assess the potential for introduction of Wasabi cultivation in Bhutan to help generate additional farmer income.

Figure 4 Water wasabi research at Tendrelthang, Yusipang

Preliminary findings indicate that water wasabi can be grown successfully in Bhutan although they are observed to be a little sensitive to frost and very cold water temperatures. The study is expected to recommend suitable altitude and right planting season for optimum Wasabi cultivation in Bhutan.

Ex-situ Cultivation Trial of Panax pseudo ginseng (Ginseng) and Paris polyphylla

A year of research into Ginseng and *Paris polyphylla* shows that the two species can be successfully domesticated. Ginseng and *Paris polyphylla* are two important medicinal plants species that are heavily and illegally collected all over Bhutan. The Department of Agriculture initiated a trial at Lamperi in response to risks of possible extinction through indiscriminate poaching of the species. Rhizomes of both the species seized by the DoFPS were used as propagules. The results are promising with a little over 2000 plantlets each growing in the trial area from these rhizomes. Assessment on planting season, crop phenology, planting depth, average size of planting materials (rhizomes) for optimum yield and production shall be continue.

Knowledge & Information Management

The Medicinal, Aromatic Plants and Spices Program (MAPS) with support from various stakeholders published two booklets in this reporting period - large cardamom cultivation manual and Chirata cultivation manual. The manual on Chirata cultivation was also translated into Dzongkha.

2 DEVELOPMENT HIGHLIGHTS

2.1 Field Crops

2.1.1 Rice

Upland and spring paddy intensification

As a part of spring paddy intensification program in the east, ARDC Wengkhar carried out a total of 12 acres spring paddy cultivation in two districts of Mongar and Samdrupjongkhar. The four varieties cultivated are Bari-26, Bari-28, IR20913 and Japanese sticky. Similarly for upland paddy intensification a total of 1.3 MT of five upland paddy varieties (Wengkhar Kambja 1 & 2, Zangthi 1, Khangma Maap and Chandhanath-3) including one drought tolerant variety were supplied to 144 households covering 55.62 acres. This intervention targets Climate Smart Villages of eastern Bhutan which were selected for their vulnerability to climate change impacts and higher incidence of poverty. An estimated production of 14.4 MT of spring paddy and 85 MT of upland paddy is expected.

The Department supported over 58 acres of spring rice cultivation as part of its effort in up-scaling rice production in Wangdue, Trongsa and Zhemgang 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 7.8MT of quality maize seeds, out of which the National Seed Centre (NSC) procured about 70 MT. At the given seed rate of 15kg/acre, the production would cover an area of 4,500 acres, directly contributing towards seed replacement across the country.

Hybrid Maize Intensification

First initiated in 2015, the Spring Maize program brought about significant progress in intensifying cropping systems, directly benefiting hundreds of households in the east. Focusing mainly in rice-fallow system, the program has immensely helped farmers through high productivity of the hybrid maize. Farmers have shown increased interest in this hybrid technology. The program involved use of 9.66 MT of hybrid maize (P3377) seeds covering a total of 670 acres in six eastern Dzongkhags (see Table 8).

Table 8 Hybrid maize intensification program in selected dzongkhags

Dzongkhag	Seed Qty (MT)	Area (acres)
Dagana	2.90	193.3
Mongar	2.00	133.3
Pemagatsel	2.00	148.2
Tashigang	0.56	38.0
Tashiyangtse	0.21	25.0
Samtse	1.99	132.5
	9.66	**670.4**

Market-driven Maize Commercialization

A program on "Market Driven Commercialization of Maize Production and Marketing" is being initiated by Regional Agriculture Marketing and Cooperatives based at Mongar in collaboration with the National Maize Program, Department of Agriculture and the Dzongkhag Agriculture Sector. The program targets enhancing production through cultivation of hybrid maize, and also assists in identifying markets. The program in its first phase has identified three geogs (Dungmin, Decheling and Norbugang) in Pemagatsel as potential sites for up scaling maize production. A total of 2 MT of hybrid maize P3377 was supplied to 215 households of the three geogs covering 148.2 acres. The EU-RDCCPP supported the purchase of hybrid maize seeds. Similar programs will be replicated in all major maize growing areas based on the results of this initiative.

2.1.3 Quinoa

Quinoa Promotion

Following its introduction in 2015, quinoa has been aggressively promoted in all 20 dzongkhags. The commodity has now been mainstreamed into the dzongkhag 12th FYP targets where it is now being promoted, including in FMCL Farms and through the Land Use Certificate (LUC) user groups.

ARDC-Yusipang successfully demonstrated cultivation of Quinoa after potato harvest in Lobnekha and Shemagangkha Chiwogs of Chapcha geog in Chhukha. Farmers have shown keen interest in potato - Quinoa cropping sequence. A total of 26 farmers were provided seeds from which five farmers produced 179 kgs of Quinoa. Support was also provided to interested private growers in organic Quinoa farming covering around 5.0 acres in Mewang geog, Thimphu.

All in all, estimated quinoa production for 2018-19 stands at 37.16 MT (see details in Table 9)

Table 9 Estimated Quinoa production in 2018-19

Sl	Region	Target (Mt) 2018-19)	Estimated Production (Mt)	Remarks/Details
1	ARDC Yusipang and 4 Dzongkhags	23	4.16	Euglena Co limited Japan had targeted 20 Mt and ARDC Yusipang 3 Mt Winter sowing was severely affected by early ad heavy frost
2	ARDC Wengkhar and 6 Dzongkhags	28	20	Includes production from station and LUCs
3	ARDC Samtenling and 5 Dzongkhags	10	8	Includes on station seed production
4	ARDC Bajo and 5 Dzongkhags	4	5	
Total			**37.16**	

Awareness Campaign

Awareness on the nutritional aspects of Quinoa was carried out in Bumthang covering all four Geogs, as well as in Wangdue that included participation by farmers and agriculture extension officers. In Tsirang, and Dagana five farmers groups have been formed to upscale Quinoa cultivation and a total of four farmers' field days were organized by ARDC Research Sub Center – Tsirang.

Over 683 teachers and 5,082 students in 19 schools and colleges also took part in awareness programs that sensitized on the nutritional benefits of Quinoa. The programs were supported by JICA and Euglena Co. Ltd (Japan), and implemented by the DoA and the Department of School Education, Ministry of Education.

Improving Agronomy & Postharvest Quality

To facilitate and improve Quinoa threshing, seed processing and packaging, a Quinoa threshing unit has been set up at ARDC Yusipang at a cost of Nu.1.00 Million - supported by Rural Development and Climate Change Response Program (RD & CCRP). Further, 12 milling machines, supported by the department and FSAP project, have been supplied across the country to help promote proper utilization of this nutritious cereal. Farmers groups using these machines are expected to enhance their Quinoa production, processing, utilization and marketing. The ARDC in Samtenling also has set up two Quinoa de-husking machines that provide milling services to Quinoa farmers in the area.

2.1.4 Oilseeds

Soybean & Groundnut Commercialization

The DoA is providing technical support to the soybean and groundnut commercialization program, started in the two rehabilitation communities of Ney (Lhuentse) and Khenedrang (Pemagatsel) with support from Bhutan Care Credits Limited (BCCL) under His Majesty's Secretariat and the dzongkhag agriculture sectors. The program aims at intensifying production of the two crops at commercial level. A total of 30 acres of soybean was cultivated by 40 farmers of Ney rehabilitation community. A farmer group "*Ney Norbu Detshen*" has also been formed to institute effective functioning and management of soybean production and processing. A similar group was constituted in Khenedrang too – the *Khenedrang Yarphel Tshogpha*, comprising 40 farmers cultivating 20 acres of groundnuts.

Similarly, ARDC-Samtenling provided 440 kgs soybean seeds to farmers in 8 south central dzongkhag as part of their research outreach program (RoP). This has brought 24 acres under soybean cultivation with an expected production of around 16.8 MT. Additionally, 45 acres in six climate smart villages in the six eastern dzongkhags of Luntshe, Mongar, Trashigang, Trashiyangtse, Pemagatshel and S/Jongkhar were brought under soybean cultivation with an estimated production of 31.5 MT.

2.1.5 Legumes & Other Cereals

Lentils Promotion

As part of the research outreach program (RoP) ARDC-Samtenling promoted lentils production across 60 households spanning a total of over 66 acres in the four dzongkhags of Dagana, Sarpang, S/Jongkhar and Samtse. The initiative produced 12.6 MT of un-husked lentils (see Table 10).

Table 10 Promotion of lentils production in selected dzongkhags in the south.

Sl	Dzongkhag	Gewog	Villages	HHs	Seed (Kg)	Area (acre)	Prod. (kg)
1	Dagana	Karmaling & Nichulka	2	10	90.00	10.00	No data
2	Sarpang	Umling, Chuerzang, Samtenling, Dekiling, Gakiling & Shompangkha	10	28	206.00	30.40	2,655.64
3	S/Jongkhar	Pemathang, Phuntshothang & Khamathang	5	20	100.00	11.00	9,350.00
4	Samtse	Tashicholing & Pemaling	3	10	88.20	15.00	600.00
	Total			**60**	**484.20**	**66.40**	**12,605.64**

Other Cereals Promotion

To encourage farmers in effective utilization of farmland following maize and rice cropping in Samtse, the department promoted sweet buckwheat production through inputs distribution that resulted in bringing around 4 acres under buckwheat cultivation with a production of 1.667 Mt.

A little over six acres of land were brought under cultivation of wheat variety *Bumthang Ka Drukchu* as part of the wheat intensification program in Chumey geog, Bumthang. The intervention also helped promote and further multiply released wheat variety

2.2 Horticultural Crops

2.2.1 Vegetables

Winter Chilli and Vegetable Commercialization

In continuation of the DoA's concerted efforts in minimizing vegetable imports from India through its commercialization drive, winter vegetable production program were implemented in south central dzongkhags based on the collaborative plan developed in May 2018 in consultation with districts and ARDCs.

With major focus on winter chilli production, the program in its second year in eight dzongkhags and 3 FMCL farms covered a total household of 1,317 with cultivated area of 364.34 acres. Besides winter chilli production, the dzongkhags were also supported with seeds for cauliflower (240 acres) and beans (314.63 acres) production.

Table 11 Overall Expenditure for the vegetable program (2018-19 FY)

Particulars	Amount (Nu.)	Funding Source
Vegetable seeds (with major share for winter chilli)	1,988,150.00 554,000.00	RGoB EU-RDCCRP
Other production inputs	133,516.00 353,940.00 3,127,021.00	RGoB EU-RDCCRP FSAPP
Printing of authentication form for sale of locally produced vegetables	141,450.00	RGoB
Review and Planning/Meeting/Field Days	142,000.00	RGoB
Supply of pre-fabricated Greenhouses (28 sets)	1,686,280.00	RGoB
Total	**8,126,357.00**	

Winter chili production which started in late November 2018 from Dagana is slated to continue till end of July 2019. As of May 2019, the area under winter chilli cultivation stands at 364.34 ac with a total production of 219.17 MT (see Table 12 for details).

Table 12 Winter chili production, acreage and income (2018-19)

Dzongkhag	Planned Area (ac)	Actual Cultivated Area (ac)	No. of HHs	Total Production (MT)	Cash Income (Nu) @100/kg (Farm gate)	Cash Income (Nu) @150/kg (Avg. market price)
Chukha	21.25	20	63	3.05	0.305	0.458
Samtse	77.5	81.67	127	21.8	2.180	3.270
Sarpang	134.85	102.76	439	119.45	11.945	17.918
Tsirang	63	51.05	212	12.27	1.227	1.841
Dagana	72.51	53.1	173	36.41	3.641	5.462
Pemagatshel	44	16.65	65	5.39	0.539	0.809
S/Jongkhar	35.5	17.5	173	4.68	0.468	0.702
W/Phodrang	12	12.5	23	10.62	1.062	1.593
Zhemgang	7	4.55	42	4	0.400	0.600
FMCL farms	23	4.56		1.5	0.150	0.225
Total	**490.61**	**364.34**	**1317**	**219.17**	**21.917**	**32.876**

The gross benefit from the program against the total expenditure (Nu. 7.887 million) as of May 2019 is estimated at Nu. 24.989 million at an average market price of Nu. 150/kg.

Comparison of winter chilli program over the two years

Comparison over the two years of the program implementation showed an increase by 13.03% in the area under cultivation with a corresponding increase of 55.84% in total production in the 2018-19 seasons as against 2017-18. The overall total investment made into the initiative for two years is Nu. 30.436 million. At the average market price of Nu. 150/kg of green chillies sold by farmers, the total gross return from the program is Nu. 53.972 million. Details in figures hereunder.

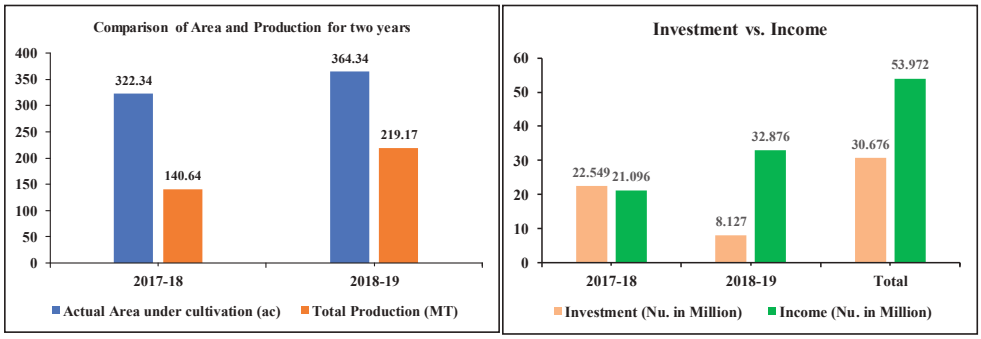


Figure 5 Two-year financial comparison for winter chili commercial initiative

Protected Vegetable Cultivation for off-season Production

Protected technologies like green houses along with water use efficient technologies (micro irrigation system) are provided to help increase production during the winter season. The department supported 28 sets of prefabricated greenhouses worth Nu. 1.686 million on a cost-sharing basis. In Tashiding geog under Dagana Dzongkhag protected cultivation demo on an area of one acre was established. The demo structure comprises 2 prefabricated greenhouses and 25 low cost greenhouses along with 2 water harvesting structures, drip irrigation sets and plastic mulch. The demo site is managed by a farmer group of 7 members.

Capacity Development

Eleven agriculture professionals from the department were trained on hydroponics at the Chaing Rai Horticulture Research Institute, Thailand in late March 2019. The program which included researchers as well as engineers was geared at equipping relevant staff with the skills and knowledge in installation, maintenance and supervision of hydroponic systems at the ARDCs. This will also facilitate effective research on hydroponics for technology generation and dissemination. It was supported by FSAPP and CARLEP.

Figure 6 Hands on training on hydroponics in Thailand

2.2.2 Potato

The Potato Program's key development highlights for 2018-19 include technology transfer through demonstration of new varieties, farmers' capacity development and evaluation of different potato germplasm. These activities address decline and stagnation of yield due to degenerating seeds and varieties.

Table 13 Farmers' capacity building on various aspects of potato farming

SL. No	VILLAGE	GEWOG	NO. OF FARMERS	DZONGKHAG
A	Training on crop agronomy and management of new potato varieties			
1	Kanakha	Kana	37	Dagana
2	Babana	Dungna	27	Chhukha
3	Papaling	Metakha	25	Chhukha
4	Balamna	Samar	31	Haa
5	Kana	Esu	30	Haa
	Total		150	
B	Training on diseases identification, seed selection, rouging in new potato varieties at flowering stages			
1	Kanakha	Kana	48	Dagana
2	Babana	Dugna	30	Chhukha
3	Papaling	Metakha	15	Chhukha
4	Balamna	Samar	28	Haa
	TOTAL		121	
c	Training on harvesting stage and field day for technology transfer, and on research evaluation on new clones			
1	Kanakha	Kana	42	Dagana
2	Choekhor	Choekhor	30	Bumthang
	TOTAL		72	
	Grand Total		**343**	

2.2.3 Fruits and Nuts

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

a) **Demonstration orchards** for mixed fruits were established in Punakha, Wangdue, Tsirang, Dagana and Gasa. These orchards which total 23 comprise 988 numbers of assorted fruits plants.

b) **Promotion of Fruits Orchards:** More than 95 acres of land were brought under fruits and nuts cultivation through various approaches such as lead farmers' approach, establishment of subtropical orchards, promotion of water melon, support to youth farming and direct support benefiting over 400 households.

Besides, the Department also established 6 focus villages for fruits cultivation in Punakha, Wangdue, Tsirang and Dagana that involved distribution and planting of around 1500 fruit plants. ARDC-Bajo alone provided direct support through provision of around 1300 fruits plants to farmers in Wangdue, Punakha and Tsirang.

c) **Capacity Building:** 32 farmers (Wangdue 9, Punakha 9, Tsirang 4, Dagana 5) were provided with systematic training on fruit tree crop cultivation and management practices.

2.2.4 Citrus

As citrus mandarin still continues to be one of the highest incomes earning horticultural produce for Bhutanese farmers generating revenue of Nu 355 million for 2018-19 season, the department implemented a number of programs to support to develop and sustain the industry.

Nationwide Citrus Rehabilitation Campaign

Rehabilitation campaigns were organized in major citrus growing districts in collaboration with ARDCs, districts and gewog extension centres, with fund support from Rural Development and Climate Change Response Programme (RDCCRP). The campaign in 24 sites in 7 dzongkhags of Dagana, Punakha,Samtse, Sarpang, Chukha, Zhemgang and Pemagatshel brought more than 1908 orchards under improved canopy management through proper pruning and training operation. Farmers were also supported with essential orchard management tools/equipments along with materials for irrigation as well as fertilizers for nutrient management. The program aimed at educating citrus farmers in management aspects as well as their importance in sustaining a productive orchard.

Figure 7 Citrus Rehabilitation & Capacity Building on Canopy Management

Capacity Building on Canopy & Orchard Management

A total of 1,073 farmers in Dagana, Punakha, Samtse, Sarpang, Chukha, Zhemgang and Pemagatshel were trained on canopy management (pruning and top-working), nutrient, water and pest management to ensure that a complete package of technologies required for citrus orchard rehabilitation is provided. As part of the program 228 numbers of trees were top-worked with high-health status budwoods of citrus varieties Okitsu wase, Tarku, Dorokha local and Bearss lime. These illustrated tree reworking techniques as well as replacement of existing varieties to diversify citrus farming. Follow up programs were carried out on managing the new developing shoots. These orchards will also serve as demonstration orchard for further technology dissemination and for impact assessment of rehabilitation initiatives.

Effective Water Management

Plastic-lined water harvesting tanks of capacity 27,000 liters were set up to help and demonstrate effective water management for communities in water scarce areas. At least 30 such water harvesting tanks were constructed (Table 14). Demonstration on development of trenches for integrated water and nutrient management for individual trees were also made.

Table 14 Water harvesting tanks set up

Sl	Dzongkhag	Geog	Tanks constructed (No.)
1	Chukha	Lochena/Jabchur	1
2	Samtse	Pemaling/ shengreygang Dophuchen/Lumby	2
3	Zhemgang	Trong/Tama	5
4	Sarpang	Dekiling	1
5	Dagana		18
6	Pemagatshel	Norbugng	2

Growers in seven dzongkhags of Chhukha, Samtse, Zhemgang, Sarpang, Dagana, Pemagatshel, and Wangdue were provided with materials to help in water harvesting along with the practical know-how. Similarly, farmers in these dzongkhags also received Suphala and Urea fertilizers and manure to support effective plant nutrient management. Bio-pesticide mixes were also provided to growers in these dzongkhags for effective control of mosses and lichens including mildews in citrus.

Capacity Building of Agricultural Staff

a) Ten agriculture officers from the Agriculture Research and Development Centres (ARDCs), National Plant Protection Centre (NPPC), National Citrus Repository Centre (NCR) and National Seed Centre (NSC) attended a short term training on "*PCR diagnosis of Virus and Virus-like Pathogens including Citrus Greening (HLB) and Advanced Techniques of Citrus Nursery Plant Propagation System*" at the ICAR-Central Citrus Research Institute (CCRI), Nagpur, India, in March - April, 2019. The

program was financially supported by the Food Security for Agriculture Production Project (FSAPP). These officials will be undertaking PCR diagnosis of diseases; shoot tip grafting to rescue commercial varieties from bacterial and viral diseases; production of high-health status planting materials, and management of pests and diseases in the nurseries and field. The NCR, after the training, has already begun strengthening the laboratory unit and undertaking the shoot-tip grafting trials.

b) An official from the citrus program availed a 4-month long professional development program on "advanced citrus nursery production and field establishment" at the Department of Primary Industry, New South Wales, Australia. It was funded through the Endeavour Executive Award, Commonwealth Government of Australia, which the candidate won through worldwide open competition. The program has greatly helped in reviewing nursery standards and development of various technical guidelines required to implement the citrus promotion and development program in Bhutan.

2.2.5 Mushroom

Contributions made in terms of mushroom development for the financial year include spawn production and supply, supporting rural farmers and commercial growers and capacity building of mushroom cultivators by the National Mushroom Centre supported by the ARDCs are detailed in Table 15.

Table 15 Support to mushroom production (2017-18)

No	Activities	Achievements	Remarks
1	***Spawn Production***		
	i. Shiitake	31474 bottles	Sawdust and grain spawn
	ii. Ganoderma	393 bottles	
	iii. Oyster	16,961 bottles	
	Mother Spawn		
	i. Shiitake	2214 bottles	
	ii. Ganoderma	15 bottles	
	iii. Oyster	412 bottles	
2	***Spawn Supply***		
	i. Shittake	19,272 bottles	
	ii. Oyster	11,954 bottles	
	Mother Spawn		
	i. Shittake	2,140 bottles	
	ii. Oyster	260 bottles	
3	***Cultivation***		
	i. Shiitake	1,23,252 billets	Growers in 15 dzongkhags (148 households)
	ii. Oyster	39, 185 bags	
4	***Backstopping growers***		
	i. Field/farm monitoring	120 farms	Central & western dzongkhags
	ii. Capacity building	a) 192 farmers trained b) 19 individuals c) 258 Desuups	- mushroom cultivation - wild mushroom identification and sensitization

The National Mushroom Centre (NMC) attended the Fourth Annual Mushroom Festival, Geney, Thimphu (15-16 August 2018). This is as part of the annual initiative in creating awareness on sustainable harvesting of mushroom and the threat of mushroom poisoning amongst stakeholders, and in an effort to showcase the natural wealth of the locality as well as to promote economic opportunities associated therein.

Figure 8 The Fourth Annual Mushroom Festival, Thimphu (August 2018)

2.2.6 MAPS

Spices Promotion- Spices Village

Ginger, turmeric, large cardamom and black pepper are some of the spices cultivated in Bhutan and are the primary cash crops for people residing in the southern parts of the country. The department supported three groups: Panibi group of young entrepreneurs, Tashibi group and Gongphu Tshesey Gongphel Peyten Tshogpa in Zhemgang Dzongkhag, and Tashicholing ginger cooperatives in Samtse Dzongkhag. Members of these groups were provided with trainings. Further, Tashicholing geog in Samtse was adopted as the Spices Village through fund support from the Internal Centre for Integrated Mountain Development (ICIMOD). This program supports farmers with planting materials, establishment of nurseries and through provision of value addition equipment.

Figure 9 Spices cultivation activities in Tashicholing, Samtse

Chiraita Cultivation

Chiraita (*Swertia chiraita*) cultivation trial supported by the French Chanell P B Company has been very successful after its initial establishment in 2015. Based on the success of 9 trial farmers in Dungmanma, Betseling, Tshothang, Lauri, Momri, Reynang and Serzor villages of Lauri geog in Sjongkhar, more farmers have come forward. By 2017 year-end farmers produced more than 200 kgs of dry Chiraita, which subsequently exported to the company in France. More than 70 farmers have now opted to cultivate the plant and by 2019 year end, they are expected to produce over 2000 kg of dry Chiraita.

Figure 10 Chiraita cultivation in Samdrup Jongkhar

Capacity Building

a) Technical support and advisory services were provided to the Nubi Menchong Nyamley Tshogdey (NMNT), Trongsa, Tensung Amsue Tshogpa, Damthang, Haa, Green Bhutan Corporation Limited, and students of the College of Natural Resources. Support includes trainings on the agronomic practices, organic farming, good agriculture practices and product development.

b) **Staff capacity building**: Five officials from ARDCs, Central Programs and dzongkhags were trained on the product development of medicinal plants at Maejo University in Thailand with fund support from EU TCP.
c) Seventeen officials from central programs and ARDCs were trained on the scientific management of large cardamom at ARDC- Samtenling with financial and technical support from FAO Bhutan.

d) Fourteen officials from ARDCs, central programs and dzongkhags made a study visit on large cardamom to Lamjung District of Nepal with financial support from the Food Security and Agriculture Productivity Project (FSAPP).

2.2.7 Floriculture & Amenity Landscaping

Royal Bhutan Flower Exhibition

The 5th Royal Bhutan Flower Exhibition (RBFE) was held at Samdrup Jongkhar from 21 to 27 February 2019. The Fifth RBFE was dedicated to the 39th birth anniversary of His Majesty the King. The event was organized jointly by the Ministry of Agriculture and Forests, Samdrup Jongkhar Thromde and the Dzongkhag Administration, Samdrup Jongkhar. Unlike the past editions, the exhibition this year focused on permanent garden and landscape development and in providing a facelift to the Thromde area in Samdrup Jongkhar. The Floriculture and Amenity Landscaping Programme of the Department of Agriculture as the technical member of the Royal Bhutan Flower Exhibition was involved in the planning and development processes of the garden as well as in participation at the floral display for the main event in Tendrelthang. The programme produced and showcased over 40,000 ornamental plants of 16 different species for the exhibition.

The event was graced by His Majesty the Druk Gyalpo, Her Majesty the Gyaltsuen, His Royal Highness the Gyalsey, His Majesty the Fourth King, their Majesties the Queen Mothers, and other members of the Royal Family. The Hon'ble Prime Minister, cabinet ministers and other senior government officials also attended the opening program.

Figure 11 The Fith Royal Bhutan Flower Exhibition in Samdrup Jongkhar

Dzongkhag Beautification Sector

In submission to the Royal Command, the Ministry of Agriculture and Forests instituted Dzongkhag Beautification Sector and a Beautification Officer (DBO) in all 20 dzongkhags. The sector is placed administratively under the dzongkhags while technically they will report to the Department of Agriculture.

As part of their capacity building initiative, all 20 DBOs attended a two-week training programme on floriculture at Maejo University, Chiangmai, Thailand. Prior to the ex-country training programme, 19 DBOs were also engaged in the Royal Bhutan Flower Exhibition 2019, Samdrup Jongkhar for a hands-on experience.

The Floriculture Programme in collaboration with the Royal Project Coordination Office with fund support from the BTFEC also provided hands-on training on floriculture and landscaping at the Floriculture and Amenity Landscaping Centre to the DBOs. The programme supported the Dzongkhag Beautification Sector with nursery equipment for floriculture nursery establishment in the dzongkhags.

2.3 Organic

The department organized and implemented a series of programs in furthering and strengthening organic farming and as well as in putting assurance system for the country's organic products.

Bhutan Organic Guarantee System (BOGS), Local Organic Assurance system (LOAS) certified products and Organic Farmers' Award

Coinciding with the World Environmental Day, the Ministry of Agriculture & Forests launched the Bhutan Organic Guarantee System (BOGS), Local Organic Assurance System (LOAS) certified products and the Best Organic Farmer Award 2019 on 5 June 2019. Launched by the Hon'ble Minister for MoAF, the BOGs documents will serve as guidelines for organic operators in applying for organic certification and in practicing the organic agriculture besides smoothening the certification process for certifying bodies.

Figure 12 Launch of Bhutan Organic Guarantee System (BOGS) & Best Organic Farmer Award 2019

Rangzhin Sanam Detshen from Gasa Dzongkhag was awarded the Best Organic Farmer Award, 2019. The award encourages farmers in coming forward and in sustaining organic farming as well as product development systems. The event also showcased certified organic products from Zhemgang (water melon and rice), Pemagatshel (cassava powder), Trongsa (Zanthoxylum) and Thimphu (tomato and adzuki bean).

Organic Asparagus & Buckwheat Production

Organic asparagus and buckwheat cultivated were supported by the Department. A total area of 182 acres spread across 14 dzongkhags is under organic asparagus cultivation and in the FY 2018-19, 40,000 asparagus seedlings were supplied to

growers in Thimphu, Paro, Wangdue. Chhukha and Samdrup Jongkhar. The current organic asparagus production stands at 91 MT.

With focus in five dzongkhags in the 12 FYP, organic buckwheat is presently grown on a total acreage of 3,199 acres in Chhukha, Haa, Gasa and Bumthang with a corresponding production of 1,714.5 MT. The department supported buckwheat seeds of around 1.5 MT for growers in these dzonghags.

Production Inputs Support

The department promoted and supported organic farming through provision of various inputs to growers around the country. These include avocado and kiwi seedlings, around 3,000 packers of assorted vegetable seeds and 2 MT potato seeds. Support was also provided in the form of low cost green houses (15 for organic model village in Haa), knapsack sprayers, bio-fertilizers, bio-pesticides and equipment for vermin-composting like plastic barrels. Around 2 MT of vermin-compost alone was handed over to organic model village in Kashi, Wangdue. These were all funded by the GEF-LDCF.

National Organic Flagship Program

The Department of Agriculture developed the National Organic Flagship Programme (NOFP) with the theme "Sustained livelihood through the commercialization of organic farming in the 12th FYP". The government approved the flagship programme with a total outlay of Nu 1 billion a period of four years. The program will focus on commercialization of selected commodities that will include 6 target export crops (buckwheat, quinoa, ginger, cardamom, mushroom and turmeric), one livestock product (trout) and one Non-Wood Forest Product (NWFP) (lemon grass oil). For domestic market, it will concentrate on asparagus, beans, chilli and cauliflower. A major part of the flagship program is the in-country bio inputs productions to enhance organic production.

Farmers Group, Individual Organic operators

In the last financial year, 68 households and one individual in Haa, Paro and Punaka registered for farmers group and as organic operator. In total they cover organic production on 34 acres of land.

Capacity Building and Knowledge Management

a) Training of Trainers (ToT)and Farmers Training

A total of 12 Dzongkhag and Geog Agriculture Extension Staffs were trained on Bhutan Organic Standard (BOS), Local Organic Assurance System (LOAS) and Organic pest and disease control.

The National Organic Program also trained a total of 132 farmers on a range of topics as illustrated in Table .

Table 16 Farmers capacity building program

Sl	Dzongkhag	Geog	HH No	Topic	Funding	Remarks
1	Dagana	Drujegang	17	Bhutan Organic Standard, LOAS and Organic pest and disease control.	Dagana Dzongkhag	
2	Haa	Samar	56	Farmers training on organic farming and demonstration of organic technologies in low cost green house farming	AFACI	
3	Gasa	Khatoed	51	Organic seed production	RGoB	Gasa Rangshin Sanam Detshen
4	At ARDC-Yusipang, T/phu		30 operators/farmers	Product Development to commercial organic operators.	GEF-LDCF	Private organic farms and staff of ARDC-Yusipang
5	Sarpang	Lhayul, chudzomgeog,	138	Basic principles, practices of organic farming and registration and certification	GEF-LDCF	Farmers from 9 vegetable group, Chudzom geog.
6	Wangdue	Lull village, Kazhigeog	15	Capacity building on bio control and bio-fertilizer formulation	GEF-LDCF	Farmers from lull village
7	Wangdue	Lull village, Kazhigeog	15	Seed Treatment(Potato) with formulation of Bio fungicides (TRICO-H)	GEF-LDCF	Farmers from lull village.
8	Wangdue	Lull village, Kazhigeog	15	Demonstration on potato cultivation, vermi-composting and asparagus plantation.	GEF-LDCF	Farmers of Lull village.
9	Wangdue	Lull village, Kazhigeog	15	Concept of Model Organic village and product development.	GEF-LDCF	Farmers of Lull village.
		Total	**352**			

b) Ex-country Capacity Building

Fifteen individuals comprising staff members, farmers and organic operators attended training programs in India and Korea as well as exhibition and exposure visits.

Figure 13 Organic leadership foundation course & BIOFACH India, 2019

c) Publications

Twenty two different posters and 5 major documents were developed to support extension colleagues, grower groups and organic operators.

Table 17 Publication details for FY 2018-19 (National Organic Progam)

Sl	Items	Quantity	Budget	Remarks
1	Organic honey production display posters	4 Posters	RGoB	For extension
2	General organic farming posters	18 posters	RGoB	For extension
3	Bhutan Organic Guarantee system (BOGS) documents	5 documents	GEF-LDCF	For organic certification

3 SUPPORT SERVICES

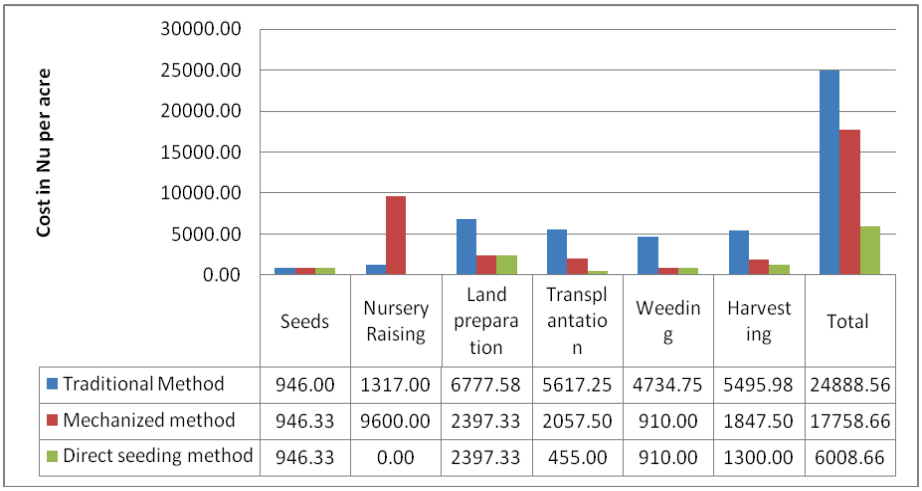
3.1 Farm Mechanisation

3.1.1 Research

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

Direct Seeding Technology

Direct seeding in paddy is popular in south Bhutan, and its potential in mitigating labour constraints as an alternative to transplanting is being assessed. Collaborative research is being undertaken to also look at suitability in colder region in consultation with ARDC-Yusipang. Economic analysis of direct seeding against others show significant reduction in costs as well as increase in production (details in following figures).



	Seeds	Nursery Raising	Land preparation	Transplantation	Weeding	Harvesting	Total
Traditional Method	946.00	1317.00	6777.58	5617.25	4734.75	5495.98	24888.56
Mechanized method	946.33	9600.00	2397.33	2057.50	910.00	1847.50	17758.66
Direct seeding method	946.33	0.00	2397.33	455.00	910.00	1300.00	6008.66

With fund support from FSAP Project field day programs were organized in Samtse, Chhuka and Sarpang where around 430 participants familiarized themselves on the direct seeder technology.

Standard and Test Codes

As in the previous FY, the AMC continued with the development of standards and codes for 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 (see Table 18).

Table 18 Standard and test codes developed based on advice of BSB

Sl	Standards	Level	Status	Remarks
1	Power Thresher	National Level	Test code and procedures are discussed with AMC subcommittee level	Draft
2	Corn Sheller	National Level	Discussed with BSB Board	Review at TC-08
3	Tractor (Test code and test procedure)	National Level	Developed test code only	Draft
4	Plough Share (Parts)	Ministry level	Draft	Review and testing for confirmation of standards needed
5	Potato digger	Ministry level	Endorsed at AMC-TC	Adoption at ministry level
6	Cardamom dryer	National Level	Endorsed test code at Subcommittee level	Need to review standard
7	Grain mill	National	Endorsed test code at Subcommittee level	Further submission to TC-08 (BSB)

Farm machineries are tested for optimum performance and safety based on existing and prescribed standards and test codes. In the previous FY five firms turned up to test their machines and were issued certified based on the performance in lab as well in field.

Figure 14 Testing of farm machinery for adoption

3.1.2 Developments

Capacity Building

The AMC's Training Section completed capacity development program that include refresher course on care and maintenance of farm machines as well as hands on training during field day programs for 1224 candidates in the past FY (details in Fig. 14).

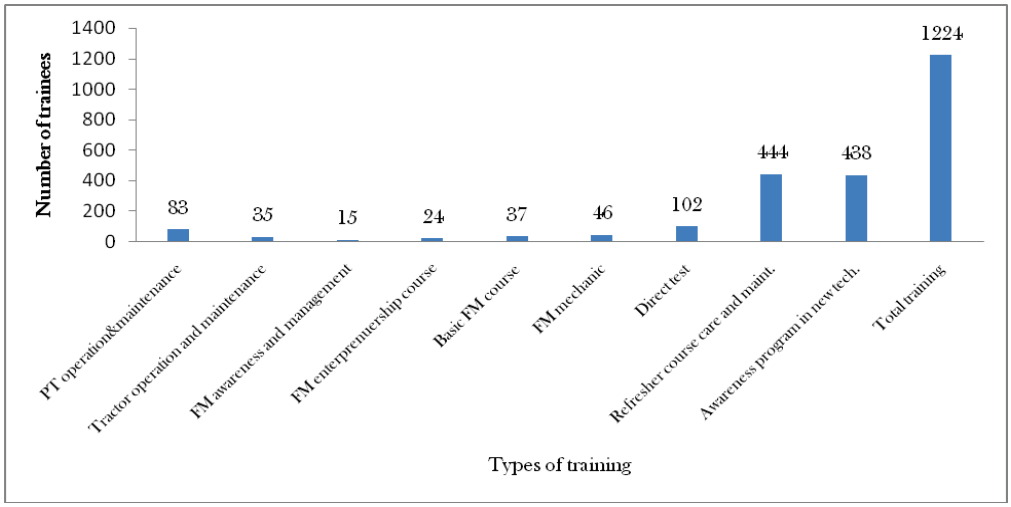


Figure 15 Training of various stakeholders on aspects of farm machinery

Figure 16 Glimpses from training programs 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), Simtokha, besides the general functions like distribution of plant protection chemicals, include:

3.2.1 Research

Survey of Vegetable pests in Thimphu and Paro

A survey was conducted to list down major vegetables grown and associated insect pests at different stages in Thimphu (Chamina in Kawang gewog and Hongtso and Yusipang in Chang gewog) and Paro (Lhaba-Jakha in Dogar gewog and Wanakha in Naja gewog). Insect pests occurring on vegetables in the sampling site was observed at

different stages (seedling, vegetative and maturity). Samples were collected and preserved in 70% alcohol.

Cabbage, broccoli, potato, radish, carrot and spinach were major vegetables grown in the survey sites. Others include garlic, spring onion, beans, peas, coriander, lettuce, chayote, onion and Chinese cabbage. These crops were attacked by pests belonging to Lepidoptera, Hemiptera, Coleoptera and Diptera orders. Cabbage, cauliflower, broccoli and spinach were attacked by cabbage aphid, cabbage white butterfly, diamondback moth, cabbage root fly and flea beetle in seedling and vegetative stages in the survey sites. No insect pests' infestation were observed at maturity stages (details in Table 19).

Table 19 Major insect pests in vegetables (Thimphu and Paro)

Dzong/ khag	Vegetable	Growth stage	Insect pests				
			Common name	Pest stage	Scientific name	Order	Family
Thimphu	Cabbage	Vegetative	Cabbage aphid	Nymph	*Brevicoryne brassicae*	Hemiptera	Aphididae
			Cut worm	Larva	*Agrotis spp.*	Lepidoptera	Noctuidae
	Broccoli	Vegetative	Diamondback moth	Adult	*Plutella xylostella*	Lepidoptera	Plutellidae
	Spinach	Vegetative	Flea beetle	Adult	*Alticini spp.*	Coleoptera	Chrysomelidae
Paro	Cabbage	Seedling	Cabbage aphid	Nymph	*Brevicoryne brassicae*	Hemiptera	Aphididae
			Cabbage white butterfly	Adult	*Pieris rapae*	Lepidoptera	Pieridae
			Diamondback moth	Adult	*Plutella xylostella*	Lepidoptera	Plutellidae
			Cabbage root fly	*Larva*	*Delia radicum*	Diptera	Anthomyiidae
			Flea beetle	Adult	*Alticini spp.*	Coleoptera	Chrysomelidae
	Cauliflower	Seedling	Cabbage white butterfly	Adult	*Pieris rapae*	Lepidoptera	Pieridae
			Diamondback moth	Adult	*Plutella xylostella*	Lepidoptera	Plutellidae

*no insect pests were observed on potato, radish and carrot
*no insect pests were observed in maturity stage

PCR Analysis of Citrus Samples for HLB Pathogen

After its initiation in 2017, the NPPC has been screening citrus plants for huanglongbing (HLB) pathogen from the National Citrus Repository at the ARDSC-Maenchuna, Tsirang. All varieties at the repository were screened in this process using real-time PCR analysis. 381 samples were collected and analyzed between 2018 and January 2019 from the mother, foundation and rootstock blocks. Test results were compared to those samples collected in 2017 based on which 25 stock plants were cleared for mass propagation and 44 plants earmarked for re-test.

Isolation of Trichoderma and *Phytophthora capsici* spp.

An in-vitro dual culture experiment was carried out to evaluate the inhibitory effect of eight isolates of *Trichoderma sp.* on four different isolates of *P. capsici*. Isolation of putative strains of *Trichoderma* sp. for control of *Phytophthora capsici* - causal agent of chilli blight was done from soil samples collected from Bjimina in Thimphu and Wangcha in Paro. Plant samples were collected from Kabjisa (Punakha). Eight putative isolates were obtained in 2017.

Bio-assay against *Phythophthora spp* in 2018-19 indicate that all eight isolates of *Trichoderma sp.* exhibited inhibition of more than 75% on all four isolates of *P. capsici.* Subsequent greenhouse bioassays in 2018 which evaluated efficacy of the isolates of *Trichoderma* sp. against the four isolates of *P. capsici* combined as one, showed reduced area in infection. *Trichoderma sp* is also indicated no adverse effect on plant growth.

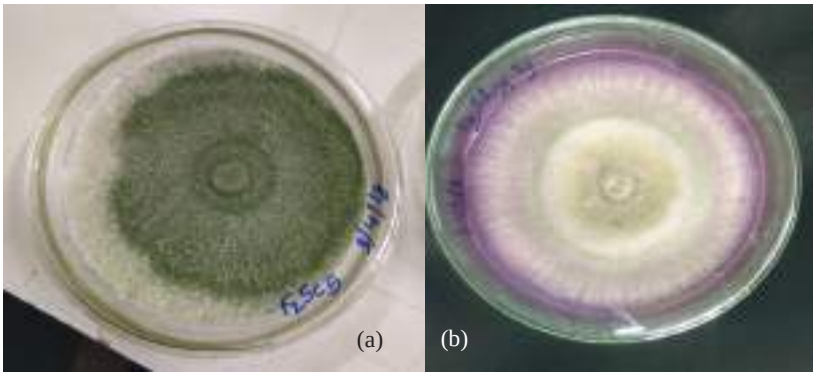


Figure 17 *Trichoderma* cultured on (a) PDA and (b) TSM

Evaluation of potassium phosphonate against Phytophthora capsici

Potassium phosphonate – a potassium salt of phosphonic acid has a systemic effect against many fungal and fungal-like pathogens. The substance's effectiveness against *P. capsici* in Bhutan was assessed in a laboratory experiment involving two isolates of *P. capsici* cultured on carrot agar medium amended with potassium phosphonate powder (Skylite Agrochem, Maharastra, India) at varying concentrations (0.2 – 0.5%). Some media were left without amendments (control).

Results showed that media amended with potassium phosphonate have inhibitory action on the growth of isolates of *Phytophthora capsici* proving its effectiveness. Based on the laboratory bioassay, a greenhouse bioassay has been initiated and data are being collected for further analysis.

Wheat Rust Surveillance

As part of its annual pest surveillance program, the NPPC continued with its survey on wheat rust pathogens such as stripe rust (*Puccinia striiformi*), leaf rust (*P. triticii*) and stem rust (*P. graminis*) which are knwn to cause serious threat to wheat production. Major wheat growing areas (Bumthang, Haa, Punakha, Paro, Thimphu and Wandue) as well as others like Zhemgang, Tsirang, and Samtse were covered. Overall, both yellow and brown rust were found in almost all the dzongkhags surveyed. Incidences of both leaf and yellow rust this year was comparatively very high. Unlike in past years, both yellow and leaf rust were observed on barley. The pustules of leaf rust were very huge on both wheat and barley crops indicating susceptible reactions. These pustules

resembled stem rust in most areas. Barberry plant acts as an alternate host for stripe and black rust. Barberries (*Berberis* spp), which is considered an alternate host of yellow rust were found in proximity of wheat and barley fields. Mahonia plant which is also implicated as an alternate host for yellow rust was recorded only in Baylandra, Wangdue.

Geo-referencing Paddy and Vegetable Crop Pests

An extensive survey to geo-reference paddy pests was carried out in Chuzergang Gewog, Sarpang dzongkhag. A total of 15 fields were surveyed. Site details as well as crop growth stages were recorded. Live pictures of pests and diseases were captured to build the image library for the National Plant Pests Database. Pests that are geo-referenced include green plant hopper, white plant hopper, brown plant hopper, white-backed plant hopper, ear cutting caterpillar, green horned caterpillar, gundi bug and mealy bug.

Similarly, geo-referencing of vegetable (cole crops) pest was carried out in the major cole crops growing areas of Thimphu (Yoeselpang, Hongtso and Jaimina) and Paro (Susana, Naja, Wanakha, and Naju) to map the precise occurrence of pests and diseases of cruciferae crops. Club root disease which infects all cruciferae crops was recorded in all the places surveyed. Other pests and diseases that were geo-referenced include diamond-backed moth, cabbage white butterfly, cabbage looper, and cabbage aphids.

Assessment of Ethoxysulfuron for Shochum Weed Control

A study was conducted to evaluate the efficacy of Ethoxysulfuron to control *P. distinctus* (shochum weed) and determine the effect on its turion under greenhouse condition. Three treatments (herbicide applied once, herbicide applied twice and no herbicide application) with three replications in randomized complete block design were used. Results show that Ethoxysulfuron was very effective in killing the weed when compared to the treatment without herbicide application. The herbicide significantly reduced the above ground parts ($p= 0.002$), below ground parts ($p = 0.003$) and the number of turions formed. The study also found a significant positive association between the above ground parts and number of turions formed, ($r (1) = 0.92$, $p < 0.001$). Linear regression indicated a significant effect of above ground parts on the number of turions formed ($R^2 = 0.84$, $p < .001$). However, there was no significant difference between the herbicide applied once and herbicide applied twice. The study will be repeated again to further confirm the preliminary results, based on which recommendations for use in the control of *P. distinctus* in transplanted rice shall be made.

Figure 18 Shochum weed growth and Shochum turions

Assessing Ethoxysulfuron Effectiveness in Farmer's Fields

In addition to the in-vitro efficacy study of ethoxysulfuron in greenhouse, a farmer's environment efficacy study was conducted where the weedicide was provided by the center to 550 households in Wangdue. Questionnaire survey through interview was conducted in 220 households. More than 90% of the respondents found the new herbicide Ethoxysulfuron effective in controlling *Shochum* and other broadleaf weeds in transplanted rice. It also concurrently reduced the number of farm labor required for weeding. All respondents wanted to continue using this herbicide in the next paddy season, substantiating its effectiveness – further evidenced in the NPPC's receipt of a demand for about 2.8 MT from Wangdue alone for 2019 paddy season.

Publication on Weeds of Bhutan

The publication "Weeds of Bhutan" by Chris Parker has not been updated since it was first published in 1992. Weeds present in the three southern districts of Bhutan viz., Samtse, Sarpang and Samdrup Jongkhar were not included. In an effort to develop a comprehensive baseline for weeds in Bhutan, weeds survey in these Dzongkhags were conducted to not only update the database but also to identify and review the presence of exotic weeds that could threaten food security and biodiversity. This information will help develop weed management strategies and action plans for new native or exotic weeds. Thirty two weed species were observed. Many new weeds such as *Sphaeranthus indicus, Cuphea carthagenensis, Tridax procumbens, Impatiens sp., Oenothera rosea* and also some invasive weeds like *Lantana camara* were also recorded. The major species density was observed in broadleaves followed by grasses and sedges. All the samples collected will be placed in the newly constructed herbarium and scientifically categorized. The survey will be an annual activity for the next four years and compressive weeds of Bhutan will be published at the end of 12th Five year plan.

Figure 19 Weeds sampling (*Ageratum houstonianum*) in Sarpang

3.2.2 Developments

Rice Pest Management through Pheromone Traps

The farmer survey conducted in 2017-2018 season showed rice caseworm and rice stem borer as the most damaging pests followed by Gundhi bug, armyworm and leaf folders. Hence, in 2018-2019 with fund support from the Asian Food and Agriculture Cooperation Initiative (AFACI) pheromone traps and lures for stem borers, army worm and leaf folder were procured and provided to farmers in Chuzergang Gewog. A total of 450 lures and 100 funnel traps were distributed with the objective of mass trapping the pests in their adult moth stages in the community. In six chiwogs of Chuzergang Geog, the pheromone traps covered 66.6 acres of paddy. At harvest end, the traps and lures were analyzed for pest counts. The highest number of insects trapped were army worm (450) followed by yellow stem borer (350), leaf folder (190) and pink stem borer (150).

Figure 20 Pheromone traps installed in paddy fields

Capacity Development

As part of the Maize TCP Project funded by FAO, training of trainers (TOT) for agriculture extension agents of Chukha, Dagana and Mongar Dzongkhags was organized in September and October 2018. The main objective was to enhance knowledge and skills on maize storage pests and disease identification and management. The program also aimed to advocate awareness on improved storage and drying methods of maize so that the extension personnel can act as resource persons for training farmers in their respective gewogs. A total of 33 agriculture extension personnel the three Dzogkhags attaended the program which had resource persons from the NPPC and NPHC.

Figure 21 Training program on maize storage pest disease management

Plant Protection Services

NPPC supplied around 19 different types of plant protection (PP) products to help manage crop pests and diseases. These PP products are broadly categorized into insteticide, fungicide, herbicides, nontoxic PP products and rodenticides. About 5,22,462 kilograms or litres of PP products were supplied from July 2018 to June 2019, the maximum quantity being herbicides (504.5MT) and rodenticides the least. Among individual PP products, butachlor supply was the highest (about 492 MT).

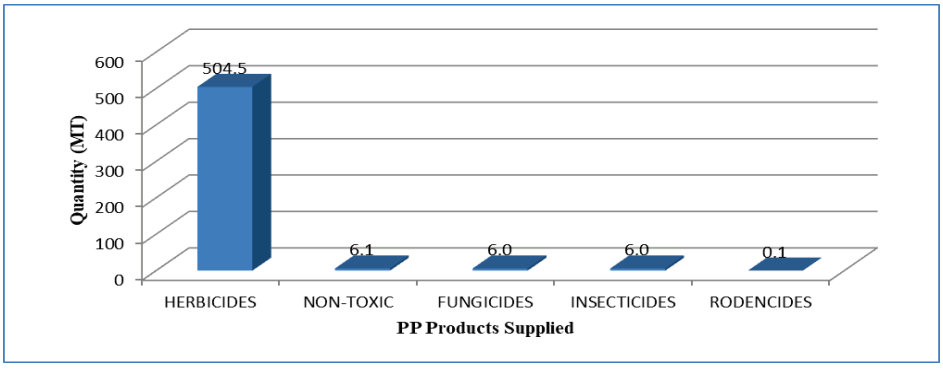


Figure 22 Quantity of plant protection products supplied by NPPC in FY2018-19

3.3 Post Harvest Program

3.3.1 Research

Oil Recovery Studies

A study on percent oil recovery from different oil seeds (mustard yellow, mustard black, sesame, and sunflower) was conducted at the Integrated Food Processing Plant, Dagapela using commercial oil expeller (Tinytech, Rajkot, India). Percent oil recovery, quantity of oil cake, time, and temperature of final oil were assessed. Results showed the percent oil recovery were 43.32% for mustard (yellow), 30.50% for sesame, 29.67% for mustard (black) and 28.73% for sunflower seeds. Study on percent oil recovery at Paro showed a recovery of 29% for yellow mustard seed, 36.5% for perilla and 6.6% for soybean seed.

Assessment of Starch Content in Maize

Maize is an important cereal crops for food, feed, seed, beverages, etc, with its major kernel composition being starch, protein, oil and minerals. A study was conducted to determine the starch content in green maize cobs. It showed that starch content in the grains vary at different growth stages of the crop with starch content and starch recovery rate increasing gradually from milk stage to physiological maturity stage. Of the four products developed from maize starch, crackers had a high score in overall acceptability by sensory panellists followed by pancake and cookies. The fried cookies scored the least in overall acceptability.

Post-harvest Storage Loss in Maize

Maize is the staple food of a majority of Bhutanese, particularly in the six eastern and six southern dzongkhags with total production recorded at 94,051 MT in 2017. However, post-harvest storage loss in maize is relatively high in Bhutan. A study – funded by FAO – was conducted in three pilot dzongkhags of Chukha, Dagana and Mongar to determine the percent post-harvest storage losses of maize due to pest and diseases in storage. It is found that major loss of maize is due to insect infestation in the three pilot dzongkhags in both the storage methods (storage on floor and hanging of cobs) being practiced in the villages (7.47 %, 35.92 %, and 10.51 % for Chukha, Dagana and Mongar respectively after three months of storage). Fungal infection is found to be the next major cause of post-harvest storage losses (0.84%, 8.04%, and 6.17% for Chukha, Dagana and Mongar, respectively). Moisture content of maize seeds in the entire pilot dzongkhags were found at an optimum level usually recommended for long term storage of maize (below 14%). The total post-harvest storage losses were determined at 22.98 % and 17.12 % for maize kept in stores/floors and hanging cobs, respectively.

Re-assessment Studies on Post-harvest Losses of Apple and Citrus Mandarin

With fund support from the Asian Food and Agriculture Cooperation Initiative (AFACI) Project, a study was carried out in 2017 to determine the post harvest loss of apples in the two districts of Thimphu and Paro. A reassessment study was done in 2018 in the same districts. The mean total post-harvest loss of apple (2017 & 2018) is estimated at 58.81% of the total production. Of the total damages and losses, 9.11% of the fruits were completely damaged and were unacceptable for both consumption and marketing, while 49.7% of the fruits were partially damaged and acceptable for both consumption and marketing. Only 26.90% of the total production reached the market without any post-harvest damages or defects. Natural causes such as diseases, insect and bird damages and physiological disorders also contributed to the total loss of apple during and after harvesting.

Similarly, a reassessment study was conducted in 2018 in the same mandarin growing districts. The mean total post-harvest damage and loss of mandarin fruits in the country (2017 & 2018) is estimated at 36.05% of the total annual production. Of this, 30.38% consisted of the partial damage that is still acceptable for both consumption and marketing, while the total unacceptable loss is estimated at 5.77%. Of the total annual production only 54.72% reached the market without any post harvest damage or loss.

Re-assessment of Post-harvest Rice Losses in Paro

With AFACI fund support study on determination of post-harvest loss in rice was conducted in Paro valley in 2017 followed by a re-assessment study in 2018. The study which assessed post-harvest losses in rice during harvesting, in-field drying, in-field transportation of harvested paddy to threshing floor and threshing process, found that the mean total post-harvest loss (2017 & 2018), irrespective of the different varieties was estimated at only 3.03% of the total production. The mean post-harvest loss at each stages of operation are 0.92% during harvesting, 1.17% during drying and 2.04% during threshing operation for all the varieties of paddy combined in the two study years.

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 developed several products on trial which include bread, cake, candy, chips, cookies, crackers, crispy bar & snack, cubes, donut, glace, jaggery, jam, juice, marmalade, pasta, paste, pickle, rollup, snacks, soap, soup, tart, tea, and wine. These products have been developed from cereals, vegetables, fruits and other crops.

3.3.2 Developments

Transfer of Post-production Technologies

Simple and effective postproduction technologies developed by the Center 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 20 Post-production technologies disseminated

Technology	Place	No	Remarks
Maize curing and storage shed	Chukha, Dagana, Mongar	9	In collaboration with NPPC under FAO funding
Onion curing shed	Shongphu, Tashigang (3) Pema Gatshel (2) (Under construction)	5	In collaboration with Dzongkhag Agriculture Sectors
Electrical dryers	Zhemgang and Pemagatshel	3	Funded by CARLEP)
Cardamom dryers	Zhemgang	4	In collaboration with Dzongkhag Agriculture Sector

Capacity Building

As part of their annual program, the NPHC carries out training programs for farmers, entrepreneurs, students, agriculture extension supervisors, youth and women groups, cooperatives, etc, on post-harvest management and processing approaches to help value add agricultural products. In the FY 2018-2019, a total of 1,191 beneficiaries were trained. Besides the usual RGoB budget allocation, the training programs were funded by AFACI, CARLEP, UNDP, dzongkhags, gewogs, READ Bhutan, and Samdrup Jongkhar Initiative. The programs were conducted in collaboration with Dzongkhags, ARDCs and Civil Society Organizations (CSOs).

3.4 Seeds and Plants Development Program

3.4.1 Developments

Seeds Production and Supply

For the financial reporting year ending June 30, 2019, a total of 627.42 MT seeds of vegetables, cereals, oilseeds and seed potatoes were produced on-farm, procured from Registered Seed Growers (RSGs) or imported and supplied to the farmers across the country. The National Seeds Centre (NSC), Paro, managed to make an overall average physical achievement of 103 % against its target in supply of seeds and seedlings. Most open pollinated variety (OPV) seeds of cereals, oilseeds and vegetables seeds are produced on farm and by RSGs while hybrid vegetables are mostly imported.

All in all, Nu.38.49 million worth of seeds were supplied which saw a slight slump as compared with the previous years as the FY did not see many project supported promotional programs, as well as due to the slow start of the initial year of the 12 FYP.

Table 21 Seeds supplied and revenue generated from the sales in 2018-19

Sl	Commodity	Type/Variety	Quantity (Kgs)	Amount (Nu.)
1	Vegetables seeds	All types	9,541.42	23,796,092.00
2	Cereals seeds	Maize, wheat, paddy	149,005.85	7,838,348.50
3	Oilseeds	Mustard, Soybean	9,236.30	818,092.00
4	Seed potatoes	Desiree	235,050.00	6,043,910.00
	Total		**402,833.57**	**51,514,953.95**

Seedling Production and Supply

A total of 330,981 numbers of high quality seedlings of temperate and sub-tropical fruit crops, asparagus and cardamom were produced or procured and supplied to the farmers, generating revenue of Nu 9.11 million. The citrus production nursery has to be relocated to Jachedphu farm (Trashiyangtse) and considerable time and effort to build the facility, owing to which there was significant decrease in citrus seedling production.

Table 22 Seedlings supplied and revenue generated from the sales in 2018-19

Commodity	Type/Variety	Quantity (Kgs)	Amount (Nu.)
Temperate fruit plants	All types	17,292.00	1,639,045.00
Sub-tropical fruit plants	All types	59,705.00	3,680,484.00
Asparagus seedlings	Merry Washington	84,880.00	339,520.00
Caradamom seedlings	Bharlangay	46,751.00	420,759.00
Strawberry seedlings	Sweet Charlie	1,508.00	10,556.00
Pineapple suckers	Queen	120,845.00	3,021,125.00
Total		**330,981.00**	**9,111,489.00**

Tissue Culture and Micro-propagation

Beginning 2014 the NSC has initiated production of tissue culture banana. In the last three years the centre has produced 35,000 tissue culture banana seedlings including 5683 of the popular international variety Grande Naine in the last FY 2018-19. These were supplied to farmers that include Khenrig Nam Sum Co-operative group in Zhemgang. The centre also produced a little over 300 kgs and 18.2 MT of seed potato mini-tubers and micro-tubers respectively.

Seed Processing and Quality Control

All seeds produced on NSC farms, through RSG and imported stocks are adequately treated with fungicides and are tested for quality analysis following International Seed Testing Association (ISTA) standards. In the current reporting year, 150 samples of cereals, oil seeds, vegetables, and other crops were tested. Besides testing, the centre also processed a total of 9,324.06 kgs of assorted vegetable seeds into quality packages of different dimensions for easy distribution.

Figure 23 Chemical fertilizers stock (left) and Seed quality testing and processing (right)

Fertilizers Supply

A total of 3,014.93 MT of fertilizers were procured and supplied across the country generating revenue to the tune of Nu.81.35 million. An assorted number of different industry standard fertilizers are being supplied in an effort to help farmers enhance crop yield and productivity (see Table 23)

Table 23 Sale and supply of chemical fertilizers

Sl	Fertilizers	Manufacturer/brand	Unit	Qty sold	Amount
1	Suphala,NPK,15:15:15	RCFL	Mt	1,192,740.00	44,847,187.00
2	Urea 46%N	KRIBHCO Ltd.(KrishakBharati Cooperative Ltd.)	Kg	1,263,280.00	25,324,241.00
5	SSP (16%P2O)	KANCHAN (Teesta Agro India Ltd)	MT	550,200.00	10,750,908.00
6	MOP (60%K2O)	Zuari Agro Chem Ltd.	MT	4,550.00	194,057.50
7	Borax (20%boron minimum)	Borax Decahydrate (20 Mule team)	MT	410.00	76,916.00
8	DAP (18%N46%P2O)	Indian Potash Limited	MT	1,550.00	74,555.00
9	Bone Meal		MT	2,200.00	90,860.00
	Sub- Total			**3,014,930.00**	**81,358,724.50**

Capacity Building

In the 2018-19 reporting year, 23 NSC staff participated in a series of capacity building programs both in-country and abroad with fund support of various projects (EU-TCP, SAARC Fund, FSAPP, IHPP and the RGoB). These include four accounts staffs who were trained on financial management, public service delivery and mid-year budget review. The centre's head attended a leadership training program while other essential staff members participated in international workshops as well as a training program on citrus nursery production at the Central Citrus Research Centre, Nagpur, India.

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. They include:

a) **Soil survey of reconnaissance scale** was carried out in Mongar, Trongsa and Samtse to collect baseline soil data from cultivated areas, classify soils and generate soil map of same scale by 2023. The survey in these dzongkhags covered 216 profile points. The DoA targets to put together a general soil map for the whole country by 2023.

Mongar profile points.

Trongsa profile points.

Samtse profile points

Figure 24 Soil profile distribution in three surveyed dzongkhags

b) The NSSC provides crucial services in the **National Rehabilitation Program (NRP)** under the National Land Commission Secretariat (NLCS). Eight separate detailed **feasibility study** was carried out to determine the soil quality, land formation, water availability and other necessary conditions required for agriculture for six dzongkhags (Tsirang, Paro, Sarpang, Chukha, SamdrupJongkhar and Dagana) to enable provision of User Right Certificate (URC) as part of the NRP.

c) A **Sustainable Land Management Technology Park (SLM-TP)** was established at ARDC-Yusipang. The park showcases important land development and management approaches such as land terracing; hedgerow plantation; brush layering; check dam and conservation pond. An erosion plot was set up too. The park will serve as a learning and demonstration site for land development technologies.

Figure 25 Different SLM technologies established at the technology park

d) Based on the positive results from previous years, **farmer extension fertilizer use trials (FEFUT)** for paddy were conducted in three dzongkhags (Paro, Wangdue and Sarpang) covering an area of 82 acres. Based on the trial, recommendations for fertilizer use were made (see Table 24). The research over the years also culminated in the publication of "Guide to Fertilizer Recommendations for Major Crops-Version 2".

Table 24 Fertilizer application rates recommendation for dzongkhags

Dzongkhag	Fertilizer (Kg)				Nutrient Ratio		
	Urea	Suphala	SSP	MoP	N	P	K
Paro	34.78	53.3	25	-	24	12	8
Wangdiphodrang	-	60	100	27	28	16	16
Sarpang	43	80	50	-	30	12	8

e) **Integrated Plant Nutrient Management (IPNM) trial** on citrus in Sarpang and Dagana that covered 537 fruit bearing trees compared IPNM treatment with that of orchards under farmers' management practices. Similar study was conducted in Paro and Thimphu on five acres of apple orchards. Results will help further refine fertilizer recommendation guide for citrus as well as advocate the use of recommended fertilizer doses.

f) With promotion of organic agriculture in the country, manufactured **organic fertilizers** are rigorously being promoted by different companies in India. To test their efficacy, some sample products are being tested on-site on various crops including cauliflower. The study is in its third repetition and reports are expected thereafter.

g) Implementation of a "**balanced fertilizer trial**" on spring paddy on 50 acres each in Gelephu & Samtse.

h) **Capacity building** of 64 staff members on baseline data collection for LULC, soil survey & SOC in the country.

3.5.2 Developments

In delivering effective soil and nutrient management services to growers and other stakeholders round the country, the Department's Soil Services Program implemented the following in the past one year:

Soil Investigation

The NSSC provided soil investigation services to a number of clients on request basis. These services are essential in making informed decisions for land-use purposes and in assessing other soil parameters. In the reporting period, the NSSC completed soil investigation reports for Hotel Six Senses - Thimphu, Royal Palace in Motithang, Thimphu, and the Bhutan Nuns Foundation at Tshalumaphay (Thimphu).

Figure 26 Distribution of sampling points for soil investigation at Six Senses -Thimphu

Cartographic Composition of Maps & Spatial Analysis

In the fiscal year, 45 major activities related to preparation of baseline maps, digitization, land use verification and map print were undertaken. The GEF-LDCF Project sites were digitally documented and spatial information updated. Some major ones include:

a) Map digitization for Gangzur, Legpa model villages, Chuzom and Jigmicholing (Sarpang), Nubi, Korphu, Langthel, and Tangsibji (Trongsa), Trong, Shingkhar, Nangkor and Buli (Zhemgang), ARDC-Yusipang SLM Tech Park.

b) Land use updates for of Jarey, Metsho, Gangzor (Lhuntse LDCF area), Bji, Sama, Gakiling, Sombeykha (Haa LDCF area), Nimshong and Nubi (Trongsa).

c) Trial location maps for different crops for the centre.

IPNM in Paddy

Following in on the activities initiated in the previous year, Integrated Plant Nutrient Management in paddy using green manure (*Sesbania aculeata*) cover crops was promoted in Sarpang, Tsirang, Dagana, Samdrup Jongkhar and Samtse covering 83.58 acres.

During the World Soil Day on 5 December, 2018, conducted in Trongsa, more than 700 farmers of Trongsa and Wangdue were provided with 1,250kgs of legume seeds.

Soil and Plant Analytical Services

Analysis of some 4,056 samples including 21 plant and water samples for irrigation was carried out by the Soil and Plant Analytical Laboratory of the NSSC in 2018-19 reporting year. Chemical analyses and analysis for soil bulk density were the two main components.

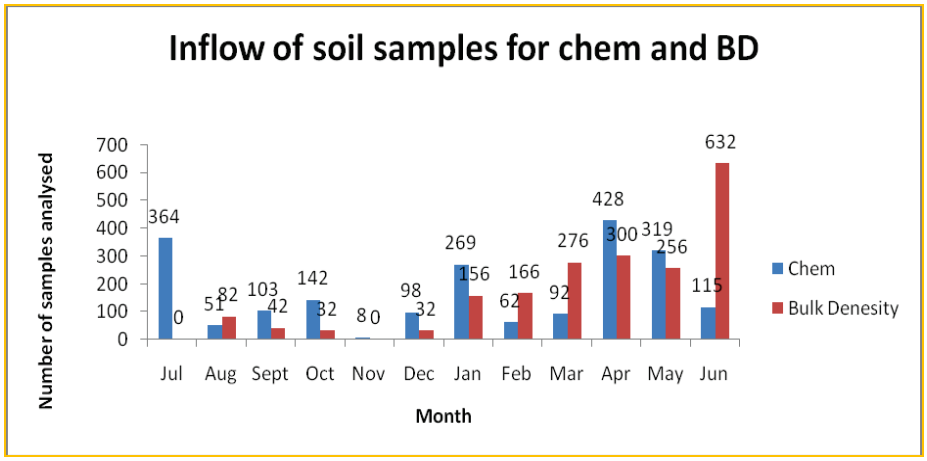


Figure 28 Number of samples analyzed for chemical and bulk density

Samples analyzed come from a range of clients that include farmers, agriculture extension, research centres and academia.

Production and distribution EM Solution

In response to the increasing demand for EM the centres is planning to up-graded its EM production capacity to 4000 liters. In the current reporting period, the centre produced 2000 liters of EM, and several schools and farmers were trained in making

effective compost using EM technology in collaboration with the School Agriculture Program (SAP).

Figure 29 Farmers and students trained in EM composting

Sustainable Land Management

For the year 2018-2019, the LMU unit had the fund support from GEF- LDCF, BTFEC and EU- RDCCRP. Major interventions carried out under different projects are indicated in the following tables:

Table 25 Land management programs supported by RDCCRP fund support

Sl	Activity	Physical progress		Financial progress (Nu.Million)
		HHS	Area (Ac)	
1	Sustainable Land Management (SLM) sensitization and Soil Fertility Management (SFM) hands on training at Gasa for agriculture extension and farmers rep.	26		0.510
2	Dry land terracing at Khatoe, Gasa	16	8	
3	Dry land terracing at Jarey, Lhuntshi	15	10.6	0.500
4	SLM sensitization and SFM training at Gomdar, S/Jongkhar	247		
5	Napier Hedgerow establishment at Denchi, Gomdargeog, S/Jongkhar	22	15	0.340
6	Water source protection at Wangphugeog, S/Jongkhar	12	2	0.025
7	Napier Hedgerow establishment at Wangphugeog under S/Jongkhar	56	32	0.153
8	Video documentation on SLM at Wangphu, S/Jongkhar	300		0.300
9	Dry land terracing at Salinggeog, Mongar	12	20	0.800
10	SLM technology park establishment at ARDC Yusipang		23	0.613
11	Installation of SLM sign board at Technology Park at ARDC Yusipang			0.120
12	Purchase of office equipment to enhance the service delivery (Laptop/Scanner/ Router/spiral binding machine/printer) 1 no			0.538
	Total		**110.6**	**3.881**

Table 26 Land management programs supported by BTEC fund support

Sl	Activity	Physical Progress		Financial progress (Nu.Million)
		HHS	Area (ac)	
1	Critical Drinking Water source protected in (5 sites) WangphuGewog	75	5	0.066
2	Procured and Supplied Legume to the farmers of WangphuGewog to increase soil fertility	280	-	0.085
3	Procured vegetable seeds to the farmers of WangphuGewog to enhance their livelihood.	300	-	0.070
4	Procured and Supplied Avacado tree seedlings to the SLM adopters of WangphuGewog.	234	-	0.204
5	Advocated awareness on SLM and LDN programs	-	-	0.050
6	Conducted soil fertility nutrient management training for the farmers of Wangphu Geog.	234	-	0.067
7	Observed World Soil Day to create awareness on the importance of soil, SLM, and LDN.	400	-	0.400
8	Organized GT to present the SLM field progress and out puts to GT members of Wangphu geog.	60	-	0.036
9	Suppled planting materials (Napier) and bio-engineering materials	-	-	0.149
10	Observed UNCCD Day to further disseminate the importance and benefits of SLM	285	80	0.700
11	Monitored and assessed SLM activities			0.038
12	Construct log and stone check dams to control gullies	Utilized for water source protection		0.040
13	Provided Incentive for construction of stone bund, Hedgerow, and terracing	43	31	0.400
	Total		**116**	**2.305**

Table 27 Land Management programs supported by GEF-LDCF Fund support

Sl	Activity	Physical progress		Financial progress (Nu.Million)
		HHs	Area (Ac)	
1	Carry out Land Use Mapping using GIS software in 18 LDCF sites under 6 pilot Dzongkhags	18		0.46
2	Sensitization on Sustainable Land Management (SLM) and Integrated Soil Fe	1869		1.70
3	Demonstrate different SLM, IPNM and Climate Smart Agriculture Approaches in 3 pilot model chiwogs	147	136.05	1.53
5	Organize short term training on Soil and Land Management	4		1.00
6	Support Soil and Plant laboratory with lab equipments			2.99
7	Training for FMCL and CMU machine operators for land development (terracing)	62		0.95
8	Training conducted on GIS for the Soil focal person from ARDC & NSSC	18		0.38
9	Napier Hedgerow establishment at Nubi, Tsamang&Saling (UNCCD day)	75	74.94	0.62
10	Capacity building in IPNM and SLM & CSA	6		1.10
11	Maintenance of ARDC soil erosion plots	4		0.200
12	Misc- (printing/SOC stock mapping etc)			1.08
	Total		**210.99**	**11.81**

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 & Forests is the lead agency. The program now focuses on supplementing food and nutrition in school feeding program to help address shifting priorities.

The SAP currently supports 327 schools inclusive of 63 central schools, with about 70% coverage and contributing 23% of fresh vegetables and over 53% of livestock produce to the school feeding program. The program provides its support in the form of trainings, inputs supply such as agriculture tools, farms machineries, seeds, seedlings, small scale livestock for educational and nutritional supplement, and awards. During the reporting period SAP successfully linked and sourced additional funds for activity implementation from FSAP Project, WFP and FAO. It has also successfully renewed its collaboration in EM technology with the Asia Pacific Natural Agriculture Network (APNAN) based in Bangkok, Thailand.

Program Expansion

In the current reporting period the program has expanded into 12 additional schools. These schools adopted model vegetable gardens for educaitonal puspose and food and nutrition supplement as part of the school feeding program. Thirty two teachers from 28 schools attended a week-long training program on integrated farming at the College of Natural Resources, Lobesa.

World Food Day

The program successfully organized the World Food Day with the global theme “Our Actions are Our Future; Zero Hunger World by 2030 is possible” on 16 October 2018 in Thimphu. The day-long program also included the SAP Awards. Agriculture produce exhibitions and food festival along with advocacy on rice fortification were parts of the event. The Best School Farm awards at the national level went to Punakha Central School (CS) followed by Yebilapcha CS, and Zhemgang for middle secondary, Tshaphel Lower Secondary School (Haa) for lower Secondary, followed by Zangkhar

Primary School (Lhuentse) for primary category. Damphu CS bagged the model schools award. Earn and Learn students engagement programme for Thimphu Thromde students was organized to engage students in their summer vacation. About 200 students and few teachers participated in the programme which introduced the concept of urban agriculture and organic principles among the 20 schools of Thimphu Thromde.

Figure 30 World Food Day celebration & SAP Awards 2018

Food Production for Nutrition Supplement

During the academic year 2018, 332 member schools and another 302 schools with vegetable gardens produced a total of 198 MT of fresh green vegetables and potatoes. Eighty schools had poultry program including 24 schools that ran poultry program for the "3 eggs/child/week policy" producing a total of 14, 71,862 eggs that not only contributed to the school feeding program but also helped sustain their SAP fund. Piggery programme is still continued in 90 schools despite the resistance and the pressure to opt out of the program. A total of 18 MT of pork is produced – a three fold reduction from previous years.

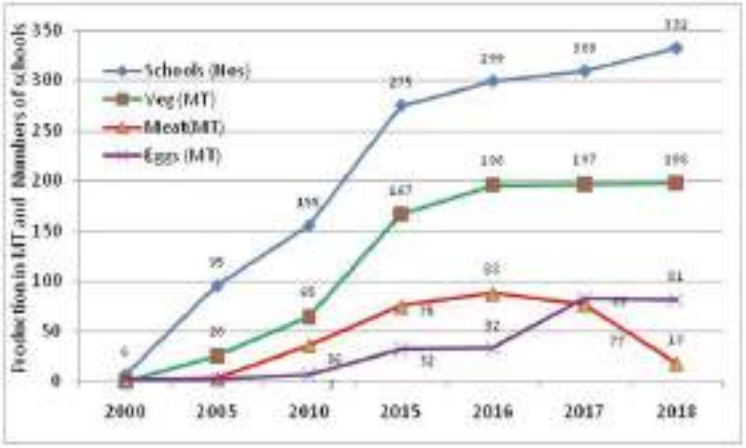


Figure 31 Production for food & nutrition supplement in schools in 2018

The School Agriculture Program (SAP) member schools (302) excluding the 30 Thimthrom schools alone have generated a total fund of Nu 9.814 million from the sale of agriculture produces.

Other Developments for the reporting year inlcude:

a) HRH Royal Thai Prince Maha Chakri Sirindhorn approved 5 additional schools on the existing 6 for financial support to expand SAP with integrated approach of WASH, Nutrition and SAP for school feeding programme. This takes the total to 11 schools under the patronage of HRH. All focal teachers and principals of these 11 schools attended awareness workshop in Thailand.

b) In collaboration with the Department of Agriculture Marketing & Cooperatives (DAMC) and FSAP Project, 16 schools were linked with farmers groups and communities to ease the marketing of locally grown vegetables into school feeding programme.

c) Organic farming in 315 schools was supported with the introduction of EM solutions.

d) SAP has been coordinating the Rice Fortification Programme, right from its inception in 2016, in collaboration with MoE, MoH, FCBL and other relevant agencies to supplement 8 essential micro minerals and vitamins in rice through school feeding programme. The Bhutan Standard for Rice is being drafted jointly with the BSB.

5 FARM INFRASTRUCTURE

The Agriculture Engineering Division (AED) is oversees all infrastructure development programs of the department and the ministry which involves building new irrigation systems, rehabilitating old ones, coordination of farm road programs and civil construction works. However, its primary focus is on irrigation and improving crop productivity and production. Some of the associated activities carried out by department in collaboration with the engineering sections attached with ARDCs and other stakeholders for the past fiscal year are summarized as follows.

5.1 Farm Roads & Land Development

Construction and maintenance of farm roads remain a priority and are being constructed either through hire of machineries from the Central Machinery Unit (CMU) in Bumthang, and Regional Machinery Units in Samtenling and Khangma on cost-sharing basis or through machines already allocated to dzongkhags. The department engaged in construction and maintenance of 400 km farm roads in FY 2018-19.

Around 600 acres of farm land have been developed and rendered cultivable employing farm machinery deployed by the department's Central Machinery Unit (CMU) in Bumthang.

5.2 Irrigation

The Department of Agriculture's Irrigation Section is responsible for building appropriate irrigation systems to enhance crop production, food and nutrition security of rural communities and RNR sector growth.

Major Irrigation Schemes

Out of the 11 irrigation schemes that the department implemented centrally in the current reporting period, five were completed and handed over to beneficiaries. These schemes total 45.50 km in length and provides assured irrigation water to over 1,200 households covering a little over 1,700 Acres of paddy fields.

Figure 32 Structures at Phendey Yuwa, Talo, Punakha (top row) & Jhatey, Sergitahng, Tsirang (bottom row)

Table 28 Total irrigation schemes (piped and open surface (Fy 2018-19)

Sl	Name of Scheme	Length (km)	Benef/ HH	Command Area (Ac)	Outlay (Mn Nu)	Funding
1	Jhatey Irrigation channel, Tsirang	7.2	64	224.00	30.0	GEF LDCF
2	Lingbay Irrigation channel, Trongsa	2.3	38	180.00	11.7	GEF LDCF
3	Phendey Irrigation Channel, Punakha	25.0	430	200.00	33.8	GEF LDCF
4	Langpa_Nobgang Irrigation Channel, Haa	10.0	60	20.00	15.0	GEF LDCF
5	Rateykhola Irrigation channel, Sarpang	3.5	187	338.00	31.2	GAFSP
6	Laringkhola Irrigation channel, Sarpang	7.5	80	310.37	37.8	GAFSP
7	Taraykhola irrigation Channel, Samtse	11.0	270	647.96	43.2	GAFSP
8	Bir Kulo Irrigation channel	2.0	26	50.00	7.80	GAFSP
9	Yabrang_Saling Irrigation channel, Tashigang	7.8	170	500.00	35.0	RDCCRP
10	Beru_Sipsoo Irrigation channel, Samtse	8.0	600	1,020.00	7.03	RGoB
11	Zhungkhar_Maenbi Irrigation channel, Lhuntse	3.0	84	116.10	19.8	RDCCRP
Total		**87.3**	**2009.0**	**3606.4**	**272.5**	

Micro Irrigation Systems (MIS) & Water Harvesting

In an effort to diversify irrigation technology, Micro Irrigation Systems (MIS) have been initiated with the setting up of smart or MIS at Zilukha, Thimphu, and at Chhimipang (Lobesa), along with a solar pump irrigation system at the Lingkana Garden in Punakha.

To improve access and availability of water for small scale agricultural activities, the department's Agriculture Engineering Division (AED) in collaboration with relevant agencies initiated the construction of two water harvesting structures at the Royal Academy of Performing Arts (RAPA) premises and Tendrelthang, in addition to one in Tsirang and two others in Dagana.

On top of paddy cultivation, other irrigation systems for tree crops and vegetables are also prioritized, and a sizeable dry land irrigation system has been initiated, particularly for cash crops like potato and citrus. Around 671 acres of dry land were brought under irrigation to support cash crops cultivation as well as lawn development and other landscaping initiatives.