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ANNUAL REPORT 2019-2020

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ROYAL GOVERNMENT OF BHUTAN

FOREWORD

It is an immense pleasure to publish the 35th Annual Technical Report of Agriculture Research and Development Centre (ARDC), Bajo, coinciding with the financial year 2019-20. It is a synthesis of the research and development activities carried out in the fields of field crops, horticulture, technical support services, and engineering services by the Centre and its Sub-Centre at Menchhuna, Tsirang. Further, the report presents the existing human resources and budget utilization status.

ARDC-Bajo implements activities focusing on its national mandate for coordination of field crops research and development, regional mandate for horticulture research and development, and commodity mandates for rice and citrus research and development. It carries out the activities in close collaboration and consultation with the Ministry of Agriculture and Forests, Department of Agriculture and its central agencies, projects, Local Government agencies, and most importantly with the farmers and other beneficiaries.

The successes and achievements made in the last one were possible because of tremendous supports from the central agencies and the projects in general and unwavering and concerted supports and efforts from JICA and Japanese Experts. All staff of ARDC-Bajo, ARDSC-Menchhuna, and Chimipang Royal Project made big efforts to contribute towards achieving planned activity targets as well as ad-hoc activities.

The Centre initiated and implemented numerous activities such as rice varietal evaluations, establishment of horticulture germplasm blocks, quinoa evaluations, citrus management trials and demonstrations, establishment of demonstration orchards, National Citrus Canopy Management, Focus Villages for fruits, vegetable evaluations and top working of fruit trees. However, regular monitoring and evaluations have still remained weak and wanting.

While firmly remaining determined to make whatever positive differences to farming communities and grateful to all those who contributed towards achieving the planned targets of the Centre for 2019-20, I would like to entreat all seniors, colleagues, supporters, and stakeholders to continue to provide full cooperation, support and best wishes.

This report is intended not only to serve as an account of activities implemented in the last one year but also possibly as technical reference and guidelines to all stakeholders involved in agricultural research and rural development to achieve national food and nutrition self-sufficiency, economic self-reliance and eventually the overarching national goal of Gross National Happiness in Bhutan.

Tashi Delek La!

Pema Chofil

Program Director

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EXECUTIVE SUMMARY

In the financial year (FY) 2019-2020, the Field Crops Sector has evaluated 180 lines at various stages of evaluation. The evaluations were done both on-station and on-farm. The test materials included the advance lines from last year's trials, local landraces, and introductions from the International Rice Research Institute (IRRI). Study on phenotypic characterization of traditional land races of rice continued this season too with 15 varieties. The Field Crop Sector conducted demonstration on direct seedling using drum seeder on-station at farmers' field. In wheat research, advance evaluation trials were conducted for Nepal and Indian lines, on-station research on bio-fortified wheat varieties and wheat rust pathological study were carried out. Two varieties quinoa and five varieties of groundnut performance evaluation trail were carried out at ARDSC, Menchhuna.

The Field Crops Sector has produced 8.2 MT of rice seed of different varieties. Altogether, the national rice programme was able to promote 12.99MT of improved seed in three Dzongkhags (Wangdue, Dagana & Tsirang). The sector also supported spring rice and upland rice cultivation with seed supply of 3.5MT and technical backstopping. The Centre procured 1.99MT minor cereals and supplied to farmers in the Region on promotional program. The Centre produced more than 2.51MT of wheat seeds of recently released varieties for seed purspose. About 2.5 MT of quinoa seed on-station at ARDC Bajo and ARDSC Menchhuna. Promotion of quinoa was carried out with technical assistance and seed support to farmers of Tsirang, Dagana & Wangdue Dzongkhags covering more than 30 ac of area. A total of 1050 kg of maize seed was produced from ARDSC Menchhuna and issued to farmers of Tsirang and Dagana on promotional basis which is expected to make a substantial contribution to overall cereals production. On top of this ARDC Bajo procured 1660 kg of *Yangtshipa* maize variety and supplied to Dagana Dzongkhag as per their demand. The Centre has procured 370 kg of mustard from NSC and distributed to farmers in the region.

In the FY 2019-20, the horticulture program focused on both the research and development activities. The sector has on-going evaluation of temperate and sub-tropical fruits and nuts germplasm of more than 20 fruits and nuts plants on-station at ARDC Bajo and ARSDC Menchhuna. Evaluation of germplasm of cardamom and citrus are on-going activities at ARDSC Menchhuna. On-station evaluation trial of high yield and nutrients content vegetables is on-going for variety release. The sector also produced and maintained breeder seeds of 12 vegetable crops released from Centre.

The Horticulture sector was engaged in seed production and distribution of improved vegetable varieties, fruits seedling production and establishment of demo-orchards. A total of 5404 grafted planting materials were distributed to establish 23 mixed fruit demonstration orchard and six focus village orchards (42 farmers) in the region. Nation-wide citrus canopy management was carried out which covered 26 orchards (4360) and 515 farmers are trained on canopy management in nine Dzongkhags. A total of 459 fruit trees were top worked in Punakha and Tsirang Dzongkhags. With support from IHPP-JICA, a total of 28 farmers (23 demonstration and 6 focus village representatives) were trained on pit digging, planting of fruit trees, fruit thinning and summer vegetable cultivation. The Centre produced 4070 bottles of straw mushroom spawn and 460 mother spawn and supplied to farmers.

The support service Research and Development program cross-sectoral discipline mandated to support in carrying out the technology development and research activities that cuts across different sectors and consists of services for Soil and Land Management, Plant Protection, Research Communication and Seed

Laboratory. The sector carried out various studies and research like Study on the Status of Important Soil Parameters in Mandarin Orchards; Sequestration of carbon into soil using Dhaincha; Response of rice to different Nitrogen application rate, plant protect research and trials and Demonstration and promotion of climate smart technologies in the region.

During the FY 2019-20 the Centre also carried out social and impact studies namely impact of outreach program; impact of electric fencing; study on the status of Important Soil Parameters in Mandarin Orchards, Dagana and Survey of insect pests of horticultural crops in West Central Bhutan.

During the FY 2019-20 the Centre has proposed six varieties and two for release out which two were released. During the FY 2019-20 the Centre has published series of publication: two journal papers; two guide books and 17 pamphlets.

The Centre initiated rice breeding and guava breeding during this FY.

Engineering Sector comprising provided engineering services for implementation of 43 activities worth Nu276.273million (M) for 12 agencies including eight Dzongkhags in 2019-20 financial year. Amongst the agencies, the highest of 23 activities were implemented for ARDC Bajo worth Nu18.545M, followed by sister RNR Agencies of 4 activities worth Nu46.870M, and Zhemgang Dzongkhag 3 activities worth Nu188.21M. In terms of value of the work the highest was for Zhemgang Dzongkhag of Nu188.212 for three activities, followed by RNR Agencies of Nu46.870M, followed by ARDC Bajo of Nu18.545M for implementation of 23 activities.

1 FIELD CROP RESEARCH AND DEVELOPMENT PROGRAM

1.1 Field Crop Research Activities

1.1.1 Introduce and evaluate new rice lines

ARDC Bajo in collaboration with the International Irrigated Rice Observational Nursery (IIRON) is organized and conducted as an integral part of the International Network for Genetic Evaluation of Rice (INGER) coordinated by IRRI with the objective to conduct preliminary evaluation of elite breeding lines and varieties under wide range of irrigated rice environments. In the FY 2019-20, the Centre received 146 lines received from IRRI as International Irrigated Rice Observation Nursery (IIRON) were evaluated for uniformity, resistance against diseases, plant height, crop stand and maturity under Bajo conditions (annexure 1). From these, twenty best lines were selected for 2020 observation nursery from which lines will undergo vigorous screening and the best ones selected for replicated initial evaluation trial (IET) in the next season.

1.1.2 Rice Advance Evaluation Trial

Under AET nine entries including standard check Bajo Kaap1 were evaluated (table 1). This trial is conducted to identify the suitable varieties with high yield potential, medium height, optimum maturity and resistance to pest and diseases for mid altitude rice growing areas. The evaluation was done in experimental plot size of 3x4 m in randomized complete block design with three replications. All standard cultural practices were applied including recommended doses of NPK and herbicide for the control of grasses and sedges. NPK and Butachlor were applied at 70:30:30 kg and 1.5 kg ai/ha respectively. In addition to herbicide application, one manual weeding was carried out one month after transplanting. Irrigation water was applied as and when required and no chemical insecticides/fungicides were used to control the diseases and pests. The crops were harvested at 85% maturity.

Table 1 Agronomic performance of advance evaluation trial 2019-20

Designation	FLW 50%	Tillers/hill	Plant height (cm)	Grain yield kg/ac
IR96120	122	12	99	1500
IR11A208	127	10	104	1200
IR09A228	121	14	108	1900
IR09A220	119	12	109	2000
IR05A235	118	19	104	1100
PK3445-3-2	122	10	103	2500
IR06N170	124	12	113	2800
IR09N522	126	19	105	1500
IR08N210	115	18	112	1210
BK1(local check)	120	13	110	1500

1.1.3 Rice Initial Evaluation Trial (IET)

In the IET fourteen lines were evaluated (table 2). This trial is basically to identify the suitable varieties with high yield potential, medium height, optimum maturity and resistance to pest and diseases for mid altitude rice growing.

Table 2 Agronomic performance of rice IET lines 2019-20

Designation	FLW 50%	Plant height (cm)	Tillers/hill	Grain yield (kg/ac)
IR11A534	132	99	13	999
IR11A255	127	112	15	1000
GSR1-3-56	124	110	12	870
IR11A501	115	111	14	800
IRRI306	115	111	17	1200
IRGSR 1-2-45	119	100	19	1240
IR12L248	114	110	15	1350
IRRRI 154	112	113	18	1200
PSBRC 18	117	12	17	1900
IR146	116	114	14	1586
IRRI 180	118	101	15	1200
IRRI156	124	92	14	1420
IRRI 123	12	114	14	1300
IR12 N168	125	100	13	1240
BK1 (local check)	132	102	16	1300

1.1.4 Rice Observation Nursery

In the FY 2019-20 we had 13 lines in observation nursery trial. This trial is conducted to evaluate the performance of the test lines in terms of yield, maturity period, adaptability, and pest and diseases resistance. All the trials procedures were followed. There was good performance of the treatments. Timely data were collected and analyzed as the result mentioned in the table 3.

Table 3 Agronomic performance of observation nursery lines 2019-20

Designation	FLW 50%	Plant height (cm)	Tillers/hill	Grain yield (kg/ac)
IRRI154	127	97	14	15000
IRRI156	124	114	16	1230
IRRI11A306	126	104	16	1200
IRRI174	120	100	17	145
IRRI123	122	101	16	1360
IRRI146	118	104	12	1250
IR12N110	116	108	16	2000
IR14D155	124	110	19	2000
IRRI248	122	82	18	1900
GSRIR1-3-56-DR-21-21	124	118	14	1875
IRRI11A501	126	114	10	200
IRRI179	118	108	11	2110
IRRI180	125	110	15	824
BK2 (Local check)	116	103	14	1350

1.1.5 Demonstration of released rice varieties

Under demonstration of released varieties, the sector has maintained seven varieties. The purpose of this trial is for technology dissemination to farmers, extension, visitors and trainees who ever visiting the Centre. Necessary agronomic practices such as irrigation and weeding were done based on requirement.

Table 4 Agronomic performance of released varieties on-station 2019-20

Designation	Plant height (cm)	Tillers/hill	Maturity days	Grain yield (kg/ac)
Bajo Maap 2	110	17	155	2000
IR 64	90	18	150	2400
IR 28	105	15	155	2000
Bajo Maap 1	100	14	150	2000
Bajo Kaap1	100	14	150	2400
Bajo Kaap 2	100	15	150	2400
IR 20913	115	12	120	1600

1.1.6 On-farm rice trials

Four gewogs under each dzongkhag were identified for on farm rice trial. Two promising rice varieties were tested in each farmer's fields. A total of 16 households/sites were engaged in on farm rice trials. The crop cut of the on-farm trials were conducted and the yield was computed. These trials will be continued in the next season 2020.

Table 5 Agronomic Performance of rice varieties at on-farm trials, 2019-20

SN	Gewog	Dzongkhag	Variety	Till/hill	Yield (Kg/acre)
1	Kabisa	Punakha	TME-50518	9	2154.16
2	Kabisa	Punakha	Zhanghan	7	2325.5
3	Baarp	Punakha	Zhanghan	12	3125.56
4	Baarp	Punakha	TME-50518	10	2658.3
5	Bjena	Wangdue	TME-50518	19	2970.25
6	Bjena	Wangdue	Zhanghan	16	2665.12
7	Daga	Wangdue	Zhanghan	12	718.5
8	Daga	Wangdue	TME-50518	14	645.25
9	Kabisa	Punakha	TME-50518	7	2554.36
10	Kabisa	Punakha	Zhanghan	8	215.56
11	Baarp	Punakha	Zhanghan	12	2282.93
12	Baarp	Punakha	TME-50518	10	2588.24
13	Bjena	Wangdue	TME-50518	19	2970.45
14	Bjena	Wangdue	Zhanghan	16	2665.12
15	Daga	Wangdue	Zhanghan	13	618.58
16	Daga	Wangdue	TME-50518	10	745.45

1.1.7 Phenotypic Characterization of Traditional Land Races of rice

ARDC Bajo has received a total 15 accessions of traditional land races of rice for the phenotypic characterization and seed production during the 2019-20 as reflected in annexure 2. All accession germinated very well. Basic morphological data were collected from accessions. The basic qualitative characters such as leaf blade pubescence, leaf sheath colour, flag leaf angle, ligule colour, ligule type and culm habit were observed and data recorded. The accessions did not show much difference in terms of leaf pubescence, leaf sheath colour, flag leaf angle colour, and ligule type. Almost all the accessions had semi-erect to descending flag leaves, which is a typical characteristics of traditional varieties. There was also diversity in basal leaf sheath colour and ligule types.

Under quantitative plant characters, basic agronomic traits and grain information were assessed. Basic agronomic traits included the plant height (cm), days to maturity (DTM), panicle length (cm) and number of grains per panicle including estimated yield (t/ac). 99 % of accessions were very tall with plant height of 170-190 cm, thus rendering them highly susceptible for lodging. Similarly, the maturity duration of all the accessions exceeded 160 days. Regarding the panicle length, most of the accessions had long panicles with medium density/compactness. Based on the grain information, conclusions were drawn on the categorization of grains into different groups such as long and short grains including the shapes such as slender, medium and bold.

1.1.8 Demonstration on direct seeded rice through drum seeder

Under direct seeding, the rice seeds are directly sown to the well prepared main field. The seeds are soaked in water and kept for 24 hours for incubation and pre-sprouting the sprouted seeds are sown in well puddled and leveled field using drum seeder as shown in the figure 1. During the FY 2019-20, the National Rice program has carried out demonstration of direct seeded rice by using drum seeder on station at ARDC Bajo, ARDSC Menchhuna and at Royal Project Chimipang (CRP). Demonstration was conducted on farm at Mendrelgang, Tsirang. At farmers' field demonstration was carried out at Lhamoi D-Zingkha Dungkhag by FMCL and technical support with seed was provided from the Centre.

Table 6 Direct seeded demonstration at various sites in 2019-20

SN	Location	Gewog	Dzongkhag	Remarks
1	ARDC Bajo		Wangdue	On-station
2	ARDSC, Menchunna		Tsirang	On-station
3	Dzomlnigzor,	Mendrelgang	Tsirang	Farmer's field
4	Daragoun	Nichula	Dagana	Farmer's field
5	Lhamoi Zingkha	Lhamoi Zingkha	Dagana	Farmer's field
6	Karmaling	Karmaling	Dagana	sub Centre
7	Nichula	Nichula	Dagana	sub Centre
8	Chimipang Royal Project	Chimipang	Punakha	On-station

Table 7 Agronomic traits of direct seeded rice at ARDC Bajo, 2019-20

Sample No	Plant height (cm)	Tillers / hill	Grains /panicle	Yield (kg/acre)
1	112	25	155	3700
2	115	22	165	3550
3	106	21	155	3325
Average	**111**	**23**	**158**	**3525**

This type of seeding is very convenient and is adopted in areas where there is scarcity of water. It reduces huge amount of production cost and planting materials. The production is at par with normal conventional method or slightly higher which is computed at 3525 kg/ac. The crop matures 15-20 days earlier than normal transplanted rice. The drawback of direct seeding is emergence of heavy weeds leading to involvement of more labourers. Farmers reported that if there is heavy rainfall right after the direct seedling than the line seeding is disassemble so the weeding by using paddy weeder is not possible.

Figure 1 Demo on direct seeding using drum seeder, Lhamoizingkha

1.1.9 Initiated Rice Breading Program

Rice breeding program in Bhutan started in mid 1980s and the country had its first formally released rice variety IR 64 in 1988. A total of 26 rice varieties have so far been developed and released in the country for different rice agro-ecologies. Of the total, 9 different rice varieties have been cross-bred and developed by Bhutanese researchers. Despite such efforts in the past, the rice breeding program saw a decline over the years. With most of the senior breeders and specialists going to exit from the system, an urgent need was felt to initiate the rice breeding program revitalize rice breeding program in the country. To start with the breeding program, the Centre has coordinated in providing training on rice breeding to develop the capacity to young researchers in first week of September, 2029. A total of 12 participants from ARDCs Wengkhar, Samtenling, Yuesipang and Bajo and staff from NSC attended the three days training program with the Rice Specialist as resource person. The researchers are taught on the basic science on plant breeding and genetics, rice crossing techniques and variety development. For rice breeding varieties like Nabja, Bonday, Bajo Kaap 1, Bajo Maap 2 and IR 64 has been selected. The rice breeding program is a continuous activity which will be carried over for few more years so that the Centre can develop cross-bread rice variety to release with the desired traits.

1.1.10 Wheat Advance Evaluation Trial of Indian and Nepal lines

Wheat is considered as third important cereal crop in Bhutan after maize and rice. In Bhutan, wheat research program started only in 1982 with the testing and evaluation of materials received from India and CIMMYT. Thereafter, numbers of variety/lines were introduced and evaluated in different ecological zones in the country. Since wheat research program started, 6 wheat varieties were released (Sonalika, Bajokaa1, Bajokaa2, Bajosokhakaa, Gumasokha kaa and Bumthangkaa Drukchu). Due to its susceptibility to wheat rust diseases, variety Sonalika was denotified. With the limited numbers of improved varieties in the country, the need for extra research effort and release of new variety is important.

With the limited numbers of improved varieties in the country, the need for extra research effort and release of new variety is found to be important. Therefore, the National Wheat Program receives numbers of wheat varieties or lines from outside for its evaluation under Bhutanese conditions. The varieties were received from Nepal and India through germplasm exchange program. The varieties are most popular released under wheat growing conditions in Nepal and are considered to be high yielding with wheat rusts resistant traits. Three Nepal lines and one Indian line were evaluated under AET in 2019-20 seasons with Bumthangkaadrukchu as local standard check.

Table 8 Agronomic Performance of Nepal and Indian wheat lines

SN	Treatments	Days to Heading	Days to Maturity	Plant height(cm)	Disease score (0-5)	Yield (T/ha)
1	Munal	95	151	90	0	3.32
2	Chyakhuru	94	151	90	0	3.08
3	Swargadwar	98	151	89	0	3.15
4	BHU 35	96	151	91	0	3.30
5	Bumthangkadrukchu (local check)	94	151	96	0	2.88

1.1.11 Participatory Evaluation Trial (PET) of Bio fortified wheat lines

Wheat is considered to be most important staple crop in most of the developing countries. Particularly in south and west Asia, half a billion people are iron deficient. The objective of bio fortifying wheat is to develop nutritionally enhanced wheat to increases people's intake of zinc and iron. The International Center for Wheat and Maize (CIMMYT) has developed numbers of bio fortified wheat lines. For adaptability and performance observation, the lines were distributed in wheat growing countries. Bhutan being part of CIMMYT activity and global wheat network, we received 50 bio-fortified entries during 2014-15 seasons. The entries underwent adaptive and observation nursery during 2014-15 and 2015-16 seasons. From 22 entries grown in 2015-16 season, eight entries were selected for observation in 2017-18 and 2019-19. In this season, six best performing bio-fortified lines from past year harvest and one local check BKD (Bumthangkaa Drukchuu) were used. Necessary agronomic practices such as irrigation and weeding were done based on requirement. Two times weeding was carried out. The lines were evaluated for days to heading, days to maturity, plant height, and yield potential and resistant to rust diseases. For determining yield potential, crop cut was carried out from area of $2x3m^2$.

Table 9 Agronomic Performance of Bio fortified lines

SN	Treatments	Days to Heading	Days to Maturity	Plant height(cm)	Disease score (0-5)	Yield (ton/ha)
1	BF 450	93	145	88	0	2.72
2	BF 422	92	138	90	0	2.74
3	BF 411	96	135	89	0	2.48
4	BF 447	95	140	90	0	2.70
5	BF 412	90	140	91	0	3.33
6	BF 415	92	145	92	0	1.80
7	Bumthangkadrukchu	94	155	94	0	2.10

1.1.12 Wheat rust pathological study

Wheat rust surveillance is one of the most important activities under National Wheat Program. Every year different wheat lines were evaluated and surveyed for rust pathological. Planting was done in December, 2017 with recommended agronomic practices. Four times diseases survey/ scoring was done keeping 15 days interval between each survey. Leaf rust is the only disease observed throughout crop season.

Table 10 Wheat rust pathological study

Entry	10 March,2020			24 March, 2020			7April, 2020			21 April, 2020		
	YR	LR	SR	YR	LR	SR	YR	LR	SR	YR	LR	SR
Annapurna	0	0	0	0	0	0	0	0	0	0	0	0
WL 1563	0	0	0	0	0	0	0	0	0	0	0	0
HD 2204	0	0	0	0	0	0	0	0	0	0	0	0
PBW 660	0	0	0	0	0	0	0	0	0	0	0	0
HD 2687	0	0	0	0	0	0	0	0	0	0	0	0
HD 2189	0	0	0	0	0	0	0	20S	0	0	30S	0
HP 163	0	0	0	0	0	0	0	20S	0	0	30S	0
RAJ 3765	0	0	0	0	0	0	0	10S	0	0	10S	0
DWB 373	0	0	0	0	0	0	0	0	0	0	10S	0
PAK 81	0	0	0	0	0	0	0	0	0	0	10S	0
Punjab 85	0	0	0	0	0	0	0	10S	0	0	30S	0
Chakwal 86	0	0	0	0	0	0	0	10S	0	0	20S	0
Faisalabad 85	0	0	0	0	0	0	0	10S	0	0	20S	0
Inquilab 85	0	0	0	0	0	0	0	0	0	0	30S	0
Faisalabad 83	0	0	0	0	0	0	0	0	0	0	10S	0
Rawal 87	0	0	0	0	0	0	0	0	0	0	10S	0
Kohsar	0	0	0	0	0	0	0	0	0	0	10S	0
Bakhtwar	0	0	0	0	0	0	0	0	0	0	10S	0
Gaurab	0	0	0	0	0	0	0	0	0	0	10S	0
Morocco	0	0	0	0	40S	0	0	60S	0	0	60S	0

Figure 3 On-station wheat trials, 2019-20

On-station trial was set up for five varieties of groundnut (Challipa Badam, Bartshampa White Badam, Yabrangpa Red Badam Yabrangpa White and Purple and Nanungpa Badam) from ARDC Wengkhar for performance evaluation at ARDSC Menchunna in April 2019. Three replications were done for all the varieties. Necessary agronomic practices such as irrigation and weeding were done based on requirement were carried out as per the trial protocal.

All the data were collected as per the protocol like germination date, flowering date, weeding and harvesting. No major pest and disease incidence were observed but there was water logged during raining season so draining of the water was done while weeding. Three times weeding was carried out. All varieties matured in same time so harvesting was one in same day. Along with yield data the plant height, weight of 100 pods of each variety were also recorded. The crop was well dried before computing the yield per acre. Among the five varieties the yield of Bartshampa White Badam had the highest average yield of three replications. The trial will be continued in the coming season.

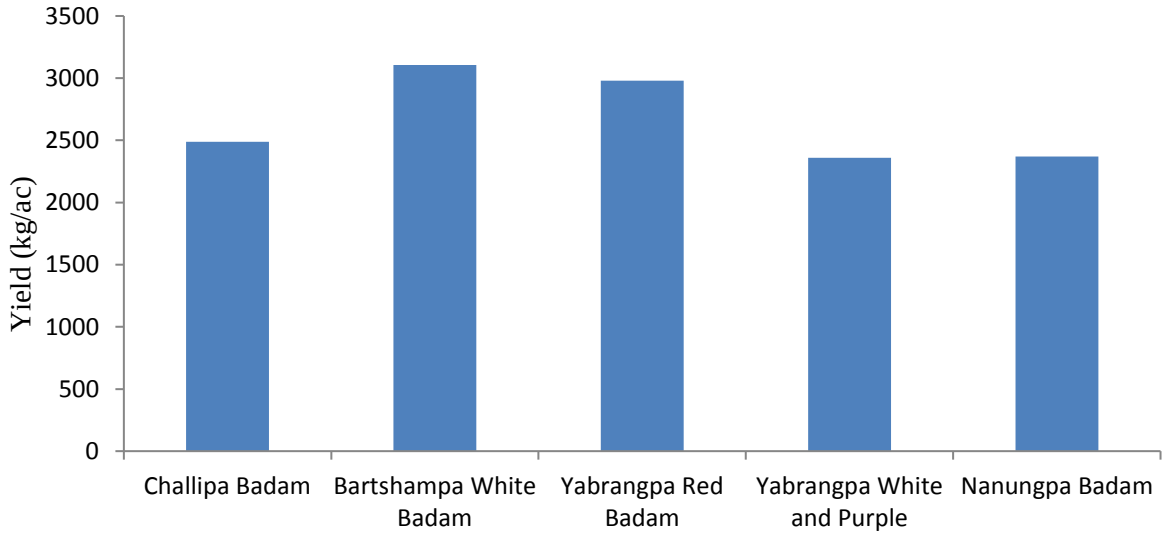

Figure 2 Groundnut yield per acre

1.1.13 Quinoa Performance Evaluation Trials

Quinoa research and development has been the most priority activities of DoA since its first introduction to the country in 2015. From a new crop in 2015, quinoa has already spread in all 20 Dzongkhags and across all agro-ecological zones. During the FY 2019-20 the sub Centre has conducted on-station and on-farm (Patala, Drujegang) trials of DOA-1-PMB-2015 and Ivory 123 varieties following all the trials procedures. Timely data were collected. No pest and diseases were observed during the growth stages. Three crop cut samples were taken with a sample size of $6m^2$ each than computed to kg per ac. DOA-1-PMB-2015 variety has higher yield compared to Ivory 123 in both conditions. Both varieties performance was better on-farm compared to o-station in both varieties. This could be of favourable altitude and weather condition of the area.

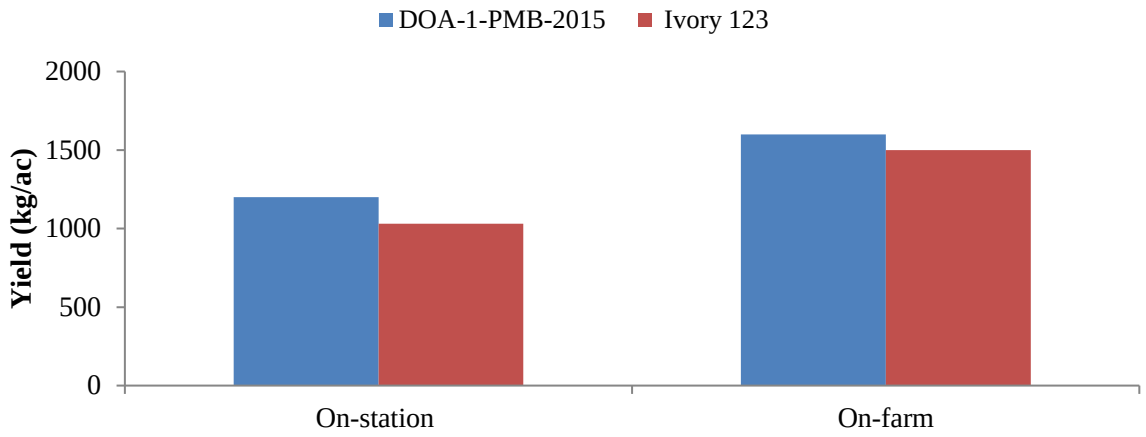

Figure 3 Graph indicating Quinoa yield kg/acre

1.2 Field Crop Developmental Activities

1.2.1 Increase area under spring and upland rice in the region

Spring and upland rice cultivation plays vital roles in achieving the objective of 12FYP to achieve 60 % of rice self-sufficiency. ARDC Bajo mandated for National Rice, the Centre has target set of 1200 ac of area to be brought under upland and spring rice in 12FYP. To achieve the target, the Centre has set target of 100 ac in the FY 2019-20 for spring and upland rice and achieved 124.67 ac of area in promotion of upland and spring rice in West-Central region. Beside technical support ARDC Bajo has supported the farmers with seed supply and other material like fertilizer, plastic for nursery (spring rice) procured and distributed in Wangdue and Tsirang Dzongkhags. The table 12 shows the paddy seed supply for spring and upland rice promotion.

Table 11 Promotion of Spring and upland rice in 2019-20

SN	Dzongkhag	Gewog	Variety	Quantity (kg)	Area (ac)	No.of HHs	Remarks
1	Wangdue	Thedtsho	No 11	750.00	30.00	40	Spring rice
2	Wangdue	Athang	No 11	225.00	9.00	15	Spring rice
3	Wangdue	Gasetshowom	No 11	75.00	3.00	4	Spring rice
4	Wangdue	Daga Gewog	No 11	200.00	8.00	5	Spring rice
5	Wangdue	Nahi	Khangma Maap	1500.00	50.00	62	Upland rice
6	Wangdue	Gasetshogom	Khangma Maap	500.00	16.67		Upland rice
7	Tsirang	Serithang	5 varieties	56.00	2.00	7	Upland rice
8	Tsirang	Barshong		150.00	6.00	48	Upland rice
Total				**3456.00**	**124.67**	**181**	

1.2.2 Produce released rice varieties seeds and maintain seeds

From the trial plots, seed production and demonstration blocks, 8.17 MT paddy seed was produced in 2019-20 season (Table 13) from ARDC Bajo and ARDSC Menchunna. Paddy seeds of the released varieties such as Bajo Kaap1and 2; Bajo Maap1 and 2; IR-64; IR20913; were produced to support promotional programs in the Dzongkhags. Bajo also produced some seeds of unreleased varieties like IR28, Ceres, TME 80518 Vietnam Rice were for seed multiplication.

Figure 4 Rice seed production at ARDSC, Menchhuna & ARDC Bajo

Table 12 Quantity of paddy seed produced from released and potential varieties 2019-20

SN	Variety	Quantity (kg)	Centre	Remarks
1	IR 64	2000.00	ARDC Bajo	Released variety
2	IR20913	1090.00	ARDC Bajo	Released variety
3	Bajo Kaap 1	646.00	ARDC Bajo	Released variety
4	Bajo Kaap2	276.00	ARDC Bajo	Released variety
5	Bajo Maap 1	250.00	ARDC Bajo	Released variety
6	Bajo Maap 2	321.00	ARDC Bajo	Released variety
7	IR 28	1090.00	ARDC Bajo & ARDSC Menchhuna	Not released variety
8	Ngabja	250.00	ARDC Bajo	Local variety
9	Vietnam Rice	250.00	ARDC Bajo	Not released variety
10	TMES 0518	1000.00	ARDC Bajo	Not released variety
11	Bonday	500.00	ARDC Bajo	Local variety
12	Wengkhar Ray kaap II	500.00	ARDSC, Menchhuna	Released variety
Total (kg)		**8173..00**		

1.2.3 Promotion of HYV rice variety seeds

Like in the previous years, the national rice continued to promote improved rice varieties on larger scale. HYV seeds were procured from National Seed Centre (NSC) and supplied to different Dzongkhags based on the potential and needs of the Dzongkhags. During the FY 2019-20 there was demand of improved rice seed from Wangdue, Tsirang and Dagana Dzongkhags only. Altogether, the national rice programme was able to promote 12.99 MT of improved paddy seed for these three dzongkhag's farmers covering 519.65ac of wetland.

Table 13 Quantity of improved paddy seed supply during the FY 2019-20

SN	Dzongkhag	Variety	Quantity (Kg)	Area coverage (ac)
1	Wangdue	No 11	1260.00	50.40
2		Yusiray kaap	1900.00	76.00
4		Bajo Kaap 1	1000.00	40.00
5		Bajo Maap 2	3900.00	156.00
6	Dagana	Khangma Maap	1600.00	64.00
7		Bhur Kamja 1	2000.00	80.00
8	Tsirang	IR 64	370.00	14.80
9		Bajo Maap 2	330.00	13.20
10		IR 20913	370.00	14.80
11		Bhur kamja 1	259.00	10.40
Total			**12989.00**	**519.56**

1.2.4 Produce released wheat varieties seeds and maintain seed

The seeds of the potential lines which can possibly make to the commercial variety are multiplied in the station for wider on-farm testing in sizable area. Seeds of three released varieties were

produced and maintained. Since its release, Bumthang Kaa Drukchu gained much popularity among the wheat growers under mid and high-altitude region. The NSC is not able to meet seed demand. Therefore, the National Wheat Program produced seeds of released wheat seed varieties and maintained as seed to be supplied to farmers in the coming season (Table 4). In 2019-20, about 2.51MT wheat seeds of following varieties were produced and maintained.

Table 14 Quantity of wheat seed produced in 2019-20

SN	Variety	Quantity produced (kg)		Total (kg)
		ARDC Bajo	ARDSC Menchhuna	
1	Bumthangkaa Drukchu	2050.00	0	2050.00
2	Bajosokha kaa	150.00	0	250.00
3	Gumasokha kaa	200.00	110.00	310.00
4	Mixture	800.00	0	800.00
Total		**3200.00**	**110.00**	**3310.00**

1.2.5 Promotion and Intensification of Minor cereals

During the FY 2019-20 ARDC Bajo has coordinated to promote minor cereals in the WC Region for conducting on farm production evaluation and support farmers for minor cereal production in the country. The seed was procured from NSC and distributed to farmers in close collaboration with the dzongkhag extensions. The minor cereals covered 65.8 ac of area in total with the supply of kg 1985.00 seeds.

Table 15 Quantity of different type of minor cereal promoted in WC region in 2019-20

SN	Dzongkhag	Seed supply	Quantity (kg)	Area (ac)	Remarks
1	Wangdue	Millet	100.00	10.00	Athang gewog
2	Dagana	Millet	100.00	10.00	
3	Gasa	Millet	40.00	4.00	Khatoed gewog
4	Gasa	Buckwheat	230.00	11.50	Khatoed & Khamoed
5	Punakha	wheat (Gumasokha)	800.00	16.00	Barp, Dzomi, Guma
6	Tsirang	wheat (Gumasokha)	400.00	8.00	From ARDSC, Menchhuna
	Dagana	wheat (NI-1073)	315.00	6.300	
Total			**1985.00**	**65.80**	

1.2.6 Quinoa seed production and promotion

The Research Centre continued with seed production and promotion of quinoa in the Region. In the FY 2019-20 the Field Crop Sector produced 2.5 MT of quinoa seed on-station at ARDC Bajo and ARDSC Menchhuna. The seed has been cleaned and stored for seed purpose.

Promotion of quinoa was carried out with technical assistance and seed support to farmers of Tsirang, Dagana & Wangdue Dzongkhags covering more than 30 ac of area. A total production of

production from dzongkhags is computed at 9.71MT. Apart from seed production and promotion the Centre also bought300 kg quinoa seeds from farmers of the region on buy back policy to be distributed to farmers in the coming season.

Table 16 Quinoa seed distribution and produced West Central Region 2019-20

SN	Dzongkhag	Seed supply (kg)	HHs covered	Area covered (ac)	Seed produced (kg)
1	Wangdue	32	20	10.67	3200.00
2	Dagana	100	60	33.30	1500.00
3	Tsirang	60	55	20.00	5010.00
Total		**192**	**135**	**63.97**	**97100.00**

1.2.7 Production of improved maize varieties and promotion

As entrusted with developmental mandate, ARDSC Tsirang also produced and maintained seeds of different released maize varieties. These seeds are exclusively used in on-farm demonstration, support to client Dzongkhags on request and other ad-hoc requests from both Department and Commodity Programs. In 2019-20 a total of 1050 kg of maize seed was produced from 3 acre of land on-station at ARDSC Menchhuna and issued to farmers of Tsirang and Dagana on promotional basis., which is expected to make a substantial contribution to overall cereals production. Maize continues to be an important cereal crop for farmers as signified by the quantity of seed request and area planted in the region. As the newer varieties are yet to be commercially available, farmers are supported with the available improved varieties. On top of this ARDC Bajo procured 1660 kg of *Yangtshipa* maize variety and supplied to Dagana Dzongkhag as per their demand.

1.2.8 Area intensification through promotion of oil seeds

Since oil crops has been declined in production over the years so to intensify the oil seed production in the Region, the Centre has procured 370 kg of mustard from NSC and distributed to farmers covering more than 82 acre of land in the FY 2019-20 as detailed in the table18.

Table 17 Mustard seed distribution 2019-20

Dzongkhag	Gewogs	Seed quantity (kg)	Variety	Area coverage (ac)
Wangdue	Nahi, Bjena, Rubesa, Daga	105.00	Yusipaka 1	23.33
Gasa	Khatoed	100.00	Yusipaka 1	22.22
Dagana	Drujegang, Tshendaygang, Kana, Tashiding	123.00	M-27	27.22
Tsirang	Barshong, Ranglinthang, Medaygang, Patashing	42.00	M-27	9.33
Total		**370.00**		**82.22**

2 HORTICULTUE RESEARCH AND DEVELOPMENT PROGRAM

2.1 Horticulture Research Activities

2.1.1 On-station Evaluation of temperate and sub-tropical fruits and nuts germplasm

ARDC-Bajo with full support from Integrated Horticulture Promotional Project (IHPP)-JICA established both warm temperate and sub-tropical fruit and nut orchards. The orchards serve as management technology generation and demonstration sites for providing hands-on training for researchers, extension agents and farmers by the Project Experts. It is also to evaluate and identify superior cultivars for diversification of fruit cultivation.

In March, 2020, one grape variety was introduced from Japan and is now under evaluation trial at ARDC-Bajo. The center will continue to introduce and evaluate promising cultivars for diversification of fruit cultivation. The center has 20 fruits with more than 85 varieties.

Table 18 Fruit crop varieties established in the germplasm block at ARDC Bajo

Crops	Varieties
Peach	Kurataki (3), Nonomewase (3), Floridasan (3), Beauty cream (3), Local (4)
Apple	Bajo apple (12)
Apricot	Khasha (2), New Castle (2)
Pear	Yakumo (3), Niitaka (3), Hosui (3), Kosui (3), Shinko (3), Chojuro (3), Local (4)
Kiwi	Hayward (19), Wengkhar Yellow (29), Wengkhar Green (24), Bajo Red (19), Male (8)
Grape	Steuben (15), Perlete (10), Campbell (32), Kyoho (7) Risamate (2), Nsehelena (2), Potland (7)
Dragon fruit	Gewai ringa (44)
Pomelo	R3P4 (40), R4P5 (40), Banpeiyu (25)
Lemon	Frost Eureka (28)
Loquat	Mogi (8), Tanaka (14)
Avocado	Brogdown (9), Hass (10), Bacon (7), Fuerte (10), Reed (6) Zutano (10), T1 (5), T2 (8), T3 (10), M1 (6), M2 (5)
Persimmon	Jiro (25), Fuyu (28), Yubeni (11), Zinjimaru (4), Taishu (3), Japan Astringent (2), Thimphu astringent (2), Local (4)
Plum	Honey Rosa (3), Santa Rosa (3), Soldum (3), Kiyo (3), Oishi wase (3)
Wine grape	Cabernet Sauvignon 337 (48), Syrah 470 (48), Cot 598 (48), Sauvignon Blanc 906 (48), Chardonnay 96 (48), Pinot Noir 72 (48), Merlot 181 (48), Petit Manseng 573 (40), Cab Franc (40)
Guava	Thai guava (48), Bajo white (4), Bajo red (4), Babji white (2), Guma red (2), Pink flesh (2), Thai giant (2), Allahabad Safeda (2)
Mango	Himsagar (3), Dashehari (5), Langra (14), amarpali (3), Irwin (2), Tommy atkin (3), Himsagar (3), Dunkin (3), Alphanso (2)
Chestnut	Unknown (2)

Data from the evaluation germplasm is recorded and maintained by the sector for analysis and to release the variety after meeting the required traits. In addition to this ARDSC Menchhuna has also maintained germplasm collection different fruits crops. They are peach (5 varieties), plum (5

varieties) pear (4 varieties), sub-tropical apple (1 variety), pecan (4 varieties), kiwi (4 varieties), citrus (5 rootstock varieties) and persimmon (2 varieties). The varieties of these fruit crops have been planted mainly for bud wood and fruit production. The scion wood is used for seedling production and also supplied to the private nursery growers. These varieties have been released or found to be promising and can be promoted for production in farmer's field.

Presently ARDSC Menchhuna maintains on-going two fruit crops trials

- Citrus rootstock compatibility trial (Established in 2008)
- Citrus varietal evaluation trial (Established in 2009)

2.1.2 Evaluate and maintain citrus germplasm

While progress on citrus research on production management are progressing, it is imperative that a system of nursery to marketing through production are further explored and institutionalized to sustain increased production and yield especially when the whole world's citrus industries are getting streamline due to dreaded graft transmissible diseases (Huanglongbing, Citrus tristeza virus, citrus exocortis viroid, phytoplasmas).Therefore, this citrus repository is a corner stone for initiating and institutionalization of citrus nursery system in order to enable supply of health tested citrus planting material in the country. The overall objective is to increase citrus production and productivity through sustainable research and development. As of June 30, 2020, NCR has be able to collect 384 numbers of cultivars in total out of which 10 numbers are added during the FY 2019-20 (annexure 5).

New collected germplasms are being evaluated on-station and on-farm through ROP. 13 varieties are 8 months old on trial in Dagana and Tsirang. In total 15 varieties out in the field for evaluation through ROP. Citrus crops are often observed with soil borne diseases. To minimize the soil borne diseases, desired cultivars were grafted on different resistant rootstock in July 2017 to June 2020. Local, Ichang papeda, volkameria, rangpur lime, rough lime, trifoliate, swingle and citron were used for the study. From the study, no disease was observed on any of the grafted plants. Study on-going at NCR, under ARDSC Menchunna.

2.1.3 Evaluate and maintain cardamom germplasm

Currently, there are 11 lines of cardamom raised inside the protected structure at ARDSC Menchhuna. They are of pure lines exhibiting all the characters of respective varieties collected from other research Centre, farmer's field in Dagana, Tsirang and Sarpang. These varieties are maintained with the objective to identify and characterize based on the morphological characteristics and also to maintain germplasm for breeding works in future.

The two recently collected lots of varieties namely Barlangey and Seremna from farmer's field in Dagana and Tsirang respectively are maintained outside in open. However, the rest of the varieties in open field were recommended to be removed by the consultant from Nepal during his visit in the 2018 as he found it to be of mixed varieties. It was further recommended that pure lines/varieties be brought from credible sources in Nepal, and Sikkim in India. The regular management practices are carried out as per the cropping schedule.

2.1.4 Initiate guava breeding program

Guava (*Psidium guajava)* is a popular sub-tropical and tropical crop which is native to Mexico and southern America. Guava (*Psidium guajava* L.) belongs to the family Myrtaceae which has more than 80 genera and 3,000 species distributed throughout the tropics and subtropics

The ARDC, Bajo conducted four varietal evaluation trial and released two varieties in the year 2010 as Bajo- bebsew and Bebsew Shakha originally known as Local variety and Pink flesh respectively. Though the released variety proved to be good in taste, skin and flavor, however it was observed to be susceptible to scab, wilt and irregular fruit shape. In the west-central region of our country there are many promising local varieties that have been cultivated aeon and aeons by our forefather but are still unknown to us. Some of the existing local varieties not only have high grade in the morphological parameters included in this research study but were also observed to be moderately resistant to disease such as scab and wilt. Owing to its importance in diversification of food baskets, the team comprising of JICA experts and the researcher had initiated guava breeding trials with the objectives to i) Produce firm and thick pulp, attractive skin, good aroma with TSS percentage and resistant to scab.

2.1.5 Effect of gibberellins acid on grapes production trial

Kyoho grapes are large, dark purple Japanese grapes introduced in 2016 by IHPP/JICA as performance evaluation trial. The purpose of introducing this variety is diversification of choices over the grapes varieties for the consumers. The trial was set with 4 plants treated with gibberellins acid and 4 plants non- treated to study the effect of gibberellins acid on improving fruit size. All parameters were followed and data were collected. Three of the plants started fruiting since 2018 and remaining plants came to fruiting successfully in 2019. This variety is seeded variety containing 2-6 bitter tasting seed in each fruit. The fruits were harvested and weighed separately of each tree.

Table 19 Effect of Gibberellins acids on grape fruits

Treatment	Weight (kg/tree)	Fruit bunch per tree	No. of seed	Brix
Treated	139.52	29.75	13	20.93
Non-treated	113	18.75	26	19.00

The result of first year fruit analysis experiment reveled that there is slight difference in treated and non-treated Kyoho grape variety although there was not very significant difference. In this regard, decision was made to repeat the trial with slight modification in design as GA was found very effective in improving fruit size and in production of seedless grapes as per reviewed literature.

2.1.6 Establishment of Fruits and Nuts Demo Orchards

The purpose of the demonstration orchard is to research and demonstrate the appropriate cultivars and cultural methods that can be adapted and adopted by farmers in their field and to inspire and motivate community for further adoption of the innovation for the economic benefit. This approach focuses on the method (Cultural operations) and result (yield, quality and market) demonstration. Based on the guidelines prepared by IHPP, demonstration orchards were established. As such 23 demonstration orchards were developed in the FY 2019-20 in the West-Central Region through Research Outreach Program (ROP) as detailed in annexure 6. Mainly Sub-tropical assorted fruits plants are planted in the demo orchards. Timely monitoring is carried out to collect data as per the IHPP guidelines.

2.1.7 Evaluation trial of high yielding and nutrient content vegetable varieties

For the high yielding and high nutrients content evaluation the following vegetables research trials are ongoing on-station as well as on farm of the various vegetables crops listed in table 19. Yield data and nutrient analysis data are collected each season. The evaluation research will continue for one more year to propose for release depending to its traits.

Table 20 Varieties high yielding and high nutrient content vegetables on trials

SN	Crop	Variety	No. of years trial	Average yield(ton/ac)	Remarks
1	Tomato	Red Tommy Toe	4	13.27	Both on station and on-farm
2	Tomato	Master	4	11.57	
3	Water melon	Kabuki	4	27.14	
4	Water melon	Blackball	4	28.34	
5	Pumpkin	Kuri	4		Japanese
6	Pumpkin	AVPU-1394	4		AVRDC
7	Bittergourd	AVBG-1301	4		AVRDC, Taiwan
8	Bittergourd	AVBG-1327	4		AVRDC, Taiwan
9	Bitter gourd	AVBG-1314	4		AVRDC, Taiwan
10	Bittergourd	Kartik	4		DoA

2.1.8 Vegetable varieties for yield performance evaluation trial

Japanese Beans varietal evaluation trial

Earlier in 2017, two Japanese pole bean varieties have been under the varietal performance evaluation at the Centre. The trial was laid using RCBD with four replications. The plants were spaced at 25*30cm and all cultural practices practiced as described by Tomiyasu et al (vegetable cultivation guidebook in Bhutan, 2018). The nutrient and plant protection of the crop was carried out as advised per the guide in the website of NSSSC and NPPC.

Table 21 ANOVA TABLE
Response Variable: Yield. (g).

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Treatment	2	78106.1150	39053.0575	14.65	0.0049
Rep	3	22186.3667	7395.4556	2.77	0.1330
Error	6	15998.2783	2666.3797		
Total	11	116290.7600			

Table 22 Mean yield of the treatment

Treatment	means	N group
Grey pole	318.75	4 b
Prime green	486.32	4 a
Brown Pole	311.82	4 b

Since the performance of the prime green variety was significantly higher than check variety (Grey Pole), as proposed, the variety was endorsed for the release during 22nd VRC, 2020.

Following all the procedure of the trial protocol, the vegetable unit under IHPP has initiated on-station adaptability and varietal performance trials of the crops listed in the table 22 during the FY 2019-20.

Table 23 On-station vegetable evaluation trials 2019-20

SN	Crop	Variety	Remarks
1	Sweet potato	Gorojima orange flesh, and pink vein	Adaptability and performance evaluation
2	Radish	Gensuke, Akino irodi, and long foot	Performance evaluation
3	Zucchini	Yellow zucchini	Varietal evaluation
4	Broccoli	Ryuokuri and SP Green	Varietal evaluation
5	Strawberry	Red flesh and Camarosa	Performance evaluation
6	Carrot	Pure red	Performance evaluation
7	Adzuki bean	Dynagon	adaptive performance
8	Ground apple		Performance evaluation
9	Colocasia	JPN Green, JPN Red	Performance evaluation

Data compilation for the one growing season was carried out. The trail will be continuing for some years and the trials until the Centre has adequate data for the variety release depending on its performance.

2.2 Horticulture Development Activities

2.2.1 Promotion of fruits and nuts through systematic training and orchard establishment

ARDC-Bajo with support from IHPP-JICA introduced Research Out-reach Program (ROP) for promotion of fruits and nut. The promising fruit varieties were provided to farmers through provision of three rounds of systematic training and material supports to establish demonstration orchards and focus village orchards.

IHPP in close collaboration with Dzongkhag Agriculture Office established 23 demonstration orchards and 6 focus village orchards through systematic training in the west central region, and direct support orchards benefiting 42 households within the region.

Table 24 List of demonstration and focus village orchard established, 2019-2020

SN	Dzongkhags	Demo orchard (No)	No of Focus village	No of HHs in Focus village
1	Wangduephodrang	6	1	10
2	Punakha	5	1	8
3	Gasa	2	2	9
4	Dagana	5	1	10
5	Tsirang	5	1	9
Total		**23**	**6**	**46**

2.2.2 Produce and promote quality fruits and nuts grafted seedlings

During the FY 2019-20, through IHP Program, the Centre could produce more than 6000 grafted diseases free seedling and a total of 5404 were distributed to the farmers in the region covering 42.66 acres of area. This was done in close collaboration with the Dzongkhag Extensions and by providing systemic training to the farmers.

Table 25 list if fruit plants distributed to farmers in the region in 2019-20

SN	Particulars	No. of fruit plant distributed	Planting distance (M)		Area (Acre)
			Plant to Plant	Row to Row	
1	Pear	1087	5	6	8.15
2	Persimmon	1596	5.5	5.5	12.07
3	Walnut	100	7	7	1.23
4	Avocado	741	6	6	6.67
5	Mid-citrus	530	5	5	3.31
6	L. Mandarin	163	6	6	1.47
7	Pomelo	2	6	6	0.02
8	Kiwi	530	6	7	5.57
9	Peach	183	5	5	1.14
10	Plum	158	6	6	1.42
11	Apricot	0	5	5	0.00
12	Loquat	119	5	5	0.74
13	Lime	6	5	5	0.04
14	D. Fruit	110	2.5	2	0.14
15	Pomegranate	10	5	6	0.08

16	Guava	0	5	6	0.00
17	Grape	69	6	6	0.62
Total		**5404**			**42.66**

2.2.3 Citrus Canopy Management

During the FY 2019-2020 the national citrus program has mobilized a sum of Nu 1M for Citrus Canopy Management in the major citrus growing areas of the nation with objectives especially to enhance the capacity of farmers and extensions in proper management of the citrus orchard, thereby increasing the yield and quality of the fruit per unit of area. A month-long, Citrus Canopy Management Program was initiated by ARDC Bajo in collaboration National Citrus Program.

The Citrus Canopy Management program covered participants hand-on training on citrus Canopy Management, nutrient application and management techniques, Control of pests and disease: Safe and proper handling of tools and implements. The program was carried in nine gewogs of seven dzongkhags. The detail of the program is mentioned in the table 26.

The program covered nine gewogs in seven Dzongkhag providing hand on training to 515 farmers in total. Out of 14247 total citrus trees in nine gewogs 4360 citrus trees were brought down under management which is more than 30%. The total orchard covered is 26 numbers.

Table 26 Nation-wide Citrus Canopy Managements Details in 2019-20

SN	Dzongkhag	Gewog	Total no. of citrus trees	No. of tree canopy managed	Total farmers trained	No. of orchards covered
1	Wangdue	Gasetshowom	880	185	30	1
2	Zhemgang	Panbang	1068	376	49	2
3	Pemagatshel	Norbugang	7363	2338	170	7
4	Samdrup Jongkhar	Orong	153	114	45	1
5		Gomdar	2700	134	29	2
6	Samtse	Dophuchen	230	30	30	1
7		Dumtey	440	81	26	1
8	Sarpang	Gakidling	262	199	72	3
9	Mongar	Kengkhar	1151	903	64	8
Total			**14247**	**4360**	**515**	**26**

2.2.4 Improvement of local cultivars through top working

Top-working improves qualities of local fruit cultivars. It also rejuvenates unproductive local and old fruit trees. The objectives were to improve qualities of local fruit cultivars and to impart top-working skills to interested farmers and extension staff. JICA- IHPP initiated the top-working of

local fruit cultivars. During the FY 2019-20 top working was carried out in Tsirang and Punakha dzongkhags. In total 459 assorted fruit trees were top worked benefiting 82 households.

Table 27 Different types of local fruit tree top work, 2019-20

Dzongkhag	HH	Peach	Pear	Plum	Kiwi	Apple	Persimmon	Mango	Avocado
Tsirang	52	141	28	41	44	10	0	10	2
Punakha	**30**	**57**	**54**	**29**			**43**		
Total	**82**	**198**	**82**	**70**	**44**	**10**	**43**	**10**	**2**

2.2.5 Produce and promote improved vegetables for commercial production

Through the support from IHPP, the horticulture sector has initiated commercial vegetable production program within the region by supplying improved seeds, technical assistance and human resources development through systematic training program. During the FY 2019-20, the Centre has produced more than 323 kg of varieties of seeds which is calculated to cover more than 236 ac of areas. The first phase as summer vegetables has been distributed to 198 households in the region which cover area of 49.31ac as detailed in the table 28.

Table 28 Summer vegetable seed production and promotion in West-Central Region in 2019-20

SN	Dzongkhag	Gewog	No. of HHs	Qty seed (kg)	Area (ac)	Vegetable crops
1	Dagana	Tashiding, Khebisa	25	46.02	16.58	pole bean, groundnut, pea, broccoli, m/green, bunching onion, soybean, okra, chili, pumpkin, bitter gourd, brinjal, tomato, radish
2	Tsirang	8 gewogs	24	4.5	9.68	bunching onion, groundnut, soybean, okra, pumpkin, chili, bitter gourd, brinjal, tomato, zucchini, watermelon
3	Punakha	Toepisa, Goenshari, Limbukha, Barp,Talo,	56	27.38	4.56	bunching onion, groundnut, soybean, okra, pumpkin, chili, bitter gourd, brinjal, tomato, zucchini
4	Wangdue	6 gewogs	57	29.5	5.33	bunching onion, groundnut, soybean, okra, pumpkin, chili, brinjal, tomato, zucchini
5	Gasa	Khamoed	36	74	13.16	bunching onion, groundnut, soybean, okra, pumpkin, chili, bitter gourd ,brinjal, tomato, zucchini, watermelon, beans
Total			**198**	**181.40**	**49.31**	

During the FY 2019-20 the Centre has produced more than 158 kg of winter vegetable which will be distributed to the farmers for commercial production in the coming season which will cover about 187ac of land.

Table 29 Winter vegetable seed production in 2019-20

SN	Vegetables	Quantity seed produced (kg)	Estimated area cover(ac)	Varieties
1	Pea	44.50	1.25	Japan long and Japan flat pea
2	Carrot	20.16	4.03	Pure red, kuroda 5", cuttings
3	Radish	34.82	7.84	Minowase, shogun, Gensuke, Shakura Jima, Long foot, Akino
4	Broccoli	30.96	112.00	Dessica, Ryuokuri
5	Mustard green	14.77	40.57	Red Rio, Mayuri, Nozawana
6	Komatsuna	4.21	11.71	Thai CC
7	Bunching onion	6.14	1.24	Kujo
8	Chinese cabbage	1.25	4.20	Kyoto 3, Nozaki, Kaga, Fujiwase
9	Cauliflower	1.14	4.20	Wengkhar Metokopi II
10	Spinach	0.45	0.06	Jiromaru
Total		**158.39**	**187.11**	

2.2.6 Vegetable breeder seed production and maintenance

ARDCs are mandated to maintain the breeder seeds of various vegetables released from their Centres. During the FY 2019-20 the Centre could produce 31.10 kg of assorted vegetables seeds as mentioned in the table … Unlike in the past year the breeder seed production has declined since there is not much demand from NSC and whatever seed produced, it is preserve as breeder seed in the Centre.

Table 30 Breeder seeds produced, maintained and issued 2019-20

SN	Crop variety	Qty. P/P (kg)	Quantity issued to (kg)	
			NSC	Other agencies
1	Bean- Borloto	5.00	-	-
2	Bean- Pusa Parvati	5.00	-	-
3	Bean- Top Crop	5.00	-	-
4	Bean- Rajma	5.00	-	-
5	Brinjal- Pusa Purple Long	0.30	-	-
6	Broccoli- Desico	1.00	0.5	-
7	Cauliflower- White Top	2.00	-	-
8	Chinese Cabbage- Kyoto 1	0.20		
9	Carrot- Early Nantes	2.00	-	-
10	Radish- Bajo Laphu 1	1.00	-	-
11	Radish- Spring Tokanashi	0.20	-	-
12	Spinach- All Green	2.00	1	-
13	Tomato- Roma	10	-	-
14	Tomato- Cherry Tomato	10	-	-
15	Tomato- Bajo Lambenda 1	0.20	-	-
16	Watermelon- Sugar Baby	0.20	-	-
Total		31.10	1.5	

Note: P/P = Quantity Produced

2.2.7 Produce and supply spawn for mushroom cultivation

Mushroom cultivation in Bhutan has created employment opportunities, due to its high market value. However, lack of quality spawn supply in the market hindered from producing at commercial scale. Therefore, the Department of agriculture under ministry of agriculture and forests entrusted all the regional ARDCs to produce spawns, and other technical support for mushroom cultivation in the region, with technical backstopping from the National Mushroom Centre. Today, with the appointment of one trained mushroom staffs, laboratory facility has been improved, and production of quality Oyster and Shiitake mushroom initiated. A total of 4070 bottles of oyster spawn and 460 bottles of oyster mother spawn were produced during the FY 2019-2020 and supported to farmers with technical assistance in mushroom cultivation.

The spawn varieties for Shiitake mushroom were SM5, M290, A577 and Nepal variety. Materials used to produce spawn were wheat grains mixed with saw dust. Spawn from Nepal variety was produced from saw dust. The Shiitake and oyster mushroom cultivation was carried out at Gasa (Khatoed), Wangdue Dzongkhag, Punakha, Tsirang and Dagana Dzongkhag. Around 75 different households were involved in shitake mushroom production. The unit caters its technical services to the five Dzongkhags of West Central region.

The spawn was supplied to interested farmers of Wangdue, Punakha, Gasa, Dagana and Tsirang. Most spawn were supplied to farmers of Wangdue and Punakha. The spawn was supplied on demand basis and supplied based on the base work done by farmers and after through technical verification.

The mother spawn was supplied to lead farmers of mushroom in Punakha and Tsirang region. The mother spawn will be used by them to further multiply and start mass production at village level. It will help in starting business and entrepreneurship and help in establishing small and cottage industries in rural area.

Table 31 Quantity of spawn supported in the Region in the FY 2019-20

SN	Dzongkhag	Mushroom spawn supplied (bottles)	Mother spawn supplied (bottles)	Remarks
1	Wangdue	1060	NA	
2	Gasa	290	NA	
3	Tsirang	950	250	For seed multiplication
4	Dagana	590	NA	
5	Punakha	1180	210	For seed multiplication
Total		**4070**	**460**	

2.2.8 Promotion of Turmeric production

Turmeric cultivation is gaining popular in Bhutan and it was identified as one of the commodities for commercialization under the National Organic Flagship Program. In continuation to the last financial year, turmeric cultivation was continued with the receipt of additional seed support. The

main objective is to find out the feasibility of mass cultivation of turmeric in different location with different physio-climatic condition.

The on-station cultivation at ARDSC Menchunna was discontinued due to very low yield which was attributed it the sub-center's altitude of 1580mals being little bit higher for turmeric cultivation. However, it was cultivated in the same location at lower Tshokhana which is located at an altitude of 1200mals with total area of 0.5acres and 2.5acres in Saleri village under Barshong gewog which is located at an altitude of 670masl.

The crop was planted in March, 2020 on a raised bed with plant to plant and row to row distance of 25 cm. It was mulched with dead grass as turmeric requires thick mulching. Weeding was carried out once till now. Last year's average yield was just about 1000kg per acre that is comparatively low.

2.2.9 Multitier cropping system (Black pepper and areca nut intercropping)

In continuation to the last financial year's activity, multitier cropping was promoted in Sunkosh village under Rangthaling gewog in Tsirang Dzongkhag by ARDSC Menchhuna. The objective of multitier intercropping system is to create higher yields per unit area and consequently higher economic return by encouraging farmers to intercrop crops with diverse characteristics (growth habit, root depth and duration) while also efficiently using the available resources like sunlight, nutrient and water. In this financial year, 100 black pepper seedlings were supplied to 10 households be planted as multitier with the areca nut plant. It was observed during the monitoring visits that the survival rate of last year's plants was about 95% though none has started to yield. Hands-on training on planting and management of the crop was also provided to the farmers.

The black pepper plants were planted near the areca nut plant after digging pits of $0.5m^2$ size. The pits were filled with mixture of FYM and top soil. Analysis on economic benefit; yield and land use will be undertaken after the plants starts to yield.

2.2.10 Cardamom nursery support and development

On-station cardamom nursery was raised after obtaining pure Barlengay seeds from a farmer in Dagana at ARDSC Menchunna. The farmer had brought the cardamom seedlings from Sikkim in India and on farm plant characters were found to match the Barlengay variety's characteristic. The seeds have just germinated and will be transferred to secondary nursery in the coming season. Technical and input support was continued to be provided to two farmers i.e. one each in Tsirang and Dagana districts. More than 7000 seedlings were produced from their nursery.

2.2.11 Strengthen floriculture production

ARDC-Bajo started floriculture research and mass production since 2016. The Centre has developed floriculture on-station site with huge collection of assorted ornamental plants. During the FY 2019-20 the Centre has produced more than 50000 potted plants. The Centre has catered in supplying more than 24000 ornamental potted plants for beautification of various institutions within the region and outside. At present the Centre has produced and maintained more than 10000 plants in the nursery.

Table 32 Inventory of different type of ornamental plant in nursery June, 2020

SN	Flower plant	Quantity (nos)	Remarks
1	Ever green	2300	mixed variety
2	Salvia	250	2 colour
3	Geranium (cutting)	220	assorted colour
4	Mari gold	262	2 colour
5	Cabbage	180	
6	Ostpeopernum	150	mixed variety
7	Holy hook	55	
8	Bougainvilli	1000	assorted colour
9	Rose	700	mixed variety
10	Peansutta	216	mixed variety
11	Hedges	1150	mixed variety
12	Agave	1800	
13	Herbs	597	mixed variety
14	Snake plant	245	
15	Spider plant	400	
16	Pencil cactus	40	
17	Others	700	
Total		**10505**	

Through the directives and seed support from DoA, the Centre produced more than 18000 potted flowering plants for Royal Flower show which was scheduled to take place by May, 2020. Due to the COVID-19 pandemic the Royal Flower show has to be postponed so in delaying the flower show the plants had to be used. Most of these potted plants were used for Wangdue Dzongkhag beautification purpose and office beautification (annexure 4).

2.2.12 Impact study of Outreach program

Integrated Horticulture Promotion Project (IHPP) has worked toward developing appropriate technologies for promoting horticulture farming, strengthening the fruits/vegetable seeds/seedling production system at ARDC- Bajo, NSC-Bajo, private nurseries and, to strengthen training and extension system for promoting horticulture farming. One of the important tools of IHPP is the Research Outreach Program (ROP). ROP is an extension approach to disseminating new technologies to farmers' field. Components of designed for the IHPP are Work group meeting & farmers' selection, Joint site selection, Systematic training, Production, distribution & planting

seedlings/seeds, and Monitoring, guidance & farmer-farmer training. To study the effectiveness of the ROP and extract useful ideas to improve it, the study was conducted using semi-structured questionnaire. Respondents for the study consisted of 21 Demonstration Orchard Farmers, two Nursery Growers, and six Focus Village Representatives. Information were collected on usefulness of training subjects, practice of the acquired skills, numbers and growth of different fruit tree seedlings plated, causes of seedling deaths, the respondents confidence to manage their orchards in the future.

The study results showed that all the farmers showed high satisfaction for all three rounds of Systematic Training.

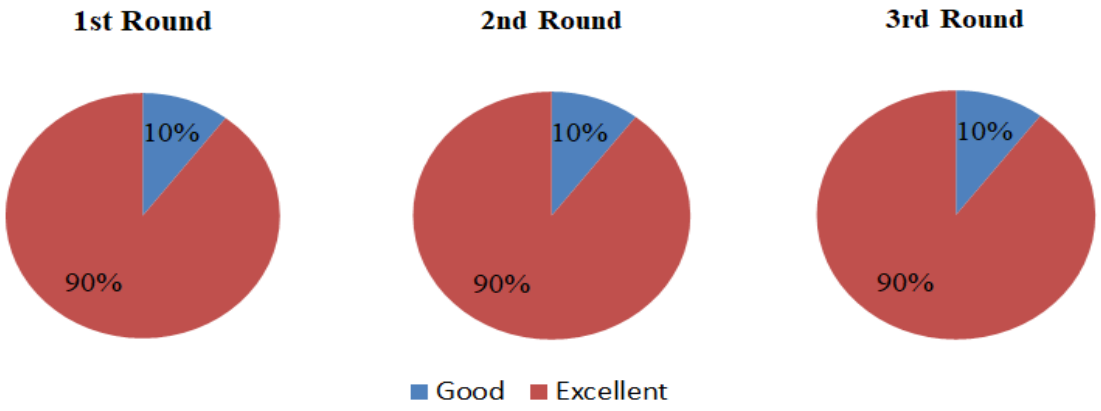

Figure 5 Overall rating of the trainings by farmers

Most of the farmers acknowledged the training subjects were useful.

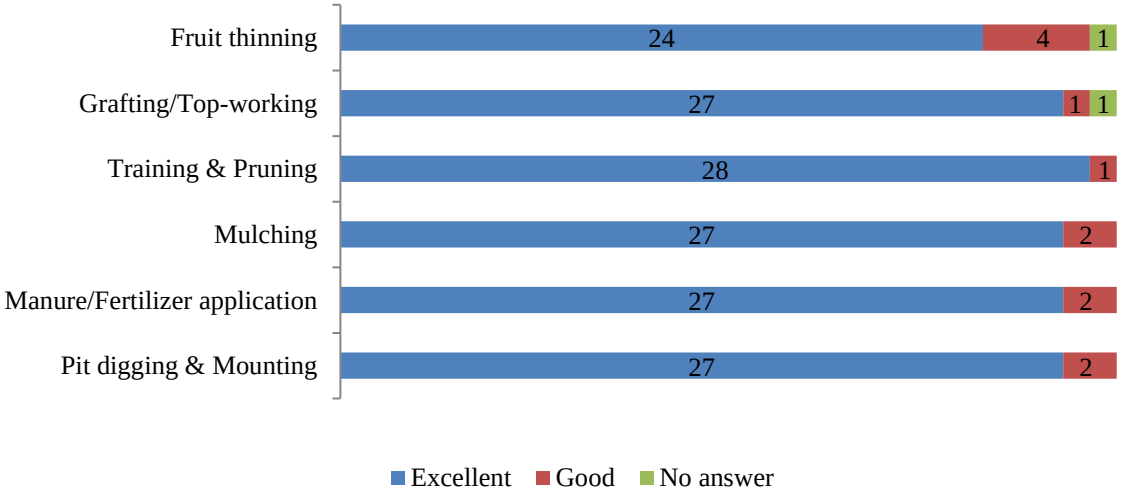

Figure 6 Rating on usefulness of different training topics

The respondents had applied most of the activities and those who have not applied are positive to apply the acquired skills. More than 1,400 fruits seedlings planted by 29 farmers. Pear was the most common fruit crop cultivated by the respondents followed by avocado and mandarin.

On all fruits, more than 80% of the farmers answered that the growth of the fruit plant seedlings as “Good” or “Excellent”.

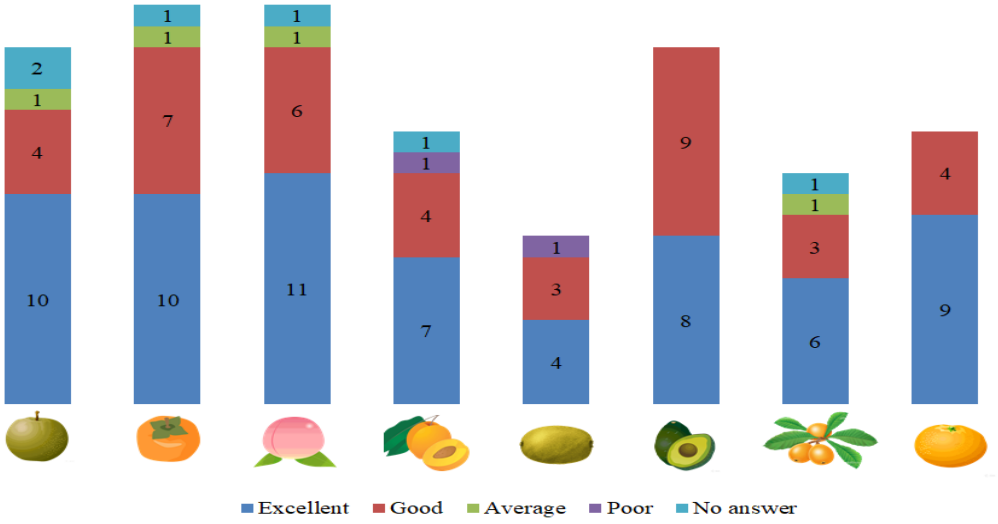

Figure 7 Health status of the different seedlings planted

Out of 1,400 fruit seedlings supplied to the respondents, 90 % of the fruit plant survived. From 29 respondents, 12 reported 69 dead seedlings from which 83% deaths reported by respondents in category D and E. “Pests and diseases” was reported as the most common and important threats of all fruits. Most of the farmers responded they could positively on confidence to manage the orchard properly in the future with the use of the skills acquired from the training.

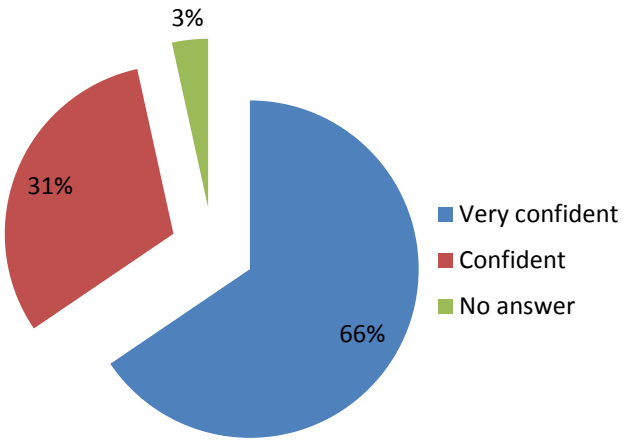

Figure 8 Farmers' confidence on use of different acquired techniques

Second batch Model Fruit Farmers gave high praise to the effect of Out-Reach Program. With the basic concept "planting the right tree in the right land", they reported most of the fruit seedlings are growing well. Many of farmers are facing the threats of pest & disease and therefore, ARDC/IHPP Bajo should provide technical assistance in the future.

3 SUPPORT SERVICES RESEARCH AND DEVELOPMENT PROGRAM

The Support Service Section is cross-sectoral discipline mandated to support in carrying out the technology development and research activities that cuts across different sectors and consists of services for Soil and Land Management, Plant Protection, Research Communication and Seed Laboratory.

3.1 Soil and Land Management

3.1.1 Study on the Status of Important Soil Parameters in Mandarin Orchards, Dagana

The study was conducted to determine the fertility status which is necessary for soil improvement recommendations to improve the mandarin productivity. The soil samples analysis results and fertilizer recommendations of the five Gewogs in Dagana are given in table 33.

Table 33 Average status of different soil parameters in five Gewogs, Dagana

Soil Parameter	Gewogs				
	Drujegang	**Tashiding**	**Tshendagang**	**Goshi**	**Kana**
Soil pH	moderate acidic	slight acidic	moderate acidic	moderate acidic	slight acidic
Percent C	Medium	medium	Medium	medium	Medium
Percent N	Low	Low	Low	medium	Low
Avail. P	very high	high	High	high	High
Avail. K	High	medium	High	medium	Medium
eCEC	Low	Low	Low	low	Low
Soil Texture	sandy loam	sandy loam	sandy loam	loam	silty clay loam

The productivity of the mandarin trees in the Gewogs can be significantly improved through supply of nitrogen into soil at right time. The improved productivity of mandarin is directly linked to food and nutrition security and improving the livelihood of our farmers.

3.1.2 Interactions of Important Soil Parameters

Soil organic carbon of the organic matter is an important soil parameter in determining soil fertility status. A correlation analysis on the soil analysis results of the Mandarin, paddy, vegetables, and maize to study the effect and validate the importance of soil organic carbon on N-P-K content and cation exchange capacity (CEC) in agricultural soil. Eighty soil samples consisting of 10 top soils and 10 sub soils from Mandarin orchard and 20 top soils each from paddy terraces, maize fields, and vegetables gardens were considered to study the interaction. The top soils were taken from a depth of 0-20 cm and subsoil from a depth of 20-40 cm. A significant (p-value<0.05) positive correlation was observed between soil organic carbon vs. N-P-K content and CEC in soil. Therefore, it could be concluded that improvement in soil organic carbon through the addition of soil organic matter could improve soil nutrient status (N-P-K and CEC) in agricultural soil, which ultimately improves food productivity.

Table 34 Correlation between SOC vs. N-P-K and CEC in Mandarin, paddy, vegetables, and maize

Mandarin	SOC	Percent N	Available P	Available K	eCEC
SOC	1.00				
Percent N	0.75**	1.00			
Available P	0.65**	0.45	1.00		
Available K	0.80**	0.91	0.38	1.00	
eCEC	0.74**	0.78	0.83	0.65	1.0
Paddy	SOC	Percent N	Available P	Available K	eCEC
SOC	1.00				
Percent N	0.60**	1.00			
Available P	0.48*	0.34	1.00		
Available K	0.47*	0.28	0.33	1.00	
eCEC	0.63**	0.47	0.44	0.45	1.0
Vegetables	SOC	Percent N	Available P	Available K	eCEC
SOC	1.00				
Percent N	0.44*	1.00			
Available P	0.95**	0.45	1.00		
Available K	0.64**	0.25	0.66	1.00	
eCEC	0.44*	0.09	0.39	0.42	1.0
Maize	SOC	Percent N	Available P	Available K	eCEC
SOC	1.00				
Percent N	0.82**	1.00			
Available P	0.85**	0.79	1.00		
Available K	0.65**	0.64	0.61	1.00	
eCEC	0.85**	0.81	0.79	0.56	1.0

Note: *(p-value<0.05), **(p-value<0.01)

3.1.3 Sequestration of carbon into soil using Dhaincha

Sesbania aculeata popularly known as Dhaincha is the most commonly used summer green manure crop in Bhutan. It is used for the fixation of atmospheric nitrogen and addition of organic matter into soil. Its cultivation must be done 60-70 days before main crop. The seeds are broadcasted in fields at the rate 30 kg/acre. At 40-50 days after sowing, the plants are incorporated into the soil. The biomass residues are left to decompose in the field for 20-30 days before cultivating the main crop. The use of green manure crops to sequester carbon into soil is new in Bhutan. The use of Dhaincha as a biochar, which can add carbon into the soil was studied. An experiment was conducted to determine the development stage of plants at which it must be converted into biochar and applied into soil. Two plots each measuring $100m^2$ were used. The seed rate (30kg/acre) was maintained in both plots. The sowing time differs by 20 days between two plots. The first plot was referred to as a matured Dhaincha block in which early seed sowing was done. The second plot, in which the seed sowing was done 20 days later, was referred to as a young Dhaincha block. At the time of sampling, the matured Dhaincha block was 60 days old and was at flowering stage. Whereas the young Dhaincha block was 40 days old and was at vegetative stage. Biochar was prepared from the two different samples using the same method of barrel and cone system. The comparison of carbon percent of the biochar prepared from the dried biomass was done. The biochar prepared from the young Dhaincha block was found to have significantly higher content of carbon percent as compared to matured Dhaincha block. Therefore, the use of Dhaincha for carbon sequestration must be done at the vegetative stage of the plant.

3.1.4 Response of rice to different Nitrogen application rate

This trial was conducted on station at Bajo in collaboration with National Soil Services Centre. Three different paddy varieties were treated with five different treatments of nitrogen fertilizer. The pre and post soil samples were collected and crop cut was done at the end. The trial will be continued for another two years and reports will be generated at the end.

3.1.5 Development and Demonstration of IPNM technologies

All technologies promoted were climate resilient in nature. The objective was to promote those technologies which will help our farmers in practising organic agriculture.

3.1.6 Demonstration and promotion of Bio-char, bokashi and azolla cultivation

The production of bio char is mainly done to promote the use of bio char as an alternative media to be use in potting mix and as a soil amendment. Till date around 1000 Kg of bio char were produced and is still continued and 500 Kg fermented rice bran fertilizer (bokashi) produced for on-station usages. Azolla are cultivated for their capability to make atmospheric nitrogen available to crop like paddy. Eight nurseries were established for further multiplication purpose. It will be

used in paddy from coming season. The Centre has also promoted azolla cultivation to 42 households in the region.

The preparation methods of these technologies were showcased to visitors visiting the Centre. On-farm demonstration cum farmers training was also done during the FY 2019-20 in the West Central Region.

Table 35 On-farm demonstration cum farmers training on Bio char and bokashi production

SN	Dzongkhag	Gewog	No. of farmers	Remarks
1.	Wangdue Phodrang	Nahi	25	Bio char and bokashi
		Bjena	25	
		Gasetshowom	25	
		Bajo SAP	100	
2.	Punakha	Baap	25	Bio char and bokashi
		Talo	25	
		Lekithang SAP	100	
3.	Tsirang	Mendrelgang	30	Bio-char and bokashi
4.	Dagana	Tashiding	30	
		Tshendagang	50	
	Dagana	Karmaling	50	Bio char, bokashi and azolla
		Nichula	50	
		Lhamoidzingkha	50	
		Kana	50	
5.	Gasa	Khatoed	30	Bio char and bokashi
		Khamaed	30	
		Laya	50	
		Total	**745**	

3.1.7 Effective Microorganisms Technology

The EM mother plant with capacity of 2000 liters was established at the Centre. It was established to cater our services to various clients of West Central Bhutan. The mother plant was established with support from Asia Pacific Natural Agriculture Network, National Soil Services Centre and School Agricultural Program.

3.1.8 Compost

It is produced for their organic matter content to be used in integrated nutrient management. 80 metric tons of composts were produced in a past year. The raw materials were organic residues available in field, chicken manure, saw dust, farm yard manure, rice brans and stalks, etc.

3.1.9 Trenching in Fruit Blocks on-station

This system of manuring was effective in fruits. Between December and January month, around 250 fruit plants at the Centre were given fertilizer and irrigation through this method. It also serves demonstration purpose to visitors.

3.1.10 Seed production of *Sesbania aculeata*

The seeds are produced for maintaining germplasm, multiplication and for future use. The produced seeds were used for on-station and on-farm activities as well as distributed to interested clients. Around 100 kg of seeds were produced.

3.1.11 Potting Technology

This technology is promoted for their ability to ensure almost 100 percent seedlings survival in field condition after transplanting. The potential of this technology are now being promoted in the farmers' field. Around 2000 polypots were used in the past year for vegetables and fruit cultivation.

3.1.12 Mulching Technology

Mulches are promoted as it helps in adding organic matter into soil. It also suppresses weed growth and retains moisture in soil. The technology is widely practiced at the Centre.

3.1.13 Vermiculture

Vermiculture is the science of breeding and raising earthworms. It is mainly done to multiply earthworms for vermicomposting purpose. Around 1 Kg of earthworms was produced.

3.2 Integrated Pest Management

3.2.1 Application methods of *Trichoderma spp.* to control *Verticillium* wilt

Wilt suppression efficacy of *Trichoderma spp.* through different application methods were tested. *Ratei*, a wilt susceptible chili variety, was cultivated in soil naturally infested with *Verticillium dahliae* Kleb. The chili plants were treated at nursery with bran mixtures (BM)/conidial suspensions (CS) of *Trichoderma viride* or left untreated. Those seedlings were transplanted into the field, to comprise nine treatments replicated and randomized in three blocks. Treatments in the field comprised application of *T.harzianum* BM/CS or control (Untreated seedlings/plants).

Nine treatments for the study were:

T1 = Control with no *Trichoderma* inputs
T2 = *T. viride* CS application in nursery only,
T3 = *T. viride* BM application in nursery only,
T4 = *T. harzianum* CS application in field only,
T5 = *T. harzianum* BM application in field only,
T6 = *T.viride* CS application at nursery with *T.harzianum* CS application in field,
T7 = *T.viride* BM application at nursery with *T.harzianum* CS in field,
T8 = *T.viride* CS at nursery with *T.harzianum* BM in field, and,
T9 = *T.viride* BM application at nursery with *T.harzianum* BM application n in field.

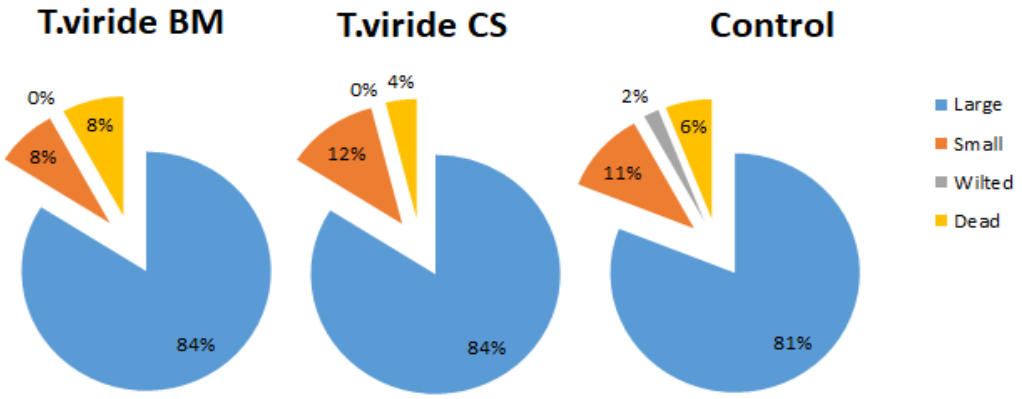

Figure 9 Seedling health in different treatments

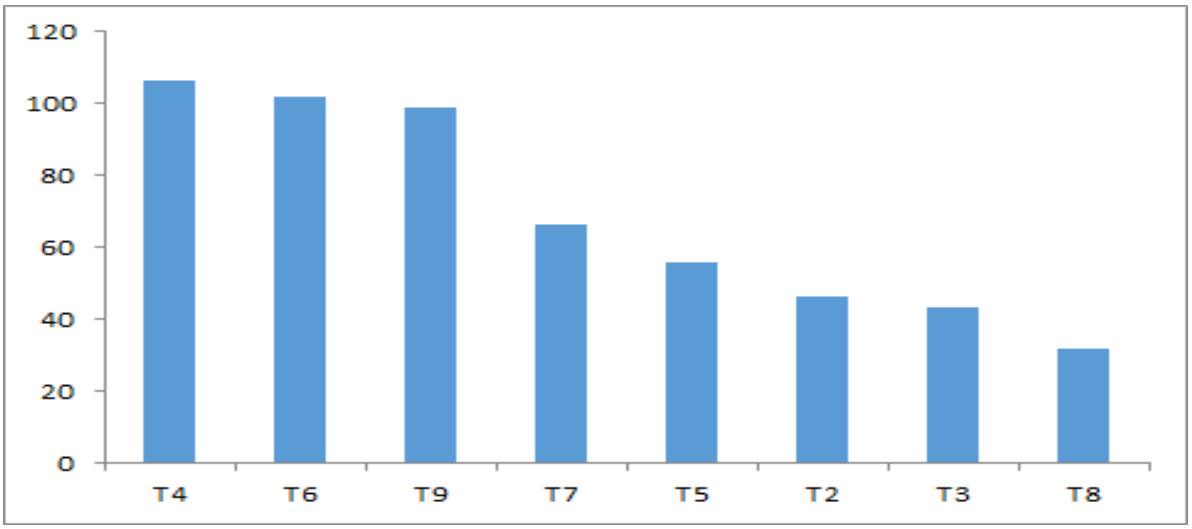

Figure 10 Percent wilt suppression over control

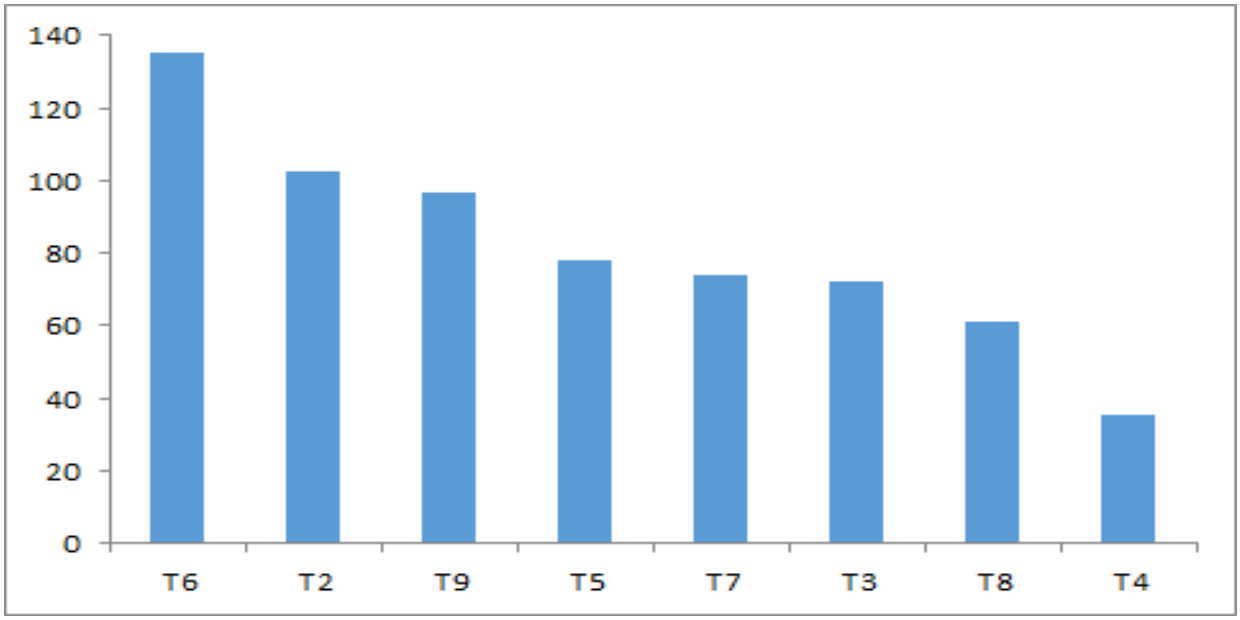

Figure 11 Percent yield increase over control

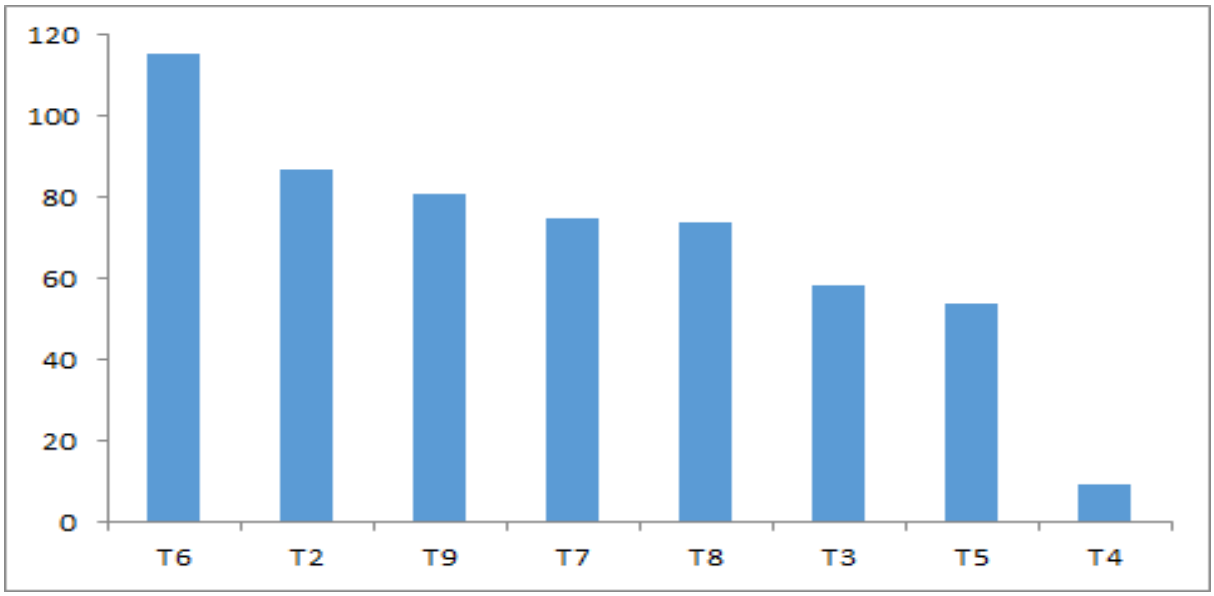

Figure 12 Percent productivity increase over control

T.viride BM application at nursery combined with *T.harzianum* BM application at field significantly ($p<0.05$) reduced the wilting compared to control, *T.viride* CS application in nursery, and *T.harzianum* CS application in field. Wilt suppression by *T.viride* CS at nursery, *T.harzianum* BM at field, and *T.viride* CS at nursery with *T.harzianum* CS at field was significantly ($p<0.05$) higher from the control. Application of *T.viride* CS at nursery combined with *T.harzianum* CS at

field significantly ($p<0.05$) increased the yield and fruiting rate over control. *Trichoderma spp.* application positively affected the fruiting rate, yield and survival rate of the chili plants.

3.2.2 Survey of insect pests of horticultural crops in West Central Bhutan

In Bhutan, the characteristic agricultural environment is aroused by the policy on organic agriculture and the religious values, which avoid the destruction of life. We investigated the occurrence condition of insect pests on main horticultural crops during September–November, 2017 and July–September, 2019.

In autumn, 2017 the insect pests, which have the highest value of occurred points, were citrus leaf miner on citrus, aphids on pear, aphids on *Brassica napus*, fruit flies on chili and armyworms on beans. In summer, 2018 the insect pests were the large white butterfly on *Brassica napus* and plant hoppers on chili, and the same on the other crops as autumn, 2017.

3.2.3 Incidence patterns of six horticultural pests at Bajo

Incidence patterns of six different horticultural pests were studied at ARDC Bajo research station during December 2019 and April 2020. Commercial pheromones manufactured by Pheromone Chemicals (Indian Company) were used for Cabbage looper (*Trichoplusia ni*), Common cutworm (*Spodoptera litura*), Chili pod borer (*Helicoverpa armigera*), and Beet armyworm (*Spodoptera exigua* Hubner). The pheromones used were species specific sex pheromones. Sugar-alcohol syrup attractant was used to trap Oriental armyworm (*Mythimna separata*). The incidence patterns will be used for designing control/management methods of these pests. Data for the study were recorded as BW0 (Dec 15-30, 2019), BW1 (Jan 1-14, 2020), BW2 (Jan 15- Feb 1, 2020), BW3 (Feb 2-18, 2020), BW4 (Feb 19-Mar 2, 2020), BW5 (Mar 3-23, 2020), BW6 (Mar 24-Apr 3, 2020) and BW7 (Apr 3-17, 2020).

Common cutworm population gradually decreased from BW0 till BW4. Then it increased by small degree to BW6 and increased by large on BW7 with 1326 moths trapped in 2 weeks. Number of moths trapped was least in BW4. Chili pod borer population remained low from BW0 until BW6. During the BW7 the moth population suddenly increased (223 moths/2 traps). Trap catch in fortnight was least (2 moths per trap) in BW1. Cabbage lopper moth population gradually decreased during the study. The trap catch was least during BW7 with two moths per trap. Highest number of moths was trapped during BW0 with 24 moths. Oriental armyworm population moths trapped was highest in BW0 with 22 moths. No moths were trapped during BW2, BW3, BW6 and BW7. Beet armyworm incidence was very less compared to other moths. The moths trapped were highest in in BW2 with only three moths trapped in two weeks in two traps.

For common cutworm and chili pod borer, mass trapping of moths may be very useful for their management starting March month to protect the crops. To fully understand the population incidence patterns, continuous surveillance of these insects is required for longer duration. Further,

host plant availabilities and population of their natural enemies during the study period with climatic information will be very useful.

3.2.4 Effect of Bordeaux spray on lichens and mosses on citrus plants

Tree lichens are common in most of the orchards. In poorly managed orchards, lichens cover branches and young shoots with dried branches, reduced growth and fruiting in severe cases. At Ganzor (under Dagana district), 10 citrus trees infested with multiple foliose and fruticose lichens were selected for the application of Bordeaux spray for lichens/mosses management. Bordeaux spray preparation: the solution was prepared as 7g lime and 7g copper oxychloride in 1 liter of water. One foot of the first (lowest) branch was selected for the study. Visual rating for the lichens/mosses infestation before spraying was carried out. The mixture was sprayed using a power sprayer. The trees were tagged for observation. After two months of spray, the lichen infestation reduced by 50-100%. Further research is required to study its efficacy, and economics with comparison to recommended methods of NPPC.

3.2.5 Incidence pattern of *Bactrocera dorsalis* on-station

To study the mango fruitfly (*Bactrocera dorsalis*) incidence pattern at the research station, MacPhail traps with eugenol lures were used. Traps were installed at 1.5m heights. Trap catch of the fruitfly indicated that the population didn't vary much during March and April months. Average fruitfly trapped in five traps were 27 flies in a week with highest catch (32 flies) during first week of April, 2020. Further trapping of the flies is required to understand the incidence pattern of the pest.

3.2.6 Demonstration of climate smart technologies for pest/disease management

Some important pest management methods are pheromone trapping (insects), fruit bagging (insects, fruit bats, and birds), fruit drop collection (insects), plastic capping (insects), netting (for insects, fruit bats and birds), ash (insects and fungi), calcium/dolomite (fungi), wood vinegar (insects and weed), and *Trichoderma spp.* biocontrol (fungi). On-station pest management methods demonstrated during this fiscal year were:

a) Pheromone traps:
    a. McPhail traps for Fruitfly at ARDC Bajo.
    b. Funnel type traps for Common cutworm, Cabbage looper, Chili pod borer, Beet armyworm, Beet armyworm, and fall armyworm at ARDC Bajo and ARDSC Tsirang. Yellow stem borer pheromone traps at ARDC Bajo.
    c. Wota T-trap for Tomato leaf miner at ARDC Bajo.
b) Fruit bagging for dragon fruit, grapes, kiwi, and mango at ARDC Bajo.
c) Fruit drop collection in drums to control different fruitfly species at ARDC Bajo.
d) Plastic capping or netting on young cucurbit crops to protect from red melon beetles.

e) Ash/calcium/dolomite application at ARDC Bajo.
f) *Trichoderma spp.* for *Verticillium* wilts in chili.
g) Netting for fruit bats and birds in persimmon, peach and pears.

3.2.7 Promotion plastic lined water harvesting ponds

In the FY 2019-20, the Centre has promoted 22 low cost water harvesting pond using silpaulin plastic lined sheet (300GSM) at Dagana Dzongkhag in project gewogs with the support from the FSAPP.

3.2.8 Study on impact of electric fencing

Electric fencing has been one of the important tools to solve Human Wildlife Conflict (HWC), especially keeping away vertebrates. During the FY 2018-19 through FSAPP support the Centre has implemented demonstration site on electric fencing using HDPE pipes as alternative to wooden posts. The current electric fence system uses wooden posts which need to be replaced every two-to-three years. A kilometre of electric fence requires some 500 numbers of wooden posts. The constant replacement of wooden posts for the electric fencing is a labour intensive, involves high labour costs and environmentally unsustainable. Therefore, there is a need to find alternate or better posts for the electric fence system. This study aims to evaluate HDPE pipe posts as alternate to wooden posts of the electric fence system.

This demo is implemented at Kana covering 35 ac area with 2.6km periphery benefiting 12 HHs. Intensity of proneness to depredation by animals and lower economic status of the recipient farmers were considered for the site selection.

Past data like area of cultivation, crops, crop loss by wild animals, crop guarding and crop yield were collected from all the beneficiaries. The first year data were collected on crop intensification and crop yield are collected. The data will be collected for some years for impact assessment of the electric fencing using alternative post to wooden post.

3.3 National Seed Testing and Referral Laboratory

3.3.1 Seed samples tested for various parameters

National Seed Testing and Referral Laboratory at ARDC-Bajo is responsible to carry out basic tests such as germination percent, physical purity percent, and moisture percent of seeds. Clients include ARDCs, BAFRA, NSC, farmers and private seed companies. The seed samples submitted through BAFRA are tested for germination percent, purity percent and moisture percent whereas seed samples from farmers are usually tested for germination and purity percent only. The seed parameters to be tested depend on interests of clients and the capacity of the laboratory to perform tests. The results and recommendations are then provided to them. The seed samples collected are

usually from vegetables and cereals crop. The table 37 indicates the details of samples tested in the fiscal year 2019-20.

Table 36 Seed samples tested in 2019-20

Crop	Variety	Beneficiary	Germination %	Moisture content (%)	Purity (%)
Brinjal	Senryo	Horticulture Sector, ARDC, Bajo	70%	6.5%	99.9%
Brinjal	Manryo		83%	7%	99.9%
Brinjal	Shinkura		76.5%	6.3%	99.9%
Brinjal	Nagaoka		77.9%	6.6%	99.9%
Paddy	BM-1	ARDC, Bajo	88.5%	12%	99.9%
Paddy	BM-2		93%	12.5%	99.9%
Wheat	Sonalika	Tshering, Dotey, Paro	90%	13%	99.9%
Paddy	Red rice		95%	12.8%	99.9%
Paddy	Japanese rice		92%	13.4%	99.9%
Beans	Boroloto		87%	6%	100%
Mustard green	Local	Tandin Bidha, Kuteyphu, Paro	85%	6.5%	99.9%
Beans	Pole beans		79%	6.3%	100%
Mustard			84%	6.5%	99.9%

3.4 Release of varieties and improve technologies

As ARDCs are mandated to release Climate smart technologies new varieties and improved technologies to be adopted by the clients, the Centre has targeted to release 11 technologies in during the 12FYP. During the first two years the Centre could release three new varieties and two new technologies as listed in the table. These technologies will be disseminated to farmers and other clients for adoption.

Table 37 New varieties and technologies proposed and released

Year	No. of varieties/ technologies proposed	No of varieties technologies released	Release variety technology
2018-19	3 no. low cost water harvesting Two varieties of pecan nuts	3	1. Low cost water harvesting 2. Bajo Thasa Targo-1 3. Bajo Thasa Targo-2
2019-20	8 no. Two climate smart technologies (azolla production, rice husk bio char) Two varieties of beans (prime green & brown pole) Two varieties of Tomato (Red Tommy Toe & Master) Two varieties of watermelon (Kabuki & Blackball)	2	1. Rice husk bio-char 2. Brown pole bean
Total number of varieties/ technologies released			**5**

3.4.1 Information management, publications and extension material development

During the FY 2019-20 the Centre has published series of publication: two journal papers; two guide books and 17 pamphlets. These are compiled in table 39.

Table 38 List of Publication published 2019-2020

Type of publication	Name of Publication	Author (s)	Remarks
Journal paper	Assessment of soil nutrient in Dagana	Kinley Tshering, Yeshi Zangpo, Tashi Phuntsho, Pema Chofil & Ugyen Dorji	Bhutanese Journal of Agriculture
Journal article in SAARC publication	Rice Technological Innovation and Value Chain Development in Bhutan: Current Status and Future Directions	Pema Chofil	Rice Technological Innovationand Value Chain Development in South Asia (SAARC)
Pamphlet	Tomato	Arjun Kumar Ghallay & Karma Dema	Starter guide
Pamphlet	Watermelon	Arjun Kumar Ghallay & Karma Dema	Starter guide
Pamphlet	Pumpkin	Arjun Kumar Ghallay & Karma Dema	Starter guide
Pamphlet	Vegetable Cultivation - Mulching	Arjun Kumar Ghallay Tashi Dorji ,Duptho Wangmo, Tshering Dema & Karma Dema	Step-up guide
Pamphlet	Bunching Onion	Tashi Dorji	Starter guide
Pamphlet	Sweet Potato	Duptho Wangmo	Starter guide
Pamphlet	Pole bean	Duptho Wangmo	Starter guide
Pamphlet	Chili	Tshering Dema	Starter guide
Pamphlet	Brinjal	Tashi Dorji, Karma Dema	Starter guide
Pamphlet	Zucchini	Tshering Dema	Starter guide
Pamphlet	Vegetable Cultivation, Land Preparation	Arjun Kumar Ghallay, Kinley Tshering ,Yeshi Zangpo, Tashi Dorji, Duptho Wangmo, Tshering Dema & Karma Dema	Step-up guide
Pamphlet	Pruning and Training _evergreen trees	Sonam Chophel & Tashi Phuntsho	Starter guide
Pamphlet	Pruning and Training _Vine trees	Sonam Chophel & Tashi Phuntsho	Starter guide
Pamphlet	Organic Material -Bokashi	Kinley Tshering ,Yeshi Zangpo,	Starter guide
Pamphlet	Processing Jam	Duptho Wangmo, Tshering Dema & Karma Dema	Starter guide
Pamphlet	Kiwi	Sonam Chophel	Starter guide
Pamphlet	Dragon Fruit	Tashi Phuntsho	Starter guide

3.4.2 Standards and Guidelines development

During the FY 2019-20, with support from IHPP, the Centre has developed two technical guide books. These books are published and circulated to relevant stakeholders in the country.

1. Guidebook on fruit cultivation
2. Guide book on vegetable production.

3.4.3 Regional Agriculture Database

ARDC Bajo has been maintaining Regional database of the West-Central Region and made it available whenever required. From this fiscal year, the Centre has generated online database for the five Dzongkhags of West-Central Region viz., Gasa, Punakha, Wangdue Phodrang, Dagana and Tsirang. The following data has been updated and made online at the Centre webpage www. rcbajo.gov.bt under the subheading "West Central Region Database"

- Extension Staff information
- Crop cut
- Household details
- Land use data
- Crop Production Data
- Electric Fencing
- Farm Road
- Irrigation

Besides these data, the Centre has also uploaded collaborative activities of the West Centre Region.

3.4.4 Visitors' information

In the fiscal year 2019-20, various groups of visitors comprising of farmers, students, youths, trainees, delegates from various organizations and agencies visited ARDC-Bajo. A total of 490 visitors (270 male and 220 female) visited the Centre on study tour and exposure trips. Different groups came with different learning objectives: farmers were interested in seeing new crop varieties which yield more; extension personnel were keen on new technologies; and trainees, guests and visitors had specific objectives to visit the Centre. In general, many were interested technologies available or adopted in the Centre.

3.5 Engineering Services

Engineering Sector comprising of five engineers provided engineering services for implementation of 43 activities worth Nu276.273million (M) for 12 agencies including eight Dzongkhags in 2019-20 financial year. Amongst the agencies, the highest of 23 activities were implemented for ARDC Bajo worth Nu18.545M, followed by sister RNR Agencies of 4 activities worth Nu46.870M, and Zhemgang Dzongkhag 3 activities worth Nu188.21M. In terms of value of the work the highest was for Zhemgang Dzongkhag of Nu188.212 for three activities, followed by RNR Agencies of Nu46.870M, followed by ARDC Bajo of Nu18.545M for implementation of 23 activities.

The highest number of 14 activities corresponding to 32.6% of the activities implemented by Engineering Sector was implemented by IBR worth Nu0.749M (0.27%) and the second highest of 10 activities (12.39%) implemented by PC worth Nu34.225M (12.39%) and the lowest of four activities (9.3%) worth Nu16.358M. In terms of estimated value of the work the highest was implemented by TGT with estimated value of Nu188.211M corresponding to 8 activities followed by PC worth Nu34.225M for 10 activities and the least of Nu0.749M by IBR.

On average each engineers implemented 8.6 activities worth Nu55.255M in 2019-20 financial year. The average value of an activity stands at 6.425M. The summary of activities implemented the sector are presented in Table 40 while the subsequent section presents profile of activities implemented by each engineer under the sector. Although the activities are listed against each individual engineers who took the lead responsibilities but most of the activities are jointly implemented through the support of other engineers the sector, even from the other sector in ARDC Bajo, ARDSC Tsirang, RP Chimipang and concerned client agencies as well.

Table 40 Summary of engineering services provided by site engineer, agencies and cost.

SN	Agency	No of activities					No of activities		Cost		Remark
		TGL	PC	NW	IBR	TGT	Total	(%)	(NuM)	(%)	
1	ARDC Bajo	7	2	2	10	2	23	53.5	18.545	6.71	
2	ARDSC Tsirang	-	-	-	1	-	1	2.3	0.025	0.01	
3	RP Chimmipang	-	1	-	-	-	1	2.3	8.574	3.10	
4	RNR Agencies	-	1	1	-	4	6	14.0	46.870	16.97	
5	Bumthang Dz	-	1	-	-	-	1	2.3	0.000	0.00	
6	Dagana Dz	-	1	-	-	-	1	2.3	0.434	0.16	
7	Haa Dz	-	-	-	1	-	1	2.3	0.038	0.01	
8	Punakha Dz	-	2	-	-	-	2	4.7	6.800	2.46	
9	Samtse Dz	-	-	-	1	-	1	2.3	0.075	0.03	
10	Trongsa Dz	-	1	-	-	1	2	4.7	0.000	0.00	
11	Tsirang Dz	-	-	1	-	-	1	2.3	6.700	2.43	
12	Zhemgang Dz	-	1	-	1	1	3	7.0	188.212	68.13	
Total- NoA		**7**	**10**	**4**	**14**	**8**	**43**	**-**	**276.273**	**100**	
Total- (%)		**16.3**	**23.3**	**9.3**	**32.6**	**18.6**	**-**	**100**	**-**	**-**	
Total- Cost (NuM)		**13.313**	**34.225**	**16.358**	**0.749**	**214.294**	**-**	**-**	**276.273**	**-**	
Total- (%)		**4.82**	**12.39**	**5.92**	**0.27**	**77.57**	**-**	**-**	**-**	**100**	

LEGEND: TGL= ThinleyGyeltshen, PC= PuranChhetri, NW= NimaWangchuk, IBR= IndraBdrRaika, TGT=Thinely Gyamtsho, IS = Irrigation Scheme.

4 ANNEXURE

4.1 Annexure 1: Financial Report as of June 30, 2020

FINANCIAL REPORT Budget in Millions

204.01 MoAF, DoA ARICULTURE RESEARCH AND DEVELOPMENT CENTRE, Bajo

Title budget	**Approved budget**	**Expenditure**	**Balance**
Execution, Monitoring & Evaluation by General Staff & ESP ARDC Bajo	56.93	56.91	0.02
Research Communication	0.70	0.70	0.00
Soil and Nutrient Mangament	0.33	0.33	0.00
Plant Protection	0.41	0.39	0.02
Field Crops	1.93	1.92	0.01
Horticulture	1.26	1.25	0.00
Operational and Management Services ARDSC Tsirang	0.86	0.86	0.00
Field Crops ARDSC Tsirang	0.63	0.61	0.02
Horticulture ARDSC Tsirang	0.95	0.94	0.01
National Citrus Repositiory ARDSC Tsirang	0.69	0.69	0.00
JICA – RgoB	1.25	1.25	0.00
FASP Project	2.43	2.15	0.27
Green Climate Fund	0.53	0.53	0.00
Total	**68.89**	**68.53**	**0.36**

4.2 Annexure 2 International Irrigated Rice Observational Nursery (IIRON) of new rice lines

ENT NO	SVCODE	DESIGNATION	PLOT NO	REP	FLW	Maturity days	Plant height	PACP_SCOR_1_9	yield kg/6m2
38	SVIN330		102	1	100	152	109.2	3	1.56
27	SVIN322		104	1	105	150	100	3	3.00
74	SVIN363		105	1	100	150	85.2	3	2.95
83	LC4	Local check (bacterial blight resistant)	108	1	94	153	92.6	3	2.00
1	SVIN375		109	1	102	154	102.4	3	2.89
54	SVIN022		110	1		148	95.6	3	2.98
78	SVIN367	IRRI 200	111	1	99	145	87.2	3	1.99
84	LC5	Local check (BPH resistant)	112	1		148	93.4	3	2.12
9	SVIN307		114	1	98	150	106	3	3.00
21	SVIN316		115	1	100	150	101.6	3	2.50
80	LC1	Local check (early)	116	1	99	152	114.6	3	2.50
22	SVIN317		117	1	100	149	101.5	3	
72	SVIN358		118	1	92	149	93.2	3	2.50
51	SVIN034		119	1	120	148	112.4	3	2.55
49	SVIN043		120	1	112	140	99.6	3	2.89
5	SVIN303		121	1	125	141	101.2	3	2.00
47	SVIN052		201	2	99	152	94	3	2.56
71	SVIN357		202	2	95	153	103.8	3	2.10
12	SVIN372		203	2	101	150	115.8	3	1.99
45	SVIN051		204	2	103	150	101.4	3	2.95
81	LC2	Local check (medium/ late)	205	2	98	146	113.4	3	3.10
13	SVIN026		206	2	99	142	96.4	3	2.13
56	SVIN374		207	2	109	142	100.4	3	2.00
58	SVIN290		208	2	98	142	94	3	1.56
25	SVIN320		209	2	106	145	103.6	3	1.56
84	LC5	Local check (BPH resistant)	210	2	102	145	104.8	3	2.36
64	SVIN344	IRRI 104	211	2	95	145	109.6	3	2.56
63	SVIN376		212	2	103	150	106.6	3	3.00
29	SVIN324		213	2	106	146	105.6	3	2.56
57	SVIN024		214	2	98	145	109.4	3	2.96
48	SVIN040		215	2	103	145	108.4	3	2.45
2	SVIN300		216	2	101	145	104	3	2.00
15	SVIN311		217	2	99	146	114	3	2.95

21	SVIN316		218	2	99	148	85.6	3	2.00
82	LC3	Local check (blast resistant)	220	2	98	150	105.8	3	2.89
70	SVIN356		221	2	93	145	99.4	3	2.95
10	SVIN308		122	1	109	145	105	3	2.15
57	SVIN024		123	1	100	145	102.2	3	2.95
23	SVIN318		124	1	105	145	83.6	3	2.56
18	SVIN313		125	1	106	145	114.2	3	2.14
59	SVIN335		126	1	103	145	90	3	2.56
12	SVIN372		127	1	109	145	98.8	3	3.00
16	SVIN312		128	1	99	145	105.8	3	2.89
37	SVIN329		129	1	98	145	117.8	3	2.10
65	SVIN346	IRRI 123	131	1	106	145	102.4	3	3.56
82	LC3	Local check (blast resistant)	132	1	97	145	102.8	3	1.45
3	SVIN301		133	1	98	145	104.4	3	2.12
25	SVIN320		134	1	95	145	99	3	2.00
19	SVIN314		135	1	99	145	94	3	2.56
60	SVIN287		136	1	100	145	99.4	3	2.12
48	SVIN040		137	1	110	145	98	3	1.56
71	SVIN357		138	1	93	145	95.4	3	1.10
32	SVIN327		140	1	104	145	111	3	2.00
52	SVIN032		141	1	109	145	99	3	1.95
61	SVIN339		142	1	99	150		3	2.13
72	SVIN358		222	2	105	150	102.2	3	3.10
50	SVIN054		224	2	86	150	80.8	3	1.50
19	SVIN314		225	2	99	150	94.6	3	1.50
27	SVIN322		226	2	99	150	98	3	2.00
54	SVIN022		227	2	98	150	101.4	3	2.00
39	SVIN331		228	2	100	147	107.4	3	2.15
30	SVIN325		229	2	105	150	110.8	3	2.98
43	SVIN031		230	2	109	150	101.8	3	2.15
80	LC1	Local check (early)	232	2	98	150	117.6	3	1.59
40	SVIN332		233	2	105	150	112.6	3	1.89
51	SVIN034		234	2	120	147	113.4	3	1.99
69	SVIN355		236	2	108	145	93.6	3	2.13
53	SVIN373		237	2	100	150	101.8	3	2.14
1	SVIN375		238	2	100	150	103.6	3	2.45
10	SVIN308		239	2	107	150	92.4	3	3.00
68	SVIN352		240	2	109	142	111.2	3	2.78
26	SVIN321		241	2	112	142	89.4	7	3.70
35	SVIN044		143	1	100	142	99.6	7	1.25

42	SVIN334		144	1	108	142	97.8	4	1.65
2	SVIN300		145	1	106	142	106.8	4	2.00
40	SVIN332		146	1	105	150	94.8	4	2.15
26	SVIN321		147	1	99	142	116.6	4	3.10
8	SVIN306		148	1	99	142	112.6	4	3.26
34	SVIN056		149	1	99	142	94	4	3.50
13	SVIN026		150	1	99	142	96.4	4	2.56
29	SVIN324		152	1	89	142	88.6	7	2.89
31	SVIN326		153	1	94	150	109	3	2.45
43	SVIN031		154	1	91	142	89.5	3	2.64
4	SVIN302		155	1	98	142	98.6	3	3.00
41	SVIN333		156	1	100	150	103.8	3	2.59
44	SVIN028		157	1	102	142	111.8	3	1.99
7	SVIN305		158	1	101	145	89	3	3.10
11	SVIN309		159	1	101	150	99	3	3.25
15	SVIN311		161	1	89	142	106.4	3	2.95
59	SVIN335		243	2	84	142	114.2	3	1.25
49	SVIN043		244	2	89	142	104.4	3	3.15
11	SVIN309		245	2	101	145	111	3	1.56
33	SVIN328		246	2	85	152	106.2	3	2.10
83	LC4	Local check (bacterial blight resistant)	247	2	104	152	98	3	1.15
62	SVIN340	IR 64	248	2	105	152	101.6	3	2.15
38	SVIN330		249	2	106	152	105.8	3	3.10
3	SVIN301		250	2	108	152	100.2	3	3.20
17	SVIN036		251	2	98	152	95.6	3	3.14
14	SVIN310		252	2	105	152	86	3	1.45
67	SVIN351		253	2	91	152	104.6	3	2.50
79	SVIN368		254	2	87	152	106	3	2.15
75	SVIN364		255	2	98	152	103.6	3	2.56
7	SVIN305		256	2	98	152	103.4	3	2.50
22	SVIN317		257	2	98	145	97.4	3	2.15
16	SVIN312		258	2	100	152	101.6	3	2.98
23	SVIN318		259	2	100	152	105	3	1.98
73	SVIN360		260	2	98	152	106.8	3	2.50
60	SVIN287		261	2	98	152	102.6	3	2.95
76	SVIN365		262	2	99	150	107.4	3	2.12
78	SVIN367	IRRI 200	263	2	99	152	90	3	3.00
56	SVIN374		164	1	98	150	98.8	3	2.89
68	SVIN352		166	1	98	152	117.8	3	2.59
73	SVIN360		167	1	99	150	108	3	3.10

81	LC2	Local check (medium/ late)	168	1	100	152	107	3	1.95
33	SVIN328		169	1	89	152	102.8	3	3.25
24	SVIN319		170	1	100	150	104.4	7	3.00
50	SVIN054		171	1	102	152	107.2	3	1.45
53	SVIN373		173	1	105	150	99.4	3	2.02
70	SVIN356		175	1	99	152	95.4	3	2.12
76	SVIN365		176	1	98	145	94.6	3	1.98
17	SVIN036		177	1	100	152	111	3	2.50
6	SVIN304		178	1	98	152	99	3	2.15
20	SVIN315		179	1	96	145	107.6	3	2.12
30	SVIN325		180	1	98	152	99.6	3	1.99
46	SVIN038		182	1	105	145	106.8	3	1.99
36	SVIN047		183	1	100	148	97.4	3	1.98
44	SVIN028		264	2	109	148	107.4	3	1.99
32	SVIN327		266	2	83	148	117.4	3	3.05
74	SVIN363		267	2	99	148	117.2	3	2.00
34	SVIN056		268	2	98	148	108.6	3	2.12
37	SVIN329		270	2	95	148	80	3	1.98
5	SVIN303		272	2	100	148	107	3	2.56
31	SVIN326		273	2	100	148	91.2	7	1.98
18	SVIN313		274	2	90	148	89	3	2.46
65	SVIN346	IRRI 123	275	2	98	148	99	3	2.56
77	SVIN366		276	2	85	145	100.3	3	2.78
42	SVIN334		278	2	100	148	105	3	3.12
28	SVIN323		279	2	99	145	102.8	3	2.00
66	SVIN350	IRRI 154	280	2	97	148	102.6	3	2.10
55	SVIN023		281	2	99	148	103.4	3	1.45
20	SVIN315		282	2	99	140	119.2	3	1.46
9	SVIN307		283	2	102	148	108	3	3.00
52	SVIN032		284	2		140	107	3	1.98

PACP SCOR 1-9--- Phenotypic acceptability

4.3 Annexure 3: Phenotypic characterization of traditional land races of rice

Accessions	Plant characters				
	leaf pubsc	Leaf sheath colour	Flag leaf attitude	ligule type	ligule colour
Acc 1	glab	green	semi erect	2 cleft	whitish
Acc 2	glab	green	semi erect	2 cleft	whitish
Acc 3	glab	green	semi erect	2 cleft	whitish
Acc 4	glab	green	erect	2 cleft	whitish
Acc 5	glab	Green	erect	2 cleft	whitish
Acc 6	glab	green	semi erect	2 cleft	Greenish
Acc 7	glab	Green	semi erect	2 cleft	Greenish
Acc 8	glab	green	semi erect	2 cleft	Whitish
Acc 9	glab	green	semi erect	2 cleft	Whitish
Acc 10	glab	green	erect	2 cleft	Greenish
Acc 12	glab	green	semi erect	3 cleft	Whitish
Acc 13	pubscent	green	semi erect	4 cleft	Whitish
Acc 14	glab	green	semi erect	5 cleft	Greenish
Acc 16	glab	green	semi erect	6 cleft	Whitish
Acc 17	glab	redish	descending	2 cleft	Whitish
Acc 26	glab	green	semi erect	2 cleft	Green
Acc 28	glab	green	semi erect	2 cleft	Whitish
Acc 29	glab	green	semi erect	2 cleft	Green
Acc 30	glab	green	erect	2 cleft	Whitish
Acc 31	glab	green	semi erect	2 cleft	Green
Acc 32	pubscent	redish	semi erect	2 cleft	Green
Acc 33	glab	green	semi erect	2 cleft	Green
Acc 34	pubscent	redish	erect	2 cleft	Green
Acc 35	glab	whitish	semi erect	2 cleft	Whitish
Acc 36	glab	green	semi erect	2 cleft	Whitish
Acc 37	pubscent	green	semi erect	2 cleft	Whitish
Acc 38	punscent	redish	semi erect	2 cleft	Whitish
Acc 39	pubscent	green	erect	2 cleft	Green
Acc 40	glab	whitish	semi erect	2 cleft	Whitish
Acc 41	glab	green	semi erect	2 cleft	Green

4.4 Annexure 4: Flowering plant potted for flower show 2020

SN	Flower plant	Quantity raised	Quantity issued	Balance	Remarks
1	Helianthus	710	0	710	Collected for seed
2	Antirrhinum	4560	3122	1438	Issued to Wangdue Dzongkhag beautification
3	Pansy	1198	820	378	
4	Salvia	494	394	100	
5	Verbena	1250	1220	30	On station
6	Viola	720	466	254	Issued to Wangdue Dzongkhag beautification
7	Dainthus	2690	2690	0	
8	Gysophila	80	50	30	On station
9	Geranium	1179	1012	167	On station
10	Lavendula	3310	2980	330	Onstation
11	Statice	1250	1230	20	On station
12	Digtalis	690	500	190	Issued to Wangdue Dzongkhag beautification
13	Poppy	270	190	80	
	Total	**18401**	**14674**	**3727**	

4.5 Annexure 5 NCR Inventory as of 30-06-2020

Cultivar name	Qty (Nos)	Country of origin	Area of collecting site	Precise location	Year of introduction
Cara Cara	5	Australia	NSW	Dareton	2013
Othsu	3	Japan	Mongar	ARDC, Wengkhar	2013
Okitsu wase	10	Japan	Mongar	ARDC, Wengkhar	2013
Yushida Ponkan	10	Japan	Mongar	ARDC, Wengkhar	2013
Otsu 4	3	Japan	Mongar	ARDC, Wengkhar	2013
Amigo mandarin	5	Australia	NSW	Dareton	2013
Cafein Clementine	3	Australia	NSW	Dareton	2013
Fingered citron	3	Australia	NSW	Dareton	2013
Mc Mohan	4	Australia	NSW	Dareton	2013
Ryan	3	Australia	NSW	Dareton	2013
Salustiana	5	Australia	NSW	Dareton	2013
Starrubby	5	Australia	NSW	Dareton	2013
Torracco Ippolite	5	Australia	NSW	Dareton	2016
Benyenda Valencia	3	Australia	NSW	Dareton	2016
hamlin	3	Australia	NSW	Dareton	2016
person brown	3	Australia	NSW	Dareton	2016
afourer	12	Australia	NSW	Dareton	2016
navel benyenoal	5	Australia	NSW	Dareton	2016
p. rubidoux	3	Australia	NSW	Dareton	2016
Berri Valencia	3	Australia	NSW	Dareton	2016
valencia reena	3	Australia	NSW	Dareton	2016
Navaline/local	3	Australia	NSW	Dareton	2016
Valencia	3	Australia	NSW	Dareton	2016
Citron-berti	3	Bhutan	Zhemgang	Berti	2013
Citron-Tshanglajong-zh	3	Bhutan	Zhemgang	Tshanglajong	2013
Citron-zurphey	2	Bhutan	Zhemgang	Zurphey	2013
Humpang-goling	2	Bhutan	Zhemgang	Goling	2013
lime-berti	3	Bhutan	Zhemgang	Berti	2013
lime-trongpam	3	Bhutan	Zhemgang	Trongpam	2013
Local-chukha	3	Bhutan	Chukha	ARDC, Wengkhar	2013
Local-dagana	3	Bhutan	Dagana	ARDC, Wengkhar	2013
Local-dorokha	2	Bhutan	Samtse, Dorokha	ARDC, Wengkhar	2013
Local-kengkhar	3	Bhutan	Mongar, Kengkhar	ARDC, Wengkhar	2013
Local-narang	3	Bhutan	Mongar, Narang	ARDC, Wengkhar	2013

Local-p/gatshel	3	Bhutan	pemagatshel	ARDC, Wengkhar	2013
Local-s/jongkhar	3	Bhutan	Samdrup jongkhar	ARDC, Wengkhar	2013
Local-samtse	3	Bhutan	Samtse	ARDC, Wengkhar	2013
Local-sarpang	3	Bhutan	Sarpang	ARDC, Wengkhar	2013
Local-shumar	3	Bhutan	Pemagatshel	ARDC, Wengkhar	2013
Local-trongsa	3	Bhutan	Trongsa	ARDC, Wengkhar	2013
Local-tsirang	3	Bhutan	Tsirang	ARDC, Wengkhar	2013
Local-yadi	3	Bhutan	Mongar	ARDC, Wengkhar	2013
Pomelo-berti	3	Bhutan	Zhemgang	Berti	2013
Pomelo-goling	3	Bhutan	Zhemgang	Goling	2013
Bearslime	10	Bhutan	Tsirang	Tsirangtoe	2013
Citron trong pam lime	3	Bhutan	Zhemgang	Trong Pam	2013
Citron	3	Bhutan	Mongar	ARDC, Wengkhar	2013
Dekoponkan/local	3	Japan	Mongar	ARDC, Wengkhar	2013
encore/local	3	Japan	Mongar	ARDC, Wengkhar	2013
Hayaka	3	Japan	Mongar	ARDC, Wengkhar	2013
sasaki/local	3	Japan	Mongar	ARDC, Wengkhar	2013
Dorokha local	10	Bhutan	Samtse	Dorokha	2013
lime Shemjong (SS)	5	Bhutan	Tsirang	Shemjong	2013
lime Tsirang toe(TT)	5	Bhutan	Tsirang	Tsirang toe	2013
local 27/28 (shumar)	10	Bhutan	pemagatshel	Shumar	2013
Local T-13	3	Bhutan	Tsirang	Tsirang	2013
maxican lime	3	Bhutan	Mongar	ARDC, Wengkhar	2013
etrog	3	Bhutan	Mongar	ARDC, Wengkhar	2013
orlando tangelo	3	Bhutan	Mongar	ARDC, Wengkhar	2013
rangpur lime	3	Bhutan	Mongar	ARDC, Wengkhar	2013
rough lemom	3	Bhutan	Mongar	ARDC, Wengkhar	2013
Kumquat	10	Japan	Mongar	ARDC, Wengkhar	2013
Otha Ponkan	10	Japan	Mongar	ARDC, Wengkhar	2013
Teshiu Ponkan	10	Japan	Mongar	ARDC, Wengkhar	2013
Tarku	10	Nepal	Mongar	ARDC, Wengkhar	2013
Bears lime-tsirang	10	Unknown	Tsirang	Tsirang toe	2013
41-42/local (Khengkhar)	3	Bhutan	Mongar	Mongar, Kengkhar	2013
47-48/local	3	Bhutan	Mongar	Mongar	2015
51-52/local	3	Bhutan	Mongar	mongar	2015
57-58/local (khengkhar)	3	Bhutan	Mongar	Mongar, Kengkhar	2015
AREP 2/local	3	Bhutan	Mongar	ARDC, Wengkhar	2015
AREP1/local	3	Bhutan	Mongar	ARDC, Wengkhar	2015
clementine/local	3	Bhutan	Mongar	ARDC, Wengkhar	2015
junar	3	Nepal	Mongar	ARDC, Wengkhar	2015

kiyomi	3	Japan	Mongar	ARDC, Wengkhar	2015
sweet spring	3	Japan	Mongar	ARDC, Wengkhar	2015
lime	3	Bhutan	Chukha	Jechhu, logchina	2015
pumelo	3	Bhutan	Pemagatshel	Pemagatsho	2015
mandarin	2	Bhutan	Punakha	Chubu, Jangwakha	2015
pumelo	2	Bhutan	Dagana	Gozhi	2019
mandarin	2	Bhutan	Samtse	Pemaling	2019
frost ureka	3	Bhutan	Wangdue	ARDC, Bajo	2019
pumelo	3	Bhutan	Dagana	Baleygang, Gozhi	2019
bigamate	3	Australia	NSW	Dareton	2013
citrus volka meria	3	Australia	NSW	Dareton	2013
pera limeria	3	Australia	NSW	Dareton	2013
poncirus pomeroy 2x	3	Australia	NSW	Dareton	2013
poncirus pomeroy 4x	3	Australia	NSW	Dareton	2013
scarlett mandaria trifoliate	3	Australia	NSW	Dareton	2013
Poncirus pomerory 2x 0110081-10	3	Australia	NSW	Dareton	2013
Poncirus rubudoux 4x	3	Australia	NSW	Dareton	2013
Volkameria 4x SRA 1079-10	3	Australia	NSW	Dareton	2013
tri 22	3	Australia	NSW	Dareton	2018
swingle	3	Australia	NSW	Dareton	2018
C 35	3	Australia	NSW	Dareton	2018
Ichang papeda	3	Bhutan	Mongar	ARDC, Wengkhar	2013
Trifoliate	3	Bhutan	Mongar	ARDC, Wengkhar	2013
Troyer	3	Bhutan	Mongar	ARDC, Wengkhar	2013
Total	**384**				

4.6 Annexure 6 IHPP demo orchard established in 2019-20

Dzongkhag	Gewog	No. of orchards	Fruit plants	Total no. of plant
Wandgdue	Nysho	1	pear, persimmon, peach, plum	73
	Daga	1	persimmon, avocado, mandarin, dragon fruit	99
	Gasetshowom	1	pear, persimmon, walnut, avocado, citrus, peach,	63
	Nahi	1	pear, walnut, persimmon, citrus,	60
	Rubesa	1	persimmon, avocado, citrus,	34
	Daga	1	pear, persimmon, citrus, kiwi	43
Punakha	Barp	3	persimmon, avocado, citrus	123
	Limbukha	2	pear, persimmon	87
Tsirang	Semjong	1	pear, persimmon, avocado, peach, loquat, dragon fruit	52
	Patsaling	1	pear, persimmon, avocado, mandarin, loquat, dragon fruit	49
	Goserling	1	pear, persimmon, avocado, mandarin, peach, loquat, dragon fruit	57
	Tsirangtoe	1	pear, persimmon, avocado, local mandarin, kiwi, peach loquat, dragon fruit	63
	Rangthangling	1	persimmon, avocado, mandarin, loquat, dragon fruit	47
Dagana	Tshendagang	1	Kiwi, dragon fruit, grape	32
	Tseza	3	pear, avocado, mandarin, kiwi, peach, plum, loquat	173
	Larjab	1	avocado, mandarin, dragon fruit, grapes	30
Gasa	Khamaoe	1	pear, persimmon, peach, plum	38
	Khatoe	1	pear, persimmon, kiwi	39
Total		**23**		**1,162**

CENTRE AT A GLANCE

The Centre was founded as Agricultural Demonstration Station in 1965. In 1982 it was re-established as the Centre for Agricultural Research and Development (CARD) basically to undertake research in rice and rice based crops. Research and farming systems was also started in the late 1980s. In 1994, the centre was renamed as RNR Research Centre to incorporate research in livestock and forest that are inseparable components of Bhutanese farming systems. Subsequent to realignment exercise by the Ministry of Agriculture and Forest to enhance the efficiency of the service delivery to farmers, development mandate was added to Research Centres in July 2008. Following the organizational development exercise undertaken by RCSC in 2016 the Research Centres is now renamed as Agriculture Research and Development Centre (ARDC).

The Centre is located at Bajo (1230masl) in Wangdue Phodrang which is 70km west of the capital city Thimphu.

At the national level ARDC Bajo is mandated to coordinate field crops research and citrus program, while at the regional level it undertakes relevant research and development for West-Central Region (Gasa, Punakha, Dagana, Tsirang and Wangdue. Phodrang). The Centre has 50.90 acres of research farm, furnished office space, modest laboratory and library facilities.

Sub-centre at Mithun, Tsirang was opened in 2006 to cater to the humid sub-tropical Dzongkhags of Tsirang and Dagana. It has about 36 acres of research area, office space and the National Citrus Repository is being developed**.** The Centre also cater the Chimipang Royal Project, Chimipang which was established in 2014 on Royal Command to demonstrate agricultural technologies and training of extension personnel and farmers.

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