ROYAL GOVERNMENT OF BHUTAN

Agriculture Research and Development Highlights 2016-2017

Department of Agriculture
Ministry of Agriculture and Forests
Thimphu: Bhutan

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FOREWORD

The Department of Agriculture is pleased to publish the Agriculture Research and Development Highlights 2016-2017. The report captures the key achievements of the research centers and central programs under the Department of Agriculture for 2016-2017 financial year. The reports submitted by various Research Centers, Central Programs and Commodity Programs under the Department were studied, and the main highlights were considered for this report.

The intention of this report is to provide an overview of progress and achievement made by the Department in one year and to serve as a baseline for the coming year. This would also allow us to reflect on the progress of the last four years and plan for the last year (2017-2018) of the 11th plan.

Each agency prepares annual progress and highlights that are comprehensive. Since this document captures on the summary, readers are requested to source information from concerned agencies if detailed information is needed. The Department would like to seek feedbacks on this report from all the readers.

With Kind Regards,

Kinlay Tshering (Ms.)
Director
Department of Agriculture

EXECUTIVE SUMMARY

The Department of Agriculture has made concerted effort to contribute to the 11th five year plan. The 4th year of the plan period (2016-2017) was an opportunity to execute as much activities so that in the final year of the plan, we can focus to wrap up the plan. With the vision "to contribute significantly for the food and nutrition security of all", the key initiatives taken are as follows:

1. The department signed the Grant Agreement for Food Security and Agriculture Productivity Project on 18th May 2017. The project is funded by Global Agriculture Food Security Program and will be supervised by the World Bank.
2. The rice program was able to take up large scale spring rice production in Sarpang, Samtse and Samdrup Jongkhar Dzongkhags. The actual farming was done by FMCL through the technical support of RDCs. The total area covered was 410 acres with total production of about 77 MT. Additionally, spring rice production at Rinchengang on about 30 acres was supported.
3. Quinoa research and promotion in the field has been picking up steadily. Two species namely *Amarilla Marangani* and *Amarilla Sacaca* have been identified for high altitude areas above 1500 masl while the Indian variety Ivory123 is found to be most suitable for areas below 1500 masl.
4. The vegetable program implemented the Commercialization of Vegetable Production project funded by Government of India. It had 20 Dzongkhags as the project area with an approved budget of Nu. 13 million. Additionally, 52 numbers of small size (50 m²) greenhouses was supplied for off-season vegetable production on cost sharing basis.
5. The third Royal Bhutan Flower Exhibition under the Patronage of Her Majesty The Gyalyum Ashi Tshering Yangdon Wangchuck was organized at the historic National Memorial Chorten, Thimphu from 4thto 11th June, 2017.The exhibition was dedicated to His Majesty the third Druk Gyalpo Jigme Dorji Wangchuck. It showcased the floral diversity, science and art of floriculture.
6. Over 30 km of irrigation channel was centrally executed benefiting 499 households covering an area of 1820 acres. Further, the Engineering Division facilitated irrigation facilities for dry land irrigation especially for vegetables, fruit crops and potato irrigating more than 875 acres and benefiting 738 households.
7. In the 2016-2017 financial year, 205 km of new farm roads was constructed and 192 km of farm road was maintained. Additionally, 168 acres of land was developed. The above figures highlighted are achieved with the use of machineries from Central Machinery Unit, Bumthang. These activities are centrally executed and the progress of the Dzongkhags is not reflected.
8. The area brought under organic agriculture in 2016-2017 financial year was about 695 acres that includes 440 acres of organic vegetables and 112 acres of buckwheat.

9. The School Agriculture Program implemented and widened the Vegetable Go to School Project in 35 piloted schools with integrated concept of school gardens with health and school feeding program.
10. New farm machineries like potato digger, cardamom dryer, hedge cutter and corn sheller were demonstrated.
11. About 286 acres of land was brought under sustainable land management practice.
12. The National Seed Center generated revenue of Nu44.52 millions from the sales of seeds and Nu 9.88 million from the sale of seedlings.
13. The 19th Variety Release Committee endorsed the release of Dragon fruit and two varieties of mustard (Yusipeka- 1 and Yusipeka 15).
14. Two new varieties of upland paddy were released. These are Wengkhar Kambja-1 and Wengkhar Kambja-2.

1. Land Utilization 2016

1.1. Dry land

In 2016, of the total estimated 129,036 acres of operational Kamzhing land holdings, 51,279 acres were left fellow (Table 1).

Table 1: Operational land holding in 2016

Dzongkhag	Dry land Own Cultivated (Acre)	Dry land left Fallow (Acre)	Dry land leased-Out(Acre)	Dry land leased-In(Acre)	Operational land holdings (Acre)
Bumthang	504	3,439	58	55	3,998
Chhukha	7,281	1,426	223	104	8,811
Dagana	8,446	1,816	358	107	10,368
Gasa	363	49	Nil	Nil	412
Haa	1,831	1,188	Nil	13	3,032
Lhuentse	1,874	2,673	89	38	4,585
Monggar	6,610	5,603	164	103	12,315
Paro	2,760	480	30	25	3,266
Pemagatshel	3,019	7,421	153	260	10,700
Punakha	1,093	435	34	21	1,550
Samdrup Jongkhar	5,027	4,735	125	96	9,859
Samtse	10,068	3,692	587	355	14,115
Sarpang	4,984	1,676	88	137	6,797
Thimphu	642	109	42	55	806
Trashigang	5,318	6,914	115	152	12,384
Trashi yangtse	1,669	2,144	61	166	3,980
Trongsa	2,027	2,636	107	82	4,746
Tsirang	5,439	831	139	90	6,360
Wangdue	3,229	928	170	318	4,476
Zhemgang	3,367	3,081	33	28	6,476
Bhutan	**75,550**	**51,279**	**2,575**	**2,206**	**129,036**

Source: Agriculture Statistics, 2016

Note: Operational land holdings= Kamzhing own land cultivated + Kamzhing fallow + Kamzhing leased in.

1.2. Wet Land

The wet land left fallow could be much higher than the one estimated in Table 2 as the biannual survey excludes the gungtong (empty households), also households which are residing at their place but not engaged in any agriculture activities. Thus keeping their lands fallow during the survey period. The gungtongs and those not engaged in agriculture activities are excluded to minimize the effect over the estimates due to the occurrence of non response by default. The total wetland harvested area includes the wet land leased in by farming households.

Table 2: Wetland utilization in 2016

Dzongkhag	Harvested Area (in Acres)	Wetland left fallow (in Acres)
Bumthang	155	
Chhukha	2,187	128
Dagana	3,950	469
Gasa	238	12
Haa	144	53
Lhuentse	1,840	378
Monggar	1,200	289
Paro	3,849	47
Pemagatshel	207	149
Punakha	7,489	336
Samdrup Jongkhar	2,320	85
Samtse	7,219	1,273
Sarpang	4,342	748
Thimphu	590	76
Trashigang	3,400	356
Trashi yangtse	2,359	289
Trongsa	1,470	306
Tsirang	3,639	380
Wangdue	5,141	684
Zhemgang	1,317	344
Bhutan	**53,055**	**6,402**

Source: Agriculture Statistics, 2016

2. Crop Production

The details of crop production in 2016 are highlighted in Table 3, 4 and 5 below.

Table 3: Cereal, Oilseeds, Spices, Legumes & Pulses and Roots/Tubers

Crop Type	Crop Name	Harvested Area (Acres)	Production (MT)	Yield (Kgs/acre)
Cereal	Paddy	53,055	85,090	1,604
	Maize	56,609	82,035	1,449
	Wheat	3,717	2,521	678
	Barley	2,451	1,702	694
	Buckwheat	6,897	3,705	537
	Millet	3,245	1,714	528
	Cereal Total	**125,974**	**176,766**	
Oil seeds	Mustard	2,395	892	370
	Groundnut	208	149	718
	Soya bean	544	254	466
	Sunflower	15	7	474
	Pyrilla/ Naam	41	12	282
	Oil Seeds Total	**3,203**	**1,314**	
Spices	Cardamom	11,086	2,736	247
	Ginger	4,773	10,871	2,278
	Spices Total	**15,859**	**13,607**	
Legumes & Pulses	Rajma Bean	1,565	994	635
	Mung Bean	952	482	506
	Legumes & Pulses Total	**2,517**	**1,475**	
Roots & Tubers	Sweet Potato	31	29	940
	Tapioca	278	415	1,490
	Roots & Tubers Total	**309**	**444**	

Source: Agriculture Statistics, 2016

Note: *The above crop production estimates are exclusive of crop damages caused by the wild animals. In the oil seeds section only mustard is used as oil for consumption.*

Table 4: Vegetable and potato production in 2016

Crop Name	Cultivated Area(acres)	Quantity Produced (MT)	Yield (Kg/Acre)
Asparagus	417	239	574
Chilli	5,538	9,907	1,789
Cabbage	2,738	6,685	2,442
Cauliflower	1,512	2,082	1,377
Carrot	607	1,276	2,103
Radish	2,871	6,490	2,261
Turnip	1,603	10,499	6,551
Beans	3,385	4,409	1,302
Peas	795	1,014	1,275
Tomato	347	455	1,310
Broccoli	725	1,004	1,385
Eggplant	408	585	1,433
Lady Finger	43	42	964
Green leaves	1,458	1,937	1,328
Onion Bulb	442	414	935
Garlic	1,409	1,176	835
Tree Tomato	-	275	-
Cultivated Mushroom	-	82	-
Dally Chilli	-	112	-
Cucumber	-	1,194	-
Pumpkin	-	3,671	-
Squash	-	2,626	-
Gourds	-	125	-
Vegetable Total		**56,298**	
Potato	**14,638**	**58,820**	**4,018**

Source: Agriculture Statistics, 2016

Table 5: Fruit production

Commodities	Total Trees(No's)	Bearing Trees (No's)	Production(MT)	Yield (Kgs/bearing tree)
Apple	242,903	196,708	6,587	33
Mandarin	1,665,797	882,807	42,003	48
Areca nut	1,423,208	726,075	9,467	13
Mango	82,153	23,494	644	27
Pear	39,575	16,726	963	58
Peach	27,087	18,131	972	54
Plum	15,849	8,920	376	42
Walnut	24,072	7,984	181	21
Jackfruit	11,113	5,406	775	143
Guava	36,405	26,360	665	25
Papaya first half yearly	7,728	4,551	107	24
Papaya second half yearly	11,406	7,639	175	23
Pomegranate	8,740	4,270	83	19
Litchi	31,805	5,602	134	24
Persimmon	3,251	1,554	49	31
Banana	350,141	107,562	3,076	29
Date Plum(Gendum)	3,484	2,017	82	41
Sugarcane	-	-	345	-
Passion Fruit	-	-	120	-
Pine Apple	-	-	67	-
BHUTAN			**66,872**	

Source: Agriculture Statistics, 2016

The trend of major crops is highlighted in the figures: 1,2,3,4,5,6,7 & 8:

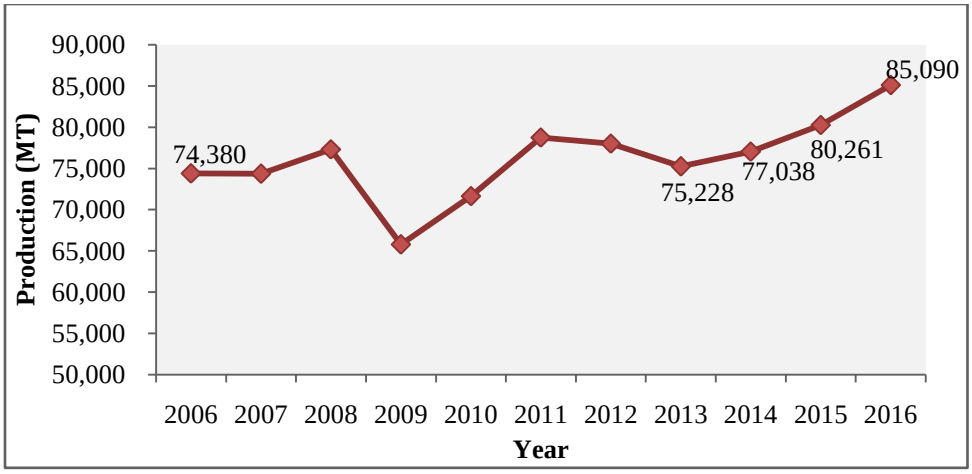

Figure 1: Paddy production trend for past ten years

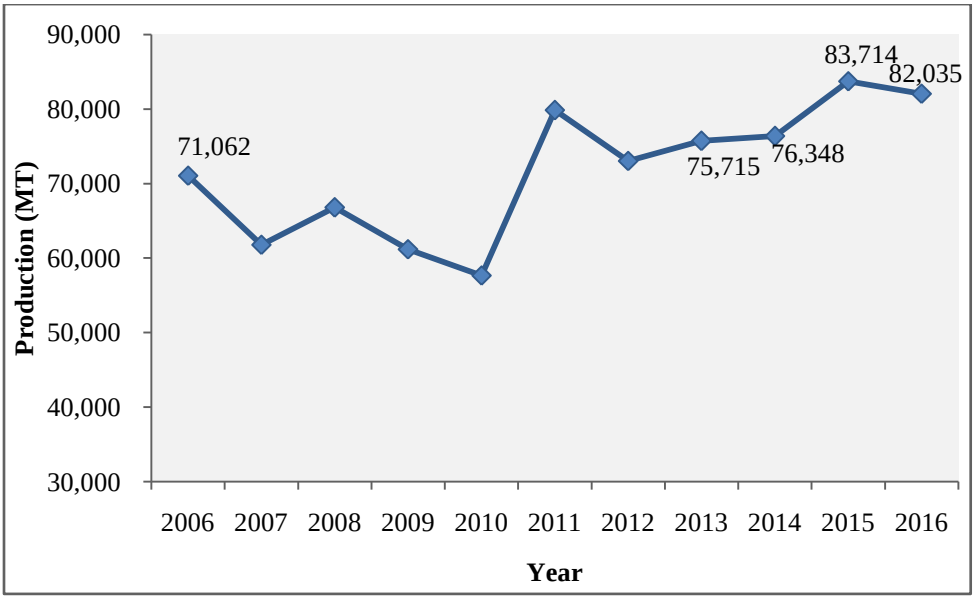

Figure 2: Maize production trend for past ten years

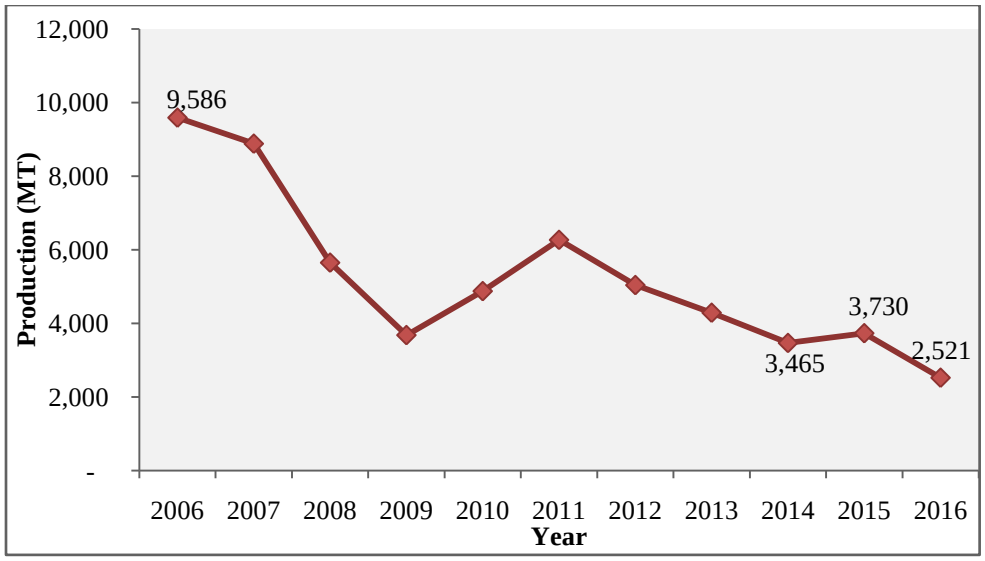

Figure 3: Wheat production trend for past ten years

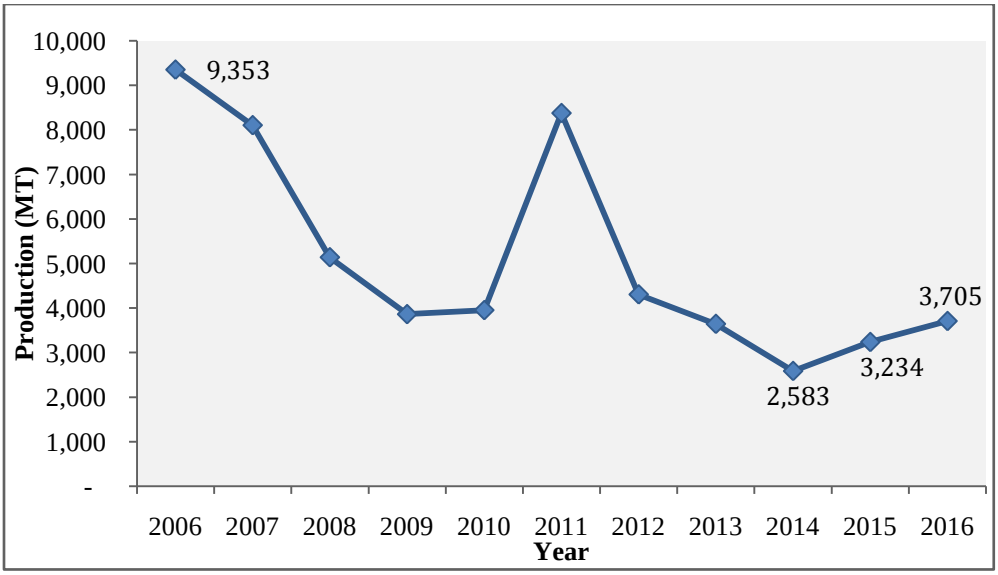

Figure 4: Buckwheat production trend for past ten years

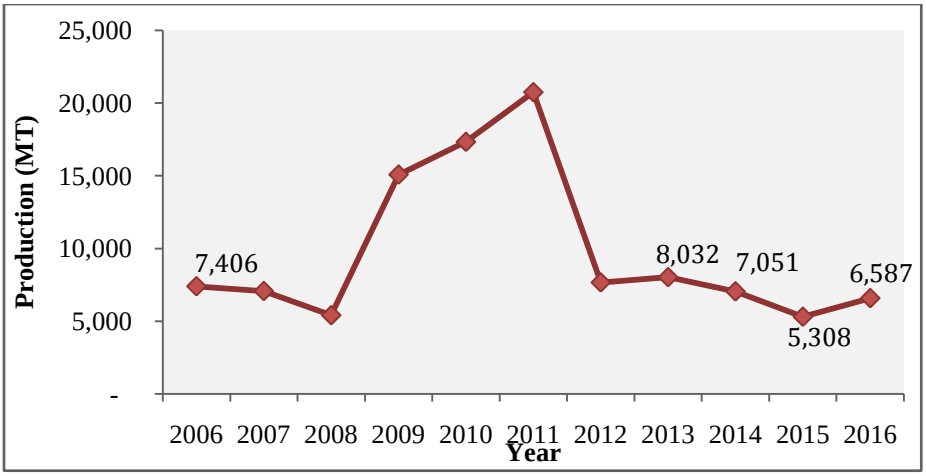

Figure 5: Apple production trend for past ten years

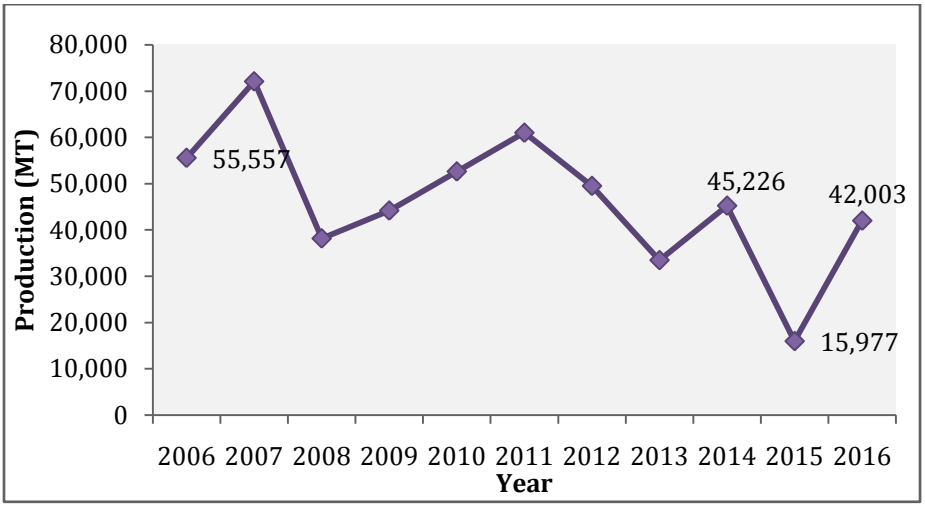

Figure 6: Mandarin production trend for past ten years.

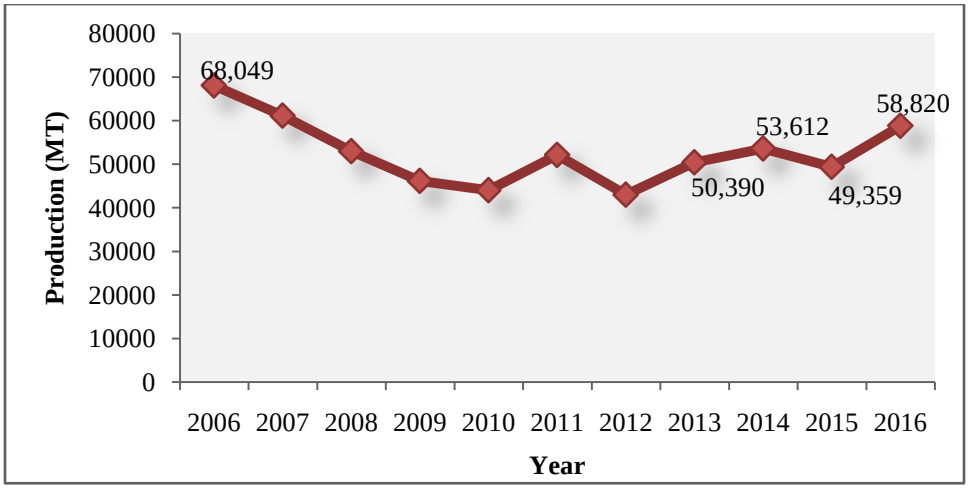

Figure 7: Potato production trend for past ten years.

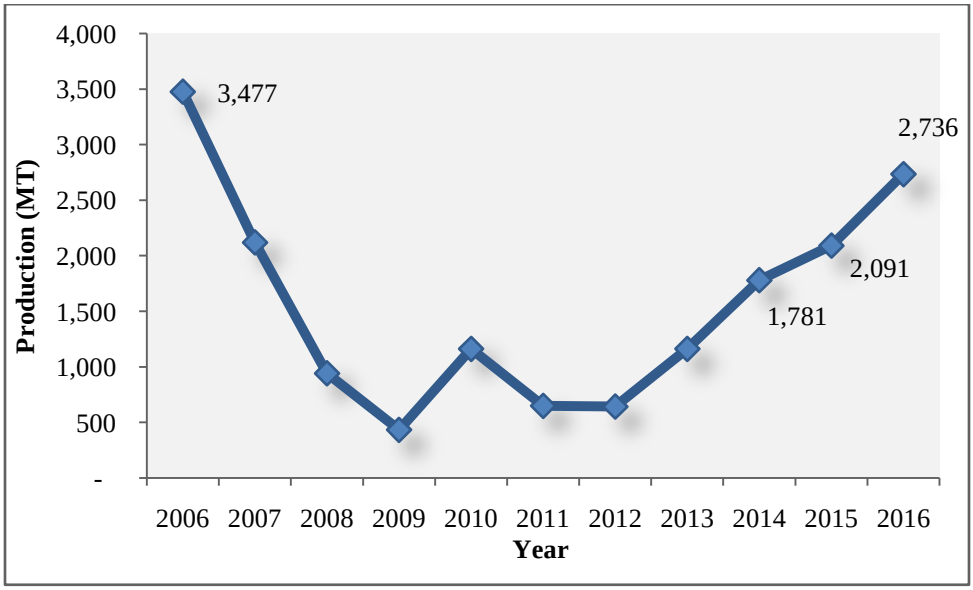

Figure 8: Cardamom production trend for past ten years

3. Road Access in 2016

The road access refers to the accessibility of farming households to any type of roads that are pliable to motor vehicles.

Table 6: Proportion of rural households by walking distance to the nearest motor able road point.

Dzongkhag	Less than 1 hour	1 to 3 hours	4 to 6 hours	Above 6 hours
Bumthang	100	0	0	0
Chhukha	72	19	4	5
Dagana	62	30	7	1
Gasa	31	0	0	69
Haa	74	3	17	7
Lhuentse	67	12	19	2
Monggar	91	7	0	1
Paro	98	2	0	0
Pemagatshel	94	4	1	.7
Punakha	98	2	0	.1
Samdrup Jongkhar	64	19	12	5
Samtse	65	17	11	7
Sarpang	85	10	3	2
Thimphu	90	0	0	10
Trashigang	87	7	5	.5
Trashi yangtse	76	19	4	1
Trongsa	93	5	2	.2
Tsirang	86	12	2	.3
Wangdue	82	10	4	4
Zhemgang	63	27	7	3
Bhutan	**79**	**10**	**5**	**6**

Source: Agriculture Statistics, 2016

4. Field Crops Commodity Development Highlights

4.1 Rice

4.1.1 Seed production

From the trial plots, seed production and demonstration blocks, paddy seed to the tune of 6 MT were produced in 2016 season. Paddy seeds of the released varieties such as Bajo Kaap1, 2; Bajo Maap1, 2; IR-64; IR20913; No.11 and Khangma Maap were produced to support promotional programs in the Dzongkhags. Bajo also produced some seeds of unreleased varieties like BRRI dhan 28 and IR28 for spring crop on ad hoc request. The seeds of varieties such as Black rice, BHT-1, BHT-2 and BHT-3 were produced for demonstration purpose only since they are longer duration varieties and quite susceptible to diseases.

4.1.2 Promotion of HYV variety seeds under commercialization program

Like in the previous years, the national rice program continued to promote improved rice varieties on larger scale. HYV seeds were supplied to different Dzongkhags based on the potential and needs of the Dzongkhags. Larger share of improved seeds have been allocated to major rice growing Dzongkhags like Sarpang, Dagana and Samtse which accounted for about 64% of the total seed supply. Altogether, the national rice program was able to promote 22.40 MT of improved seed comprising of six varieties across the Dzongkhag.

Additionally, from the on-station produced seeds, ARDC-Bajo was able to supply 1.8 MT HYV seeds to the Dzongkhags and various agencies which comprised of 9 varieties. Thus, taking the total seed supply to 24 MT.

4.1.3 Spring rice (double cropping)

Upon the command of the HE Sanam Lyonpo and through the support of the DoA, the rice program was able to take up large scale spring rice production in Sarpang, Samtse and Samdrup Jongkhar Dzongkhags. The actual farming was done by FMCL through the technical support of ARDCs. The total area covered was 410 acres with the total production of about 77 MT of paddy.

Additionally, ARDC Bajo has continued to support spring rice production at Rinchengang on about 30 acres. Unlike in the south, the yield at Rinchengang is quite high with over 2.0 MT per acre and in order to scale up spring rice in other areas, the center has collaborated with Dzongkhag and tried at Hebisa and Basochhu under Gasetshogom Geog involving 3 farmers. The average yield was good (1.97 t/acre) but since it is on a smaller area, there was problems of bird damage.

4.2 Maize

4.2.1 Crop Intensification through promotion of hybrid maize

In order to intensify maize cultivation and increase crop yield, the potentials of using hybrid maize started in2015. Promoted as spring maize mostly in low lands in the rice fallow system, its

cultivation has picked up over the years. Nonetheless, the higher cost of maize seed at Nu.180 per kg has raised concerns over the program's sustainability.

For sustainability, the National Maize Programs has now adopted a 50:50 cost-sharing mechanism for the time being and plans to phase out free seed supply gradually. A total of 13,000 kg of hybrid seeds were supplied to farmers in six Dzongkhags in 2016-17 costing about Nu 2.3 million supported through Dzongkhag and RDC Wengkhar Program. A total of 805.6 acres of hybrid maize was cultivated with a total production of 1288.96 MT.

4.2.2 Strengthening Maize Processing & Product Development

In order to enhance and sustain maize production, product diversification and value addition plays a critical role. The usage of maize for food needs to be developed beyond the conventional *Kharang*, *Tengma* and flour. Hence, farmers were trained to develop the popular maize or maize-based products.

A total of two trainings were carried out in Lingmithang and Dewathang (Samdrup Jongkhar Initiative - SJI) with technical support of the Integrated Fruit Processing Plant at Lingmethang and the Geog Agriculture Extension Offices. 38 farmers were trained in collaboration with IFPP Lingmithang and Geog Agriculture Extension Officer with fund support from GoI.

Various post-harvest machineries were supported through the GoI assistance for Cereals, Vegetables and Oil Seeds Intensification Program. Six sets of mini portable corn flour mills and 15 sets of corn sheller were provided.

Picture 1: Participants of SJI farmers and product developed by participants

4.2.3 Capacity development of extension and farmers

Three Extension Officers from Mongar, Chukha & Dagana and five researchers (3 from RDC Wengkhar and 2 from RDSC Tingtibi and Tsirang) attended five days training on Maize Research & Development in Asian Tropics at CIMMYT-Hyderabad in ICRISAT Campus from 27th February to 3rd March 2017. The training was organized as a part of on- going collaboration for HTMA project. It was funded by GoI through the Cereal and Vegetable Oil seeds Crop intensification Project.

4.3 Quinoa

Quinoa as a new nutrient dense cereal was introduced in Bhutan in 2015.The adaptation trials of quinoa in Bhutan started in 2015 with two species namely *Amarilla Maranganiand* and *Amarilla Sacaca* received from the Food and Agriculture Organization (FAO).In the beginning of 2016, six new varieties were again introduced from Peru with support of the FAO. Currently, Research and Development Centres (RDCs) are evaluating 10 different varieties introduced from different sources.

The primary objectives of introducing and adapting Quinoa in Bhutan are to diversify the cropping systems, adapt this versatile crop to the different growing environments as a climate resilient crop, and to enhance the food and nutritional security of the Bhutanese people.

4.3.1 Highlights

The updated highlights of two years of research and development activities of Quinoa are:

i. Bhutan is successfully acclimatizing and adapting Quinoa for diversifying its existing farming system and by adding a new crop to enhance the food and nutritional security.
ii. For the rapid promotion of this nutritious and healthy food, the DoA has accorded Quinoa a commodity status which is at par with other major staples like rice and maize.
iii. In 2015-16 over an estimated 40 acres was cultivated in 20 Dzongkhags covering 1000 farmers.
iv. The estimated production from Agriculture Research and Development Centres (RDC) and farmer's field in 2016 was about 1000 Kg. Most of the produce from RDCs will be used as seed for next season while some will be de-hulled and promoted as a new food for creating awareness. Some farmers have consumed their produce while some have sold in the local markets.
v. Two species namely *Amarilla Marangani* and *Amarilla Sacaca* have been identified for high altitude areas above 1500 masl while the Indian variety Ivory123 is most suitable for areas below 1500 masl.
vi. A simple information booklet with basic information on the package of practices for cultivating quinoa has also been published.
vii. One national awareness workshop was organized for the stakeholders on 29th June, 2016.
viii. A very rudimentary cost of production has been established for quinoa from the preliminary results. The estimated cost of production is Nu. 75/kg of quinoa.
ix. As commanded by His Majesty the King, quinoa was successfully evaluated at Phajoding, Dochula and Samtse and the results can be obtained from the center.
x. Four small-scale quinoa de-hulling machines have been introduced and are being demonstrated to the farmers.
xi. Two researchers from RDC-OA Yusipang attended the International Conference on Quinoa and have developed linkages with relevant institutions and professionals.
xii. One national paper on Adaptation of Quinoa for Food Security in the Himalayan Kingdom of Bhutan was also presented in the International Quinoa Conference held in Dubai from 6th-8th December, 2016.
xiii. Quinoa cultivation has been successfully demonstrated in lower elevations as a winter crop that could be sown from September to November and harvested in February-March. In 2016 winter season, cultivation of quinoa has been successfully demonstrated to farmers in Sarpang, Samtse and Chhukha Dzongkhags.

xiv. The target for promotion of quinoa in 2017 has been set at 120 acres in consultation with the Dzongkhags during the National Agriculture Conference.
xv. Farmers Field Days were conducted at two sites in Chhukha and one site in Haa to share the lessons and promote the crop.
xvi. One farmers training supported by Dzongkhag was conducted for 25 farmers in Bji Geog in Haa.
xvii. Farmers were trained on cooking quinoa dishes in Sarpang, Chhukha and Haa.
xviii. A brief funding proposal for up scaling up quinoa research and development has been submitted to MoAF.

4.3.2 Quinoa Cost of Production

The determination of the cost of production is the fundament parameter that will guide the pricing of the produce. Given the fact that quinoa is a new crop that is being adapted to the local growing environment, it is currently cultivated in small area that influences the estimation of the cost of production. Nonetheless, the preliminary results have been used to estimate a very rudimentary cost of production to facilitate the discussion on marketing; potential price structure and buy back mechanism from the farmers.

The preliminary cost of production ranges from Nu 57 to 444 per Kg of quinoa seed. The highest cost of production of Nu 444 per kg was recorded for Dawakha under Dogar Geog in Paro while the lowest costs of production of Nu 57 per Kg were recorded for Chaskar in Mongar. The cost of production is largely influenced by the cost of labor which varies quite substantially within the locations. Assuming a purchase price of Nu. 100/Kg, we estimated the Gross Margin and Net Profit per acre of quinoa crop. The preliminary results indicate that Quinoa cultivation was profitable only at Yusipang, Chaskar and Khangma.

Considering only the 3 sites with positive returns with a mean yield of 734 Kg/acre, the mean cost of production is estimated at Nu 75/Kg. The mean net profit is estimated at Nu.16, 293 per acre.

The average cost of production in major quinoa growing countries like Peru, Bolivia and Ecuador is estimated Canadian $ 142 per acre which is equivalent to Nu 7258 per acre. The estimated cost of production per acre based on the preliminary yield estimates in Bhutan ranges from Nu 38,500 to Nu 338,843 per acre.

In India the average yield of quinoa varies from Rs 600- 700 Kg/ acre with an estimated total cost of production of Rs. 16000 per acre. The selling price of quinoa ranges from Rs 100- 150 per Kg. The average cost of production is Rs 27/ Kg

4.4 Oilseeds

The field crops sector of Research and Development Centre for Yusipang has also been given the responsibility to coordinate the National Oilseeds Program. The Department of Agriculture accorded a commodity status and such focus to the Oilseeds Program enabled to implement various activities in the 11th FYP.

The overall target of the National Oilseed Commodity Program in the 11th FYP is to increase the domestic edible oil self- sufficiency from 6% to 9 % by 2018. In absolute terms, the production of mustard should increase from 1332 MT to 2000 MT by 2018 to achieve the overall objective.

Picture 2: A mustard field in Eastern Bhutan

4.4.1 Crop cut result for 2016

The crop cut result for varieties like BARI Sarisha 14 and 15 showed that the yield ranges from 150 kg/acre in Tseza Geog in Dagana to 633 kg/acre in Bidung Geogin Trashigang. These varieties are yielding higher than our existing varieties in most of the promotional sites and farmers have indicated preference for the recently released varieties.

4.4.2 Oilseed diversification

Mustard is the only oil crop, which is predominantly grown in the country for oil purposes. Oilseeds diversification is an effective option for making sustainable improvements in oilseeds production. Hence equal importance was rendered in promoting sunflower and groundnut as a part of the oilseeds diversification activities. 200 kg of BARI Sunflower 2 was procured from Bangladesh and is being evaluated in RDC Bajo, Samtenling and Yusipang. Seeds were also promoted in Bumthang and Sarpang Dzongkhags. Preliminary yield data from Sarpang Dzongkhag is very low with a total production of 850 kg from an area of 11 acres. The Dzongkhag agriculture sector carried out an analysis on oil recovery using sunflower and mustard. Five Kg of sunflower and mustard was compressed in an oil expeller. Sunflower produced 2.3 liter of oil in comparison to 1.9 liter of mustard oil. By virtue of its oil content, ease in cultivation and better yield, it posses enormous potential in our conditions in addressing gaps in oilseeds production.

In addition 2000 Kg of groundnut seeds was purchased in collaboration with RDSC Khangma and was distributed to four main Dzongkhags of Chukha, Mongar, Tashigang and TashiYangtse.

Picture 3: Groundnut integrated with apple at Genekha and grown alongside maize at Khamdang

5 Horticulture Commodity Development Highlights

5.1 Vegetable Program

The vegetable program implemented the Commercialization of Vegetable Production project funded by Government of India. It had 20 Dzongkhags as the project area with an approved budget of Nu 13 million.

Picture 4: Protected cultivation

5.1.1 Key highlights

1. Promoted 1,628 numbers of sprinklers worth Nu. 1.709 million to enhance water use efficiency in water scarce area where vegetable cultivation is taken on commercial scales.
2. Supplied 29,890 packets of chilli seeds, 11,059 packets of cauliflower seeds, 43,298 packets of beans seeds, 3,678 packets of tomato seeds and 34,692 packets of bulb onion seeds worth Nu. 3.079 Million to 17 Dzongkhags. The seeds were supplied to enhance production of these vegetables in winter season to substitute import. In total, 1,964 acres of land will be brought under vegetable cultivation and the expected production is 3,644 MT.
3. Supplied 52 numbers of small size (50 m²) greenhouses for off-season vegetable production on cost sharing basis. The total cost for 52 sets of small size greenhouses amounts to Nu. 2.159 million.
4. Trained about 550 farmers of nine Dzongkhags on improved vegetable production technologies. The total cost for the training was Nu 0.450 Million.
5. 12 The staffs comprising of Dzongkhag Agriculture and Researchers from RDCs have attended 10 day training on "protected cultivation of high value vegetables at the Centre of Excellence for Vegetable (CEV), Haryana, India. The total cost for the training was Nu.1.39mm million.
6. Three agriculture staff has participated in 5 day study visit to Manipur to study improved agriculture and horticulture technologies. The total expenditure incurred for the study visit was Nu. 0.100 Million.
7. 10 Dzongkhag agriculture staff from various Dzongkhags participated in 10 Day study visit to Himachal Pradesh, India to study improved horticulture technologies. The total cost for the study visit was Nu. 1.100 Million.
8. Review and planning meeting for winter chili production was conducted for 8 Dzongkhags (Chukha, Samtse, Sarpang, Samdrupjongkhar, Zhamgang, Trsirang, Dagana and Pemagatshel). The total expenditure for the planning meeting was 0.400 Million. The total area for chili cultivation is planned around 608 acres and the expected production is around 973.72 MT.

5.2 Fruits and Nuts

Under the JICA JPP Grass Root Project on "capacity building and introduction of innovative technologies for apple production, productivity and processing", various hands-on training on apple grafting and pruning was conducted both in Bhutan and Japan.

5.2.1 Training on apple pruning and grafting

Hands-on training on apple pruning and grafting was conducted at RDC-OA, Yusipang. There were 6 extension staffs from Thimphu Dzongkhag, 1 staff from Department of Agriculture and 3 researchers from RDC-OA, Yusipang. Scion woods of Koko and Miya Fuji varieties were grafted on the Japanese rootstock variety *Malus prunifolia* which were planted in 2016. Apple pruning was also demonstrated in farmer's orchard at Yusipang.

Picture 5: Demonstration of apple grafting technique

The same hands-on training was carried out for at Kyichu monastery at Paro for the agriculture officials of the district. The participants had the opportunity to practically carry out pruning of apple.

5.2.2 Training on rootstock multiplication

Apple rootstock (*Malus prunifolia)* propagation technique through stem cutting was demonstrated at RDC-OA, Yusipang. The participants planted about 250 cuttings and the success rate was about 80%. Stem cuttings of the different varieties (MM 109, MM 206, MM 111) of apple rootstock that are maintained by the RDC-OA were also planted as an observation trial to compare its success rate with the Japanese variety. It is observed that the Japanese variety has comparatively better success rate than our variety.

5.2.3 Fruit quality testing

In September, 2016, apple fruit quality testing methods was demonstrated by the Japanese team. One staff from the department, three staffs from RDC-OA Yusipang and four staffs from the College of Natural Resources took part in the training at RDC-OA Yusipang. The training focused on collection and assessment of quality parameters viz. fresh weight, disease and insect attack, fruit shape, fruit length, diameter, skin color index, fresh firmness, soluble solid content and titratable acidity. For the training, the counterpart from Japan contributed the necessary laboratory equipment's for fruit testing.

After the fruit assessment, it was concluded that the fruits were harvested much before it reaching physiological maturity. The Japanese team was of the view that October would be the best time to harvest.

5.2.4 Ex-country training in Aomori, Japan

First batch of Bhutanese went to Aomori prefecture in Japan for training in apple harvesting and processing in October, 2016. The officials were given hands-on training on apple harvesting,

cider making and an opportunity to learn various management practices existing in Aomori. The trainees also visited apple farms, nurseries, apple auction yards and cold stores in the prefecture.

5.2.5 Second batch trainees at Aomori

The second batch of 4 officials went to Japan in February, 2017 for period of one week. The officials have had an opportunity to try hands- on pruning of apple trees in the Fujisaki farm. The season was best for pruning of trees owing to the fact that the trees went into complete dormancy.

Picture 6: Trying hands-on pruning

The training extensively covered on the logic and reason behind why and how the pruning helps the tree nutrient regulation and optimum production.

5.2.6 Assorted temperate fruit orchard establishment at Samarzingkha

The Fruits and Nuts Program in collaboration with Department of Forests and Park Services undertook the establishment of assorted temperate fruit orchard at Samarzingkha Agro-forestry Project Site under the instruction of the Ministry. The project covers an area of more than 600 acres. The project site was undertaken with following objectives:

1. Bringing the barren land under productive horticulture and forestry cultivation
2. Act as a demonstration site for educative purposes
3. Income generation for sustenance and profit generation in long run

The orchard was established after land terracing with the technical support from National Soil Services Centre, Semtokha. A total of around 52 acres of land was brought under terracing on which fruit crops were planted. Temperate fruits like walnut, apple, pear, persimmon, peach, apricot and chestnut were planted. A total of 4600 numbers of assorted fruit plants were planted in June, 2017.

The survival rate of fruit plants was around 95 % which validates that the technique of potting and planting of temperate fruit plants during monsoon season can be successfully carried out in places where water is scarce. The DoFPS is in the process of installing irrigation system in the area. In the next coming season, the total of additional 3000 assorted fruit will be planted in collaboration with DoFPS.

Picture 7: Seedling planted in terraces

5.3 Floriculture and Amenity Landscaping Program

5.3.1 Production of Assorted Ornamental Plants

Over 150,000 numbers of assorted ornamental plants were produced at the Floriculture and Amenity Landscaping Centre. The flower thus produced was used for garden landscape, floral decoration in various national events and for the Royal Bhutan Flower Exhibition 2017.

Picture 8: Marigold Flower at FALC, Dechencholing

5.3.2 Capacity building on floriculture and amenity landscaping

Although the program had no budget for capacity development, efforts were made to organize capacity building program to enhance the capacity of the people involved in floriculture activities. Some of the activities carried out were as follows:

5.3.3 Training on grafting techniques

Training on grafting techniques was conducted for the staff working at the Royal Projects (Samtenling Tree Nursery and Floriculture Amenity Landscaping Program) on 17 March, 2017.

5.3.4 Training on Floral arrangement

A short training on floral arrangement was organized at the National Biodiversity Centre in preparation of the Royal Bhutan Flower Exhibition 2017. The training was conducted TICA Volunteer Ms. Venus Pugdeekong. The training was attended by staff from FALC, Samtenling Tree Nursery and National Biodiversity Centre.

5.3.5 Study Visit to Miharu, Japan

As a Part of the JPP Project "Urban Greenery Revitalization by Enhancing Capacity on Floriculture and Amenity Landscaping" two teams from the Department of Agriculture attended a study visit to Miharu Japan to enhance the technical skills on floriculture and Amenity Landscaping. The First team comprising of two members attended from program from 02 - 30 July 2016 and the second team also of two members attended from 9/02/2017 to 22/02/2017.

5.3.6 Support to Private nurseries/florists, NGO/CSO and public agencies

To encourage and support private nurseries taking up floriculture, following activities were undertaken under the program.

- Supply of low cost poly house and shade net to progressive private nurseries. Purchase of seeds & seedlings from private nursery.
- Set up stalls for the sale of floriculture and related products.

During the Royal Bhutan Flower Exhibition 2017, the Ministry installed and provided stalls to interested private nurseries to sell plants and floriculture related products free of cost. Since there was no budget for such support, the budget for set up stalls was supported by the Ministry of Economic Affairs. Nu 588,887 was earned as revenue from the sale of ornamental plants.

5.3.7 Exhibition/conference/show

To create awareness on cleanliness, organized and beautiful community and promote floriculture and amenity landscaping as alternative means of livelihood, the Ministry display flowers on important national events annually. This year also the ministry showcased floral decoration on the following events.

- 11 December, 2016 (National Day, Trongsa)
- 5 February, 2017 (Birth Anniversary of His Highness The Gyelsay)
- 21 February, 2017 (Birth Anniversary of His Majesty The King)

5.3.8 Royal Bhutan Flower Exhibition 2017

The third Royal Bhutan Flower Exhibition under the Patronage of Her Majesty The Gyalyum Ashi Tshering Yangdon Wangchuck was organized at the historic National Memorial Chorten, Thimphu from 4 to 11 June, 2017.The exhibition was dedicated to His Majesty the third Druk Gyalpo Jigme Dorji Wangchuck. It showcased the floral diversity, science and art of floriculture. This year, along with 7 Bhutanese garden participants, three international organizations participated in the exhibition: (i) Japanese garden (ii) Thai garden and iii) Indian Garden. The representatives showcased their garden art and techniques.

Picture 9: Royal Bhutan Flower Exhibition 2017 at National Memorial Chorten

5.3.9 Floriculture and landscaping centers/sites established/maintained

In addition to the regular maintenance of the Floriculture and Amenity Landscaping Centre, the staff were also involved in landscape development the Dechenphug Lhakhang and the Kichu Lhakhang.

5.3.10 Project Activities (BTFEC)

The program titled "Conservation and Sustainable Use of Indigenous Flora in Bhutanese Gardens and Landscapes" is financially supported by Bhutan Trust Fund for Environmental Conservation (BTFEC) and is for 3 years (January 2017 to December 2019). The total cost of the project is Nu. 7.12 Million. Under the project the following activities were carried out in the fiscal year 2016-2017:

1. Purchased laptop for the program. The procurement of working gear, field tools and the research activity shall be carried out in the coming period.
2. Few native plants were collected and maintained at the Floriculture and Amenity Landscaping Program, Dechencholing.
3. Procured 5 fabricated greenhouses (20x5) and 30 rolls of shade nets. The structures shall be supplied to respective centres/agency for maintenance and multiplication of plants. Irrigation materials, nursery tools and other inputs shall be procured and supplied in the coming period.
4. Two officials from Ministry of Agriculture and Forests attended the Goyang International Flower Festival. The Festival showcases flowers and various plant products. The event also exhibit unique and rare plants.

5.4 Citrus

5.4.1 Germplasm collection, introduction and repository establishment

5.4.1.1 Citrus Germplasm collected and maintained within the country

Citrus (mandarin selections from orchards and backyards along with wild citrus types) collected from Tsirang, Sarpang, Samste, Mongar, Punakha and Wangdue districts are propagated and held at National Citrus Repository, Mithun.

5.4.1.2 Citrus germplasm and rootstock seed introductions from Australia

Seven new orange varieties were introduced from Australia in November 2016. The varieties have been propagated at the NCR, Mithun and the Research and Development Centre, Wengkhar. The varieties are processing orange selections and will be available to support the future development of a juice processing in industry in eastern Bhutan. Swingle Citrumelo and Flying Dragon rootstocks, introduced from Australia have been germinated and will be tested as potential future rootstocks in Bhutan.

Picture 10: Citrus germplasm and rootstock at NCR, Mithun

5.4.2 National citrus repository (NCR) Mithun, Tsirang

The maintenance and recovering of two screen houses was finished with a third structure 70% complete. The NCR is currently developing mother trees to be supplied to the new National Seed Centre (NSC) citrus propagation nursery being under establishment at altitude (1700mASL) in Trashiyangtse, eastern Bhutan. The Jachedphu NSC, Trashiyangtse farm has already started raising citrus seedlings and more than 50,000 seedlings will be made available for farmers in the coming season.

5.4.3 Citrus Nursery Protocols and Standards

A minimum standard for citrus nursery production and propagation material has been formulated and reviewed to streamline the nursery production process in Bhutan. A citrus repository protocol has also been developed and reviewed based on citrus repository protocols in Australia. Both operating procedure and protocol documents are finalized and will be circulated for compliances in the field.

5.4.4 Citrus Growers Survey

The citrus program with the support of extension officers completed the citrus growers' survey in areas supported by ACIAR project. More than 250 households were covered under survey. Survey questionnaires after compilation will be sent to ACIAR project counterpart in Australia for analysis. This report will be not only important to analyze the impact of project activities, but also to guide us in making decisions on research and extensions works on citrus.

5.4.6 Knowledge and management of key pests and diseases

Citrus Pest management

The National Plant Protection Centre (NPPC) continued with its program on citrus pest management in the ACIAR project supported areas. The NPPC has initiated a survey to select trial sites for *Phytophthora* root rot studies in citrus. Experiments will be conducted in the coming season.

Citrus Pest Management booklet

A 'Citrus Pest and Disease Management' booklet has been published by the National Plant Protection Centre (NPPC) incorporating the latest information generated from the ACIAR project on managing citrus pests and diseases in Bhutan.

Pests of Bhutan Website and Database

The NPPC launched the website on 'Pests of Bhutan' and a Database with all updated information on citrus and other crops. Current citrus pest information was provided from ACIAR project activities in Bhutan.

Fruit Fly Management Technology Dissemination

The NPPC conducted a fruit fly management campaign for citrus growers in Dagana. The campaign emphasized an area-wide method of management and use of newly developed and more effective control techniques. This area wide management- which is found effective will be promoted in other citrus growing areas in the coming season on a larger scale.

Studies on huanglongbing (HLB) and citrus psyllids – through PhD study program

Highlights:

- *Diaphorina communis* adults can acquire the HLB pathogen,'*Candidatus Liberibacter asiaticus'* ('*C*Las') but at a low rate.
- *Diaphorina communis* feeds and develops exclusively on curry leaf when given a choice. However, a low to negligible rate of development of *Diaphorina communis* observed on mandarin under no-choice conditions.
- There is no evidence that curry leaf can harbor '*C*Las'.
- No evidence of transmission of '*C*Las' by *Diaphorina communis* from infected mandarin to mandarin or curry leaf could be established. *Diaphorina citri*is more commonly found below 1200 m while *Cacopsylla heterogena* is found quite abundantly at higher altitudes.'*Candidatus Liberibacter asiaticus'* is more prevalent at elevations up to 1100m. At elevations above 1200 m, '*C*Las' may have been introduced in planting materials but remained localized due to absence of

Diaphorina citri at these altitudes. In the absence of a vector, it is possible to grow mandarins and other *Citrus* species and hybrids above 1200 m using pathogen-free planting material.

- Three species of green psyllids occur in Bhutan, one on citrus and two on *Zanthoxylum* sp.The green psyllid occurring on mandarin, wild citrus, lemons, limes and oranges in Bhutan belong to one species, *Cacopsylla heterogena*.
- The two psyllids collected from the *Zanthoxylum* sp. are confirmed as *Cornopsylla rotundiconis*, and the other is an undescribed species of *Cacopsylla*.
- *Cacopsylla heterogena* can acquire '*C*Las' under field conditions.
- There is no evidence of '*C*Las' in *Cornopsylla rotundiconis* and *Cacopsylla* sp., the green psyllid species recorded on *Zanthoxylum* sp.

5.4.7 Orchard management practices, nutrition and water supply

Canopy management

The citrus program and ARDC Wengkhar in collaboration with Districts/extensions conducted canopy management, nutrient and irrigation training and campaigns in Sarpang and Pemagatshel districts. In Sarpang, five orchards were pruned completely by the participants as part of hands-on training. More than 86 farmers and 6 extension staff participated in the program. In Pemagatshel, more than 300 farmers were involved along with extension officers. This program has motivated more number of farmers both in these two districts and other areas. This programme is helping to educate farmers towards managing orchards, particularly to rehabilitate the old orchards.

Picture 11: Citrus canopy management in Sarpang and Pemagatshel

Water Conveyance options

Two-day training was conducted for the extension officers, field manager and farm attendants of Kana citrus farm and key farmers in the Dagana district. The participants were also trained on other orchard management practices such as leaf sampling for nutrient analysis, phenological stages of citrus, tree planting techniques and disease diagnosis.

Demonstration orchards

Seven demonstration orchards set up in collaboration with Research and Development Centres (Bajo, Samtenling, Wengkhar, Mithun and Yusipang) remained active in 2016/17. These pilot

orchards are situated across six citrus growing districts in Bhutan. The orchards provide a training resource for capacity building programs developed for farmers and extension personnel. Through these initiatives, more farmers are becoming aware of management technology and are coming forward to adopt in their orchards, particularly for the management nutrients and irrigation.

Establishment of commercial orchard

In collaboration with FMCL, more than 101 Acre of mandarin orchard has been established in Dolebchen under Kana Gewog in Dagana. The orchard is planted with more than 20,000 mandarin grafts, and it is being maintained and managed by FMCL. This initiative is first of its kind to transit citrus production to a larger and to a commercial scale.

Soil sampling and nutrition

Citrus leaf/soil sampling and analysis has been completed for the demonstration orchards and for some other key citrus orchards. Citrus fertilizer recommendations have been finalized and reported. This will able to guide the nutrient management of orchards under different conditions.

5.4.8 Capacity building of Agricultural staff and farmers

In Bhutan

- Two-day training on water conveyance options was provided to the extension officers of Dagana districts; farm manager and farm attendants of Kana citrus farm; and key citrus farmers of the Dagana.
- Two day stakeholder workshop was organized to review citrus nursery standards, repository protocols and huanlongbing (HLB) issues in the nurseries and field and discuss the latest research work and views of stakeholders.
- Canopy management, nutrient, plant protection and irrigation management training conducted for the extension staff and farmers of Sarpang and Pemagatshel districts as part of technology transfer activities by ACIAR project officers.
- A seminar on PCR technology was conducted for the plant protection officers of the NPPC and NCR by Dr. Nerida Donovan, DPI.

In Australia

- One Agriculture Supervisor, NSC - Samtenling completed a 28-day training program during November and December 2016 on 'Citrus Nursery Skills and High Health Status Tree Production' in collaboration with NSW Department of Primary Industries. Training was conducted at Eyles Citrus Nursery, Kenthurst, Sydney, NSW and at Victorian Citrus Farm's nursery, Mildura, Victoria.

In Brazil

- Two officer working for citrus programme and research attended the 13th International Citrus Congress in Foz do Iguacu, Brazil from the 18th -23rd Sept. 2016.

6 Irrigation development

The Agriculture Engineering Division (AED) is tasked to develop and maintain the agricultural infrastructures with the focus on irrigation structures since the Department's main focus is on food self sufficiency. To keep abreast with the changing climatic conditions and varying rainfall pattern, the AED has already adopted various efficient irrigation conveyance systems. Few schemes which are already functional using the lift irrigation, piped irrigation and micro irrigation systems during the financial year 2016-17 are given in Table 7.

Table 7: Details of irrigation schemes constructed in 2016-2017 FY

Sl. No.	Dzongkhag	Gewog	Name of Scheme	Length (km)	No. of HHs	Command Area (Ac)	Remarks
1	Samtse	Yoeseltse	Kuchidiana	7.40	256	962.20	Mixed mode
2	Lhuntse	Minjey	Ngarigangchu	8.10	84	200.70	Piped irrigation
3	Lhuntse	Minjey	Ngarchu/Serchu	5.50	72	362.40	Piped irrigation
4	Lhuntse	Tshengkhar	Phawangchu	8.00	55	151.70	Piped irrigation
5	Samtse	Ugyentse	Thakuri Kholsi	1.60	32	142.80	Lift Irrigation
				30.60	**499**	**1819.80**	

Further, the division has facilitated irrigation facilities for dry land irrigation especially for vegetables, fruit crops and potato during the financial year 2016-2017 irrigating more than 875 acres and benefiting about 738 households.

Pictorial presentations of irrigation activities are as below:

Picture 12: Lift Irrigation Infrastructures

Picture 13: Improved open & piped Irrigation Systems

Picture 14: Micro Irrigation Systems

7 Rural access/ farm roads

Isolation, drudgery and lack of accessibility led to substantial investments in farm roads in Bhutan and farm roads are seen as the main determinant factor leading to agricultural development. The current plan period continues the thrust on construction of farm roads with a total of 686 new farm roads covering a length of 2497.2 km being planned to be taken up during the plan period. However, the actual number and length of farm road constructions will be much more as most of the Gewog Development Grant (GDG) budget allocated by the government is utilized by the Geog for farm road construction. Today most of the remote areas are connected.

In the 2016-2017 financial year, 205 km of new farm roads was constructed and 192 km of farm road was maintained. Additionally, 168 acres of land was developed. The above figures highlighted are achieved with the use of machineries from Central Machinery Unit, Bumthang. These activities are centrally executed and the progress of the Dzongkhags is not reflected. A summary is given in the Table 8.

Table 8: Farm Road and Land Management activities, 2016-2017

Sl No	Dzongkhag	New Farm Road	Farm Road Maintenance	Land Development
1	Bumthang	7.5	-	20
2	Chukha	18	-	-
3	Dagana	-	-	1.5
4	Gasa	5.5	10	-
5	Haa	4.95	13	15
6	Lhuntse	25.1	30.5	66
7	Mongar	10.8	17.6	-
8	Paro	-	-	-
9	Pemagatshel	7	12	-
10	Punakha	1.2	18.1	25
11	Samdrupjongkhar	13.1	-	-
12	Samtse	19	30.5	-
13	Sarbang	17.5	-	-
14	Trashigang	12.5	14	0.5
15	Trashiyangtse	12.6	9.5	-
16	Thimphu	5.1	-	40
17	Trongsa	4.7	-	-
18	Tsirang	3.5	-	-
19	Wangduephodrang	27.8	32	-
20	Zhemgang	9	9	-
	Total	**204.5**	**192.2**	**168**

8 National Organic Program

8.1 Training of Trainers (ToT), Farmers Training and Capacity Building.

In the fiscal year (FY) 2016-2017, the NOP conducted numbers of ToTs, farmer trainings and few capacity buildings as listed below:

8.1.1 Training of Trainers

A total of 4 ToTs were organized, which was attended by a total of 48 staffs. The topics covered were:

1. Organic agriculture & certification systems.
2. Bio fertilizers implementation guidelines, organic agriculture and certification systems.
3. General organic agriculture practices for sustainable farming.
4. ToT cum farmers training on general organic agriculture and organic asparagus production.

8.1.2 Farmers Training

A total of 357 farmers were trained in 13 Dzongkhags (Sarpang, Thimphu, Punakha, Zhemgang, Trongsa, Bumthang, Tserang, Chhukha, Paro, S/Jongkhar, Pemagatshel, Tashigang and Mongar). The training primarily consisted of organic vegetable cultivation, bio-slurry utilization in agricultural crops.

Picture 15: Farmers training at Patshaling, Tsirang

Picture 16: Farmers training in Paro

8.1.3 Capacity building through Ex-Country Training

To build the capacity of stakeholders and staffs, the program sent 9 officials for training and study tour to India and South Korea funded by AFACI and EU-GCCF projects.

8.1.4 Important workshops/seminars

The important workshops/seminars organized by the NOP are:

1. The National Workshop on Road map for organic agriculture policy in Bhutan
2. Organic Farming Research and Education
3. Technical seminar on organic rice production

8.2 Organic asparagus production

A total area of 203 acres were under organic asparagus cultivation, spread across 14 Dzongkhags namely, Thimphu, Chhukha, Dagana, Samtse, Bumthang, Wangdue, Punakha, Paro, Gasa, Zhemgang, Chukha, Tsirang, S/jongkhar and Trashiyangtse with current production of 96 MT.

8.3 Organic buckwheat production

The organic buckwheat cultivation was focused in five Dzongkhags (Chukha, Haa, Gasa, Bumthang & S/Jongkhar). NOP supplied the buckwheat seeds to Gasa & Samtse, whereas for S/Jongkhar Dzongkhag, the seeds were supplied through the Dzongkhag budget. Currently a total area of 1217.5 acres is under organic buckwheat cultivation with the production of 764.6 MT.

8.4 Production support Inputs/Infrastructure

A total of 42 numbers green house plastics and 1 full set of green house, 3 numbers of bio-digester and 5 numbers of bio-slurry compost drying sheds were supported.

8.5 Projects initiated

The National Organic Program handled three projects in the FY 2016-17. Some of the projects will continue in next financial year (Table 9).

Table9: Projects handled by the NOP in the FY 2016-17

Sl. No	Project Title	Duration	Funding	Remarks
1	Organic Village adoption (AFACI project)	3 years	AFACI	Haa
2	Country assessment for going 100% organic	7 months	ICIMOD	National assessment
3	Creation of Active Local Communities through the Introduction of Organic Agriculture with the System of Circulating Natural Materials in Bhutan	3 years	JICA NOP Joint partnership program.	Paro, Thimphu, Punakha and Wangdue.

8.6 Participation in the World Soils Day:

The NOP participated in theWorld Soil Day celebration on 5th December, 2016 in Tsirang Dzongkhag with the theme "Soils and pulses, a symbiosis for life".

The certified organic potatoes from Gasa were launched for sale to public on 18th November, 2016 at Centenary Farmers Market in Thimphu. The NOP collaborated with the Dzongkhag in registration processes.

Picture 17: Certified organic potatoes

8.7 Promotion/Generation of organic agriculture technologies supported

The organic agriculture technologies promoted by the program is highlighted in Table 10.

Table 10: Organic agriculture technologies

Sl #	Technology promoted/generated	Nos.	Remarks
1	Demonstration of organic paddy transplantation for weed control	3	Through JICA JPP on the control of weeds in paddy.
2	Bio-digester adoption	3	Through budgetary and technical assistance.
3	Bio-slurry compost technology	5	Through Bio-gas project
4	Vermi-compost technology	2	Technical assistance from the NOP
5	Liquid manure preparation	6	Disseminated through 4 TOTs and 2 farmers' trainings.
6	Bio-pesticide preparation	6	Disseminated through 4 TOTs and 2 farmer's trainings.
7	Heap composting	4	Through 2 farmers training and 2 TOTs.
8	Technologies promoted through Animations	3	Technologies in soil nutrient management and plant protection
	Total	**32**	

8.8 Area increased under organic management in FY2016-17.

The area brought under organic agriculture in 2016-2017 financial year is about 694.91 acres that includes 440 acres of organic vegetables and 112 acres of buckwheat.

9 School Agriculture Program

9.1 Introduction

School Agriculture Program (SAP), has been realigned with the Agriculture Production Division, DoA, MoAF as a joint collaboration with Department of School Education, MoE since year 2000. It was initially started with 6 piloted schools and now expanded its activities with 320 schools covering 56% of total schools in the country. As a joint program, technical and financial supports are rendered by Ministry of Agriculture and Forests while policy and manpower supports are looked by Ministry of Education.

Picture 18: Vegetable production by students

The program supports SAP member schools with inputs supply such as (agriculture tools, farms machineries, seeds, and seedlings), training of focal teachers and small scale livestock for educational and supplementing nutrition in the school feeding program. The main objective of the program is to provide basic skills and awareness in modern farming creating awareness and interest towards self employment opportunities as wholesome education. In feeding schools, it also supplements nutritious fresh vegetables and eggs/meats from the SAP activities. Most of the project have completed their project life and now solely dependent on state funding of average of Nu. 3-4 Million as annual budget with occasional donor funding viz, WFP, FAO and Vegetable go to School Project. Best School Farms among SAP schools are awarded during World Food Day on 16th October every year in collaboration with Department of School Education, FAO and WFP.

9.2 Major activities

- Training of 32 school teachers on integrated farming (vegetables, mushroom and livestock farming) including integrated concepts of WASH, feeding and nutrition at College of Natural Resources, Lobesa.
- Implemented and winded the Vegetable Go to School Project in 35 piloted schools with integrated concept of school gardens with Health and school feeding program.
- Supply inputs (vegetable seeds to 285 schools and agriculture tools in 15 schools)
- Supported three schools in establishment of livestock program pigs and pullets in 3 Central schools for educational purpose and supplementing nutrition through eggs and meat in their school diet.
- Awareness program, competitions, Awards and certification held during World Food Celebration on October 2016 at Laya organized together with Royal High Land Festival.

9.3 Production progress by SAP schools

During the academic year 2016, 275 schools participated in vegetable gardening inclusive of 24 schools in mushroom cultivation producing 196 MT of assorted vegetables (Figure 9). And 76 schools had piggery program and produced 88 MT of pork that was consumed by students of feeding schools to supplement nutrition.

A total of 76 schools have been rearing pullets at different scales with production of 588,000 numbers of eggs as reported in 2016 academic year (Figure 10).

About 60% of them are consumed in the feeding schools with subsidised rate from the feeding stipend while 40% sold outside for generating fund to sustain the program.

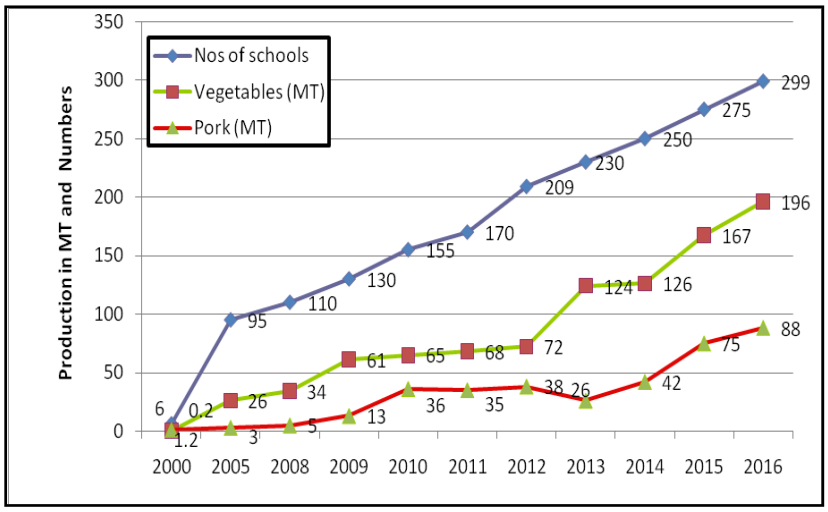

Figure 9: Vegetables and meat production

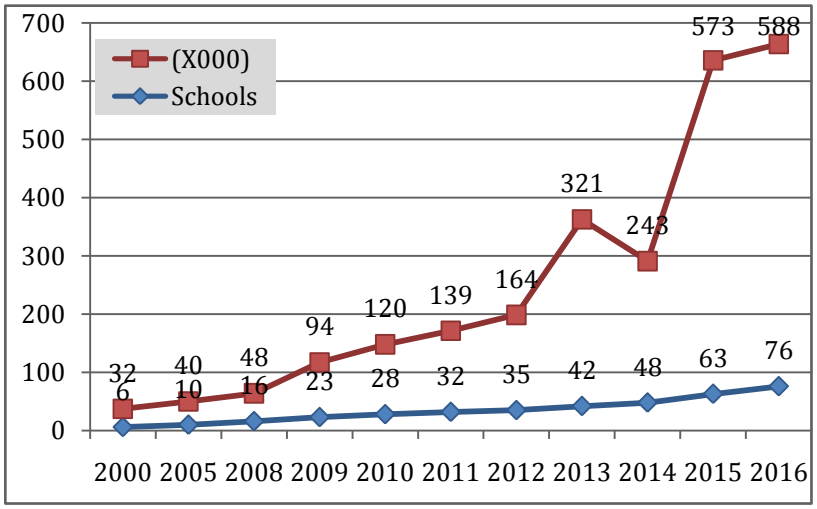

Figure 10: Egg production

10 Support Services Program

10.1 Agriculture Machinery Centre, Paro

10.1.1 Eleventh Five Year progress and achievement for four years

Table 11: Cumulative target and achievement of four years of the 11th plan

Section	11th FYP Target	Unit	Total Achieved (2013-2017)	% Achieved
Appropriate training on farm machineries are provided	2350	No.	1781	75.79
Appropriate farm machineries developed and disseminated through R&D activities	6	No.	5	83.33
	Technology sourced	No.	11	-
Quality and safe farm machineries and spare parts are ensured	6	No.	4	66.67

10.1.2 Technology dissemination through R&D activities

10.1.2.1 Development of potato digger as an attachment for power tiller

The potato digger is an implement which digs and loosens the soil making it easy to collect the potato. However potato collection has to be carried out manually. Five sets of potato diggers for 120 power tillers were developed and conducted series of tests in the farmers' fields in Phobjikha and Paro. It was observed that it works well in the row bed fields accessible to power tiller and without weeds.

Picture 19: Demonstration of potato digger

10.1.2.2 Development of cardamom dryer

Improved cardamom dryer was tested and farmers feedbacks were collected during the field awareness programme held at Tsirang, Dagana ,Samtse and Sarpang. The farmers were interested to adapt the technology and hence the order for 66 sets was decided. Hence in order to encourage the cardamom production and also to provide more awareness to the user across the country, the centre in collaboration with SFAMP-II had procured 40 sets and also supported Dagana Dzongkhag with 26 sets with their budget. These 66 sets will be installed in the coming year during the cardamom drying season.

10.1.2.3 Development of hedge cutter

Hedge cutter is a simple machine for harvesting paddy, wheat and other crops in sloppy or terrace fields. The machine was tested in farmers' fields across Paro Dzongkhag for its performance test in comparison with manual and brush cutter. The hedge cutter is very effective except for tall variety crops. Operation of hedge cutter is easier than serrated brush cutter. The users showed keen interest to adopt the technology.

10.1.2.4 Develop corn sheller

AMC had developed the corn sheller for small scale farmers. It was found very effective during the laboratory test with 100% shelling efficiency and 110 - 130 kg per hour capacity. However it was important to know users' views. Hence the machines were taken to farmers' fields for feedback. The first round of feedback collection was done by Khangma office of AMC. If necessary the corn sheller will be modified based on the feedback.

10.1.3 Training on farm machinery

10.1.3.1 General training

The trainings conducted under the general category are as follows:

1-1 Developing of Standard & Curriculum of the courses

1-2 Operation PT (Basic)

1-3 Intensive Farm Mechanization (Basic)

1-4 Intensive Farm Mechanization (Advance)

1-5 Operation (Tractor Basic)

1-6 Operation repair & maintenance & Installation of post harvest machine

1-7 Seasonal Operation (Reaper, Harvester, Transplanter)

1-9 Repair & Maintenance (PT Basic)

1-10 Repair & Maintenance (PT Advance)

1-11 Repair & Maintenance (Tractor)

10.1.3.2. School agriculture training

The training was imparted to school and college students in farm mechanization activities. The details of the trainings are below:

2-1 Agriculture Mechanization Technical Training (TTI)

2-2 Agriculture Mechanization Technical Training (TTI)

2-3 School Agriculture Program (School Students)

10.1.3.3 Non institutional training

It is basically awareness on all types of farm mechanization technologies in the country. It is targeted to visits made by farmers and all other stakeholders. The visitors shall be shown all types of machines in all centers and this will help promote technologies. The details are below:

- Regional FM Awareness (farmers visit to centre)
- Awareness through Media (Basic operation & maintenance, safety)

10.1.3.4 Training record for one year

In total 981 participants were trained. The overall training record is detailed in figure 11.

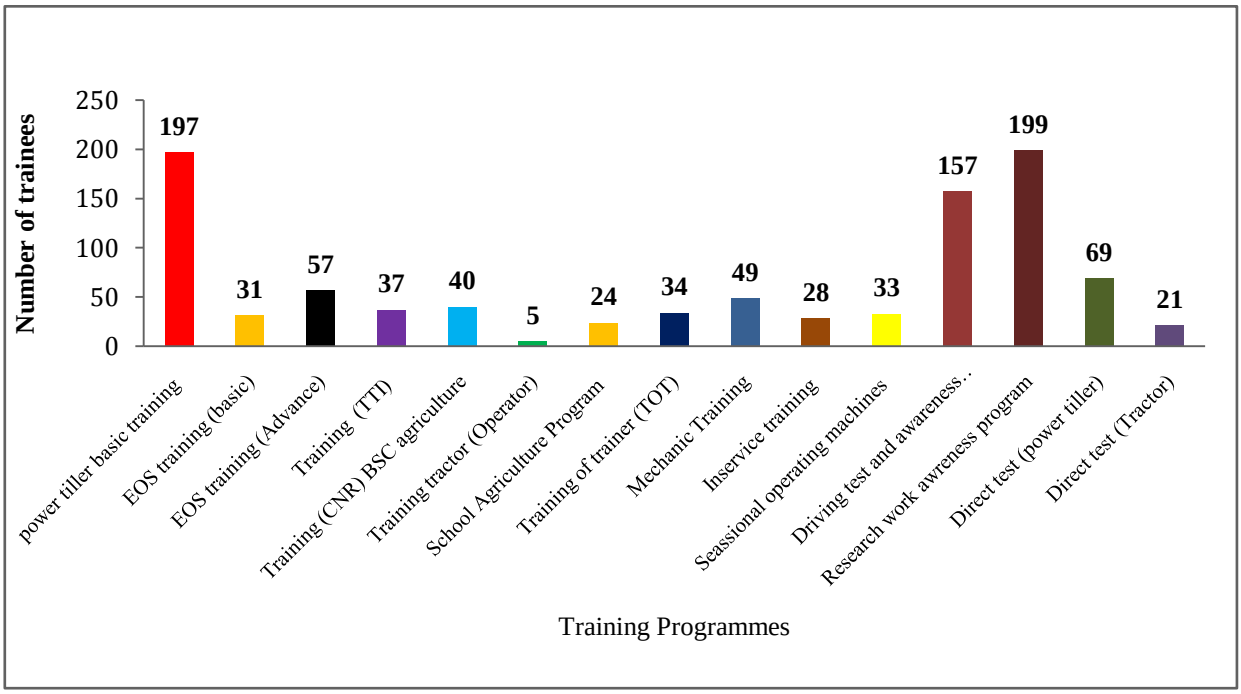

Figure 11: Overall training conducted in the fiscal year 2016-2017

10.1.3.5 Curriculum and standard development for farm machinery

This course is designed to provide the knowledge, skills and attitudes of an individual to become competent as power tiller operator and mechanic in accordance with industry standards.

In collaboration with Training and Professional Services Division, Department of Human Resources, Ministry of Labor& Human Resources, Agriculture Machinery Training Section

developed competency based standard and curriculum (NC2) for power tiller operation and maintenance involving all the resource persons, fields staffs and operators.

10.1.4 Standardization of farm machinery

10.1.4.1 Development or harmonization of standards & test codes of farm machines

AMC developed standards for farm machinery in collaboration and guidance from the Bhutan Standard Bureau under the Technical Committee for Mechanical Engineering. The section has developed Standards, Test Codes & Test Procedures for a) power reaper, b) rice mill, c) cereal flaking machines and d) oil mill.

10.1.4.2 Testing the machine based on standard and test codes

Power reaper

The standard and test code for power reaper has been developed and the test items were measured.

Rice Mill

The followings are the operation test items to evaluate the machine performance:-a) milling capacity, b) milling recovery-broken rice -head rice and c) handling test

Picture 20: Rice mill test in the field after the reference testing in laboratory

Cereal flaking machine

The corn flake machine is commonly used in Bhutan to produce the corn flake. It is roller pressing type. The following are the test items to be measured: 1) verification of structure 2).safety test (noise and food grade materials) 3) operation test in the field like flaking capacity and flaking recovery 4) handling test.

Oil Mill

The test items to be measured for oil mill are verification of structure, safety test (noise and food grade materials) and operation test in the field.

10.1.5 Awareness program /workshop /seminar on the standardization of farm machineries

A day long awareness and consultative discussion on Farm Machinery Standards and Implementation Strategy was officially opened by Hon'ble Lyonpo on 21st June 2017 at Paro by launching first national standard for power tiller basic requirement (Part I) BTS 34: 2017. The program was jointly organized by the Agriculture Machinery Centre (AMC) and the JICA project under AMC. There were both public and private participants dealing with farm machinery import. The National Power Tiller Standard was also launched.

Picture 21: Hon'ble Lyonpo, lunching the 1st National Standard for PT Basic Requirement

10.1.6 Calibration and accreditation of measuring equipment's and laboratory

The measuring equipments such as digital weighing balance, spring balance, digital vernier caliper, steel measuring scale, measuring cylinder, steel cup, pitch gauge, measuring tap, micro meter has been calibrated with extensive support from the Bhutan Standard Bureau (BSB) office. The BSB has issued the sticker with certificate of test / calibrated results as a public services and it was also informed that the facilities are available for length, volume, and mass calibration of equipments.

10.2 National Post Harvest Center, Paro

10.2.1 Technology dissemination

10.2.1.1 Construction of multi-purpose electric dryers

Due to the multi functionality of the electric dryers and an increasing number of interested beneficiaries, 133 numbers of dryer were constructed in 13Dzongkhags in this financial year. 30 numbers of dryer at Paro was constructed on cost sharing basis with the Dzongkhag Agriculture Office and 25 numbers of dryer in Trongsa Dzongkhag are being completed on request. Dryers are constructed on a cost sharing basis where beneficiaries contribute local materials and labor while the center provides electrical equipments, cement and technical support. The beneficiaries use dryers for drying of vegetables, fruit, herbs, meat and dairy products.

Picture 22: Electric dryer construction in process

Picture 23: Completed Electric Dryer

10.2.1.2 Dual Energy Chirata dryer

NPHC has undertaken a trial and testing of dual energy dryer for Chirata at Shingkhar Lauri in Zhemgang and Linghzi in Thimphu. The initial trial and testing of the dryer was done at RDC, Yusipang. The prototype was then replicated at Shingkhar and Lauri. This activity was conducted in collaboration with RDC Yusipang and RDC Wengkhar. The dual energy dryer combines the principle of the existing NPHC designed multipurpose electric dryer equipped with a dark plastic panel to entrap solar energy. This provides an alternate heat source for drying the produce. The dryer operates on solar energy during sunny weather and electric energy at night and during rainy weather. A total of 4 numbers of dual energy electric dryers were constructed at Lauri Geog, Zhemgang and Thimphu.

10.2.1.3 Procurement and distribution of deep fat fryer

Center and the 4IFPPs also distributed 40 numbers of deep fat frying sets in the FY 2016-2017 as per requisition from 8 Dzongkhags on a 50 % cost sharing basis. The center also assisted in procurement of 3 numbers of large scale frying unit for Chukha, Dzongkhag. Along with the distribution, the beneficiaries are also given hands on training in processing of chips from potato and banana.

10.2.2 Training

Various training programs on post harvest and processing were imparted to farmers, entrepreneurs, students and extension officials as per the requirement and demand. The 17 different trainings benefited 473 participants.

10.2.3 Research

10.2.3.1 Modification of existing ambient potato seed stores

Upon monitoring and evaluation of the existing ambient potato seed store in the field, it was found that the existing structures were not optimally utilized due to problems of sprouting. Therefore, in an effort to study effect of certain storage condition on the sprout inhibition in potato seed stores, the engineering section conducted a trial with three different storage parameters namely 1) high capacity inlet fan 2) ethylene 3) LED lights. It was found that all this parameters had certain degree of sprout inhibiting effect but the maximum effect was that of the high capacity inlet fan. The result of the research will be implemented in the structures that will be constructed hereafter provided fund is approved.

10.2.3.2 Product development trials

The following products have been developed by the processing section at center:

1. Banana Products
2. Dehydrated Egg Powder
3. Dog Wood Wine
4. Dehydrated Powdered Cheese processing
5. Wheat noodle
6. Avocado Processing
7. Wood Apple Ice cream
8. Dehydrated Guava and Guava Preserve
9. Quince jam, jelly & Candy

10.2.4 Others

Further trial on already established products like jackfruit candy, roll up, fruit wines, buckwheat processing, fruit and vegetable candy was done in order to optimize the process in an effort to reduce the cost of production and to determine the most suitable and economically viable process and conditions.

10.2.5 Procurement of food processing, laboratory and post harvest equipments

Equipment like orange pulper, jet washer, spray dryers, refractometer, pH meter, salt meter, deep freezer, vacuum packaging machine, heavy duty vegetable cutting machine, food grinder, baking oven, walk in cold store equipment and refer truck was procured by the center.

10.2.6 Maintenance and engineering work

1. Assisted in procurement of maize processing equipment for FIC Lingmithang. The technical team inspected and verified all the equipment procured for maize plant.
2. Developed asparagus harvesting tool.

3. A comparative study was carried out to see the difference between fuel wood distillation unit and electric steam generator. Steam generator was found to be more efficient.
4. Major maintenance of 60 MT cold store was done with installation of new pipelines.
5. One walk in cooler unit was installed at FIC Goling, Zhemgang and a new shed was constructed.
6. Major re-roofing of the ZECS at Dagapela was carried out.
7. Started cultivation of high quality maize seed at IFPP, Dagapela and plantation of apple seedlings at the centre.
8. Installation of washing and cleaning unit at the processing lab.
9. Maintenance of drains and flower garden at the centre.
10. Drying packaging and labelling of hypericum tea.
11. Vacuum packaging of rice and lentil on request from FMCL.
12. Trial processing of reconstitution of dried powdered cheese powder on request from Gasa.
13. Pear candy processing for VVIP.
14. Organized ToT workshop for FAO on 'Post Harvest Management of Fruits and Vegetables'.
15. Conducted chemical analysis of apple for RDC-OA, Yusipang.

10.2.7 Farmers group and cooperative

The staffs at the IFPP, Goling, Shumar and Dagapela were also involved in providing technical guidance in operation of the orange pulpers and other facilities to the farmers group at the respective IFPPs.

10.2.8 Cold store and pack house services

10.2.8.1 Apple cold store services

The 60 MT cold store is utilized mainly for storing apple and is operational for 6 months. It's a paid service delivery system whereby interested farmers and entrepreneurs can store their apple at a nominal price of Nu 1.00 per box per day.

10.2.8.2 Supply of packaging materials

Center has also supplied corrugated fiber board boxes to VVIPs and ministries for packing of fresh fruits and vegetables. A total of 1700 CFBB boxes were issued.

10.2.8.3 Availing Plastic Crates Hiring

The center gave plastic crates on a rental basis to interested farmers and entrepreneurs for a nominal fee of Nu 0.50 per crate per day. For the year 2016-2017, crates were given on hire to the exporters for post harvest storage and transportation of apple. There was no requirement during the orange harvesting season. 1820 crates were provided on hiring services to 8 exporters and 200 crates to Gasa.

10.2.9 Other ad-hoc activities

1. One walk in cooler unit was installed at FIC Goling, Zhemgang and a new shed was constructed for the unit.
2. Technical support to FMCL for drying of paddy.

3. Survey was carried out with NPPC for monitoring the existing maize storage technology. The data will be used for modification of existing ambient maize stores in coming fiscal year.
4. Assisted in procurement of net bags and vacuum packaging machines for organic potatoes from Gasa Dzongkhag.
5. Assisted in procurement of deep fat frying unit to Chukha and Paro Dzongkhag.
6. Helped and assisted in the arrangement of logistic for Her Imperial Highness Princess Mako's visit to Paro.
7. Trained farmers under the Samdrup Jongkhar initiative on basic practices of food processing at IFPP Lingmithang.
8. Assisted in food product development trials and processing of dried cheese powder under the Queens Project.
9. Conducted the trial on dehydration of egg powder with the livestock division.
10. Assisted in transporting cut flowers and other arrangements work during the flower exhibition at Paro.
11. Execution of SAARC Development Fund Project (PHT & ZECS Project)
12. Re-roofing of ZECS, IFPP, Dagapela
13. Procurement of orange pulper at IFPP, Lingmithang
14. Execution of AFACI Project is detailed below.

a) Development of extension manual for post harvest management of apple in both English and Dzongkha. The centre has been training the growers in proper harvesting and postharvest handling operations and management of apples. The publication of the extension manual was funded by Asian Food & Agriculture Cooperation Initiatives (AFACI), Korea.

b) Training of farmers in proper post harvest handling of apples in Paro and Thimphu: 175 apple growers in Paro and Thimphu Districts were trained for 1 day on proper post harvest handling of apples to minimize post harvest losses. The training was done in collaboration with Thimphu & Paro Dzongkhags and funded by the AFACI project.

10.2.10 Capacity Development Programs

- Hosted ToT on 'Horticulture Chain Management' for participants from 10 SAARC and AFARCA countries from 26th to 30th September 2016. The ToT was funded by Food and Agriculture Organization, Asia Region, Bangkok.
- One staff attended the ToT workshop on 'Capacity Development on Horticulture chain management in SAARC countries in Thailand'. The workshop was organized by FAO from 14th to 18th November 2016 for duration of 4 days.
- Three of the staffs were trained on 'Post Harvest Management of Fruits and Vegetable in developing countries' at Thailand for duration of 12 days. The training was jointly organized by TICA and Colombo plan.

10.3 National Plant Protection Center, Simtokha

10.3.1 Awareness program on armyworm management

The National Plant Protection Centre in collaboration with the Dzongkhag Agriculture Sector of Trongsa carried out awareness program on armyworm management. 130 farmers participated in the awareness program. Pheromone traps and lures were supplied to the farmers.

Four pheromone traps and one Rain O Matic (Electronic rain gauge) were installed in the Upper Nubi to study the emergence time of armyworm moths, monitor the moth flight period and moths trapped per trap per week and rain fall in the Geog to forecast the armyworm outbreaks in the Geog.

10.3.2 Citrus fruit drop collection and destruction campaign

The centre in collaboration with the Dzongkhag Agriculture Sector of Dagana carried out two days campaign on citrus fruit drop collection and destruction at Drujagang Geog, Dagana from 17-18/11/2016. The main objectives of the campaign were to educate and sensitize the importance of community approach of collection and destruction of dropped citrus fruits, to create awareness on different methods of citrus fruit drop collection and destruction and to collect preliminary data to determine the causes of citrus fruit drop. Approximately 2-3 MT of citrus fruits were collected from an acre of orchard. In addition, trial on "Fermentation Method of Citrus Fruit Drop Destruction in Drums" was set up in the field. The campaign drew 109 participants including farmers and the local officials.

Picture 24: Farmers collecting dropped fruits

Picture 25: Dropped fruits collected

10.3.3 Farmers Training on cole crop pests & diseases management

The centre in collaboration with the Paro Dzongkhag Agriculture Sector conducted 2 days farmers training on cole pests and diseases management at Naga Geog as part of AFACI Project on 18-21/6/2017. 50 farmers from the Geog attended the training program. The team presented on major pests and diseases management of cole crops followed by field demonstration of installing and setting up of pheromone traps against diamondback moth. A presentation on safe use of pesticides was also done to ensure safety of farmers while handling pesticides.

Farmer survey was condcuted to detemine the major pest problem faced in cole crop production in the Geog. 33 participants were selected randonmly and interviewed by the NPPC team. The survey showed the cabbage aphid caused the maximum damage (8/33) followed by cabbage

white butterfly (6/33), diamondback moth and club root (5/33), cabbage loopers (4/33), cut worm (3/33) and harlequine bugs (2/33) respectively.

10.3.4 Farmers training of chili blight management

Chilli blight management awareness program was conducted at Ramjar in Trashiyangtse and Kangpar and Thrimshing in Trashigang. A total of 151 chilli growers from Ramjar, Kangpar and Thrimshing were trained on various management practices of chilli blight through demonstrations including cultural methods of management such as crop rotation, nursery preparation, bed preparation and intercultural operations like furrow irrigation. Participants were also introduced on seed and seedling treatment with Copper Oxycholoride and Ridomil for areas with record of chilli blight infection in previous years.

As part of the program, the team from NPPC demonstrated solution preparation for seed and seedling treatment, bed preparation, transplanting and other agronomic practices. Participants were also sensitized on importance of safety gears and PP product disposal.

Picture 26: Farmers training on chilli blight management

10.3.5 Survey of maize storage systems and storage pest problems

This report is a preliminary report on surveys conducted on the maize storage systems and storage pest problems in the Project (FAO/TCP 3603) Pilot Sites. The survey was conducted by the team consisted of staffs from the National Plant Protection Centre and the National Post Harvest Centre. The team was assisted by concerned Geog extension staffs and the concerned village Tshogpas. The survey was conducted from February to March 2017.

The average area under maize cultivation ranges from about 0.3 to 4 acres. The larger maize areas were observed in Dagana and Mongar. Some preliminary estimate of yield suggests that it is well below the national figure, which is about 1- 1.2 tons per acre.

Commonly, two types of maize varieties are grown by all farmers in survey areas- Yangtsipa and the white kernel type with full husk cover. The preference for these varieties varied among farmers. The sowing and harvesting of maize period do not differ much in project pilot sites. The first sowing is done in late February/early March and the second sowing is done in July/August.

The maize crop losses in storage are the main problem observed in all pilot sites. On average, the losses range from about 10 to 80-90 percent. Among various causes such as rodents, bird, disease, all farmers are unanimous in blaming storage insect pests as the number one problem. In some cases, insect damage in the store alone reaches 100%. The most commonly insect pest observed was maize weevil, locally known as “elephant” and rodents.

Maize crop is hardly sold for cash income in all survey areas, except in Dagana where some farmers could earn some cash from sale of maize. Almost all surveyed households, maize is used as staple food, animal feed, seed and some households uses for brewing local alcohol.

Picture 27: Maize drying techniques

10.3.6 Other activities

1. Increased demonstration and mass trapping of rice stem borer, armyworms and leaf folders using pheromone traps (AFACI).
2. Surveyed and documented rice pests (AFACI).
3. Increased demonstration and promotion of use of super grain bags against maize storage pests (TCP Project).
4. Surveyed and documented maize storage pests (TCP Project)
5. Enhanced capacity of farmers and EAs on storage pest management and storage design.
6. Evaluated the efficacy and promoted the use of pheromone traps against tomato leaf miner (AFACI).
7. Promoted the use of pheromone traps against diamondback moth (AFACI).
8. Evaluated the efficacy and promoted the use of pheromone traps against chilli cut worm.
9. Increased demonstration and promotion of baits/pheromone traps against citrus fruit fly.
10. Conducted nationwide citrus fruit drop collection campaign.
11. Increased demonstration and mass trapping of potato tuber moth using pheromone traps.
12. Evaluated the efficacy and promoted the use of boric acid and spinosad against red ants (second year).
13. Evaluated the efficacy and promoted use of pheromone traps/baits against mango fruit fly.
14. Increased demonstration of banding, white washing and plugging against walnut trunk borer.
15. Farmers trained on lichen management in apple.
16. Farmers trained on red palm weevil management in areca-nut using pheromone traps.

10.4 National Soil Service Center, Simtokha

The annual progress for 2016-2017 financial year is highlighted below.

1. Large scale integrated plant nutrient management practice was promoted in 101.33 acres. The actual target of 200 acre was not met due to fund constraint.
2. Over 2500 soil samples were analyzed for optimum soil fertility management.
3. Training of Trainers (TOT) for extension staffs for Paro, Thimphu, Wangdi, Punakha Dzongkhag and soil focal persons from ARDCs on Soil and land management was conducted.
4. A total of 4 ISFM trials in onion and cabbage were conducted and 10 acres of ISFM trial on potato was implemented.
5. Two trials of improved MAPs technology were promoted at Chukha and Tsirang.
6. Three ISFM trials in citrus were demonstrated in farmer's field at Sarpang and Dagana Dzongkhag.
7. Eight farmer's trainings on ISFM for rice, citrus, onion and potato conducted.
8. About 900 households of Jarey, Thangrong, Wangphu & Jamkhar Geog were sensitized on SLM practices. World Soil Day celebrated at Tsirang Dzongkhag (400 participants).
9. About 65 acres was brought under SLM stone bund and 216 acres was brought under SLM Napier hedgerow in Jarey & Thangrong Geog in Lhuntse. Additionally, under BTFEC project, landslide stabilization work in 5 acres was carried out at Jarey Geog.
10. SLM sensitization to DT & RNR staff of Wangdi, RNR staff of Trongsa and farmers of Limbukha & Talo of Punakha was done that covered 90 participants.
11. Organized a seven day study tour to Thailand for 15 RNR staff & GT members on SLM practices from Jarey & Thangrong Geogs.
12. Established 8 numbers of soil erosion plots to study sediment flow at Whenkhar, Samtenling & Yusipang, Chimipang Royal project, Lumang, Goshing, Tingtibi & Yangneer.
13. The center investigated 237 cases of Land Conversion (Chuzhing to Kamzhing) in eleven Dzongkhags (Thimphu, Punakha, Trongsa, Trashigang, Mongar, Trashiyangtse, Paro, Chukha, Dagana, Tsirang and Wangue Phodrang) in three batches viz., 25th, 26th and 27th. The reports are duly produced and are available for reference in need.
14. The centre investigated 2 soil/ land with problems relating to degradation, contamination, nutrient mining and flooding. a) Conducted technical assessment of Chakalum dumping site under Rubesa Geog, Wangdue Phodrang to investigate the possibility of restoring the dumpsite back to Chuzhing which was leased to PHPA-I. The report for the assessment and recommendations was submitted. b) Carried out Land degradation assessment at Wangsisina under Mewang Geog, Thimphu.

Picture 28: Technical assessment of Chakalum dumping site under RubesaGeog, WangduePhodrang

15. For the implementation of SLM technologies, 2 sites were assessed. 1) Conducted feasibility study at Nabchay and Labtsakha under Limbukha and Talo Geogs respectively, under Punakha Dzongkhag. 2) Conducted feasibility study at Wangphu Geog under Samdrup Jonkhar Dzongkhag.
16. Two cases of soil investigation in Kamzhing and orchards were carried out. a) Study conducted at Ramthangka apple orchard under Tsento Geog, Paro Dzongkhag for which preliminary report is available. b) Investigation of citrus tree was done at Dechencholing Palace.
17. About 8 numbers of cartographic compositions of maps, printing and spatial analysis was carried out by the center. Following are the activities carried out
    - Digitized the farm roads of Sarpang Dzonkhag for forest updation with FRMD.
    - Conducted land and forest cover updation with FRMD.
    - Prepared base map for six eastern Dzongkhags for Commercial Agriculture and Resilient Livelihoods Enhancement Program (CARLEP).
    - Prepared base map and printed for all Geogs of Zhemgang Dzongkhags for land management campaign.
    - Base map printed with cadastral and land use data.
    - Prepared base map of Wangphu Geog to carryout soil survey.
    - Digitized Ramthangka orchard map at Paro.
    - Prepared covariate maps to prepare soil carbon map of Bhutan (mean temperature and precipitation, slope, land use and land cover map and Normalized Difference Vegetation Index(NDVI)
18. Collected baseline information from Gasa, Punakha, Wangdi, Dagana, Haa, Chukha and Paro. Database information is available.
19. Soil survey in Wang watershed basin was completed. The data was collected from the targeted areas using digital soil mapping method.
20. Conducted 2 feasibility studies for User Right Certificate (URC) for the National Rehabilitation Project (NRP) in five eastern Dzongkhags (Lhuntse, Trashiyangtse, Mongar, Trashigang and Pemagatsel). Reports for the studies are produced.
21. Carried out land suitability study for kiwi cultivation at Paga, Chukha upon request by a group of agriculture entrepreneurs.
22. The center provided technical guidance and training to 6 interns who turned up to the centre for their mandatory university assessment. Training was provided to the interns from Uttrakhand Technical University, India; Baba Farid Institute of Tecnhology, India; College of Natural Resources, Lobesa and Soil Focal Persons from RDC, Wengkhar

Picture 29: Napier hedgerow establishment

Picture 30: Check dam construction

10.5 National Mushroom Center, Simtokha

National Mushroom Centre is the national coordinating and referral Centre for the mushroom development program and is responsible for the overall coordination of the mushroom development program in the country. However, the National Mushroom Centre has specific roles and responsibility for fulfilling the role of a national coordinating agency as well as a mushroom development service centre. The centre provides direction and guidance to the mushroom development program in the country concerning mushroom production and collection activities.

10.5.1 Media preparation and inoculation

10.5.1.1 Saw dust media preparation

For the fiscal year 2016-2017 laboratory section has prepared a total of 4,944 bottles of saw dust media for Shiitake mushroom spawn production. Part of this (1000 bottles) has been used as mother spawn for distribution to the Mushroom Spawn Units in the RDCs. Some bottles were used for mushroom cultivation in Trongsa, Dagana, Paro Thimphu and Chukha Dzongkhag. Khangma under RDC Wengkhar has prepared a total of 14865 bottles of Shiitake mushroom spawn. In total 19,809 bottles of Shiitake mushroom spawn was prepared.

10.5.1.2 Grain media preparation

The Laboratory section has prepared a total of 2,922 bottles of wheat grain media for Oyster mushroom spawn production and 67 bottles of grain media for Agaricus mushroom spawn production. Khangma under RDC Wengkhar prepared 3,003 bottles, RDC, Bajo prepared 870 bottles and RDC, Samtenling prepared 2,091 bottles. In total 8953 bottles of grain media was prepared in the FY 2016-2017.

10.5.1.3 Agar media preparation and tissue culture

Agar media is the commonly used medium to carry out the tissue culture of available mushroom strain. For the fiscal year 2016-2017, the laboratory section has prepared 41 liters of agar media and tissue cultured with different strains of mushroom. The strains in the mycelium bank are stored in PDA (Potato dextrose agar) medium. For wild mushrooms and cordyceps other media are also used.

10.5.2 Spawn supply

10.5.2.1 Shiitake mushroom spawn

The laboratory section has supplied a total of 2,887 bottles of mother culture of Shiitake mushroom mostly to the Central and Western region of the country. Khangma under RDC Wengkhar has supplied a total of 6,448 bottles of Shiitake mushroom spawn to the eastern region of the country. In total 9,335 bottles of Shiitake spawn was supplied in the FY 2016-2017.

10.5.2.2 Oyster mushroom spawn

A total of 2,348 bottles of Oyster mushroom spawn were supplied by the laboratory section, NMC. Khangma under RDC Wengkhar supplied 779 bottles, RDC, Bajo supplied 695 bottles and RDC, Samtenling supplied 1027 bottles of Oyster mushroom spawn. In total 4,849 bottles of Oyster mushroom spawn was supplied to growers across the country in the FY 2016-2017.

10.5.3 Mushroom Cultivation

A paradigm shift from subsistence mushroom farming to market driven mushroom farming (commercial mushroom farming) is driving well in the country after understanding the nutritional value of mushroom and more demand in the country as well as from outside the country.

10.5.3.1 Shiitake mushroom

A total of 40,089 billets in 21 households were inoculated with different strain of Shiitake spawn by the Extension section with support from other staffs and ESP in Central and Western part of the country by the NMC. Khangma under RDC Wengkhar inoculated a total of 46,240 billets in 66 households mostly in the eastern part. In total 86,329 billets in 87 households were inoculated in the FY 2016-2017.

10.5.3.2 Oyster Mushroom

A total of 7,044 bags/blocks of Oyster mushroom were cultivated in FY 2016-2017 by NMC. Oyster mushroom cultivation was carried out in school, VVIPs and individual growers. Khangma under RDC Wengkhar cultivated a total of 1942 bags, RDC, Bajo cultivated 2085 bags and RDC, Samtenling cultivated 3,081 bags of Oyster mushroom. In total 14,152bags of Oyster mushroom was cultivated in the FY 2016-2017.

10.5.4 Monitoring

Periodic monitoring of cultivated billets at regular interval is very important after the cultivation of mushroom. A total of 227 visits to mushroom farms throughout the country were monitored during the fiscal year 2016-2017 by NMC. Two trips to the East and one trip to the east central region was made in collaboration with the experts from the JPP Project at NMC. The trip to the eastern and central region was combined with training of mushroom staff in the region and Gewog Extension Officers More technical back up was desirable but due to constraints with experienced staff and mobility, it was not possible. This is affecting the productivity of mushroom by the growers, particularly for new mushroom growers.

10.5.5 Trainings

10.5.5.1 Training of staff and mushroom growers

NMC has trained more than 300 participants that include both the staffs and farmers to enhance the knowledge and skills of mushroom cultivation. The topics covered were spawn Production, oyster mushroom cultivation, shiitake mushroom cultivation and training on sustainable harvesting of cordyceps and management of wastes during cordyceps collection.

10.5.5.2 Training in Japan

NMC in collaboration with the JICA Partnership Program organized 10 days training on Mushroom Cultivation Technology in Japan from 14th to 24th February 2017. NMC staff, RDC-Bajo and EAs of Thimphu, Wangdue and Trongsa Dzonkhgag participated in the training program. During the training program, participants learnt the cultivation techniques of Shiitake mushroom cultivation in wood logs and sawdust, golden needle mushroom, King Oyster, Oyster mushroom, *Hypsizygus marmoreus* (Brown beech) and *Pholiota microspora* (nameko).

10.5.6 Wild mushroom collection and identification

The study and collection of wild mushroom is very important to ensure sustainable harvesting. As such, NMC has been taking up the study of wild mushroom during the rainy season. 230 species of wild mushrooms were collected from Lamperi Park and Geney Geog forest. This exercise was conducted with support of expert from Japan, Dr. Watanabe and Dr. Hosaka. Out of 230 species collected 192 species were identified and prepared for DNA test which could be executed with the help of Japanese Mycologist Dr. Hosaka.

10.5.7 Second Annual Mushroom Festival in Geney Geog

The National Mushroom Centre conducted the Second Annual Mushroom Festival in Geney Geog in collaboration with the Geog administration and Department of Forest and Park Services. It was held on 15th and 16th August 2016 at Geney Zampa, with financial support from the Tourism Council of Bhutan. Besides others, the objective of festival was to promote conservation and sustainable harvesting of wild mushrooms, especially Matsutake. Prime Minister Tshering Tobgay was the Chief Guest at the 2nd Annual Mushroom Festival and was accompanied by the Minister for the Ministry of Agriculture and Forests. On the second day the Minister for the Ministry Works and Human Settlement graced the occasion.

Different types of mushrooms from nearby forests were collected and the live samples were displayed with clear identity of each mushroom as poisonous, edible, non edible and edibility unknown. In addition, poster containing medicinal properties of different edible mushrooms, toxin of different poisonous mushrooms and sustainable harvesting manual were displayed.

Picture 31: Second Annual Mushroom Festival in Geney Geog

10.5.8 Jomolhari Mountain Festival

National Mushroom Centre also took part in the Mountain Festival organized by Jigme Dorji Wangchuck National Park under Department of Forest and Park Services. The rationale behind for organizing such event at Dangojang, Soe Geog is mainly to promote and preserve the habitat of endangered species the so called Snow Leopard. The Park conducted this year's festival on 25th and 26th of October 2016.

The main purpose of participation of NMC in the festival was to create awareness on sustainable harvesting management high value mushroom like sew shamong (*Exidia spp*) and cordyceps. Moreover, the participation was also aimed to disseminate information on mushroom poisoning and importance of mushrooms in our daily diet.

10.5.9 Trial on Ganoderma (Lingzhi) mushroom

A cultivation trial on Ganoderma mushroom was conducted collaboratively with Dr. Kazuo Watanabe, Expert from Japan and Miss Naruemon Perstwong, Mushroom Culturist, Thai Volunteer.*G. lucidum* strain was ordered from Thailand.

It was observed that Grain mother spawn took shorter time for incubation than sawdust mother spawn. Grain mother spawn took 1 month to mature whereas sawdust mother spawn took 2 months to mature and it could be preserved for longer time without contamination. The trial is still ongoing and the data and result is yet to be compiled.

Picture 32: Cultivation trial on Ganoderma mushroom

10.6 National Seed Center, Paro

In theyear2016-17, as per the marketing plan and annual sale targets projected, NSC could manage to supply seeds/seedlings of various kinds with overall average physical achievementof85%. However, in reality when compared with the actual demand received for seeds and seedlings in the reporting year, the overall achievement comes to 94 % of the actual targets. The overall achievement as per the annual targets dropped down from previous year 2015-16 because demand of asparagus, straw berry and cardamom decreased and the centre could not sell much though the production targets were achieved as per plan. The other contributing factor for low overall achievement is due to not being able to supply citrus graft sin light of HLB infection. As usual, the overall sale targets vis-à-vis actual supply were mainly attributed by promotion of seeds/seedlings and crop intensification and commercial agriculture programs of the Dzongkhags and Geog outlined in 11th Five Year Plan.

10.6.1 Seeds production and supply

A total of 684.04 MT seeds of vegetables, cereals, oilseeds and seed potatoes were produced in the farm, procured from Registered Seed Growers or imported and supplied to the farmers across the country. The centre generated revenue of Nu44.52 millions from the sales of seeds. During the reporting period, the centre could meet or supply seeds of cereals, seed potatoes, vegetables, and oilseeds more than the annual targets. Altogether (cereals, oilseeds, seed potatoes and vegetables) an average of 127.5 % was achieved despite so many challenges like erratic and ad-hoc demand from clients and other market influences.

Picture 33: AFACI delegation visit to wheat seed production in RSG field, Bajo

10.6.2 Seeds supplied and revenue generated

In 2016-17, NSC has transacted a total of 419.99 MT of seed potato comprising of red variety (Desiree) and White varieties (Kufri Jyoti and Khangma Kaap) produced in the NSC farms and Registered Seed Growers. Seed Potato alone could generate revenue of Nu.10.87 million in 2016-17. NSC has been focusing on meeting the in-country demand for seed potatoes till date and exporting seed potatoes could be explored in the coming years.

10.6.3 Seedlings production and supply

A total of 2,84,704numbers of high quality seedlings of temperate and sub-tropical fruit crops, asparagus and cardamom were produced or procured and supplied to the farmers at affordable price and on time and generated a revenue of Nu.9.88 million. The total number of seedlings transacted decreased by around 169,343 numbers seedlings (37 %).The decrease in sale volume of seedlings and planting materials is mainly due to decreased sale of cardamom and asparagus seedlings and unable to 13,000 numbers of citrus grafts (worth Nu.1.17 m) and in light of HLB infection. In the event of HLB infection in Samtenling Regional Centre, the citrus production program of NSC has been now shifted to Jachedphu farm, Tashiyangtse in the east.

Picture 34: Mango Grafts Production at Bhur

10.6.4 Tissue culture

Apart from normal micro and mini-tubers production of potato in Tissue culture laboratory and aeroponics, banana varieties viz; Grand Naine (G-9), Chinichampa, Ghewkola, Dhusrey and Jaji were propagated in the Tissue Culture Laboratory at Paro and produced around 15705 numbers out of which 11,521 numbers were sold to the farmers.

About 18,912 numbers (104.81kg) mini-tubers of Desiree and Khangma kaap potatoes were produced for further multiplication of quality foundation seeds in Phubjikha farm. To capitalize the growing market demand, trials are on to initiate propagation of Kiwi, Avocado, Cardamom and Apple Rootstock. As of now, successes have been found in the multiplication of kiwi and apple rootstock development through tissue culture.

Picture 35: Tissue cultured banana seedlings

10.6.5 Fertilizer supply

As usual in 2016-17, chemical fertilizers were procured through normal tendering process from suppliers. The volume of fertilizers procured was primarily based on the past sales trend supplemented by demand indentations from the client Agriculture Sales and Services Representatives (ASSRs), Dzongkhags and other relevant agencies. For the easy access, distribution and affordability by the clients mainly farmers; fertilizers are repacked in smaller units of 5 kgs, 10 kgs and 20 kgs. Till June 30, 2017, atotal of 3320.27 MT of fertilizerswas procured and supplied across the country. The centre generated total revenue of Nu 86.64 millions.

Figure 36: Repacked Fertilizers into smaller units

11 Highlights from Research and Development Centers

11.1 Research and Development Center -Wengkhar

11.1.1 Horticulture

11.1.1.1 Release of new fruit crop- Dragon fruit

One new fruit crop Dragon fruit was released for low to mid altitude areas. The fruit can be grown from 300 to 1600 m above mean sea level. It is considered a health food given high content of vitamin C, fibres and antioxidants.

Picture 37: Dragon Fruit

11.1.1.2 Evaluation of Blueberry varieties

Blueberry evaluation block comprising of 7 varieties (Blueray, Bluecrop, Legacy, Misty, Nelson, Revielle and Toro) was established at ARDSC Khangma in March 2016. Though the evaluation is still at initial stage, plants are doing fairly well and at least five varieties have started to flower in 2017.

11.1.1.3 Evaluation of heat tolerant varieties of vegetables

Climate change is expected to have significant impact on agriculture. Hence, evaluation of heat tolerant varieties of vegetables was done. For example, cabbage, cauliflower and radish are cool season crops and produced only in winter. In view of climate change adaptation, new varieties of cabbage (Asha and Bengal king), cauliflower (Pragati 40 and White Express 50), and radish (Hybrid 35 and OP 45) were successfully grown during peak summer (June to July) at Wengkhar and Lingmethang conditions.

11.1.1.4 Basic seeds production of vegetables crops

Production of quality seeds to maintain basic seeds of the vegetables germplasm and also to support vegetables commercialization through research outreach program are part of vegetable research and development activities. Hence, till date, 170 Kg of assorted vegetables were produced.

11.1.1.5 Protected cultivation of vegetable crops

Protected cultivation is widely practiced. However, till date, no research on protected cultivation, especially its economic benefits compared to conventional cultivation, has been done. Hence, a research on protected cultivation has been initiated at on-station.

11.1.1.6 Domestication of Chirata

Chirata is one of the important medicinal herbs that farmers, especially from Shingkhar Lauri under Samdrup Jongkhar Dzongkhag trade across the border to earn cash income. Until recently, it was believed that herbs cannot be cultivated and hence there was issue of sustainability. However, with technical support from Chanel Company in France, RDC Wengkhar, RDC Yusipang and Forestry sector has successfully established Chirata nursery and now expanded to 35 households under Lauri Geog in Samdrup Jongkhar.

11.1.1.7 Establishment of demonstration orchards

As part of DoA's target to bring at least 50 acres of land under fruit crops per year in each of the Dzongkhags and also as demonstration orchard to encourage farmers to take up fruits cultivation, RDC Wengkhar has contributed to bring about 79 acres under fruits cultivation.

11.1.1.8 Citrus orchards canopy management under Nganglam Dungkhag

From 13th to 17th February, 2017, mass citrus orchard management campaign was conducted under Norbugang Geog, Pemagatshel involving 40 citrus growers (4,265 plants) from 3 Chiwogs. It was conducted in collaboration with the Dzongkhag Agriculture Sector. The participants were also provided with tools for canopy management such as saw and secateurs.

11.1.1.9 Promotion of water melon

Watermelon has become one of the important cash crops for farmers. Local production of watermelon is also one of the initiatives to reduce import of watermelon from across the border. During the 2016-17 period, 110 households from 5 Dzongkhags have cultivated approximately 25 acres of watermelon.

11.1.1.10 Promotion of onion

Promotion of onion cultivation especially after rice harvest when the land is left fallow is one the initiative to reduce the import of onions. In 2016_17, 636 households from 5 Dzongkhags have cultivated more than 72 acres of onions.

11.1.1.11 Promotion of mushroom

Fund from the Climate Change Adaptation Project was used to purchase equipments to enhance the spawn production capacity of Mushroom Unit at ARDSC Khangma. With this support, the Unit managed to produce 14,865 bottles of Shiitake spawn and 3,003 bottles of Oyster mushroom spawn. In six Eastern Dzongkhags, 32,281 billets of Shiitake mushroom and 1,942 bags of Oyster mushroom were inoculated. In addition, 6 commercial mushroom farms were supported to take up 46,240 billets of Shiitake mushroom with the credit from Rural Enterprise Development Corporation Limited. Further, as part of the capacity building, a total of 130 farmers and staffs were trained in mushroom production and management. A total income of about Nu 987,645.00 from six eastern Dzongkhags was generated.

11.1.1.12 Support to commercialization of vegetables

As part of the CARLEP's program to promote vegetables commercialization in the project sites, one vegetable commercialization site in each of the Dzongkhag was established. The total area under the vegetables commercialization comes about 48 acres involving 145 farmers. Till date, they have earned roughly Nu 987,645.00 from sale of vegetables. In addition, in the three nearby Geogs of Mongar town, about 29,700 slips of Asparagus seedlings were supplied to 100 households.

11.1.1.13 Capacity building of EAs and farmers

A total of 548 farmers and extension agents were trained on six different topics.

11.1.2 Publications

The center published the following:

1. Staggered Vegetables Production Manual
2. Avocado nursery production manual
3. Research activities in field crops program
4. Maize research and development
5. Evaluation of climate resilient maize varieties

11.1.3 Field Crops

11.1.3.1 Large scale promotion of hybrid maize

The spring maize production, especially in rice-fallow system, has brought immense benefit to the farmers. However, the supply of free seeds every year raises the issue of sustainability and thus in 2016 spring season the seeds were supplied on 50:50 cost-sharing. A total of 15 MT of hybrid seeds were supplied to six Dzongkhags.

11.1.3.2 Strengthening Maize Processing & Product Development

Farmers were trained to develop the popular maize or maize-based products. Two trainings were carried out in Lingmithang and SJI Dewathang. In collaboration with IFPP Lingmithang and Geog, 38 farmers were trained. The fund from GoI project was used to procure 6 sets of mini flour mills and 15 corn shellers to be supplied to the groups.

11.1.3.3 Promoting upland paddy through outreach programs

2710 Kg of upland paddy were procured and supplied to 447 households covering 144.7 acres in five Dzongkhags. Seeds were sown in April 2017.

11.1.3.4 Capacity development of Extension and farmers

Three extension Officers from Mongar, Chukha & Dagana and five researchers (3 from RDC Wengkhar and 2 from ARDSC Tingtibi and Tsirang) attended five days training on advances in Maize Research &Development in Asian Tropics at CIMMYT- Hyderabad in ICRISAT Campus from 27th February to 3rd March 2017.. The training was organized as a part of on- going collaboration for HTMA project. It was funded by GoI support to Cereal and Vegetable Oil seeds Crop intensification Project.

11.1.3.4 Evaluation of climate resilient maize varieties

The National Maize Program received four sets of trials (65 entries) from the HTMA project – CIMMYT for evaluation across five locations in Bhutan. The trials were conducted at ARDSC-Lingmethang, Sunkosh and Waichur in collaboration with RDC Bhur and ARDSC-Tsirang. Similarly, 30 entries were received from CIMMYT-Hyderabad having various stress tolerant

traits such as drought, heat and flood. These were evaluated in ARDSC-Lingmethang as a non-replicated observation trial. Entry no 6 in Waichur and 14 in Sunkosh are performing better than other entries in multi location trials. More field days will be organized in 2017 to further evaluate based on farmers' preference in all the sites.

11.1.4 Promoting alternative Irrigation Systems

11.1.4.1 Water harvesting from roof and perennial ground water sources

In order to help reduce the water shortages, the centre for the first time established a method of water collection from roof rain-water and from small perennial ground water sources.

With financial support from CARLEP-IFAD, ACIAR, and EU-CCAP projects, rain water harvesting from the roof of the training hall and perennial ground water flowing from lower walls of research and administrative building was established. The storage tanks are then connected to the main pipeline which feed water to irrigate the research and demonstration blocks at Wengkhar. The findings can be useful to understand and demonstrate the potential to farmers and develop harvesting models for promotion.

11.1.4.2 Establishment of overhead sprinkler irrigation in orchard

In order to reduce labor requirement for irrigation and also to improve the efficiency in water application in the orchards, over-head sprinklers irrigation system was established for the first time at Wengkhar.

Picture 38: Overhead sprinkler system

11.1.4.3 Linking local weather stations to internet based climate data management

In order to enhance access to climate data and maintain proper record of climate data from the local weather stations at the centre and sub-centers, data records (temperature, humidity, soil moisture, solar radiation, and UV rays) from the weather stations are uploaded on a central server through leased line or broadband internet connections.

The data records are also linked to a local drip irrigation system established for the indigenous citrus research and demonstration block and several green houses at the centre so that the irrigation system incorporates the latest climate data such as rainfall and soil moisture in scheduling the irrigation in these blocks and green houses. Periodic data from the local weather stations are also published on an online weather data web www.weatherunderground.comto provide end users with near real-time data acquisition and visualization in these localities.

11.1.5 Establishment of Climate Smart Villages in the region

In order to enhance resilience of vulnerable villages to the impacts of climate change, the centre with support of EU-GCCA and CARLEP-IFAD initiated the establishment of Climate Smart Villages (CSVs), which are a cluster of households or a community selected based on their

vulnerability in which interventions are to be made. A detail Participatory Vulnerability Assessment (PVA) is carried out to establish baseline and identify vulnerabilities and identify interventions. A total of 9 villages have been identified and interventions in these villages have also started with financial supports of CARLEP-IFAD and EU-GCCA provided to RDC Wengkhar and the Dzongkhags.

11.1.6 Up scaling electric fence technology to reduce human wildlife conflict

Nine villages in three Geogs of Mongar, Trashigang and Samdrup Jongkhar Dzongkhags have been installed with 39.57 km of electric fence covering 403.57 acres of farmland. The beneficiary farmers were also provided with hands on training on installation, maintenance and safety aspects of electric fence. The cost for the material inputs was supported from European Union- Global Climate Change Alliance (EU-GCCA) fund and the beneficiary farmers provided labor and wooden posts for installation of electric fencing.

Picture 39: Installation of electric fencing at Pangthang, Wangphu Geog. Samdrupjongkhar

11.1.7 Improvement of potting media mixture at RDC-Wengkhar

With the aim of improving on-station potting media mix and initiate process of bio fertilizer production, a bio fertilizer production process was established at RDC Wengkhar with fund support from CARLEP – IFAD.

11.1.8 Sustainable land management at Threlphu village under Kangpara Geog

Coinciding with the World Day to Combat Desertification on 17th June 2017, the centre in collaboration with Trashigang Dzongkhag organized a Sustainable Land Management Campaign at Threlphuchewog, Kangpara Geog which is one of the Climate Smart Villages identified during the year. With fund supports from CARLEP IFAD, about 30 households planted Napier grass along the side of 8 KM farm to protect landslide along the farm road; planted Napier grass in some 20 acres of steep land; distributed 400 numbers of Ficus seedling and planted 100 numbers of bamboo and 2000 numbers of broom grasses in landslide prone areas.

11.1.9 Video Documentation of Field Works

As a part of the training material development for the promotion of farming technologies, two video documentaries were developed and circulated. These video extension materials are “RDC Wengkhar Farming Technology Options: Towards Commercialization of Agriculture” and

"Shitake Mushroom Cultivation". Both videos are available online through the www.carlep.gov.bt. DVD copies of the former are also made available to users.

11.1.10 Trainings and workshops

Every year, the centre is organizing various types of trainings, workshops and seminars for the farmers and staffs for capacity enhancement. About 15 various trainings and workshops have been organized by the centre.

11.1.11 Regional database

In order to stream line data sources and validation of regional data for the Department of Agriculture, the centre initiated the establishment of a Regional Data Base. During the year, data for crop cut for year 2016, farmers group, fallow land, and household list of the region has been collected. Additional data sets will be collected and updated for the region.

11.1.12 Crop Competition and fair at Trashitse, Womrong, Trashigang

Coinciding with the 109th National Day Celebrations in Trashigang, RDC Wengkhar, OPM CARLEP and Trashigang Dzongkhag jointly organized crop competition and fairat Trashitse Higher secondary School, Womrong. The program consist of mainly training of Extension Staff in the use of and organizing the crop competition as a tool to assess development intervention followed by selection and exhibit of different farm produces particularly vegetables promoted by the Dzongkhag in these areas.

11.1.13 Farming Technology Exhibition at Gyelposhing, Mongar

The RDC Wengkhar and the OPM CARLEP joined with other MoAF agencies in the region in celebrating the first Birth Anniversary of HRH the Gyalsey from 5th to 10th February 2017 at Gyelposhing, Mongar. More than 1500 visitors attended the program that lasted for 6 days with exhibitions, fairs and cultural programs organized as a part of the Gyelposhing Tsechu.

A citrus diversity, vegetable garden with live exhibits, quinoa exhibition, farm machineries, poster displays and sale of farm produces particularly fruits and processed products by selected farmers were the major events. Water use efficient irrigation systems and crop protection technologies were also displayed. A flower and landscape model developed for the event was a popular site for the visitors coming from all over the region.

Picture 40: Her Excellency Lyonpo Dorji Choden at the crop competition and fair

11.1.14 Irrigation and infrastructure development program

11.1.14.1 Renovation of irrigation channels

Major Renovation of Ngarigangchu irrigation scheme under Minji Geog of Lhuntse Dzongkhag was completed during the FY 2016-2017. The 8.41 km irrigation scheme covers total of 1,022 acres command area and benefits 264 households. The overall project cost was Nu 28.20 million funded by GoI.

11.1.14.2 Construction of new irrigation channels

About 70 % of the works for the Chokpogang irrigation scheme located in Melongkhar village under Yalang Geog was completed. Tt will benefit 314 households and covers 146 acreage of command area. The length of the scheme is 7.25 km and the designed project cost was 43.25 million funded by GoI.

A 7.25 km Domkhar irrigation scheme under Tshenkhar Geog will benefits about 314 households and covers 146 acres of command area. The channel was constructed at a cost of Nu 43.25 million funded by GoI.

11.1.14.3 WUA formation and training

WUA formation and training were completed for three irrigation schemes namely Chokpogang, Tumburi and Domkhar irrigation scheme through training and revitalization of WUA members.

11.2 Research and Development Center for Organic Agriculture, Yusipang

11.2.1 Field crops

Field Crops research program is one of the main research programs of RDC-OA Yusipang. The Field Crops Sector has three national mandates and regional mandate to support the four client Dzongkhags of Haa, Paro, Thimphu and Chhukha. The national mandates of the sector are:

- Coordination of the national oilseed commodity program
- Coordination of the national quinoa commodity program
- Coordination of the high altitude rice research and development program

11.2.1.1 Cardamom nursery production

Large Cardamom (*Amomum subulatum Roxb.*) was once one of the main cash crops in the mid and lower altitudes of Bhutan. However, due to heavy incidence of disease, cardamom production declined and became almost negligible in terms of production. Ramsey, Dzongu Golsey and Varlangye were the common cultivar grown in the country.

These cultivars from the Dorokha were sown in the nursery at lower and higher altitudes on a pilot basis. They are being multiplied for plantation at the commercial level.

About 8000 saplings were produced at Baeyulkunza village and the seedlings were distributed to the 50 households. About 5000 seedlings were produced at Darla and were distributed to local farmers and Nubi Geog in Trongsa.

Picture 41: Cardamom seedlings produced at Baeyulkuenza

Picture 42: Training on cardamom cultivation - Baeyulkuenza

The Varlangay and Golsey cultivars distributed to farmers detected no pest and diseases so far. The farmers were confident to raise seedlings through seed techniques.

11.2.1.2 High altitude rice research and development

High altitude rice research was initiated in 1996 following the outbreak of rice blast in 1995 in the high altitude rice growing areas. So far, four blast tolerant and high yielding rice varieties have been released. These varieties are Yusiray maap 1 and Yusiray kaap 1 released in 2002 and Yusiray Maap 2 and Yusiray kaap 2 in 2010, popular in Paro and Thimphu valley.

11.2.2.2 Oilseed research

The Department of Agriculture adopted the promotion of high yielding varieties introduced from Bangladesh and Nepal to achieve the oilseed target as one of the key strategies. The 19th Varietal Release Committee (VRC) eventually released BARI Sharisha 15 (Yusipeka- 15) introduced from Bangladesh and Lumle Tori 1(Yusipeka- 1) introduced from Nepal. A total of 10056.5 kg mustard seeds consisting of three high yielding varieties namely Bari Sarisha 14, Bari Sarisha 15 and Lumle Tori 1 were supplied to various Dzongkhags in 2016.

11.2.2.3 Oilseeds varietal release

The 19th Varietal Release Committee endorsed the release of Lumle Tori 1 and Bari Sarisha 15.. Both Lumle Tori 1and BARI Sarisha 15 was introduced in 2014 from Nepal and Bangladesh respectively. The varieties along with other high yielding varieties such as BARI 14, Unnati, Pragati were evaluated under different agro-ecological zones across the country. The two varieties were considered for release depending on its yield data from various parts of the country since its introduction. The average yield of the existing varieties is 300 kg per acre and hence it is extremely important to find varieties surpassing the old cultivars in order to achieve the national goals. Upon reviewing the performance of the varieties, two varieties were released formally on the 11th of May 2017.

11.2.3 Other achievements

- As a taskforce member the specialist contributed to the development of Standards for Power tillers.
- The standard s for rice mill, rice reaper and cereal flaking machine is under preparation
- One paper on quinoa adaptation was presented in the international conference on quinoa in Dubai held from December 6th-8th 2016.

11.2.3 Horticulture Sector

11.2.3.1 Germplasm maintenance

Germplasm maintenance is a very important activity for a research centre. Till date the centre released 2 varieties of apple, 2 varieties of walnut, one variety of cherry and two varieties of strawberry. Since horticulture research is one of the main activities of RDC Yusipang, the following numbers of varieties on temperate fruit plants and rootstock cultivars are maintained in the germpalsm collection.

11.2.3.2 Training on apple grafting, pruning and fruit thinning

In collaboration with the technical assistance from Hirosaki University, Japan, hands on training on grafting technique was imparted to the researchers from RDC Yusipang and the extension staff of Paro, Thimphu and Haa Dzongkhags. The experts also demonstrated techniques to rejuvenate the old apple trees by heading back the old branches. Training on apple tree pruning was also conducted in farmer's orchard at Yusipang. Similar training was conducted in the farmer's field in Paro. In June 2017, experts from Hirosaki University conducted training on apple fruit thinning at Yusipang and in the farmer's fields in Yusipang and Paro.

11.2.3.4 Pear variety trial

Evaluation trial on 5 new pear varieties (Hosui, Hakuri, Chojuro, Nitaka and Shinko) was established at Dawakha in 2007 to study the performance of these varieties under farmer managed conditions. We installed bird proof nets on the tress and the farmer managed to harvest about 50 boxes of pear fruits from this trial and sold at Nu 1200-1500 per box.

11.2.3.5 Demo orchard on high density apple plantation

High density apple plantation technology is a method in which plants are planted at very close spacing maintaining a distance of 1 -1.5 meters plant to plant and 3-3.5m row to row. The technology can be adopted if there is limited land available. Thus, a demo orchard on high density apple plantation was established at RDC Yusipang in 2014 to demonstrate on the advantages of the technology.

There are 456 numbers of apple plants in the demo orchard. With proper maintenance and regular monitoring of the plants, most plants have grown well and some have started bearing fruits. They are expected to attain economic bearing stage in 2019 - 2020.

11.2.3.6 Promotion of avocado and citrus (pomelo) plantation

Seedlings of avocado and grafted plants of pomelo were propagated in Darla and distributed to farmers in Baeyulkuenza, Bongo Geog in June 2017. This was done to promote cultivation of exotic fruits for income generation in this remote rural village in Chukha Dzongkhag. 297 seedlings of avocado and 44 pomelo seedling were supplied to the focal village.

11.2.3.7 Observation trial on kiwi production.

Damjee, a remote village in Bongo Geog under Chukha Dzongkhag has been found suitable for production of kiwi fruits. Fruiting was very good and about 15kg of kiwi fruits were sold in CFM Thimphu at a whole sale rate of Nu 200/kg. In 2016, the farmers harvested about 50kg and sold at CFM Thimphu at the rate of Nu 200/- per kg and generated cash income of Nu 10,000/-.

Picture 43: Kiwi fruits in Damjee

11.2.3.8 Research and development on vegetables

11.2.3.8.1 Maintenance of basic seed of released varieties

Till date RDC Yusipang released 5 varieties of lettuce and the centre is responsible to produce and maintain basic seeds of these released varieties. Adequate quantities of basic seeds are produced and stored for supply to other concerned agencies as and when demanded.

11.2.3.8.2 Maintenance of nutrition garden

A nutrition garden has been maintained in the centre with assorted vegetables, herbs and spices to demonstrate to the visitors about the importance of managing small scale nutrition garden by adopting crop rotation, inter cropping, composting technology and crop diversity.

11.2.3.8.3 Evaluation of cold tolerant Korean chilli varieties

His Excellency the Minister for Ministry of Agriculture and Forests had brought seeds of 11 varieties of cold tolerant chilli from Korea. We raised nursery from these seeds at RDC, Yusipang and the sowing was done May 4, 2017.The germination % was quite low and seeds seemed to be of old stock extracted from the common market. The seedlings from the nursery were transplanted in the field.

11.2.3.8.4 Trial on bio-fertilizers

A trial was conducted to find out alternative means of replacing the excessive use of chemical fertilizers with an organic means to maintain soil health and clean environment. The trial was conducted on cauliflower crop and there were five treatments, viz. FYM inoculated with Azotobacter and potassium bacteria; vermin-compost; liquid manure from bio-digester tank; cattle urine and control.

Though the research finding did not yield result of statistical significance, the yield of cauliflower was slightly higher in the FYM with bacterial inoculated treatments.

11.2.3.8.5 Farmers training on vegetable production in Green House

RDC Yusipang, in collaboration with the Dzongkhag Agriculture Office of Paro and Thimphu and with the financial assistance from National Vegetable Program conducted series of training on protected vegetable cultivation from January 18, 2017 to January 24, 2017 at different locations.

The number of farmers trained in Paro Dzongkhag was 100 and Thimphu, 95. In total, 195 farmers having greenhouses from Paro and Thimphu including four entrepreneurs from Rehabilitation Centre, Paro have been trained.

11.2.4 Potato seed source trial

In Bhutan, the practice of informal seed potato system is higher than the formal seed potato system. As a result, it has been assumed that the quality of potato tubers supplied to growers are of inferior quality resulting into low yield leading to decrease in potato production at the local, regional and national level. Therefore, a trial was established in Yusipang to study the quality of seed potato (Desiree) of different sources. However, the trial will be harvested in September 2017 and the data will be available in 2017-18 FY.

Picture 44: Seed potatoes trial of different source

11.2.5 Technical support rendered to other agencies

11.2.5.1 Technical Support to Tarayana Foundation

As per the request from Tarayana Foundation working for the community development in the Yokha village under Sangbaykha Dungkhag in Haa, the centre extended technical assistance for installation of green house and training of farmers. Two technical staff from RDC Yusipang attended the program as resource persons. Farmers were trained to install green house by using

locally available materials like bamboo instead of metal pipes which are expensive. Training was also imparted to the farmers on establishment of vegetable nursery and production of vegetables in the green houses.

11.2.5.2 Technical support to the Tensung Amsu Tshokpa, Haa

Training and technical support was provided to the members of the Tensung Amsu Tshokpa on vegetable cultivation techniques and production. Free vegetable seeds were also provided. Vegetable production was found to be successful both in the green houses and in the open field.

11.2.5.3 Participation in the fruit plants plantation program in Agro-Forestry Farm

All the staff and ESPs of RDC Yusipang participated in the fruit plants plantation programme in the Agro-Forestry Farm, Samarzingkha for 3 days (2nd June, 8th June and 29th June 2017). The plantation site was very steep, windy and dry, and the irrigation water supply is quite scarce. Unless, there is intensive care and proper management, the site is not suitable for growing fruit crops. Walnut plants that were planted last year were severely infested by beetles and most plants were damaged.

11.2.6 Medicinal Plants Program (MAP)

11.2.6.1 Germplasm collection of high altitude medicinal plants

The *Veronica himalayensis* (Domna domthri), *Dracocephalum taguiticum* (Tiyangku), *Meconopsis paniculata* (Utpal serpo) and *Meconopsis superba* were successfully domesticated and established in herb garden.

11.2.6.2 Maintenance and development of MAP herb garden

The Medicinal and Aromatic Plants Herb Garden at Yusipang was established to collect and grow the rare and potential MAP species found in the country. More than 60 MAP species that are difficult to collect and cultivate were established in the herb garden. More than 70 species of high altitude medicinal plants are established. Further the schools in Thimphu valley, Department of Traditional Medicinal Services and farmers alike were supplied with seeds and seedlings for cultivation in their areas.

11.2.6.3 Cultivation trial of Chirata in Lauri Geog, Samdrup Jongkhar

Channel Perfume Beautae, (Channel PB) France signed an agreement with MoAF to conduct cultivation trial with the objective to buy the chirata if chemical analysis proved positive results. Thus, cultivation trials were started.

First lot of cultivated Chirata (18 Kg dry) was exported to Chanel PB France in October 2016 @ of Nu 600/ kg. The local wild collected Chirata was sold @ Nu 90 per kg at the auction yard in Lauri Geog in April 2017. More than 100 farmers were trained for a period of two days on the chirata nursery raising technique, transplanting, weeding, harvesting, postharvest care, drying and packaging. Three progressive farmers and researchers visited commercial Chirata growing areas in Nepal. From the initial 9 Chirata trial growers, the number of Chirata cultivators increased to 41 growers in 9 villages of Lauri Geog. It was successfully proven that Chirata can be cultivated on farmer's field using seeds collected from the natural strand.

11.2.6.4 Backstopping to Nubi Menchong Nyamley Tshogdey

In collaboration with the Department of Agricultural Marketing Cooperatives (DAMC), Bhutan Association for Women Enterprises (BAOWE) and the MAP Research Program, the medicinal plant growers of Nubi Geog were encouraged to form the Nubi Menchong Nyamley Tshogdey (NMNT), a medicinal plant cooperative of 150 households The ICIMOD funded CFC (Common Facility Center) was utilized to process and package the products.

11.2.6.5 Documentation of morphological characters of Ophiocordyceps

Since the legalization of cordyceps collection in 2004, its collection and marketing has been going on smoothly and steadily. However, concerns were expressed that the Bhutanese cordyceps are not the same as the ones that comes from China or Tibet. It has therefore become critical that the Bhutanese cordyceps harvested at different stages of maturity be tested for active contents and be compared with the Tibetan/Chinese cordyceps.

The last three years morphological research result shows that the Bhutanese cordyceps are equally good as the Chinese ones if not better. It was revealed that there are three different eye colors among the Bhutanese cordyceps population, viz, yellow, red and black. The size varies drastically between the lots collected from different habitats and between the lots collected in different years.

11.2.6.6 Domestication trial of *Paris polyphylla* (Daw thog sumpa) and *Panax pseudoginseng*(Dingiraja) at Lamperi

Paris polyphylla (Daw thog sumpa) and *Panax pseudoginseng*(Dingiraja) are two important medicinal plants heavily and illegally exploited in Bhutan in the recent times. Both the species are haphazardly and prematurely collected all over the country and exported through illegal traders. A research was conducted on the domestication of these two species.

A plot measuring approximately 1.5 acres of land was developed and was planted with the rhizomes of *Paris polyphylla* and *Panax pseudoginseng* supplied by Department of Forests and Park services from their seized lots. The rhizomes are shooting out, regularly weeded, and forest compost applied, shading net is installed.

Picture 45: *Paris polyphylla* seeds

With the support from Bhutan Trust Fund for Environment Conservation (BTFEC), seeds of *Paris polyphylla* was collected from all over the country, treated for stratification and sowed in Lamperi and Yusipang. Care taker shed was constructed and poly house for plant propagation is installed.

11.3 Research and Development Center, Samtenling, Sarpang

11.3.1 Rice Research Activities

11.3.1.1 Initial evaluation trial on upland rice

Forty nine lines were introduced from International Network for Genetic Evaluation of Rice (INGER) coordinated by IRRI. The INGER trial is to be evaluated under purely rainfed upland environment with low to medium input. The primary objective is to conduct preliminary evaluation of elite breeding lines and varieties under a wide range of unfavorable upland rice environments. In 2016, 20 selected lines from previous set based on performance were evaluated.

The data of 50% flowering, plant height, yield t/ha were calculated for the test entries. Among the total entries, IR 12L339 was found to be the shortest duration with 50% flowering at 80 days after sowing while IR 83106-B-B-5 out yielded the other lines (3.76 MT/ha). However, further selection of entries will be done in next season based on uniformity, earliness and other traits as none of the entries performed better than the check.

11.3.1.2 Advance evaluation trial on Green Super Rice

The Third Green Super Rice Project- Rainfed Lowland Yield Trial (GSR-RFLL) was organized and conducted as integral part of International Network for Genetic Evaluation of Rice (INGER) coordinated by IRRI. Fourteen entries were selected from the previous initial evaluation trial. The objective was to evaluate performance of elite breeding lines from the GSR project under a wide range of rainfed lowland rice environment.

The highest grain yield was obtained from the entry IR 83142-B-60-B which was 4.18 t/ha and the yield of standard check Bhur Ray Kaap II was 3.83 t/ha as well as the shortest duration in terms of 50% flowering (97 days after sowing). The best entries will be selected and further evaluated to select best elite lines under our paddy environment.

11.3.1.3 Advance evaluation trial on rainfed paddy varieties

Eleven entries advanced from the initial evaluation trial on rainfed paddy lines conducted in previous season along with the two standard checks. The trial was conducted to create platform for further selection of promising lines under rainfed condition.

Results show that under rainfed condition, CT 18821-3-4-3-2SR-3P (3.84 t/ha) out yielded the standard check variety Bhur Kambja 1 & 2 (3.76 and (3.29 t/ha) on grain yield. Few lines are shorter (less prone to lodge) in height than checks and few are early maturing.

11.3.1.4 Initial evaluation trial on early maturing rice varieties

The trial material was selected from the Bangladesh lines for the normal planting season. The objective was to evaluate the performance of early maturing rice varieties under Bhur agro-ecological conditions so that early maturing paddy variety will spare land for other crops.

The grain yield was estimated from the single plot (5.04 m^2) and none of the test entries performed better than the standard check Bhur Kambja 1 (3.47 t/ha) except Ceres. Based on earliness and other desirable agronomic traits, further selection and evaluation shall be performed.

11.3.1.5 Observation trial on new rice lines from BHU, Varanasi

Five new lines were introduced to RDC Samtenling through National Rice Program. Those lines were from Banaras Hindu University, India. To evaluate the performance of newly introduced paddy lines on yield potential, plant height, maturity, and resistance to common pest and diseases under Bhur agro-ecological zone.

Two lines viz., HURB10-9 and HUR4-3 performed better than the standard check. The test entries will be further evaluated in the coming season in next phase of adaptability evaluation.

11.3.1.6 Breeders and traditional paddy seed maintenance

As a mandate of breeders to maintain pure and clean source seed, we perform purification of released and promising paddy varieties from the panicle selection done in previous season. In 2016, breeders' seed of 9 released and promising varieties were maintained. In order to conserve and purify traditional paddy varieties, we have produced seed and maintained traditional varieties.

11.3.1.7 Adaptive trial on drought tolerant rice varieties

RDC Samtenling participated for multi-location trial of SAC (SARRC Agriculture Centre) on drought tolerance. The drought stress tolerant varieties are developed and coordinated by SAC. We received six lines coded with accession nos.

Three entries initially emerged but failed at reproductive stage. One accession no. 101 out yielded the local check.

11.3.1.8 Initial Evaluation Trial on rice varietal evaluation (UP0N)

The trial material was selected from the introduction trial 2013 of International Network for Genetic Evaluation of Rice (INGER) program. The objective was to evaluate the performance of upland rice varieties under agro-ecological conditions of lowland rice environments.

The data of 50% flowering, plant height and yield were collected but the grain yield of the test entries were estimated. Among eleven entries, B3688-TB-25-MR-2 out yielded the check as well as other entries. The seeds of these entries were collected for further evaluation in the next season after making selection.

11.3.1.9 Evaluation of spring paddy

Rice is staple food of Bhutan with per capita consumption of about 140 kg. Promoting double cropping of paddy in the Southern Foothills could enhance rice self. Therefore, evaluation of rice varieties was done with the objective to select best variety as spring crop with high yielding potential and early maturing attributes. Total of 8 early maturing paddy varieties were evaluated by using IR20913 as standard check.

Three lines performed better than the standard check. BRRI 49 yielded highest with 2.4 tons per hectare under spring paddy condition. To further make selection, superior lines will be selected and evaluated under spring paddy condition.

11.3.2 Maize Research Activities

11.3.2.1 Trial on Heat tolerant maize

In order to combat the negative impact of heat stress, CIMMYT International has embarked on development and testing of heat tolerant maize hybrids through Heat Tolerant Maize for Asia (HTMA) project.

Bhutan also joined HTMA to access the germplasm and evaluate under our condition in order to prepare against any possible heat stress on maize in future. Accordingly, 3 sets of trials has been received from Wengkhar to be tested at Samtenling in 2016-2017season. The objective was to evaluate the performance of heat tolerance lines in Bhutan.

11.3.2.2 Evaluation of pre-rice maize varieties

The pre- rice maize (Arun 2) variety trial was established at the center in the month of March 2017 with 3 replications. The objective was to evaluate the yield performance of pre rice maize variety (Arun 2).

The pre-rice variety Arun 2 was evaluated at ARDC Samtenling with improved and local standard checks. Arun 2 out yielded local Tegsumpa but it could not perform better than Bhur Ashom1. However, it is earlier than both the checks varieties and the variety will be retained for further assessment.

11.3.3 Effect of sowing time on performance of wheat varieties

Wheat in southern Bhutan has minimum acreage despite the crop having potential to lower national pressure on rice import and wheat flours like *Maida*. Amidst other cash crops, wheat is hardly cultivated crop**.** As part of promotion and with objective to determine correct time for sowing wheat in south, we have conducted a trial using staggered sowing.

Out of four varieties, Bajoka 2967 failed to germinate in all time of sowing. DBW 107 and DBW 39 showed better performance in yield when sown on 30th November. BARIGOM26 performed better when sown in 15th December and also average when sown on 30th November. The result shows that when sown earlier than 30th November, plant height was shorter with less sterility heads. When sown in mid-December, plant height increases but grain filling was less. Hence, we can conclude that last week of November to first week of December as best time for sowing wheat in southern Bhutan.

11.3.4 Performance evaluation of groundnut varieties for sub tropical zone

Two Japanese groundnut varieties were evaluated on yield performance and other agronomic traits under subtropical conditions. These varieties were planted in 9th March 2017 in single large observation plot without replications. From the result, we have drawn that Japanese small ground nut gives higher yield compared to large ground nut.

11.3.5 Local finger millet evaluation and characterization

Southern region has good traditional varieties of finger millet. Today the cultivation of millets in the region is scanty. With objectives to characterize and evaluate local germplasm of finger millet, the centre made an effort to collect local varieties having different vernacular names from various villages of southern Bhutan.

Among different varieties, Local compact millet gave highest yield of 2090 kg/ha. The second highest yield was attributed by Katikay kodo and Kalo akkey with equal yield of 2000 kg/ha. They were followed by Larangay black local and Jumkey kodo yielding to 1950 kg/ha and 1900 kg/ha respectively in comparison to other local varieties. Among all the local varieties, Local compact millet yielded higher than Limithang Kongpu I (2090 kg/ha > 2000 kg/ha) but lesser than Limithang Kongpu II (2090 kg/ha < 2120 kg/ha). The shortest variety was Murkay kodo measuring 65 cm and Katikay kodo is the tallest with 172 cm height.

11.3.6 Fruits and Nuts Research Activities

11.3.6.1 Litchi varietal evaluation

In the year 2007, seven varieties of litchi were introduced from India & Thailand and established at RDC- Samtenling. Evaluations of all the lines were conducted out of which two varieties sourced from India namely Bedana and Muzafarpur was released in 2012 with the name Early Bedana and Chaaskarpa respectively. In addition, two Thai varieties (Hong Houy & Sampao Kaew) were found promising and thus further evaluation was being initiated.

Picture 46: Bedana, Hong Houy and Sampao Kaew

11.3.6.2 Mango varietal evaluation

The few mango varieties released till date are all sourced from India having alternate bearing habit which is the major drawback in the production of mango. Moreover, the existing varieties of mango date backs to 2002 and 2010 and there is no new variety released till date. Therefore, mango germplasm evaluation was done at Samtenling (375masl) mainly with the three varieties introduced from Thailand in the year 2004 with the objective to identify well performing varieties and to be released as one of the promising mango varieties.

Picture 47: Chinwang, Duncan Tommy Atkin variety

The varieties evaluated were Chinwang, Duncan and Tommy Atkin. All four varieties possess good horticulture characters except the incidence of fruit fly (*Bactrocera dorsalis*) in all varieties. So, it may be concluded that all the varieties are very promising offering the opportunity to expand its area of cultivation.

11.3.7 Vegetable Research Activities

11.3.7.1 Performance evaluation of AVRDC tomato lines

To explore the scope of cultivating tomato during hot wet summer, 4 heat tolerant tomato lines from AVRDC were introduced and adaptive research was carried out at RDC Samtenling.

Roma variety of tomato was not good variety in the southern region during the hot wet summer season. The heat tolerant tomato varieties supplied by AVRDC did better than the Roma variety. From four different varieties supplied by the AVRDC, 9803 (5.37 MT/Ac) out yielded others followed by 9001 (4.87 MT/Ac).

11.3.7.2 Screening of high yielding pole bean varieties

The farmers of southern region seem less interested to grow beans variety supplied by NSC (pole white). Rather, they grow local variety called Dulal bori. So, to validate the reason for growing Dulal bori and yield potential, the evaluation of local beans (Dulal bori and Purple with check Pole white) was carried out in ARDC Samtenling.

From the yield data, it was found that both the varieties yield is lower than that of check one. However, among the varieties, Dulal bori out yielded purple bori (4.64 MT/ha > 2.61 MT/ha). Although pole white is highest yielder, Dulal bori is preferred by farmers.

11.3.7.3. Performance evaluation of AVRDC heat tolerant chili

Evaluation of 11 heat tolerant varieties of chilli introduced from Taiwan in 2011was continued against the check varieties: Indian chilli and Surjamukhi. The objective was to evaluate the adaptability and performance of the heat tolerant varieties of chilli.

Among eleven chilli varieties, AVPP-0904 was the earliest flowering followed by AVPP-0907. However, the AVPP-9905 out yielded (0.19 MT/acre) the others followed by AVPP-0907. Although AVPP-9905 is late flowering (77.3 days) than AVPP-0904 (71 days), it is highest yielding variety. Therefore, AVPP-9905 is recommended for cultivation in terms of yield parameters.

11.4 Research and Development Center- Bajo

14.4.1 Field Crops

14.4.1.1 Rice research: on-station and on-farm evaluation of rice

In 2016-2017, the field crops program has evaluated ninety germplasm which are at various levels of evaluation. The evaluations were done both on-station and on-farm. The test materials included the advance lines from last year's trial, local land races, introductions from the International Rice Research Institute (IRRI), and the Banaras Hindu University (BHU) in India.

Forty lines received from IRRI as International Institute Rice Observation Nursery (IIRON) were evaluated for uniformity, resistance against diseases, plant height crop stand and maturity under Bajo condition. From these, twenty best lines were selected for 2017 observation nursery from which lines will undergo vigorous screening and best ones will be selected for replicated initial evaluation trial (IET) in 2018.

11.4.1.2 Initial evaluation trial (IET) on rice

Under IET, 18 entries including local check as Bajo Kaap2 were evaluated.

Picture 48: Initial Evaluation Trial on Rice

All the entries have performed quite well and in terms of grain yield t/ha. However, the grain yield in absolute values ranged between 5.00 t/ha and 7.00 t/ha. The test materials were actually the advance lines of 2014 IRRI nursery and were the best selections from the previous two years of varietal evaluations at the research station. Among the germ plasms tested in the current experiment, IR 11A-208, IR 06N-170 and IR 09N-522 were the top three performers with grain yield record of 7 t/ha, 6.8 t/ha and 6.6 t/ha respectively. Lowest grain yield was recorded in IR 09A-228 (5.5 t/ha) and CT16658-5-2-3SR-2-1(5.56 t/ha), and their values were also below that of the standard check (BK 2) which produced 6t/ha. IR 06M-150, IR 9L-120, IR 09A-220, IR 10N-269, IR 05A-235, and Sahabhaji yielded slightly over 6 t/h ha. Based on the yield performance and other parameters, 14 entries were selected for advanced evaluation trial in 2017 season.

11.4.1.3 Advance evaluation trial on rice

Five advance lines from the previous years' trial (AET) were re-evaluated on a larger plot following standard protocol and same management practices. Bajo Kaap 2 was used as the standard check and the grain yield from these entries were compared to that of Bajo Kaap 2.

The grain yield of the test varieties ranged between 6.6 t/ha to 8.14 t/ha. Highest yield was obtained from TIME 80518 followed by Sarju 52 with 6.51 t/ha and the lowest yielding entry was Ceres 1 (6.1 7 t/ha), though not much different from the standard with 6.43 t/ha.

In terms of days to flowering (DFT), all the entries took less number of days (average of 124 d) as compared to the standard check (125). Overall, the entries had more or less had same maturity duration, thus, would fall in the medium maturity group. On the other hand, most of the entries

were taller than the standard check (96 cm) except Sarju-52 and Zhunghun with plant height of 91 cm and 87 cm respectively.

11.4.1.4 Characterization of germplasm

RDC maintains breeder seeds of seven improved rice varieties such as IR-64, IR20913, Bajo Maap1, Bajo Maap2, Bajo Kaap1, Bajo Kaap2 and Khangma Maap. These varieties have been widely promoted in the mid-altitude regions of the country ever since their official releases but basic information on the plant morphology and agronomic traits have not been documented. The rice researchers have initiated work on basic characterization of released varieties including some of the popular local land races. The local varieties studied included Ngabja, Tan Tshering and Bonday. The varietal traits of released varieties grown in the region can be sourced from the rice program office at Bajo.

11.4.1.5 Other field crop activities

In summary, during the 2016-17 financial year, the field crops program evaluated more than 100 accessions of cereal crop's germplasm of rice, wheat, and quinoa. 78 entries at various level of evaluation of which five at advance stages of evaluation were carried out under the rice commodity. The five at advance stage includes TIME 80518, Zhonghan, Sarju-52 and Ceres 1&2, which are currently being evaluated for in the farmer's field in different Dzongkhags for field multi-location trial. The best performing ones will be selected and proposed for released in the next variety release committee meeting in 2018. The other activities under the rice commodity include on-station demonstration of released varieties and seed production for rice promotional program.

Under the wheat commodity, the center produced more than 2 tons wheat seeds of recently released varieties; Bumthang kaa drupchu, Bajosokha kaa *and* Gumasokha kaa which will be used for wheat promotional program in the potential Dzongkhags. The other activities include on-station research on bio-fortified wheat varieties and on-farm demonstration of integrated nutrient management technologies in Wangdue-Punakha valley.

Under the oil seed commodity, two mustard varieties; Barisharisha 14 and Lumley tori and a sunflower variety introduced from Nepal were tested at the station.

The centre also showed some progress on quinoa in terms of on-station and on-farm evaluations in the region. A number of demonstrations were conducted in the region from which seeds were collected for further multiplication in the current financial year. From the on-station trial, the centre was able to confirm its potential as both spring and summer crops. The yields were quite appreciable and in order to promote this new crop, there will be more evaluation and demonstrations in the near future.

11.4.2 Horticulture

The objective of horticulture crops research is to improve rural livelihood and to achieve vegetable and fruit self-sufficiency in the region and at the national level. The research and IHPP activities of the horticulture sector include Germplasm evaluation, generation of crop management technology, post-harvest practices, improved seeds, plant propagation techniques and maintenance of mother plants and breeder seeds of released crops besides varietal evaluation. The sector also focused on broadening the genetic base of the prioritized horticultural

crops through either introduction or selection from local diversity. The on-station research comprise of research on fruits and nuts, vegetables, and medicinal and aromatic plants at both Bajo and sub-station Tsirang. ARDSC Mithun also manages National Citrus Repository for production of clean citrus propagation material through regular biological indexing and testing of identified mother trees and cardamom germplasm collections.

On stations, progress in 2016-17 included, development of on-station research field infrastructure and revitalization of soil health. About 13 acres of land has been developed along with the farm infrastructure (farm shed, irrigation channels, drainages and internal farm road). A total of 1.5 km of internal farm road has been constructed. All the terrace area (14 acres) is well connected with the irrigation water. More than 100 tons of compose (Bajo – 60 and Tsirang – 40) was prepared and incorporated into the soil to enhance soil health. The area is currently planted with high value fruits and vegetables. Generation of management technology is initiated for grapes, kiwi, avocado, dragon fruit, persimmon and citrus.

Production of quality seeds and seedling is the key to sustain successful horticulture farming. Therefore, horticulture sector initiated generating nursery technology for fruits and vegetables in enhancing production of quality seeds and seedling. A total of four large plastic houses (5x40 meters) and two (5x20 meters) dimension are established at RDC Bajo. About 1400 fruits seedlings were produced and promoted by establishing demonstration orchards and focus villages. About 150 kg of vegetable seeds were produced of which 120 kg was promoted in West Central Region (WCR). Remaining 30 kg was saved for further multiplication.

11.4.3 On-farm activities

A total of nine assorted fruit demonstration orchards were established in four Dzongkhags. The survival of fruit plants in the field is above 90% as of now although it was planted in dry winter season (February-March, 2017). In order to increase the quantity of high quality seed production, four new nursery operators are trained and provided with the basic supports. We also learnt that the onion promoted could not compete in market in terms of price and quality. Out of five cucurbits identified and promoted, field extension and farmers showed their keen interest for pumpkin and watermelon. However, unlike in research field, these crops also suffered low germination and few incidences of insect pests.

11.4.4 Plant protection

During the 2016-17 financial year, the plant protection sector played a key role in the control and management of pod borer pest out-breaks in chilli crop in Punakha Dzongkhag. The center collaborated with NPPC in supplying and installing pheromone traps for control of the pest. To increase awareness on chili pod borer and to advocate the use of pheromone traps, a farmers' training was conducted at Guma Geog, Punakha in collaboration with NPPC and Punakha Dzongkhag.

To document the challenges confronted by farmers and identify the main constraints for the declining wheat production over the years, a survey was conducted in collaboration with National Wheat Program and FC sector of the center. The study identified that crop depredation by wild animals (mainly Sambhar deer, monkeys, and wild boars) and stray cattle as the main reason behind farmers declining wheat production.

The sector involved in providing demonstration, monitoring, installation and hands on training of Electric Fencing in three Dzongkhags other than Dagana and Tsirang (looked after by ARDSC-Mithun) of the West-Central region.

11.4.5 Soil and land management

In the 2016-17 fiscal year, the unit carried out soil sampling for all the fields of the Centre (horticultural and field crop's field) including ARDSC-Tsirang. Based on soil analysis report analyzed and interpreted by SPAL (soil and plant analytical laboratory) NSSC, Semtokha, the unit prepared the recommended fertilizer dosage and nutrient management practices for respective sectors.

To create awareness on the importance of organic soil nutrient management, vermi-composting was revived at the center. On station sowing of Dhaincha (*Sesbania aculeata*)seeds for seed production and multiplication for supplying to farmers for improving soil fertility organically

11.4.6 Research and communication

During the fiscal year 2016-2017, the unit in consultation with concerned sector has documented six technical reports on new technologies generated by the centre. The sector also developed three posters on emerging agriculture technologies for display at the centre. Apart from documentation, the sector routinely updated the information about the centre in the centre's webpage www.rcbajo.gov.bt with updated news, information and reports. The unit also contributed relevant news and articles in MoAF webpage for information sharing. In addition, the unit also provided protocol services to diverse groups of visitors interested in agriculture research and development.

11.4.7 Engineering

Engineering sector mostly deal with the implementation of developmental activities such as site supervision services of construction work, infrastructure development, and road maintenance and irrigation infrastructure.