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Agriculture Research and Development Centre
Bajothang, Wangduephodrang
Department of Agriculture
Ministry of Agriculture and Forests

ROYAL GOVERNMENT OF BHUTAN

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ANNUAL REPORT 2017-2018

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FOREWORD

It is a great pleasure to publish the 33rd Annual Technical Report of ARDC Bajo for the financial year 2017-18. The report format follows the earlier format for standardized reporting across ARDCs.

The annual report synthesizes the research and development activities carried out within a year from July to June coinciding with the RGoB's financial year. It covers the research and development activities carried out in field crops, horticulture, technical support services, engineering and sub Centre ARDSC, Menchuna, Tsirang. The report also provides highlights of activities implemented at Chimipang Royal Project. Further, the report presents the human resources, budget utilization, number of visitors to the centre and meterological information in addition to the technical reports.

Besides generating relevant and appropriate technologies, their usage and applicability in the field need to be tested, validated and then promoted. The centre thus accords high priority in testing and applying the generated technologies in the field in partnership with Dzongkhag extension colleagues. In some cases, we directly bring our best technologies and promote among farming communities as part of Research Outreach Program. Showcasing and promoting of technologies is also our prime responsibility and this fits very well with the new and expanded mandate of research and development. We continue to build and strengthen our linkages and partnerships with regional and international agricultural research organizations, other national centres, extension partners, farmers and more.

This report is intended to serve as a useful technical reference to all stakeholders involved in agricultural research and rural development to attain Gross National Happiness in Bhutan and beyond.

Trashi delek to all the readers.

Pema Chofil

Program Director

FROM THE EDITORS

The Ministry of Agriculture and Forests plays a crucial role in poverty alleviation and improvement in the livelihood of the Bhutanese people. This can only be achieved by enhancing the agricultural productivity by stimulating growth through technological innovations. The Research and Development Centres are in the forefront in generation and dissemination of appropriate agricultural technologies.

This publication highlights the annual research and development work carried out from 1st July till 30th June of the financial year 2017-18. After Research Centres became Research and Development Centres, equal importance is given to promoting and disseminating the proven technologies. Research component includes mainly varietal evaluation trials of field and horticulture crops. In addition, research activities on soil fertility management and pest (insect, disease, and weed) management and seed testing are important. This report includes research activities on field crops which comprises cereals, oilcrops, grain legumes and quinoa, and horticulture which comprises vegetables and fruit plants. In addition to research, developmental activities are also reported. It also includes provision of improved agricultural inputs such as seeds and seedlings of improved varieties, fertilizers, farming tools and mushroom production. The report also includes soil fertility, plant protection and RNR Engineering. In addition, farmers are empowered through transfer of skills, knowledge and farming technologies.

We hope this publication will serve as a useful information base and reference to our readers including academicians, development workers, students and field extension workers.

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GLOSSSARY OF ACRONYMS

ADTC	Agriculture Demonstration and Training Centre
AET	Advance Evaluation Trial
ARDC	Agriculture Research and Development Centre
ARDSC	Agriculture Research and Development Sub-Centre
AVRDC	Asian Vegetables Research and Development Centre
BAFRA	Bhutan Agricultural and Food Regulatory Authority
CIMMYT	International Center for Wheat and Maize
CRP	Chimipang Royal Project
DAO	Dzongkhag Agriculture Officer
DoA	Department of Agriculture
DTF	Date to Flowering
DTM	Date to Maturity
EM	Effective Microorganism
FMCL	Farm Machinery Corporation Limited
FSAPP	Food Security and Agriculture Productivity Project
FYM	Farm Yard Manure
GAFSP	Global Agriculture and Food Security Program
HDPE	High-Density Polyethylene
HLB	Huanglongbing
HYV	High Yielding Varieties
IET	Initial Evaluation Trial
IHPP	Integrated Horticulture Promotion Project
IIRON	International Irrigated Rice Observation Nursery
IPM	Integrated Pest Management
IPNM	Integrated Plant Nutrients Management
IRRI	International Rice Research Institute
IWP	Individual Work Plan
JICA	Japan International Cooperation Agency
LBR	Late Blight Resistant
LCR	Large Cardamom Repository
MoAF	Ministry of Agriculture and Forests
NBC	National Biodiversity Centre
NCR	National Citrus Repository
NCT	National Coordinated Trial
NPK	Nitrogen Phosphorus Potassium
NPPC	National Plant Protection Centre
NSC	National Seed Centre
NSSC	National Soil Services Centre

ORP	Outreach Programme
PST	Project Support Team
RBFE	Royal Bhutan Flower Exhibition
RCBD	Randomized Complete Block Design
RCSC	Royal Civil Service Commission
RNR	Renewable Natural Resources
RPCO	Royal Project Coordination Office
RPF	Royal Project Foundation
SAP	School Agriculture Program
SLM	Sustainable Land Management
TSS	Total Soluble Sugar
USDA	United States Department of Agriculture
VET	Varietal Evaluation Trial
WGM	Work Group Meeting

EXECUTIVE SUMMARY

FIELD CROPS

In 2017-2018, the Field Crops program evaluated 130 germplasm 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). From the trial plots, seed production and demonstration blocks, 10 MT paddy seed was produced in 2017 season. 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 and Zhanghan for seed multiplication and to supply to farmers for on-farm research. Like in the previous years, the national rice program continued to promote improved rice varieties on larger scale. HYV seeds were supplied to different Dzongkhags based on the potential and needs of the Dzongkhags. Larger share of improved seeds has been allocated to major rice growing Dzongkhags like Sarpang, Dagana and Samtse which accounted for about 64% of the total seed supply. The program also catered to other regions based on the demands and needs. Altogether, the national rice programme was able to promote 25.03 MT of improved seed comprising of six varieties in Sarpang, Wangdue, Dagana and Punakha Dzongkhags.

ARDC Bajo received a total of 124 accessions of traditional land races of rice from NBC for phenotypic characterization and seed production during the 2017 season. Of the 124 accessions, 114 germinated and basic morphological data were collected from 96 accessions. However, all 96 accessions did not do well and some had to be discarded. Most of the lines were found to be highly susceptible to diseases and heavy lodging. Thus, we could study and harvest seed from only 90 accessions despite all efforts. Moreover, most of the lines were also highly mixed and had to be discarded during harvesting. Overall, the phenotypic characterization exercise was a success and gave immense experience to our new researchers and field workers.

Under the wheat commodity, the Centre produced more than 1.98 MT of wheat seeds of recently released varieties, Bumthangkadrupchu, Bajosokhakaa and Gumasokhakaa which will be used for wheat promotional programmes in the potential Dzongkhags. The other activities included on-station research on bio-fortified wheat varieties and on-farm demonstration of integrated nutrient management technologies in Wangdue-Punakha valley. Under the oil seed commodity, five varieties (Unnati, Pragati, BARI Sharisha 14, BARI Sharisha 15 and M 27) were evaluated with RCBD design with 3 replicates. All the five varieties yielded less than national average yield. The low yielding of the varieties could be due to delay in sowing.

ARDC Bajo continued with the evaluation and demonstration of promising lines both on-farm and on-station in West-Central Region. The evaluation and demonstrations were carried out in the three regional dzongkhags of Wangdue, Dagana and Gasa covering 25 acres land. The Quinoa varieties included Ivory 123, Amarilla Marangani and Amarilla Sacaca which have been tried at different agro-ecological conditions. Ten varieties of quinoa as winter crop after maize or any dryland crop inlow altitudes areas were demonstrated to the farmers which also helped in rapid seed increase and distribution of potential varieties for promotion among the farming communities. Large observation plots were used. The following varieties were evaluated: Amarilla Marangani, Blanca de Junin, INIA 415 Pasankalla, INIA 427 Amarilla Sacaca, Huancayo, Hualhuas, Salcedo INIA, INIA 420 Negra Collana, DoA-1-PMB-2015 and Quinoa Ivory 123.

HORTICULTURE

The horticulture sector focused on both the research and development activities in the financial year 2017-2018. The Integrated Horticulture Promotional Project (IHPP)-JICA established 14 new germplasm orchard of subtropical apple, papaya, dragon fruit, kiwi, grapes, avocado, persimmon, peach, plum, pear, citrus pomelo, lemon, grapefruit, loquat, passion fruit and kumquat, in addition to the existing 10 old fruit orchards (guava, peach, pear, persimmon, mango, pomegranate, avocado, walnut, chestnut, and pecan). The sector was engaged in seed production and distribution of improved vegetable varieties, fruits seedling production and establishment of demo-orchards. A total of 3068 grafted planting materials were distributed to establish 23 mixed fruit demonstration orchard and six (6) focus village orchards (62 farmers) in the region during 2017-2018 FY. More than 900 rootstock seedlings raised and maintained for grafting, and 5500 grafted seedlings made available for development of demonstration and focus village orchards in Jan-Feb 2019. Two private fruit and nut nursery grower from Punakha dzongkhag were identified and provided three rounds of systematic training along with other selected orchard farmers. A total of 887 fruit trees were top worked (Punakha-505 + Wangdue-332=887) during the FY-2017-2018. On-station evaluation of the performance of the tomato lines (Master, Fukuju and Red Tommy Toe) under mid altitude conditions completed, and made available for release was carried out. The sector also produced and maintained breeder seeds of 12 vegetable crops released from centre.

Beside this the sector also supported farmers with mushroom spawn and capacity development on mushroom production. 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 in the FY 2017-2018.

TECHNICAL SUPPORT SERVICE GROUP

The technical support service grup compromise Soil and Land Management Unit, Integrated Pest Management (IPM) and Research Communication.

Soil and Land Management Unit is responsible for providing technical support services related to soil and plant sample testing and giving recommendations and necessary services related to soil and land management. Over the year, we are involved in soil sampling in farmers' field and also on station for research purpose. The unit also carried out activities to promote organic farming in the region. Promotion of green manuring, composting, and vermi-composting and use of EM solution are being promoted in the region. The unit also promote and carried out various SLM activities in the region in collaboration with Dzongkhags and NSSC Semtokha to combat land degradation. We maintained a Napier multiplication block which is the source of Napier cuttings used in SLM activities. In order to have concrete data on land degradation in the region two soil erosion measuring plot are being maintained at Royal Project Chimipang and ARDSC Menchuna respectively.

Major actiovities carried out by IPM unit are: Survey study on Insect Pests, its Natural Enemies and Diseases Occurrence in Fruits and Vegetables in West Central Bhutan; The efficacy of Mixol 72 against chilli blight, trials on Electric Fencing Using HDPE Pipe and Bird Net Installation for Pear and Persimmon Orchard; Large Scale Promotion of IPM Technologies which includes Comparative-demonstration on use of herbicides againstshochum and other rice weeds (On-station) and Rice stem borer management using pheromone traps (On-station and on-farm)

The Research Communication sector is mainly responsible for disseminating successful research results of all research disciplines of the Centre to the extension system of various departments for their adoption and adaption. In 2017-18 a total of 10 publications were developed and published. These publications consist of both technical and extension materials. Beside the development of extension materials, the Centre published a series of technical papers in both international and national papers as journal papers. RCO Unit has collected detailed lists of RNR publications produced by ARDC Bajo as well as publications shared by other sister RDCs, Central Agencies, Department and other relevant agencies and maintained in the library as reference. Library cataloguing has been maintained by the sector. To maintain the historical records, the RCO Unit has carried out research on documentation of old pictures and photos of research activities of ARDC-Bajo into photos albums. More than 2500 pictures are categorized, levelled and maintained into photo album under various research activities.

During this fiscal year 2017-2018, this Centre was visited by various groups of visitors comprising farmers, students, youths, trainees from various schools & institutes, Dzongkhag RNR Extension staff and Research officials. Learning objectives of visitors varied from one group to another. It has been found that farmers are more interested in seeing new crop varieties, which are high yielding. Extension personnel are also keen on new technologies and information related to those technologies whereas trainees, outsider guests and other institution visitors have specific objectives visiting the Centre.

NATIONAL SEED TESTING AND REFERRAL LABORATORY

The National Seed Testing and Referral Laboratory was recently established as per the Organization Development program of RCSC and has two staff working in it. It is responsible for carrying out necessary tests like germination, purity, moisture etc. It is the referral point for testing various parameters in seeds of various crops and caters its services all over the country. Currently, most of their clients include ARDCs, BAFRA, NSC, interested farmers and private seed companies. The laboratory is in serious need of Laboratory Officer to further strengthen the work and activities of the laboratory. In the past one year around 150 samples from vegetables and cereals crops were tested at the laboratory.

ENGINEERING SECTOR

Engineering services provided by the Engineering Sector included preliminary site visits, total station survey, preparation of designs, drawings, estimate, BoQ, tender document, tendering & awarding, implementation, passing of bills, and taking over of the work from the construction firms. In 2017-18 the sector provided services for 46 activities with estimated value of Nu 697.636 million. This translates to average of 11.2 activities per engineer per year based on the bid price was Nu 24.002 m per engineer.

From a total of 56 activities 19 activities were related to irrigation infrastructure development while 37 were related to general construction works. These activities were implemented for six agencies (ADRC Bajo, ARDSC Tsirang, Royal Project Chimipang, NSC Bajo, NSC Phobjikha and DFO Dagapela) in the region under the Ministry of Agriculture & Forests and four Regional Client Dzongkhags (Dagana, Punakha, Tsirang & Wangdue).

Amongst the ten agencies the highest number of engineering services were provided to ARDC Bajo of 19 activities followed by Royal Project Chimipang, Divisional Forest Office-Dagapela, and Dzongkhag of 12, 9 and 8 activities respectively. In terms of estimated value of the work the highest was for Dzonkhag Administration Wangdue worth Nu 598.678 m

followed by Divisional Forest Office Dagapela of Nu38.635 m, Dzongkhag Administration Punakha (Nu 33.974 m), DA Tsirang (Nu 31.317 m), DA Dagana (Nu 29.499 m), Royal Project Chimipang (Nu28.034 m), ARDC Bajo (Nu13.594 m) and rest were worth less than Nu 3.0 m.

CHIMIPANG ROYAL PROJECT

At Chimipang Royal Project (CRP) during the 2017-18 financial year, the Field crops program utilized 25 acres of wetland under various crops production and completed 15 acres of land development to standard terraces. The CRP produced 19 tons of paddy and one ton of Mung Bean.

Seven acres of land was used for producing different seasonal vegetables. A total of 10 acres land is utilized for fruit orchard and two acres under floriculture production. Different fruit trees are planted and being managed. Mushroom program focused on production of Shiitake and Oyster mushroom. The program cultivated 3000 Shiitake billets and 815 bags of Oyster mushroom. A total of 211 kg of oyster mushroom was produced whereas Shiitake is still under incubation period. Straw berry program multiplied and produced 10,000 runner plants and 215 boxes of fresh fruit. Floriculture program supplied flowers to various important national events and the Royal Bhutan Flower Exhibition 2018 in Punakha. During the financial year 2017-18, the CRP produced more than 41,000 potted flowers.

Forestry sector executed activities on ornamental tree nursery, plantation for greenery, windbreak, irrigation supply, orchid production and landscaping. The sector constructed two irrigation reservoirs and supplied drinking water from Chasagang. Landscaping was done in identified location and ornamental tree species were planted. Both native and exotic varieties of orchid supportedby Royal Project Foundation, Thailand were promoted.

AGRICULTURE REAEARCH AND DEVELOPMENT SUB-CENTRE, TSIRANG

The Agriculture Research and Development Sub-Centre (ARDSC) is located at Menchuna, Tsirang. At the Sub-Centre, the horticulture sector with the support of the IHPP/JICA project, engaged in seed production and distribution of improved vegetable varieties, fruits seedling production and establishment of demo-orchards. In the financial year 2017-18, more numbers of demo orchards and increase in supply of vegetable seeds were achieved. One of the key achievements was the watermelon cultivation which was promoted for the first time in Tsirang district. The fruits and nuts trials and germplasm maintenance are also regular annual activities which were implemented successfully. Besides the main objective to maintain high health status citrus mother block, the National Citrus Repository also supplied citrus seedlings and citrus orchards were established both at Tsirang and Dagana districts.

The field crops sector focused on the evaluation of rain fed rice lines, on farm evaluation of advanced rice lines, characterization of traditional rice varieties received from National Biodiversity Centre, Serbithang and on-farm evaluation of popular local rice variety Khamtey. On station and on farm trials of heat resilient maize lines and three varieties of quinoa were other major activities. The three varieties of quinoa evaluated gave promising results and is planned to be scaled up in the coming financial year through increase in on-farm production. Seed production of improved wheat and mustard varieties were also implemented in this financial year. The seeds were distributed to promote these improved varieties.

1 FIELD CROPS

1.1 Rice Research

In 2017-2018 FYP, the Field Crops program evaluated 130 germplasm 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). The details of rice research activities undertaken by ARDC Bajo are discussed under the following headings.

1.1.1 Introduction Nursery

In 2017-18, forty eight 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 condition (Table 1-1). From these, twenty best lines were selected for 2018 observation nursery from which lines will undergo vigorous screening and best ones will be selected for replicated initial evaluation trial (IET) in 2019.

Table 1-1: Agronomic performance of IIRON on station

SN	Designation	50% FWD	Plant Height (cm)	No. tillers (per hill)	Grain yield (ton per ha)
1	TP18154	132	99	11	7.00
2	TP30619	127	112	10	6.70
3	TP30614	129	110	13	7.60
4	TP30622	112	111	15	6.00
5	TP30623	124	111	12	6.50
6	TP30605	115	111	9	5.80
7	Local check	117	100	12	5.50
8	TP30602	116	103	11	5.50
9	TP30617	127	115	12	5.80
10	TP30596	115	92	13	6.50
11	TP30601	112	88	14	5.80
12	TP30612	125	92	15	6.10
13	TP30627	136	110	14	6.00
14	TP24362	119	107	11	6.00
15	Local check	120	103	10	6.00
16	C48(local check)	118	95	14	5.50
17	TP16228	98	78	9	3.50
18	TP30615	119	91	14	6.10
19	TP30626	128	106	11	5.80
20	TP21654	118	100	13	5.50
21	TP30604	114	104	8	5.50
22	TP30621	132	113	13	5.40
23	TP30597	126	104	12	5.50
24	Local check	114	104	9	5.00
25	TP30616	120	124	13	5.60
26	TP30624	112	114	12	5.40
27	EN-047	120	115	13	4.80
28	TP30613	122	105	12	6.00
29	TP30611	117	114	10	4.70
30	Local check		101	10	5.50

31	TP26777	132	125	13	5.10
32	TP30598	127	110	16	5.20
33	TP30599	126	108	14	6.50
34	TP30600	116	108	13	4.70
35	TP24370	132	100	12	5.80
36	TP30620	129	106	11	6.40
37	TP30484	116	108	11	6.60
38	TP30610	119	106	11	6.40
39	TP30603	115	105	11	6.10
40	TP29714	127	109	12	6.40
41	Local check	124	109	12	5.90
42	TP30607	120	97	11	5.30
43	TP30618	126			
44	TP30625	113	101	15	7.00
45	TP30609	110	113	10	5.50
46	TP30606	116	106	12	6.10
47	Local check	121	110	12	5.70
48	TP30608	118	109	12	5.80

The information on the performance of selected lines is presented in Table 1-2 below. The selected lines fall within a maturity duration of 130-160 day with plant height ranging from about 90 cm to 115 cm.

Table 1-2: Agronomic performance of observation lines on-station.

SN	Designation	50%FWD	Plant height (cm)	No. of tillers (per hill)	Grain yield (t/ha)
1	IRRI 154	127	97	14	4.71
2	IRRI 156	132	114	16	5.11
3	IR 11A 306	124	104	16	4.05
4	IR 12N 110	134	100	17	8.40
5	IR 14D 155	126	103	16	4.25
6	IRRI 174	119	101	12	4.25
7	IRRI 123	118	92	16	4.30
8	IR 12L 248	120	101	17	5.50
9	GSR IR1-3-S6-XI-YI	122	111	13	5.25
10	IR IIA 534	118	102	15	5.25
11	IRRI 146	120	87	11	4.75
12	GSR IR1-14-D12-L1-L1	118	104	13	4.65
13	IR IIA 501	116	83	15	4.20
14	IRRI 180	124	110	19	5.15
15	IR IIA 255	132	90	18	4.75
16	IR 1OM 210	105	82	19	3.40
17	IR 12L 130	122	115	14	4.80
18	IR IIN 313	126	109	16	4.67
19	IRRI 179	124	18	16	5.75
20	BK 2	116	103	14	3.80

1.1.2 Advance Evaluation Trial (AET)

Under AET, 16 entries including standard check Bajo Kaap2 were evaluated (Table 1-3). 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 from an area of 5.04 sqm.

Table 1-3: Agronomic performance of AET lines on-station

SN	Designation	DTF	Plant height (cm)	No. of tillers (per hill)	Grain yield (t/ha)
1	IR96120	120	110	12	8.20
2	IR11 A208	123	102	10	7.20
3	IR10 E336	122	106	13	7.14
4	IR09 A228	121	105	12	6.94
5	IR09 A220	117	106	15	8.53
6	IR10 N269	121	103	15	7.14
7	IR05 A235	122	113	10	6.94
8	PK3445-3-2	126	109	13	8.13
9	CB 08514	119	106	15	9.12
10	IR 06N 170	123	100	15	7.34
11	IR10A 134	121	103	16	7.34
12	IR09N 522	121	98	13	6.94
13	IR08 N210	121	98	12	7.53
14	MMP	124	102	11	5.35
15	SAHABHAGI	116	102	10	6.94
16	BK 2	112	97	11	7.20

1.1.3 Seed production

From the trial plots, seed production and demonstration blocks, 10 MT paddy seed was produced in 2017 season (Table 1-4). Paddy seeds of the released varieties such as Bajo Kaap1and 2; Bajo Maap1 and 2; IR-64; IR20913; were produced to support promotional programmes in the Dzongkhags. Bajo also produced some seeds of unreleased varieties like IR28, Ceres, TME 80518 Zhanghan were for seed multiplication and to supply to farmers for on-farm.

Table 1-4: Quantity of seed produced from released and potential varieties

SN	Variety	Quantity (kg)	Remark
1	Bajo kaap -1	192	Released variety
2	Bajo kaap -2	197	
3	Bajo maap -1	513	
4	Bajo maap-2	428	
5	IR 64	4009	
6	IR 20913	515	

9	IR 28	1799	Not released
10	Ceres	517	
11	TME 80518	60	
12	Zhanghan	138	
15	Nabja	262	local variety
16	Tan Tshering	260	
17	Bonday	222	
18	Trial boarders (Mixture)	1638	from trials
	Grand total	**10,750**	

1.1.4 Promotion of HYV variety seeds

Like in the previous years, the national rice continued to promote improved rice varieties on larger scale. HYV seeds were supplied to different Dzongkhags based on the potential and needs of the Dzongkhags. Larger share of improved seeds has been allocated to major rice growing Dzongkhags like Sarpang, Dagana and Samtse which accounted for about 64% of the total seed supply. The programme also catered to other regions based on the demands and needs. Altogether, the national rice programme was able to promote 25.03 MT of improved seed comprising of six varieties across the Dzongkhag (Table 1-5).

Table 1-5: Quantity of improved rice seeds supplied to potential Dzongkhags, 2017-18

Dzongkhags	Bhur K1	IR 64	Khangma Maap	YRM2	Bajo Maap2	No 11	Total
Sarpang	13,030	0	0	0	0	0	13,030
Punakha	0	1,000	1,000	600	1,500	0	4,100
Wangdue	0	800	0	800	1,000	1,300	3,900
Dagana	0	0	3,350	0	650	0	4,000
Total	**13,030**	**1,800**	**4,350**	**1,400**	**3,150**	**1,300**	**25,030**

1.1.5 Phenotypic characterization of traditional land races of rice

1.1.5.1 Introduction

ARDC Bajo received a total of 124 accessions of traditional land races of rice from NBC for the phenotypic characterization and seed production during the 2017 season. Of the 124 accessions, 114 germinated and basic morphological data were collected from 96 accessions. However, all 96 accessions did not do well and some had to be discarded. Most of the lines were found to be highly susceptible to diseases and heavy lodging. Thus, we could study and harvest seed from only 90 accessions despite all efforts. Moreover, most of the lines were also highly mixed and had to be discarded during harvesting. Overall, the phenotypic characterization exercise was a success and gave immense experience to our new researchers and field workers. The basic plant characters are discussed briefly in the following paragraphs.

1.1.5.2 Qualitative characters

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 (Annex 1 and 2). Almost all the accessions had semi-erect

to descending flag leaf which is a typical characteristic of traditional varieties. There was also diversity in basal leaf sheath colour and ligule types as detailed in the Annexes.

1.1.5.3 Quantitative characters

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). As seen in Annex 3 and 4, 99% of accessions were very tall with plant height of 170-190 cm, thus rendering them highly susceptible to lodging. Similarly, the maturity duration of all the accessions exceeded 160 d and some even took as many as 200 days to mature. Regarding the panicle length, most of the accessions had long panicles with medium density (compactness). For grain type analysis, length, width and L/B ratios of the grains (paddy and dehulled grains) were taken using digital vernier calipers. Based on the grain information, inferences 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 as detailed in the Annexes. The grain analysis also included data on kernel and hull colours.

1.1.5.4 Post harvest grain analysis

Analysis of grains after the harvest showed that there was great diversity in size, colour and shapes. Annex 5 presents information on the grain of accessions saved for conservation at the gene bank at NBC. The grain categorization into three different shapes and sizes were done based on the scale of Standard evaluation system of the International Rice Research Institute (IRRI, 2002).

1.2 Wheat Research

1.2.1 Evaluation of Nepal Lines

Wheat is considered as third important cereal crop in Bhutan after maize and rice. Wheat covers roughly 4% of total cultivated area with production proportion of 3 % in the country as per 2016 RNR statistics. Globally wheat is the leading source of vegetable protein in human food. In Bhutan, wheat research program started only in 1982 with the testing and evaluation of materials received from India and CIMMYT. Thereafter, numbers of 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, Bajosokha kaa, 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. In 2017-18 season, the Centre received three wheat lines (varieties) from Nepal for observation of its production and performance under Bhutanese conditions. These varieties are released and most popular under Nepalese conditions and are considered to be high yielding with wheat rust resistant traits.

Trial was established with single plot design with plot size of 5m x 3m and row to row spacing of 20 cm was maintained. A seed rate of 40 kg/acre and fertilizer dose of 80:40:40 NPK (kg/ha) was applied. Due to delay in paddy harvest and unfavorable weather conditions, sowing was done on 15th December 2017. Timely irrigation, weeding and necessary agronomic practices were carried out based on field situation and requirement. Following international standard format, crop cut from 2x3 m^2 areas was done. Agronomical parameters for days to heading, days to maturity, plant height and yield potential were assessed. The lines were also evaluated for uniformity and resistance against rust diseases.

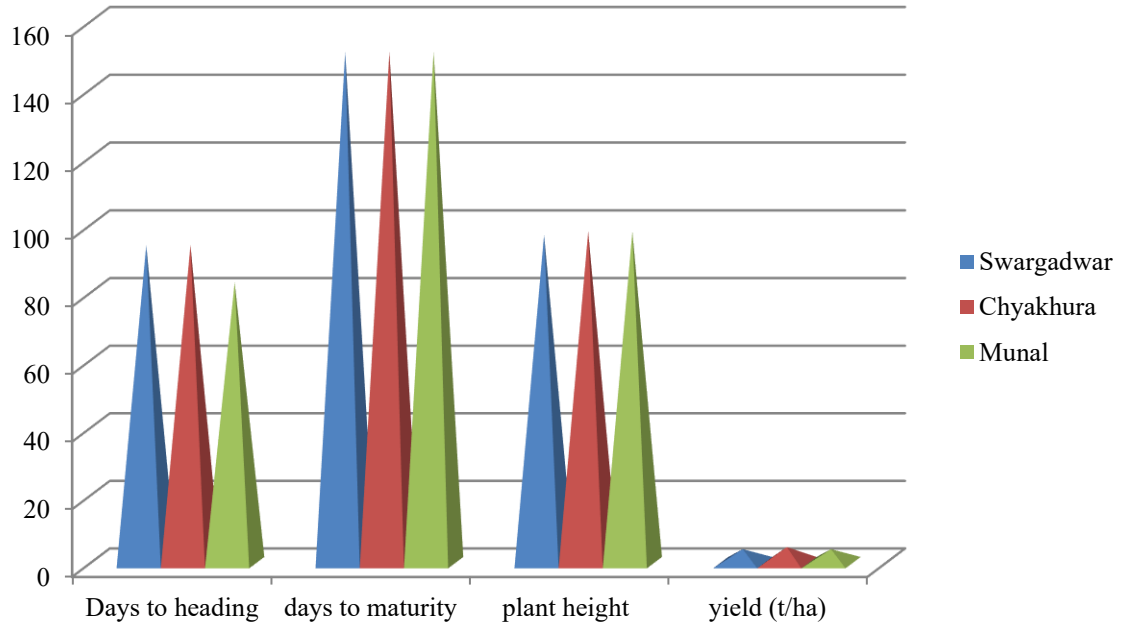


Figure 1-1: Graph indicating plant agronomical parameters

Among the three lines, Munal variety headed first with 83 days from sowing. All three varieties took 151 days to mature. All varieties were grown under same field conditions and uniform agronomic practices and fertilizer application. The Chyakhura and Munal variety had same plant height (98 cm each) on average. However, in term of yield, Chyakhura variety yielded more (4.6 t/ ha) compared to variety Swargadwar and Munal (4 t/ha).

Of the three evaluated lines, all of three showed uniform performance and production under Bhutanese conditions. The slight differences in plant height, days to heading and yield could be due to respective variety potential and minor field conditions and management practices. In terms of disease scoring, all 3 varieties are found resistant to rust diseases with zero score. No other pests and diseases were observed during field visit and diseases scoring. The varieties will be evaluated under Advance Evaluation Trial (AET) in 2018-19 wheat season.

1.2.2 Biofortified lines

Biofortification is a process to increase the bioavailability and the concentration of nutrients in crops through both conventional plant breeding and recombinant DNA technology. It is an idea of breeding crops to increase their nutritional value. Biofortification is seen as an upcoming strategy in dealing with deficiencies of micronutrients in the developing world. 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 biofortifying 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 biofortified wheat lines. The Centre has received 50 biofortified 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.

The trial was established in December, 2017 with single plot design. Plot size of 4mx6m^2 and spacing of 20cm between rows were maintained. Fertilizer dose of 80:80:40 NPK (kg/ha) was

applied. Eight bio-fortified entries 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 $2x3m^2$.

Not much difference was observed for all entries in terms of days to heading, plant height and yield potential. Entries BF 415, BF 434 and BF 450 headed early with 92 days from sowing date (Table 1-6). Entries BF 450 showed shortest plant height of 89 cm compared to entries 415 which had 99 cm plant height as the tallest among the 9 entries. None of the entries were observed with rust diseases infection beside minor occurrence of loose smut (Ustilago nuda) on few plants. In term of yield potential, entries BF 447 and BF 422 yielded highest with average yield of 4.60 t/hac, whereas entries BF 411 and BF 434 gave least yield of 3.60 t/ha respectively.

Table 1-6: Agronomic performance of biofortified wheat lines

SN	Treatments	Days to Heading	Days to Maturity	Plant height(cm)	Disease score (0-5)	Yield (ton/ha)
1	BF 447	93	151	97	0	4.60
2	BF 422	94	151	92	0	4.60
3	BF 431	98	151	93	0	3.50
4	BF 411	96	151	93	0	3.60
5	BF 415	92	151	99	0	4.30
6	BF 434	92	151	92	0	3.60
7	BF 412	94	151	90	0	4.30
8	BF 450	92	151	89	0	3.60
9	BKD (Local check)	94	151	95	0	4.00

Most of the local and released wheat varieties are noticed to be deficient in essential micronutrients like zinc and iron. Therefore, it is important to conduct proper research or study to evaluate wheat cultivars for its micronutrients contents. The entries received from CIMMYT which got adequate Zn and Fe content can be used for breeding purpose in future to improve our local and released varieties in order enhance nutrients content. The harvested seeds will be tested for its essential micronutrients content.

1.2.3 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 (Table 1-7). Leaf rust is the only disease observed throughout crop season.

Table 1-7: Wheat rust surveillance scoring

Entry	2 March, 2018			17 March, 2018			1April, 2018			16 April, 2018		
	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
Faislabad 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
Faislabad 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

1.2.4 Seed production and maintenance

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 regions. Since the National Seed Centre (NSC) is unable to meet seed demand therefore, the National Wheat Program produced seeds of Bumthang Kaa Drukchu. In 2017-18, seeds of following varieties were produced and maintained (Table 1-8).

Table 1-8: Quantities of wheat seed produced and supplied to Dzongkhags

Dzongkhags	**Variety**	**Quantity (kg)**		**Remark**
		Produced	**Supplied**	
Paro	Bumthangkaa Drukchu	1,635	500	
Haa	Bumthangkaa Drukchu	-	700	
Wangdue	Bajosokha kaa	160	-	
	Gumasokha kaa	180	2,480	
Total		**1,975**	**3,680**	

1.3 Oilseeds Research

1.3.1 National coordinated trial on the vvaluation of mustard varieties

Rapeseed and mustard particularly *Brassica campestris* variety toria (tori or peka) is predominately grown and is the major traditional oil crop in the country. It is generally cultivated as a second crop after potato in the hills and after maize and rice in the mid and low altitudes. Rapeseed and mustard production are low compared to other crops, since in most of the areas, mustard just depends on residual nutrients applied to the main crop. The national average yield of mustard is 300 kg/acre. Over the years, area and production of mustard in the country are found declining, which resulted in increasing import of cooking oil. The declining trend could be due to number of factors like less marketing scope for oils products due to easily available oil products in the market, low yield potential of available

mustard varieties, cultivation of cash crops etc. Thus, the need for high yielding varieties and proper research is felt by the National Oilseeds Program. Some of the released varieties such as T-9, BSA, PT 30 and M 27 are more than 20 years old and yield performance has stagnated over the years. The National coordinated trial on the evaluation of mustard varieties is carried out in multi-locations and ARDC-Bajo is one of them.

Five varieties (Unnati, Pragati, BARI Sharisha 14, BARI Sharisha 15 and M 27) were evaluated with RCBD design with 3 replicates. Bari Sharisha 15, introduced from Bangladesh and released as Yuesipeka 15 in 2017 is used as standard check and Yuesipeka 1, originally known as Lumley Tori 1 as local check. Plot size of 15m^2 with spacing of 30cmx10 cm is kept. Thinning and irrigation are carried out when ever needed, and weeds were controlled through two times hand weeding. The trial was established on 12th December, 2017. Data on plant height, number of sliqua per plant; plot yield and yield potential per acre were recorded. The crop cut is taken from a plot size of 6m^2. The trials were harvested on 4th April, 2018.

From five different varieties evaluated, Barisharisha 15 and Yuesipeka 1 had the tallest plant height measuring an average of 58 cm each. However, in terms of number of sliqua per plant, Unnati variety had the highest with 39 siliqua per plant while Barisharisha 15 had the least number of sliqua per plant at 29. Regarding seed yield, Yuesipeka 1 gave maximum yield of 220 kg per acre; while Barisharisha 14 gave least yield of 116 kg per acre.

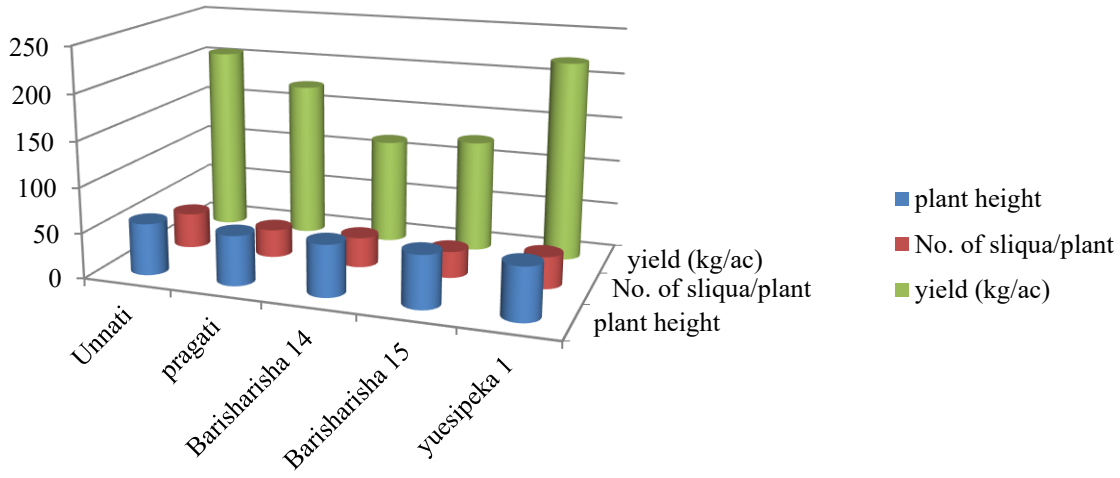


Figure 1-2: Morphology and agronomic differences between variteies

All the five varieties yielded less than national average yield. The low yielding of the varieties could be due to delay in sowing. Usually mustards and rapeseeds are sown right after paddy harvest (late October or November) under Wangdue- Punakha valley. Since there is need to evaluate and identify high yielding mustard and rapeseed variety in the country, the particular trial will be repeated in 2018-19 season.

1.4 Quinoa Research

1.4.1 On-station and on-farm evaluation of quinoa

ARDC Bajo continued with the evaluation and demonstration of promising lines both on-farm and on-station in West-Central Region. The evaluation and demonstrations were carried out in the threeregional dzongkhags of Wangdue, Dagana and Gasa. For these Dzongkhags, a

total of 25 kg quinoa seeds was supplied which was estimated to cover about 25 acres land (Table 1-9). The quinoa varieties included Ivory 123, Amarilla Marangani and Amarilla Sacaca which have been tried at different agro-ecological conditions.

Table 1-9: Quinoa seed distributed for West Central Region 2017-18

SN	Dzongkhags	Variety	Total (kg)	Area (acres)
1	Gasa	Amarilla Marangani & Amarilla	25.0	5.00
4	Dagana	Quinoa Ivory 123	50.0	10.00
7	Wangdue	Amarilla Marangani & Amarilla Sacaca	52.8	10.56
Total			**127.8**	**25.56**

In2017-18 ARDC Bajo also purchased seeds from Dzongkhag (Table 1-10) and other central agencies and the seeds were further distributed to the other dzongkhags and farmers for promoting the crops.

Table 1-10: Quantities of seed produced and purchased

SN	Variety	Quantity (kg)		Producing agency
		Produced	Purchased	
1	A. Marangani	-	170.00	NSC, Phobjikha
2	A. Marangani	-	52.80	Phobji Geog, Wangdue
3	Ivory 123	61.00	50.00	Dorona Geog, Dagana
4	A. Sacaca	50.00	-	
Total		**111.00**	**272.80**	

1.4.2 Evaluation of two quinoa varieties as a winter crop

The objectives of the evaluation were to evaluate the performance of ten varieties of quinoa as winter crop after maize or any dryland crop inlow altitudes areas, and to demonstrate the crop to the farmers and undertake the rapid seed increase and distribution of potential varieties for its rapid promotion among the farming communities. Large observation plots were used. The following varieties were evaluated: Amarilla Marangani, Blanca de Junin, INIA 415 Pasankalla, INIA 427 Amarilla Sacaca, Huancayo, Hualhuas, Salcedo INIA, INIA 420 Negra Collana, DoA-1-PMB-2015 and Quinoa Ivory 123.

Since quinoa seeds are very small and should be handled carefully. Quinoa requires a level, well drained seedbed to avoid water logging. The seeds were sown in line at a row to row spacing of 60cm. Planting was done in line for easy weeding. The seeds were sown uniformly in line and later thinned to maintain a plant to plant spacing of 10-12cm. Good amount of FYM was used in the trial plots. Suphala was also applied during sowing time as it gives good result. Two to three hand weeding were done for good crop growth and weed management. Whole plot was harvested. Harvest usually begins when the plants have dried, turned a pale, yellow or red color and leaves have dropped. The results are computed and presented in Table 1-11.

Table 1-11: Agronomic performance of Quinoa varieties

SN	Variety	Germination (%)	*Plant height (cm)	Grain yield (kg/acre)	Days to maturity
1	Amarilla Marangani	100	103.60	300	110
2	Blanca de Junin	100	102.00	375	115

3	INIA 415 Pasankalla	100	97.20	850	105
4	INIA 427 Amarilla Sacaca	100	130.00	675	114
5	Huancayo	100	107.80	650	118
6	Hualhuas	100	117.00	500	115
7	Salcedo INIA	100	97.40	500	119
8	INIA 420 Negra Collana	100	74.00	400	115
9	DoA-1-PMB-2015	100	105.00	875	105
10	Quinoa Ivory 123	100	87.00	425	105

* Average height of ten plants.

2 HORTICULTURE RESEARCH

2.1 On-station research activities

2.1.1 Establishment of fruits and nuts germplasm

2.1.1.1 Introduction

Research centres across the country depend on ARDC-Wengkhar for the scion woods currently. Moreover, the private nurseries have narrow access to the improved cultivars hampering the multiplication and availability of seedlings. Information on these local and exotic cultivars is limited. There is a need for the establishment of a germplasm block in different parts of the country. Moreover, there is a need to assess adaptability of exotic cultivars of temperate and sub-tropical fruit crops to identify superior cultivars for fruit diversification. Therefore, ARDC-Bajo established germplasm block of exotic and local promising cultivars for future multiplication. These orchards are aimed as a main source of quality scion wood and seeds in future for west central region. Records on vegetative growth, pests and diseases, and their phenological stages for timing of the cultural operations are maintained.

2.1.1.2 Materials and method

Fruit trees were planted in terraces following contour in square and triangular layout. The released and local cultivars/varieties were planted as standard checks for the evaluation of exotic fruit cultivars. Improved fruit management such as pruning/training, fruit thinning and pest control/management were practised for all the orchards. Pruning and training was practised in the month of December and January. Open centre training system was adopted in most fruit crops. Kiwi and grapes were trained on the permanent structure called the trellis where two main branches trained over the wires. Minimum training was adopted on the new plantations while heavy training was adopted for established orchards to manage the tree canopy. For improved fruit size and quality, fruit thinning, fruit thinning was practised for twice or thrice in a season. To protect the fruits from birds, orchards (with grapes, pear, persimmon, loquat, guava and peach) were netted. Fruit bagging was also practised for protection against insect pests, birds and fruit bats. A uniform fertilization of the orchards was done through green manuring, fertilizers and compost manure. The current climatic condition of Bajo requires irrigation in every two-three days interval. Pesticides against pests and diseases were done as and when necessary. Horticulture researchers of the centre collectedinformation on fruit weight, shape index, firmness, and TSS (mass sucrose) content of the pome fruits. For nut crops; fruit weight, size, shell thickness, kernel content, kernel colour and softness were assessed. For other fruit species, fruit weight, size, firmness, and mass sucrose content were assessed.

2.1.1.3 Tools and equipment

Refractometer was used to determine the TSS of fruits. Fruit size was measured with vernier calliper. Citric acid content was assessed by titration method.

2.1.1.4 Results

ARDC Bajo with support from Integrated Horticulture Promotional Project (IHPP)-JICA established 16 new germplasm orchards of subtropical apple, papaya, dragon fruit, kiwi, grapes, avocado, persimmon, peach, plum, pear, pomelo, lemon, grapefruit, loquat, passion fruit and kumquat (Table 2-1), in addition to the existing 10 old fruit orchards (guava, peach, pear, persimmon, mango, pomegranate, avocado, walnut, chestnut, and pecan).

Table 2-1: Fruit crop varieties established in the germplasm block

Crops	Varieties
Peach	Kurataki, Nonomewase, Florida sun, Ngawang
Apricot	Khasha, New Castle
Pear	Yakumo, Niitaka, Hosui, Kosui, Shinko, Chojero
Kiwi	Hayward, Wengkhar yellow, Wengkhar Green, Bajo red, Male
Grape	Stubin, Portland, Campbell, Kyho
Dragon fruit	Thailand
Pomelo	R3P4, R4P5, R3P9
Lime	Frost Ureka
Loquat	Mogi, Tanaka
Avocado	Brokdown, Hass, Bacon, Zutano, Local selections
Persimmon	Jiro, Fuyu, Yakumo, Zinjimaru, Hanagosho, Taishu
Plum	Honey Rosa, Santa Rosa, Soldum, Kiyo, Oishi wase
Citrus	Dekopon, R4-P5, Hayaka, Ohtsu-4, Kumquat, Clementine, Ohta-p, Tharku, Banpeiyu

The orchards also serve as the management technology generation and demo-site for providing hands-on training for Researchers and extension agents by the Project Experts. Information on the evaluation of local and exotic varieties for identification of potential varieties from the germplasm collection is covered in individual crop reports presented as separate topics in the later sections.

2.1.2 Dragon fruit (Hyploceruc undatus) Adaptability Trial

2.1.2.1 Introduction

Dragon fruit is a fruit of several cactus species, most importantly of the genus Hylocereus. It is native to South and Central America, belong to perennial epiphytic plant. It is also commercially cultivated in Vietnam, Thailand, Malaysia, Israel as well as Sri Lanka. It is mostly cultivated in the tropical region of the world, where the region experiences wet summer, as well as dry zone with the irrigation facilities. Dragon fruit is new crop and it is now gaining popularity in Bhutan. To add another high value crop to the already existing fruit crops, the Centre conducted an adaptability trial in the sub-tropical region of the country to evaluate its performance under sub-tropical condition at ARDC Bajo on station.

Figure 2-1: Dragon fruit samples

2.1.2.2 Materials and Methods

40 dragon fruit vines were brought from ARDSC, Lingmethang and planted in four lines with spacing of 1mx2m at ARDC Bajo on station. About 600 kg of Farm yard and chicken manure and about 500 g of suphala were applied during field preparation in an area of 50m^2. Training of the branches was done by maintaining only two main branches and establishing trellises with wooden column and car tyre. Black plastic mulching with timely intercultural practices was followed for proper growth and development. Data on flowering, maturity and other fruit characteristic were recorded for analysis. Random sampling method was used to collect fruits for the study.

2.1.2.3 Result & Discussion

Most of the vines started producing fruits after one year of planting. The first flowers bloomed (white flower) around mid–June and it takes around 14 days to flower from the bud. Fruit matures in 30-35 days at optimum temperature (160C-300C). However, in low temperature, it takes about 40-44 days. In sub-tropical region, the vines start fruiting from June till December and it undergoes dormant phase for another 6-7 months. The crop does not have any major pest and disease infestation but some of the lower stems had been damaged by the rodents. It was observed that the flowering and maturity is late than the tropical areas and therefore also have effect on the size, weight and brix content. The information on morphological and fruit characteristics is presented in tables 2-2 and 2-3 as average of the samples.

Table 2-2: Morphological characteristic of the samples harvested for first year

Date of flowering	Date of harvest	Average yield(kg)
Mid June	Mid-July to Dec	16.00

Table 2-3: Fruit characteristics and quality aspects

Weight (gm)	Dia (cm)	Length (cm)	Peel thickness (mm)	Peel weight (gm)	Fruit skin (colour)	Fruit pulp (colour)	Brix (%)
372.2	8	10.56	3.28	108.6	Pink	White	10.4

2.1.2.4 Conclusion

The dragonfruit (Gewarinpa 1) released from ARDC Wengkhar performed well under ARDC Bajo condition. Therefore, it is recommended for the places with agro-climate similar to ARDC Bajo.

2.1.3 Evaluation trial on Mango

2.1.3.1 Introduction

Mango is a popular fruit and consumed all over the country. The fruit is mostly cultivated in tropical region of the country and now adopted in some sub-tropical region. But there is limited information on varietal evaluation under subtropical condition. The objective of this trial was to evaluate the promising mango cultivar which is suitable for the sub-tropical region of Bhutan.

2.1.3.2 Materials and method

Tomy atkin, Chin Hwang and Bajo amchukuli-1 were the lines for evaluation. Tomy atkin and Chin Hwang cultivars varietieswere introduced from Thailand in 2003.Trees were planted at spacing 4mx4m in single line with five trees for each cultivar. The morphological and fruit characteristics of the treatments were compared against Bajo amchukuli-1(Deshari). Bagging and netting of the fruits against insect and bird attacks was practised. Dried stalk and natural dropping were used as harvest indices for the study. Organoleptic test was conducted for the taste evaluation.

2.1.3.3 Result and Discussion

The two cultivars were both observed to be late varieties and have better shelf life compared to Bajo amchukuli-1. Morphological characteristics of the treatments are stated in Table 2-2. Both the cultivar surpassed the control in all the parameters (Table 2-3). In the Organoleptic

test, 100% of the participants preferred two cultivars to Bajo amchukuli-1. Tomy atkin surprisingly proved as one cultivar to be recommended both in tropical and sub-tropical region against the hope of the researchers.

Table 2-4:Morphological characteristic

Cultivar	Tree appearance	Fruit shape	Flowering time	Harvesting time
Tommy atkin	Spreading	Large &Oval	Feb-March	August
Ching Hwang	Spreading	Oblong	Feb-March	Mid Oct-Nov
Bajo Amchukuli-1	Spreading	Small &Oval	Feb-march	Mid Oct-Nov

Table 2-5:Fruit characteristic and quality aspects

Cultivar	Average Dia(cm)	Average height(cm)	Averagefruit weight (gm)	Average Brix (%)
Tomyatkin	10.0	13.54	693	17.4
Ching hwang	94.0	219.00	1200	23.1
Bajo amchukuli-1	5.4	9.10	156	16.0

2.1.3.4 Conclusion

The Tomi atkin and China hwang cultivars are recommended for subtropical region as well.

2.1.4 Evaluation of bitter gourd Lines from AVRDC

2.1.4.1 Background

Bitter gourd (Memordica charantia) also known as bitter melon, balsam pear, bitter apple and bitter African or wild cucumber is one of the important vegetables. The market for the bitter gourd is increasing as many people purchase it for its taste and health benefit such as anti-diabetic properties. However, the local bitter gourd which is smaller in size is not popular and the ones imported from India with high health risk dominate the market. The objective of this study was to evaluate the performance of the bitter gourd lines under mid altitude conditions and recommend the best line for cultivation in similar agro-climatic condition.

2.1.4.2 Materials and method

A total of seven varieties were used with local cultivar as control. The seeds were sown in second week of April and transplanted in first week of May. Twelve plants per line were planted at plant to plant distance of 2mx2m. Bamboo trellis was used to provide support for the vines. The seeds for the succeeding years are maintained from the best performing lines. The performance of the different lines was compared against the local.

2.1.4.3 Results

From the performance of the different lines against local, the three top performing lines AVBG 1301, AVBG 1314, and AVBG 1327 were selected. These three lines are still under observation in current season. Further study will be carried out before the recommendation.

2.1.5 Evaluation of Pumpkin Lines from AVRDC

2.1.5.1 Background

Pumpkin (*Cucurbita moschata*) is an annual warm season crop with branched tendrils. The local pumpkins are very large in size. The pumpkins are sliced into smaller sizes and sold.

This system of market isunhygienic. This study was aimed forselecting better marketable sized pumpkins and recommend for cultivation under similar agro-climatic condition.

2.1.5.2 Materials and method

The treatments were AVBP-1394, AVBG-1396, AVBG- 139 and Wengkher Kakur. The popular local variety Wengkhar Kakur was used as check. The seeds were sown in the third week of February 2018 and transplanted in last week of March. For each line, 10 plants were planted for the study at 2mx2m spacing. Random sampling method was used for fruit selection for the study. The performance and the fruit characteristics were compared.

2.1.5.3 Results and Discussion

The AVPU-1397 was bigger in size and heavier compared to the check. The AVPU- 1394 and AVPU 1396 were smaller and weighed lesser than Wengkher Kakur. The average weight, diameter, and height of the different treatments are given in Table 2-6.

Table 2-6: Fruit specifications of different treatments

Variety/Lines	Average weight (gm)	Average diameter (cm)	Average height (cm)
AVPU 1394	862.7	13.55	7.68
AVPU 1396	1185.1	14.55	9.14
AVPU 1397	1363.3	16.30	8.45
Wengkher Kakur	1305.5	13.85	9.75

2.1.5.4 Conclusion

From the study, AVPU 1394 is recommended for cultivation. The fruits of this line were the smallest and weighed minimum.

(a) (b) (c) (d)

Figure 2-2: Pictorial presentation of pumpkin varieties

2.1.6 Adaptability Evaluation of Tomato Lines (*Lycopersicum esculentum*)

2.1.6.1 Background

Every year, a huge amount of tomato is imported from India. To attain self-sufficiency, we need to produce enough. However, there are limited cultivars that perform well under local agro-climate. In order the meet the local demand, there is a need to identify and produce varieties which perform well under local conditions. The objective of the study was to evaluate the performance of different lines and recommend for cultivation.

2.1.6.2 Materials and method

ARDC Bajo started evaluating three tomato lines; Master and Fukuju from Japanand Red Tommy Toe from Australia provided by Department of Agriculture. Rattan, the released variety was used as check. The seeds were sown in first week of February 2018 and transplanted in first week of April. A total of 36 plants with spacing 60cmx50 cm were planted for each tomato lines. The plants were tagged after planting in order to reduce biasness and error. Ten plants from each line were randomly selected and evaluated to find out the performance of the individual lines. The non-marketable yields of the different lines were collected.

2.1.6.3 Results and Discussion

The average yield, fruit weight, and percent non-marketable yield of the different lines were compared. The Fukuju line gave the highest yield (Table 2-7) but the highest percent non-marketable yield. Percent non-marketable yield was the least for Red Tommy Toe.

Table 2-7: Fruit Performance of lines

Variety/Lines	Average Weight (gm)	Weight/Fruit (gm)	Non-Marketable Yield (%)
Master	864	89	16
Fukuju	1321	120	25
Rattan	562	72	23
RTTO	990	18	5

2.1.6.4 Conclusion

From the study, Red Tommy Toe an Australian variety ranked second in yield but the percent non-marketable yield was least. Therefore, Red Tommy Toe line is recommended for further study and release for cultivation under local agro-climatic condition.

2.1.7 Evaluation tomato lines for year-round cultivation

2.1.7.1 Introduction

Tomato is a popular vegetable grown all over Bhutan and there is a great demand for a year-round tomato production and supply in the market. However, the local varieties are susceptible to phytopthora blight disease and remain a challenge for crop cultivation for year-round production. The object of this activity was to evaluate the late blight resistant lines to release for cultivation under year-round cropping system.

2.1.7.2 Materials and method

In order to check the suitability of the lines for year-round production, ARDC, Bajo cultivated 8 different lines and compared the performance against check (Rattan) during July to September 2017. First batch seeds were sown in July and transplanted in September. The second batch seeds were sown in August and transplanted in third week of September. Spacing for transplant was 50cmx60cm. Using random sampling method, ten plants from each replication were evaluated. Attacks by different pests and diseases were studied.

2.1.7.3 Results and findings

The July-August batch failed and no data was collected. The average yield and percent non-marketable yield of the different lines from the second batch transplant indicates that LBR-6 yielded highest followed by CLN 2366 A (Table 2-8). The yield of the prominent local variety (Rattan) was the least. The high percent non-marketable yield of Fukuju line was due to fruit cracking and higher susceptibility to different pests and diseases.

Table 2-8: Productivity of different lines

Lines	Average Yield (gm)	Non-marketable Yield (%)	Remark
Master	726	23	
LBR-6	968	17	
Fukuju	553	66	
Rattan	280	20	
CLN 2070 A	90	44	
CLN 2366 A	938	2	
LBR-10	770	27	
LBR-11	793	19	
RTTO	711	2	

2.1.7.4 Conclusion

The CLN 2366 A and RTTO performed better than the rest and were less damaged by pest and diseases in Bajo condition. The lines will be studied under different environmental conditions at different on-farm sites. Other indicators to be studied in the on-farm sites are the plant growth habit, resistant to pest and diseases.

2.2 Horticulture Developmental Activities

2.2.1 Production of quality seeds and seedlings

The lack of quality planting materials in the region is seen as main drawback for sustainable horticulture development in the region. Moreover, lack of trained private nursery operators in the region also contribute to impacting the development. Therefore, to address insufficiency of quality seeds and seedlings, the IHPP/ARDC Bajo expanded the existing nursery, focusing on ensuring the availability of seeds and seedlings in the region. Besides, one of the main out-put of the project is to train private nursery growers in the region, and to support them with promising mother plants. This nursery and mother trees also serve as a training field for private nursery operators and extension agents where hands-on training on different grafting techniques and technical guidance are provided. The objectives were to produce quality seedlings required for research outreach program and support private nursery operators in establishing the mother block of the released varieties, and conduct hands on training.

The potential varieties of both released and promising cultivars of fruits and vegetables are produced and maintained. The nurseries are managed following the improved nursery production practices. For rootstock production seeds of local fruits are extracted in the absence of improved commercial rootstocks. Scion woods are collected from the mother block maintained at the station and from ARDC Wengkhar during Dec-Jan. Grafting operations were done during the month of February end (green house) and March-April (open field). During the fiscal year 2017-18, a total of 4963 grafted fruit crops, and more than 10000 rootstocks were produced (Table 2-9).

Table 2-9: Planting materials produced and maintained in nursery

Particulars	Variety	Total	Remarks
Pomelo	R3P4, R4P5, R3P9	110	Grafted
	R3P4, R4P5, R3P9	60	Grafted
Grapes	Campbel	50	Cuttings

Avocado	Hass	15	Grafted
	Bacon	15	Grafted
	Brokdown	25	Grafted
	Fruti	25	Grafted
	Zutano	20	Grafted
	Local avocado selection	20	Grafted
	Rootstock Seedlings	2,000	Seedlings
Lemon	Frost Ureka	20	Grafted
	Kumquat	100	Grafted
Citrus rootstock	Trifoliate USDA	100	Rootstock
Apricot	New Castle	80	Grafted
Kiwi	Wengkhar green (Elm Wood)	300	Grafted
	Wengkhar yellow (Yellow Joy)	150	Grafted
	Bajo Red	250	Grafted
	Male kiwi	90	Grafted
	Heyward	200	Grafted
	Rootstock seedlings	500	Seedlings
Persimmon	Rootstock seedlings	2,000	Rootstock
	Jiro	230	Grafted
	Fuyu	400	Grafted
	Zinjimaru	130	Grafted
	Yubeni	230	Grafted
Loquat	Mogi Tanaka mixed	300	Seedlings
Pomegranate	Chaula	1,500	Seedlings
Pecan nut	Mixed	242	Seedlings
Walnut	Local	300	Rootstock
	Local Soft	500	Grafted
Pear	Shinko	178	Grafted
	Niitaka	360	Grafted
	Hosui	600	Grafted
	Yakumo	350	Grafted
	Chojero	800	Grafted
	Kosui	300	Grafted
	Meigetsu	190	Grafted
	Mixed	200	Grafted
	Local root stock	1,000	Seedlings
Guava	Pink flesh	1,000	Seedlings
Peach	Local	13	Seedlings
	Beauty cream	70	Grafted
	Florida sun	15	Grafted
	Kurataki	50	Grafted
Plum	Honey Rosa	140	Grafted
	Ohishi Wase	30	Grafted

	Soldum	160	Grafted
	Kiyo	100	Grafted
	Santa Rosa	90	Grafted
Dragon fruit	Thai	50	Seedlings
Total		**15,158**	

Vegetable seeds were also produced on-station as to maintain basic seeds and for outreach program and varietal evaluation trials (Table 2-10).

Table 2-10: Vegetable seeds produced on-station

SN	Name of crop	Variety	Quantity (kg)
1	Broccoli	Desico	26.00
2	-do-	SP Green	4.60
3	Bunching Onion		2.50
4	Cauliflower	White Top	2.50
5	-do-	Wengkhar Metokopi I	6.50
6	-do-	Wengkhar Metokopi II	5.00
7	Chinese Cabbage	Kyoto	0.49
8	-do-	Ousho	1.75
9	-do-	Mix	1.90
10	Mustard Green	Wengkhar Patsey I	10.00
11	-do-	Wengkhar Patsey II	2.12
12	Radish	Minowase	24.00
13	-do-	Shogoun	26.00
14	-do-	Sakurajima	13.00
15	Spinach	Jiromao	5.73
16	Pea	Japan Long	9.75
17	-do-	Japan Flat	31.00
18	Beans	Gray pole	50.00
19	-do-	White pole	50.00
20	-do-	White dwarf	30.00
Total			**302.84**

Outcomes and recommendations

- Fruit and nut nursery production technologies suitable within the region are available at ARDC-Bajo. Seven private nursery operators were established and trained in nursery production and management.
- The centre should continue to support the local nursery operators, through hands on training and technical backstopping.
- To cater the seed and seedling needs of the region, promote more trained private nursery growers.
- Identify vegetable seed growers in the region and provide basic training on seed production and maintenance.

2.2.2 Vegetable breeder seed maintenance

ARDCs are mandated to maintain the breeder seed of various crop released from their centre. The vegetable breeder seed produced maintained, and issued from July 2017- June 2018 are as (Table 2-11) below.

Table 2-11: Breeder seeds produced and maintained

SN	Crop variety	Qty. P/P (kg)	Quantity issued to (kg)	
			NSC	Other agencies
1	Bean- Borloto	11.50	2.0	3.0 (Wangdue, Bjena gewog)
2	Bean- Pusa Parvati	12.00	5.0	4.0 (Tsirang)
3	Bean- Top Crop	18.00	5.0	8.0 (5kg,3kg (BHSS))
4	Bean- Rasma	13.00	-	6.0 (Tsirang and Dagana)
5	Brinjal- Pusa Purple Long	3.40	0.2	1.9 (Punakha and Wangdi).
6	Broccoli- Desico	3.60	-	3.0 (Tsirang, Wangdue and Punakha)
7	Cabbage- Golden Acre	0.10	-	-
8	Cauliflower- White Top	2.50	-	2.0 (Punakha and Wangdue)
9	Chinese Cabbage- Kyoto 1	0.05	-	-
10	Carrot- Early Nantes	1.50	0.2	1.0 (com.veg production) Punakha & Wangdue
11	Chilli- Sha Ema	0.10	-	-
12	Radish- Bajo Laphu 1	1.50	-	-
13	Radish- Spring Tokanashi	0.10	-	-
14	Spinach- All Green	5.50	-	4.0 (Punakha, Wangdue Tsirang)
15	Tomato- Roma	1.00	-	0.5 (Punakha and Wangdue).
16	Tomato- Cherry Tomato	0.20	-	-
17	Tomato- Bajo Lambenda 1	0.20	-	-
18	Watermelon- Sugar Baby	0.05	-	-

Note: P/P = Quantity Produced

2.2.3 Promotion of fruits and nuts

The past extension system in promoting the fruit and vegetable crops failed due to lack of proper planning and implementation system. Trainings on fruit and vegetable cultivation were provided but inputs required such as quality seeds and seedlings were not provided, which resulted in poor adaptation of recommended practices. The IHPP-JICA introduced the new system for promotion of fruits and nuts through systematic training and orchard establishment in the region wherein complete package of training on fruit cultivation along with the required inputs. Objectives were to promote fruits and nuts through systematic training and orchard establishment in the region and to establish demonstration orchards to demonstrate management technology to farmers.

ARDC-Bajo in collaboration with Dzongkhag Agriculture Office and gewog extension selected potential farmers based on the criteria developed by IHPP. Pre-selection of farmers was done by the geog agriculture extension. Before providing training joint verification of the site selected was carried out by team from researchers, IHPP-JICA Expert and Gewog EO, where feasible orchard layout was done and informs farmers to start preparing the pits. The confirmed farmers were called for training at the Centre. Three rounds of training are provided to demo-orchard, nursery growers and focus village representatives by IHPP/ARDC-Bajo: first training as awareness tour to ARDC-Wengkhar followed by second training (planting, training and pruning), and third training (Fruit thinning and summer vegetable cultivation techniques). During the FY 2017-18, a total of 23 demonstration

orchards and 6 focus villages were established in the region benefiting 62 households with systematic training to demonstration and four focus village representatives. In total 3219 planting materials were supplied covering more than 30 acres of land.

Table 2-12: List of demonstration and focus village orchard established

SN	Dzongkhags	Demo orchard (No)	No of Focus village	No of HHs in Focus village	Area covered (acres)
1	Wangduephodrang	6	2	31	9.5
2	Punakha	8	2	12	9.0
3	Gasa	1	0	0	0.5
4	Dagana	4	1	10	6.0
5	Tsirang	4	1	9	5.5
Total		**23**	**6**	**62**	**30.5**

Findings and recommendations

- Out Reach program is efficient and popular method for extension approach. Through ORP many farmers and Gewog extension officials are trained systematically on orchard management (grafting, training, pruning and fruit thinning), summer vegetable cultivation (Pumkin, zucchini, brinjal, okra and water melon) and off- season winter vegetable cultivation training in high altitude regions.
- With outreach program, various demonstration orchard and focus villages are established whereby other farmers can take example from. Farmers and extensions gave positive feedback on systematic training approach. Many farmers are willing to attend three rounds of systematic training to have demonstration orchard on their farm. This Outreach program will be thus continued henceforth as majority of those trained gives positive responses.

2.2.4 Support to Private nursery growers in the region

ARDC Bajo with support from IHPP-JICA project has been providing technical support as well as inputs to the private nurseries in the West central region. The objective was to make quality planting materials for fruits and nuts in the region in Dagana, Tsirang, Wangdue and Punakha.

From 2016, ARDC Bajo identified three private nurseries in the region. During this year the Centre identified two more private nursery growers. Now the region has five private nurseries. The sector supported all nursery growers with rootstock seeds for pear, persimmon and peach. Grafted planting materials were also supplied to develop mother plants and progeny block for future propagation. The nursery farm located at Kana under Dagana Dzongkhag and Ngawang under Wangduephodrang Dzongkhag were supported on grafting of persimmon seedlings.

Two orchards were supplied with scion wood of persimmon and walnut for grafting in their nursery. Now these two nurseries have made available of about 1000 grafted persimmon and 300 grafted walnut. Following are rootstock seeds and mother tree seedlings supplied, and grafted.

Table 2-13: Rootstock seeds supplied to private nurseries

SN	Name of farmer	Dzongkhag	Gewog	Nursery plants (No)	Mother tree (No)
1	Tshering Wangchuk	Wangdue	Nahi	1000 Persimmon rootstock, 500 Pear rootstock	21 Persimmon, 24 Pear,
2	Sangey Dema	Wangdue	Nawang	780 Persimmon rootstock 650 Pear rootstock	12 Pear, 18 Persimmon
3	Tshagey	Punakha	Toep	1 kg peach, 1 kg persimmon 1 kg pear	5 peach, 4 plum, 10 persimmon
4	Tshetu	Punakha	Limbukha	1 kg peach, 1 kg persimmon 1 kg pear	7 peach, 12 pear, 7 plum, 13 persimmon
5	Ganga Ram Chohan	Dagana	Kana	1000 persimmon, 500 pear	12 persimmon

Finding and recommendations

- Inputs in terms of rootstock seeds, seedlings (mother plant), and nursery grafting were supported in the respective nursery field, besides hands-on training on grafting operations provided.
- All existing private nursery growers are functional and few new interested farmers have applied to take up fruit nursery enterprise.

2.2.5 Improvement of local fruit cultivars through top-working

One of the effective ways of improving local fruit cultivar is through top-working. The technique is used in improving and rejuvenating unproductive local and old fruiting trees. It has gained wide popularity among farmers and extension staff for improvement of local fruit tree. Objectives were to improve the local fruit cultivars with improved and superior cultivars, diversify fruit cultivation by the farmers to enhance faster cash income and to create awareness to the farmers on the system of top-working.

This program was initiated by IHPP-JICA for improvement of local inferior fruit cultivars through rejuvenation by top working with improved and superior Asian fruit cultivars. For this Punakha and Wangduephodrang Dzongkhags agriculture sector were involved and carried out the program in February and March 2018. Top working was carried out after providing training to farmers and extension staff. This was done to ensure, skills learned from the training is applied practically in the field. The local fruit trees such as pear, persimmon, walnut, peach, plum, apricot and kiwi were top worked (Table 2-14 and 2-15). A total of 887 fruit trees were top worked (Punakha 505 and Wangdue332) during the FY-2017-2018. The top-worked fruit trees have proven as the effective techniques for rejuvenation of the fruit plants.

Table 2-14: The number of local fruit trees top-worked in Punakha Dzongkhag, 2017-18

Dzongkhag	Geog	Peach	Pear	Persimmon	Plum	Apricot	Walnut	Kiwi
Punakha	Shangana	4	14	15	0	0	0	0
	Kabjisa	18	7	19	0	3	13	0
	Guma	25	17	19	2	3	35	0
	Toedwang	5	6	6	6	3	7	0
	Toepisa	10	2	5	9	2	10	10
	Talo	28	69	6	0	0	17	0
	Barp	4	0	2	2	0	3	0
Total		***94***	***115***	***72***	***19***	***11***	***85***	***10***
Wangdue	Kazhi	11	13	4	0	0	14	0
	Nahi	4	12	21	3	0	18	0
	Rubesa	19	23	5	3	7	9	0
Total		***34***	***48***	***30***	***6***	***7***	***41***	***0***
Grand Total		**128**	**163**	**102**	**25**	**18**	**126**	**10**

Table 2-15: Local fruit trees top worked in Wangdue Dzongkhag, 2017-18

SN	Name	Dzonkhag	Geog	Peach	Pear	Persimmon	Plum	Apricot	Walnut
1	Namgey	Wangdue	Kazhi	2	2	0	0	0	3
2	Lhamu	Wangdue	Kazhi		3	0	0	0	0
3	Ngedup	Wangdue	Kazhi	2	3	0	0	0	5
4	Pem Dorji	Wangdue	Kazhi	2	2	0	0	0	2
5	Lhap Dorji	Wangdue	Kazhi	0	2	0	0	0	1
6	Pem Choki	Wangdue	Kazhi	1	1	2	0	0	0
7	Choney Pem	Wangdue	Kazhi	2	0	1	0	0	1
8	Gyeltshen	Wangdue	Kazhi	2	0	1	0	0	2
1	Gado	Wangdue	Nahi	1	3	0	2	0	2
2	Sonam Zam	Wangdue	Nahi	3	9	0	1	0	16
3	Tshering Wangchuk	Wangdue	Nahi	0	0	21	0	0	0
1	Tashi Pem	Wangdue	Rubesa	2	1	0	1	1	0
2	Gomchen	Wangdue	Rubesa	1	1	1	0	0	1
3	Nachum	Wangdue	Rubesa	2	3	0	0	0	3
4	Sangey Dorji	Wangdue	Rubesa	4	4	0	0	0	1
5	Kinley Pemo	Wangdue	Rubesa	3	2	1	0	1	0
6	Tshewang Lham	Wangdue	Rubesa	2	0	0	1	1	0
7	Naphey	Wangdue	Rubesa	0	1	0	0	0	1
8	Tashi Zam	Wangdue	Rubesa	1	3	1	0	0	0
9	Chencho Dorji	Wangdue	Rubesa	1	1	0	1	2	0
10	Sangey Dema	Wangdue	Rubesa	1	4	0	0	0	3
11	Bagam	Wangdue	Rubesa	2	1	0	0	2	0
12	Mang Ap	Wangdue	Rubesa	0	2	2	0	0	0
	Total			**34**	**48**		**6**	**7**	**41**

Research Findings and recommendations:

- Through such activities, it creates a common platform for researchers and extension personals for close collaboration in dissemination of technologies to the needy clients in the region.
- Farmers are made aware of research systems and the technologies available with research institution
- Close monitoring plays a crucial role in success of the activities both in on- farm and on-station.

2.2.6 Vegetable production program in the region

In 2017-2018, in order to promote potential vegetables in farmer's field, IHPP-JICA in collaboration with the Dzongkhag provided the different type of vegetables seeds and seedlings for promotion to Punakha, Wangduephodrang, Tsirang, Dagana and Gasa. This was carried out based on the discussion during the work group meeting (WGM). The objectives of the program are to promote commercial vegetable production to ensure availability of fresh vegetables in the market through the year, creation of awareness on the feasibility of new vegetables and annual income generation and to improve nutritional intake of the individual.

Table 2-16: Vegetable Promotion in West-Central Region in 2017-18 through IHPP

SN	**Crop**	**Seed rate**	**unit**	**Seed produced**	**Area covered (acre)**
1	Cabbage	300	g		
2	Broccoli	180	g	14900	82.78
3	Cauliflower	180	g	7000	38.89
4	Chinese cabbage	300	g	1350	4.50
5	Chili	300	g	1000	3.33
6	Tomato	160	g	1000	6.25
7	Egg plant	300	g	1000	3.33
8	Carrot	600	g	20000	33.33
9	Rdish	4.0	kg	97.5	24.38
10	bulb Onion	1.6	kg	38	23.75
11	Bunching onion	2.0	kg	10	5.00
12	Watermelon	1.2	kg	12	10.00
13	Zuchhini	1.5	kg	8	5.33
14	Pumpkin	1.0	kg	15	15.00
15	Pea	40.0	kg	30	0.75
16	Dwarf bean	40.0	kg	80	2.00
17	Pole bean	20.0	kg	80	4.00
18	Mustard green	1.0	kg	4.75	4.75
19	Spineach	2.0	kg	14	7.00
20	Asparagrus	0.46x1.52m	sq m	20000	2.00
	Total area covered				**276.38**

Nine vegetable varieties such as Broccoli (Desico, SP Green), Cauliflower (Wengkhar Metokopy I, W. Metokopy II and White top), Bunching onion , Chinese cabbage (Kyto and Ousho), Mustard green (Wengkhar Patsey I and W.Patsey II), Radish (Minowase, Shogoun and Sukurajima), Spinach (Jiromaru), and pea (Japan long and Flat) have been promoted to

farmers of Punakha(Goenshari, Limbukha, Tobesa, Talo, Shangena), Wangdue (Sephu, Dangchu, Phubjee, Nigsho, Kazhi, Nahi, Rubesa and Bjana), Gasa (Khatoe and Khamoed), Tsirang and Dagana to produce off-season vegetable. Seeds of vegetables such as bean (Gray pole, White pole and Gray dwarf), Okra, chilli, capsicum, tomato, egg plant, bulb onion, carrot, water melon (Kabuki & black ball), two varieties of pumpkin (Ebisu & Wengkhar Kakur), and two varieties of zucchini (Indian green and yellow) were also promoted to grow as summer vegetable.Both summer and winter vegetable seeds were produced at the station and seeds supplied to the farmers through Extensions. Seeds production started from August, 2017 to June 2018. About 14 vegetable cultivars have been promoted (Table 2-16).

The improved nursery raising and management with the use of poly tunnels to grow nursery and improved cultivation practices were demonstrated to farmers during systematic training. However, production data have not been received from dzongkhag.

The project also promoted production of two varieties of water melon (Kabuki & black ball), two varieties of pumpkin (Ebisu & Wengkhar Kakur), and two varieties of zucchini (Indian green and yellow). During 2016-2017 farmers were supplied with seeds with hands on training to grow watermelon, pumpkin and zucchini. However, the program failed as the cultivation practice was new to farmers. Therefore, in 2017-2018 FYP the sector produced seedlings and distributed to interested farmers, with additional inputs of poly plastic sheet to protect the young seedlings from beetles' attack and to maintain high temperature during growing stage. It is interesting to learn that there was some harvest, and few farmers earned some income.

Table 2-17: Summer vegetable seedling distributed

Dzongkhag	Gewog	Date of distribution	No. vegetable seedling distributed		
			Pumpkin	Zucchini	Water melon
Punakha	Barp	16/3/2018	90	15	50
Punakha	Chubu	16/3/2018	40	25	50
Punakha	Toedwang	16/3/2018	85	26	100
Wangdue	Athang	16/3/2018	100	25	50
Wangdue	Rubesa	16/3/2018	50	25	50

A farmer from Chubu earned about Nu. 15000 from the sale of water melon, water melon weights 6 kilogram on average and was sold @ of Nu.70 to 80 per kilogram and Nu.300-350 per piece. Since this crop was introduced for the first time, the centre organized a day long field day involving media and the farmers. The farmers' participants expressed their interest on water melon cultivation and even existing farmers indefinitely like to expand the area under water melon.

Findings and recommendation

- The centre has been successful in production and maintenance of quality vegetable seeds.
- Demand for quality seeds from ARDC has increased. The centre is now looking for vegetable seed growers within the region to train and support in producing quality seeds.
- Water melon, cucumber and zucchini can be successfully grown if seedlings are raised in the plastic house

2.2.7 Potato production in water scarce area

Gyemkha and Wampaykha chiwog under Phangyul Geog is located at an altitude of 1750 - 2100 masl. Farmers of these two chiwogs mainly depend on cereals and summer vegetables. Last year farmers were provided with Kufrijyoti variety which did not fetch good market

price so this year Desiree variety was supplied to 19 farmers under two chiwogs. Besides its high preference in the market, study is also being conducted to see if it can provide good yield under water scarce conditions. A total of 3850kg of Desiree variety was distributed to 19 households. During the seed distribution the farmers were briefed on technical knowhow. Potato tubers were planted during December month under rain fed condition. Yield was calculated from an area of 2x3m^2 crop cut, taking the mean of three random crop cuts in every household. ARDC along with the Gewog Extension facilitated in monitoring and yield assessment in the field.

Comparing the yield of potatoes in the two chiwogs, Wampaykha Chiwog have higher yield than Gyemkha Chiwog. The average yield of potato in Wampaykha Chiwog was 7.72t/ac and 6.14t/ac in Gyemkha Chiwog. Yield ranged from 3.37 to 16.41t/ac in Gyemkha Chiwog while in Wampaykha Chiwog it ranged from 4.89 to 16.41t/ac. It is observed that the difference in the yield (Table 2-18) is mainly due to the planting time management practices followed by the farmers in the two Chiwogs. Some farmers had not carried out weeding and earthing up on time which must have attributed to low yield. Some farmers applied only farmyard manure while those farmers applying both farmyard manure and inorganic fertilizers in their fields yielded very high yield ranging from 9.88 to 16.41 t/ac. The results showed that despite the scarce water in the two Chiwogs, potato yield was good. This must be due to the already existing fertile soils and the best management practices followed by the farmers for potato cultivation.

Table 2-18: The average potato production data (t/ac) of 19 individual farmers

Farmers name	**Chiwog**	**Village**	**Yield (t/acre)**
Tashi	Wampaykha	Wampaykha	10.51
Kanju	Wampaykha	Wampaykha	8.03
Wangdi	Wampaykha	Wampaykha	5.11
Rinchen Dorji	Wampaykha	Chembji	11.64
Kinley Dema	Wampaykha	Chembji	16.41
Singye Lham	Wampaykha	Chembji	12.03
Sonam Dem	Wampaykha	Chembji	4.95
Dorji Om	Wampaykha	Chembji	4.66
Gyenza	Wampaykha	Chembji	3.37
Singye Dem	Wampaykha	Chembji	10.45
Pem Choden	Wampaykha	Tshemina	8.26
Thuji Om	Wampaykha	Tshemina	5.17
Gyembo Dorji	Wampaykha	Eusabu	3.99
Khandu	Wampaykha	Eusabu	3.43
		Average	**7.72**
Phurba	Gyemkha	Semina	5.38
Dema	Gyemkha	Gyemkha	5.56
Om	Gyemkha	Gyemkha	5.00
Phub Zam	Gyemkha	Nabitsha	9.88
Sonam	Gyemkha	Gyemkha	4.89
		Average	**6.14**

2.3 Floriculture

2.3.1 Production of quality seeds and seedlings

Floriculture research has been recently taken up by ARDC Bajo from 2016-17. The Centre produced and supply to different institutions for beautification and landscaping purpose. In 2017-18, the Centre cattered to Royal Bhutan Flower show with potted flowering plants which was celebrated at Punakha. Beside Royal Flower show, the Centre supplied to various institutions like school, RNR Centres, Dzongs, towns planning recreation parks, Armed Forces (RBG), and mega hydro projects (PHPA I &II).

Table 2-19: The quantity of flower produced and distributed, 2017-18

SN	Flower plant	Total produced (nos)	Issued (nos)	Balance (nos)
1	Marigold	10071	5735	4336
2	Celosia	970	667	303
3	Pansy	2797	2298	496
4	Dainthus	782	541	241
5	Snap Dragon	2227	1608	624
6	Dahlia	1800	681	1119
7	Petunia	2280	1124	1156
8	Vinca	920	681	239
9	Lavendula	500	170	0
10	Osteospermum	1160	25	475
11	Salvia	2680	1105	1575
12	Aste	1214	1187	27
13	Aster	1102	581	526
14	Impatients	200	0	200
15	Portulaca	210	142	68
16	Geranium	161	151	10
17	Sweet willium	473	230	243
18	Evergreen	1000	0	1000
19	Orchid	2000	0	2000

2.4 Mushroom production

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 DoA under MoAF 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, Thimphu. Today, with the appointment of one trained mushroom staff, laboratory facility has been improved, and production of quality Oyster and Shiitake mushroom initiated. A total of 1000 bottles of shiitake mushroom and more than 4000 bottles of oyster mushroom spawn were inoculated and produced during FY 2017-18. 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 70 different households were involved in shitake mushroom production. The unit caters its technical services to the five Dzongkhags of West Central Region.

2.4.1 Oysters mushroom cultivation at Jibjokha Lower Secondary School

Mushroom cultivation training was conducted in Jibjokha Lower Secondary School to give their students and teachers know-how about oyster mushroom cultivation. The training was organized by School Agriculture Program (SAP) Coordinator together with request and interest shown by the teachers and students of SAP club. The coordinator requested our Centre to support in terms of technical and other the training was funded by ARDC, Bajo which includes mushroom spawn and other basic materials. Before the commencement of the training, the teachers and students were briefed about dos and don'ts of cultivation. A total of 26 bags of Oyster were cultivated during the training program and will help them in generating income for the agriculture club of the school.

2.4.2 Trial on Oyster feasibility growth under four different treatments

UT mushroom farm at Martsikha, Gasetshogom was established in April 2016 with 3000 billets. The technical support was rendered from National Mushroom Centre (NMC). Since Shiitake takes a longer period during incubation, they have planned to cultivate oyster mushroom as an alternative source of income to repay their loan instalment. With that they have cultivated oyster with technical support from NMC. They have been inoculating oyster mushroom production for almost one year but they have faced high levels of Trichoderma infection, causing substantial losses, with majority of blocks being disposed of following severe infection. Hence, the purpose of this trial was to investigate each stage of the cultivation process, using a number of different diets, other additional nutrient and inoculation methods with view to reduce contamination rates in substrate blocks, leading to improved production of oyster mushrooms. The trial was set up from Aug 22-25, 2017.

All the existing substrate bags were removed from the fruiting shed prior to establishment of this trial as whole blocks were infected with trichoderma. All rooms were cleaned thoroughly before any work was conducted. A 70% alcohol solution was used to clean all walls and floors. Cleaning was first carried out in the inoculation room, moving to the cooling room and finishing with fruiting room. Due to an absence of a clean room for inoculation work it was recommended that a clean chamber was constructed to allow minimal introduction of airborne microbes during the inoculation process. A frame was built from wood and covered with plastic sheeting.

Trial design: A total of 28 substrate blocks were prepared and four different treatments were used having different nutrients composition. Each treatment was replicated seven times. The details of each treatment are outlined as below.

Table 2-20: Summayr of trial design

Treatment	Nutrient added	Moisture content of substrate (%)	Weight (kg)	No. of bags	Remarks
Treatment 1	Rice bran added with spawn	50-55	3.5	6	
Treatment 2	Rice bran spread over substrate	60	3.5	2	
Treatment 3	Calcium carbonate spread over substrate	50-55	3.5	2	
Treatment 4	Plan substrate	50-55	3.5	18	

Substrate were packed in gunny bags and loaded into the metal drum to sterilize which ran for 30 to 40 min for complete sterilization. After sterilization, blocks were transferred from the sterilization drum to the cooling room through air tight plastic bag and kept for 24 hours.

Workers were briefed on cleaning themselves before entering the cooling room, with clean slippers worn and hands properly washed.

Preparation of inoculum (Pleurotus ostreatus, strain WOI and BO-I) was conducted in the fruiting room following misting the air with 70% ethanol. All workers entering the cooling room or inoculation room during this stage were briefed on cleaning. Hands and arms were scrubbed with soap and water. Bare feet or slippers were sprayed with ethanol and worn to prevent the introduction from additional microbes. Spawn bottles were wiped with 70% ethanol with the necks and cotton plugs flamed before opening. A sterile hook was used to remove the surface layer of the spawn. Bottle necks and cotton plugs were re-flamed and re plugged. A metal bowl was sterilized with ethanol and flaming, and transported upside down into the inoculation chamber. All spawn bottles were re-wiped with ethanol and placed in the center of the chamber. Spawn was removed from the bottles and placed in the bowl inside the chamber using a sterile hook. This was kept covered with clean, ethanol sprayed, plastic sheeting when not in use. The complete blocks were kept under observation at least for 5 days before going for pricking to drain out excess water from the block.

(a) (b)

Figure 2-3: (a) Mushroom spawning and (b) Mushroom incubation

2.4.3 Study on wood log cultivation of Shiitake in lowlands

Bhutan is endowed with biodiversity and rich in forest resources including a deciduous oak of Quercus griffithii and evergreen Castanopsis spp, which are adapted for wood log cultivation of shiitake (Lentinula edodes). It is about 30 years since cultivation techniques of shiitake was introduced into Bhutan and still the cultivation is being conducted by the techniques similar to the Akiyama method brought into Bhutan for the first time. In this method spawning is carried out right after trees are cut and divided into 1m logs and then a vertical bulk stack method is employed, in which pine leaves are laid on billets and then covered with plastic sheets to keep a slightly warmer condition inside and protect from drying. In addition, it is one of the distinct characteristics in Bhutan that the cultivation is carried out inside a shed and not outside. The climatic conditions however in Bhutan are very different depending on places, which suggest it is not appropriate to disseminate the same cultivation method to entire country. The case study was supposed to conduct by the conventional method for the purpose of clarifying technical problems causing poor mycelia colonization in billets in cooperation with a mushroom grower in lowlands in Bhutan.

Test logs were selected from freshly cut log in the forest. The logs were separated size wise into three groups, i.e. small logs with more than 7cm in diameter, middle size logs with 7-15cm and big logs with more than 15cm and the test logs in three groups were of 15 number

respectively, resulting in 45 test logs in total. The test logs are all measured for moisture content followed by weight measuring and finally stapled with number tags on the both cut ends.

Weight, moisture and diameter were taken right after the log harvest from the forest. The study was conducted to extract technical problems in wood log cultivation of shiitake with different incubation method than the conventional one in lowlands of Bhutan in cooperation with a mushroom grower.

Table 2-21: Property of test logs in three groups separated size wise

Size	No. of logs	Diameter (cm)	Weight (kg/log)	Moisture contain (%)
Small logs	15	7.1 ± 1.1	4.14 ± 1.37	49.9 ± 4.2
Middle logs	15	10.3 ± 1.4	8.25 ± 2.52	50.7 ± 2.0
Big logs	15	14.9 ± 1.8	17.91 ± 3.56	50.9 ± 3.8

2.4.4 Oyster cultivation at Kilkhorthang Gewog under Tsirang

Kilkhorthang Gewog under Tsirang Dzongkhag is just few miles away from our ARDSC Menchuna. The main source of cash income for farmers is from selling the farm products along the high way. Farmers there cultivate paddy and chilli as their main cash crops and the raw material like paddy straw is readily available for the oyster cultivation. At this time, the cultivation was focus on oyster mushroom cum oyster spawn production. The cultivation was organized with request and interest shown by the farmer themselves. The expenses for the raw materials like paddy straw, drum and plastic for the cultivation was borne by farmer themselves with the technical support from ARDC, Bajo.

The cultivation was started with the brief talks on selection of raw materials and its storage. The importance of draining of water from straw and sterilization of raw materials was also explained. The problems they will face during incubation and how to deal with such problems were also explained. A total of 38 balls were cultivated and the method used was layer by layer in which plastic bag is used. In this method sterilized straw is layered with the spawn broadcasted evenly on the top of each layer until the bag is filled. Before those balls are set for incubation, we have to prick the whole area of the balls in order to drain out the excess water that was there inside the straw. The plastic balls are then kept inside the dark room and the required temperature of 20-25 degree Centigrade is maintained during incubation. Then the following advices were suggested to them.

- White cotton like fluffy mass will grow through the substrate within a week or two which indicate the good mycelium run.
- After three weeks or so the whole substrate should turn white indicating the completion of the spawn run or incubation.
- If there is a sign of mushroom pin head then they have to remove that area for watering because if we remove whole plastic than some parts of mycelium run may not matured to form proper fruit shape and while watering it may damage the network of the mycelium.
- While watering, care should be taken to prevent the water from collecting at the base, as it will eventually initiate infection.
- After the first harvest, the substratum should be kept in a dry and cool place for resting for about a week after which it can be made to sprout again by spraying water. After three fruiting time the size of the substratum will go on reducing since it gets consumed by the mushroom mycelium.

A total 30 bags of the oyster mushroom were cultivated under this program.

2.4.5 Building farmer's capacity in Oyster and Spawn production

The mushroom generated over 30% of annual income of the farmers and the money from the trade has been used to invest in agriculture to buy cows, diversify crops, and buy power tillers. Thus, the fungal income enabled farmers to increase overall income. This strategy was also strongly supported by the Department of Agriculture under MoAF. The main task of Regional Research Centre is disseminating the know-how of mushroom cultivation in their respective region, Spawn multiplication and to educate about mushroom management with the support from National Mushroom Centre.

Oyster mushroom production is a lucrative business in wetland based farming system to enhance income of farmers. The by-products of paddy crop (straw) are better utilized as substrate for oyster mushroom production. The technology is being promoted to farmers and its adoption rate is increasing in the wetland based farming communities. However, farmers lack confidence in adopting the technology due to inadequate skills and knowledge. Therefore, it was necessary to train farmers and built confidence in oyster mushroom production and spawn multiplication thus enabling farmers to produce oyster mushroom at commercial scale. In order to do that an interested farmer from Pelrithang chiwog, Gosaling Gewog under Tsirang Dzongkhag was trained and currently has the capacity to produce oyster and its spawn.

The necessary equipment like laminar flow, autoclave, and other basic items like calcium carbonate, alcohol were already provided before. The spawn production was started bit later after completion of establishment of laboratory. The spawn multiplication training like how to operate autoclave, usage of laminar flow, and spawning were also provided. Till date they have multiplied 770 of bottles of spawn and 90 packets of spawn using plastic. They have the potential to increase their production capacity if there is demand in the market. The program was supported by mushroom unit under Horticulture sector of ARDC Bajo.

2.4.6 Promotion of Shiitake and Oyster mushroom in the region

The Shiitake and oyster mushroom cultivation was carried out at Gasa (Khatoed), Wangdue Dzongkhag, Punakha, Tsirang and Dagana Dzongkhag. The total of 20 different households cultivated the mushroom. The aim of the program was to promote cultivation of high value crops (mushroom), improve diet habit and to enhance cash income of the farmers and create awareness to the farmers on oyster mushroom cultivation. Table 2-22 provides the details of shiitake mushroom produced.

Table 2-22: Shiitake mushroom promoted within FY 2017-2018

SN	Name	Dzongkhag	Village	Spawn No	Date	Total billets
1	Tashi	Gasa	Omchugang	54	8-9/3/2018	1000
2	Cheychey		Newakha	24	10/3/2018	640
3	Dorji Dem		Datakha	24	11/3/2018	600
4	Pasang		Lungkha	24	12/3/2018	500
5	Karma Dema		Tsherikha	24	13/3/2018	560
6	Kuenzang		Zana	54	14-15/3/18	1000
7	Sangay Dorji		Zamizam	54	16-17/3/2018	1000
8	Dem		Thangkha	24	18/3/2018	530
9	Sana Zam		Lhanakha	24	19/3/2018	700
10	Zam		Baychu	24	20/3/2018	500
11	Tshering		Baychu	24	21/3/2018	500
12	Dophu		Mani	24	22/3/2018	500
13	Penjor	Punakha	Thinleygang	38	17/2/2018	900
14	Pema		Kabesa	40	28/3/2018	800
15	Thinley	Punakha	Teowang	40		800
16	Chenga	Wangdue	Bajo	40	23/2/2018	1000
17	Yangdon		Thedtsho	35	27/2/2018	1000
18	Yeshi Tenzin		Nyalakha	50	30/3/2018	700
19	Ugyen Tshomo		Gasetshogom	70		1500
20	Kaziman Gurung	Dagana	Khebisa	45	28/4/2018	450

3 TECHNICAL SUPPORT SERVICE GROUP

3.1 Soil and Land Management Unit

Soil and Land Management Unit is responsible for providing technical support services related to soil and plant sample testing and giving recommendations and necessary services related to soil and land management. Over the year, we are involved in soil sampling in farmers' field and also on station for research purpose. The unit also carry out activities to promote organic farming in the region. Promotion of green manuring, composting, and vermi-composting and use of EM solution are being promoted in the region. The unit also promotes and carries out various SLM activities in the region in collaboration with Dzongkhags and NSSC Semtokha to combat land degradation. We maintain a Napier multiplication block which is the source of Napier cuttings used in SLM activities. In order to have concrete data on land degradation in the region two soil erosion measuring plot are being maintained at Royal Project Chimipang and ARDSC Menchuna respectively. It will help us in building concrete national database regarding soil loss. The various activities conducted during fiscal year 2017-2018 are summarized below.

3.1.1 Production and maintenance of Dhaincha seeds

Production and maintenance of Dhaincha (*Sesbania acualeata*) seeds, a green manure crop is an annual activity at the Centre. The main objectives of this activity are to provide seeds for on farm use and interested farmers, make Dhaincha seed available for next season and to practise IPNM in crops using Dhaincha. In 2017-2018, the sector produced 1000kg of Dhaincha seeds. The produced seeds were distributed as follows.

Table 3-1: Seeds of Dhaincha produced and distributed

SN	Name of the Agency	Amount distributed (kg)	Purpose
1	CRP, Chimipang	500	For on-station use at Chimipang
2	Gasetgom Gewog	100	For interested farmers
3	On-station use	50	For green manure trial
4	On-station use	30	Seed production for 2018-19 season
5	Field Crop Sector, ARDC Bajo	50	For on-station use
6	Horticulture Sector, ARDSC Menchuna	100	For on-station use in IHPP activities
7	Horticulture Sector, ARDC Bajo	75	For on-station use in IHPP activities
8	FMCL Bajo	15	For on-station use
9	Bajo HSS	10	For on-station use

Around 500 kg of the seed distributed were used in terraces which are used for paddy and wheat cultivation. On an average 300 acres of terraces were sown with green manure. This activity will be carried out annually to meet the seed requirement of the client dzongkhags of West Central region, SAP schools and for trial purpose and on-station use.

3.1.2 Vermicomposting, composting and distribution of chicken manure

The Soil and Land Management unit is responsible to carry out on-station activities regarding organic farming. In 2017-2018, the unit produced about 1000 kg of vermin-compost. The main objective of this activity is to produce vermin-compost using the locally available materials using locally available earthworms. The produced vermin-compost was used in improving the soil fertility status of our surrounding office gardens and lawns. Around 500 kg of vermicompost were also used in rice terraces. This activity will be continued to serve as

a vermi-composting demonstration to the farmers visiting the Centre. The effectiveness of EM solution in Vermi-composting and composting will also be studied in the coming season.

Composting of bio-degradable materials available at the on-station is used for composting. The compost produced was used for horticultural and field crops. The composting is also done through sawdust and chicken manure. The procured saw dust and chicken manure are mixed and kept for decomposition for 45 days and then used in the fields. The distribution of chicken manures and saw dust to farmers are also done with available budget. One truckload of chicken manure was also supplied to a farmer at Medagang, Punakha.

3.1.3 Pre-rice green manure trial using Dhaincha

The effectiveness of Dhaincha in improving rice yield was carried out at the Centre in collaboration with field crop sector. The Dhaincha seeds were broadcast in six selected terraces by the field crop sector on 17th April 2018. The before Dhaincha soil sampling was done on 16th April 2018. The main objective of the study was to compare those six terraces grown with Dhaincha with other terraces grown without Dhaincha in terms of rice yield and soil fertility status before and after cultivation of Dhaincha.

However, the seeds took long time to germinate and none of the six terraces could produce Dhaincha of sufficient height and biomass for incorporation before paddy transplantation. Only about 15 percent of the seeds managed to germinate and attain a height of about 10cm from ground level after 50 days from the date of seed broadcasting. Although the Dhaincha could not attain the appropriate height and biomass, the whatsoever produced biomass from the 15 percent germinated seeds was incorporated into the soil on 29th May 2018. The post Dhaincha soil sampling was done on 7th June 2018. The soil samples were submitted to NSSC Semtokha for analysis.

The main lessons we learned from this study was the importance of irrigation water and the date of Dhaincha broadcasting. For this particular study no irrigation was provided to see the adaptability of Dhaincha in natural condition. The study failed because they were no rainfall in the Bajo area from the period of April to late May and the seeds failed to germinate. This shows that we did seed sowing very early this season. The lessons learned will be put into good use next season while carrying out similar study in various crops. Although we will not do crop cut in paddy to compare yield but we will compare the soil fertility status of those six terraces before and after sowing of Dhaincha as soon as we get analysis results from NSSC Semtokha.

3.1.4 Soil erosion measuring plot

Land degradation through soil erosion is one of the major environmental issues in the country, however, the nation as a whole lack reliable hardcore data to support the visual observations. To respond to this concern, a soil erosion measuring plot was established at ARDSC, Menchuna and CRP, Chimipang with the financial support from SLM project. The objective of this activity is to establish the soil erosion database for the region and ultimately contribute for the national soil loss database. Soil loss data collection from the established plot is being done at CRP Chimipang and at ARDSC Menchuna.The data collected are submitted to NSSC Semtokha for anlaysis on monthly basis.

3.1.5 Effective Microorganisms Technology

Effective Microorganisms (EM) solution is being used daily in various activities. It is used in composting, smell suppression of chicken manures, with irrigation water in fields and for smell suppression in drains and toilets. It is popular among SAP schools in making compost

and Bokashi making. Currently EM mother solution is collected from NSSC Semtokha and distributed to interested individuals and SAP schools by the Centre after preparing it into secondary solutions. Over the past one year 200 liters of EM mother solution was collected from NSSC Semtokha and are distributed as follows.

Table 3-2: Distribution of EM solution

SN	Name of agency	Quantity as in Mother solution (litres)
1	On station use in composting and smell suppression of drains	50
2	Samtengang Central school	75
3	Bajo Higher secondary school	25
4	ARDC Bajo staff	5
5	Composting with IHPP	20

The use of EM solution in vermicomposting and seed germination will be studied in the coming season. The use of EM solution in compost making also helps us in practicing IPNM in various crops. Furthermore, EM mother solution producing laboratory with the capacity of 2000 liters will be established at ARDC Bajo with support from NSSC Semtokha.

3.1.6 Napier multiplication block

The main objective of this activity is to continue the supply of Napier cuttings whenever required. Napier has the dual benefits as it can be used as hedgerows in SLM activities and can be even fed to cattle. Currently one Napier multiplication block is maintained near vermicomposting pit. In the coming season another Napier multiplication block will be established just above the mushroom laboratory.

3.2 Integrated Pest Management

3.2.1 Insect Pests, its Natural Enemies and Diseases Occurrence in Fruits and Vegetables in West Central Region

3.2.1.1 Introduction

The change in climate is evident from the increase in global average temperature, changes in the rainfall pattern and extreme climatic events. The change in temperature and CO_2 level plays a pivotal role in insect population dynamics. The seasonal and long term changes affect the fauna, flora and population dynamics of insect pests (Karuppaiah et al., 2012) leading to shifts in their distribution of host and pathogen resulting to more crop losses (Coakley et al., 1999). The change in climate CO_2 levelalso leads to an increase in number of insect populations (Leonard, 2006). Similarly, rising levels of CO_2 and temperature directly influence occurrence of pests and diseases in crops affecting crop production and yield. Elevated CO2level reportedly resulted in severe pests' attack or damage to crops in due course of meeting their nitrogen need (Venkataraman, 2016). Elevated CO_2 level has also shown to help in easier over-wintering of pathogens while higher temperature favored thermophilic fungi (Venkataraman, 2016). These favorable conditions of insect pests and diseases cause crop losses resulting to food insecurity.

Bhutan is predominantly an agrarian society, with majority (about 69% of its population) relying on agriculture for their livelihood. About a third of the population of Bhutan faces food insecurity (Adubi, 2017 and CIAT, 2017). Crop damage by insect pests and diseases is the 4th major challenge for horticulture farming in west central region of Bhutan (IHPP, 2017) thus affecting the country's food security and food self-sufficiency (CIAT, 2017).

Insect pests and diseases affects yield and production of major crops (mandarin, areca nut, banana, chilli, kidney beans, and radish) resulting in generation of low household income. Often, insect pests and diseases result in crop failures that lead to food scarcity and high prices of the available food and thus hinder the goal to achieve food security. Across the globe, the insect pest or disease outbreaks have caused huge crop losses, threatened the livelihoods of million vulnerable farmers in terms of food and nutrition security (FAO, HP).

The Royal Government of Bhutan promotes organic agriculture in the country to support Buddhist religious precept against killing. On the other hand, the pressure to enhance high crop yield and attain food security led to increased use of plant protection chemicals (PPC) that contaminates the ecosystem (Fernando, 2017). Irrespective of the toxicity and the persistence, several different types of PPC were used in Bhutan until 1989. It was in 1992 that the policy of the country on plant protection was directed towards Integrated Pest Management (NPPC, 2015).

Integrated Pest Management (IPM) is an ecosystem based strategy that focuses on long term prevention of pests or their damage. It uses a combination of techniques; cultural, biological, physical and chemical. Pest identification; distinguish between pests, beneficial organisms through monitoring the pests and natural enemies is essential for successful IPM approach. IPM requires information on loss potential and pathogen biology, ecology and epidemiology, and basic concepts of plant disease management (Razdan et. al., 2009). Variations in insect distributionand activity are important factors for consideration in the development of economical and effective insect-pest management and control programs (National Research Council, 1969).The knowledge and understanding of the occurrence of various insect pests and diseases in a locality is important for developing local counter measures against insect pests and diseases .Such information on pest and disease incidences and level of crop damage or losses caused by the pests and diseases in Bhutan is limited (NPPC, 2015). The objective of this survey was to study the occurrence of various insect pests, their natural enemies, diseases, and their vectors of fruits orchards and vegetables farms in different parts of its range within West Central Region of Bhutan to serve as a basis for determination of effective IPM Control measures.

3.2.1.2 Materials and Methods

Site Selection

The farms and orchards for the study were selected in consultation with district agriculture officers of the region and the research officers of ARDC, Bajo

Tools and equipment:

Sweep net (Shign Konchukon, 35 cm in diameter and stick with 120 cm in length) was used to catch the insects. The insect samples were collected in vials (As one co.ltd, 17X27X55mm) and preserved in 70% ethanol for identification works. Yellow sticky traps (Alista Science, 257X100mm) were also used to trap insect pests and natural enemies.

3.2.1.3 Methodology

In the months of September to October 2017, a total of 35 farms and/or orchards were surveyed in the altitude range of 300 m to 2,150 m (Table 3-3). The simple random sampling method (R. Mead et. al., 1993) was used to select the trees in an orchard for survey followed by stratified random sampling to inspect the leaves for presence of insect pests or disease symptoms. In an orchard, 5 random trees were selected from which 5 old and 5 new leaves were randomly inspected for the presence of insect pests, beneficial insects, and the disease symptoms. For vegetable farms, simple random sampling method was used where 25 plants

were inspected for insect pests, beneficial insects and the disease symptoms. The population density of relatively immobile insect pests was recorded by direct in situ counting. To study the larval density of fruit flies in fruiting crops, fruits of these crops were collected from the local markets in Punakha and Wangdue districts, and from the study farms and orchards. For each crop, 20 fruits were randomly selected and investigated for the fly larvae.

To investigate the vectors of citrus greening disease pathogen, careful visual inspection on the leaves of the citrus plants and alternate hosts was carried out. Insect pests and natural enemies were also investigated by a sweeping method. Using the sweep net, 20 sweepings were carried out in an investigation on weeds nearby different crops to study the relative population density in the orchard/farm surroundings. Yellow sticky traps were also used for trapping insects. The yellow sticky traps were appropriately changed and data on different insects trapped were recorded. Insect pests and disease incidence were rated in the farms. The percent infestation of different pests was calculated based on number of insects per leaf or fruit or stem or the whole plant. The disease incidence in an orchard or farm was calculated as below (Berger, 1980):

$$\text{Diseaseincidence} = \frac{\text{Number of disease plants} * 100}{\text{Total number of plants}}$$

To analyze the incidence of a pest across the region, the frequency distribution was used. The Pests and diseases were categorized in ranks according to the occurrence across the region under important fruit and vegetable crops of the region.

3.2.1.4 Results

Survey site:

The study area includes a total of 35 farms and/or orchards under Dagana, Punakha, Tsirang and Wangdue districts in the elevation range of 300 m to 2,150 m. The crops surveyed at different farms and orchards are tabulated against the farm or orchard name (Table 3-3).

Table 3-3: Investigation points of the survey

Alitude (m)	Points	Fruit tree	Vegetable
Wangdue Dzongkhag			
1,220	Bajo	Citrus, Grape, Mango, Papaya, Pear, Persimmon	Bean
1,220	Bajo	Apple, Citrus, Mango	Bean, Chili, Indian mustard, Radish, Tomato
1,220	Bajo	Apple, Citrus, Grape, Mango, Papaya, Pear	Bean, Chili, Indian mustard, Radish, Tomato
2,190	Bjaktey, Kazhi	-	Cabbage, Chili, Eggplant, Bean, Radish
2,150	Bjaktey, Kazhi	-	Bean, Chili, Eggplant, Radish
1,840	Jagatokha, Kazhi	Citrus, Persimmon	-
610	Gewog, Daga	Avocado, Citrus, Guava	-
640	Dohamchey, Athang	-	Chili, Egg plant, Indian mustard
1,510	Talidoho, Nahi	Citrus	Broccoli, Indian mustard
1,630	Doltochen, Nahi	Walnut	-
2,070	Tshokothanglca, Nahi	Apple, Citrus, Pear, Persimmon,	Bean, Cabbage, Chili, Eggplant, Indian mustard, Radish

Punakha Dzongkhag			
1,250	Phuntsho, Pelri	Mango	-
1,250	Phuntsho, Pelri	Avocado	Indian mustard, Radish
1,920	Noobgang, Talo	Peach, Persimmon, Plum	-
1,840	Laptsakha, Talo	Pear	Bean, Broccoli, Chili
1,520	Wolakha, Talo	Citrus, Mango, Peach, Pear	Chili
1,340	Damchoe, Kabjisa	Citrus	Bean
1,370	Rimchu, Goenshari	Citrus	-
1,740	Jazikha, Shangana	Persimmon	-
1,610	Silna, Toepisa	Avocado, Citrus, Peach, Pear, Persimmon	-
1,280	Chimipang, Baap	Avocado, Citrus	-
Tsirang Dzongkhag			
1,190	Pangthang, Beteni	Citrus	Bean, millet
1,180	Damphu, Kilkorthang	Citrus	Radish
1,180	Damphu, Kilkorthang	Citrus	-
440	Southern area	Citrus	-
300	Southern area	Citrus	-
850	Noorbuthang, Phuentenchhu	Citrus	Bean, Chili
690	Sergithang Maeg, Tsirangtoe	-	Bean, Chili
580	Gaicey Kharka, Tsirangtoe	-	Bean
Dagana Dzongkhag			
760	Trashiding	-	Bean, Chilli, Indian mustard
980	Khagochen, KalidzingKha	Citrus	No vegetable
870	Baleygang, Gozhi	Guava	Bean, Indian mustard, Millet
880	Baleygang, Gozhi	-	Broccoli
924	Baleygang, Gozhi	Citrus	-
1,030	Lower Gozhi, Gozhi	-	Bean, Chilli
1,280	Middle Gozhi, Gozhi	Citrus	Chilli
836	Lower Tsendagang, Tsendagang	-	Bean, Chilli
845	Lower Gesarling, Gesarling	Citrus	Chilli

"-"= No vegetable or no fruits

A: Important Fruit crops of West Central Bhutan and their pests and diseases

Mandarin, Mango, and Pear are the top three fruit crops in west central Bhutan. Grapes, persimmon, subtropical apple, papaya, kiwi, walnut, pecan, peach and apricot are other fruit crops cultivated in the region.

1. Citrus

Incidence/Occurrence of Citrus pests and diseases in the region

The citrus leaf miner and snails respectively were the most and least frequent pests of citrus recorded across the region (Figure 3-1). The HLB was the most frequent disease of citrus observed in the region (Figure 3-2).

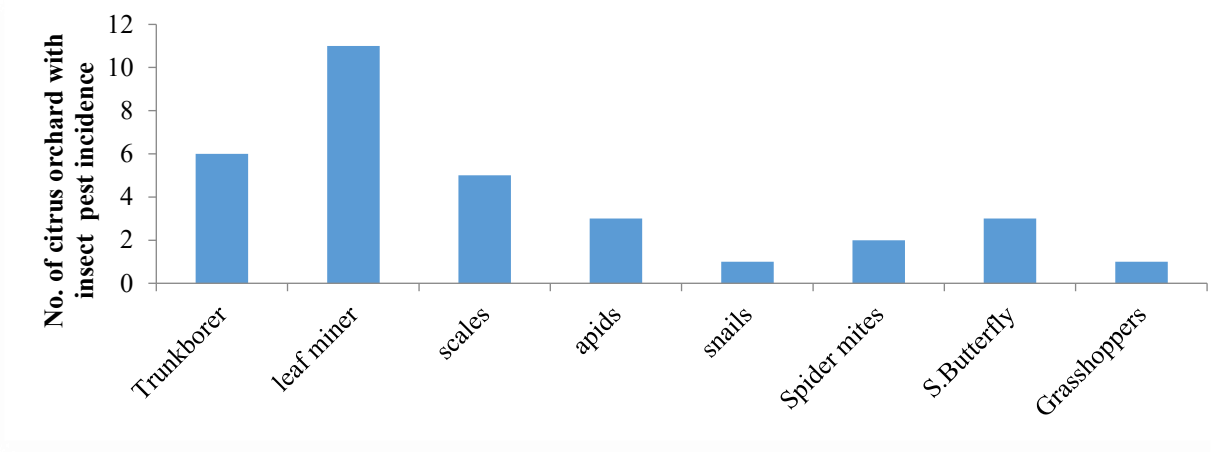


Figure 3-1: Incidence of Citrus pests in the west central Bhutan (Sept-Oct. 2017)

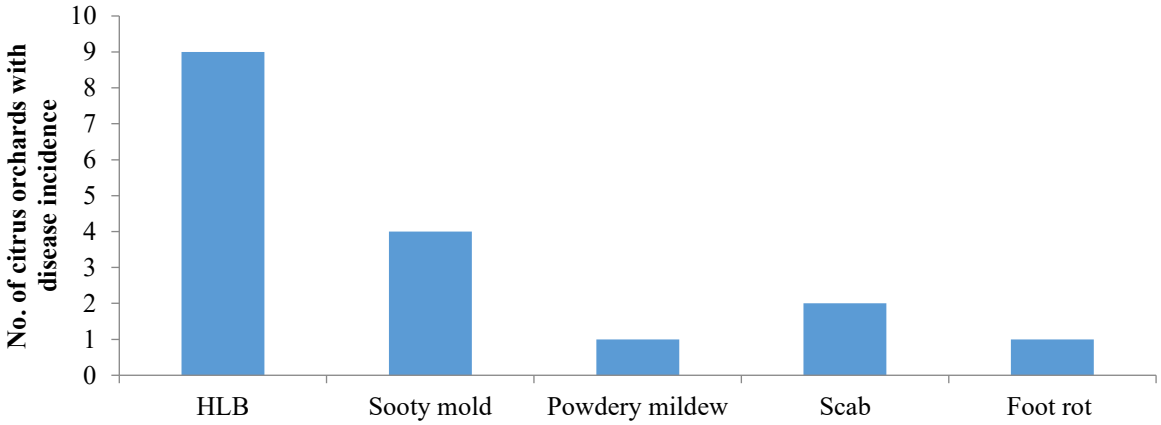


Figure 3-2: Incidence of Citrus diseases in the west central Bhutan (Sept-Oct. 2017)

Percent Infestation of different citrus pests in the region

1.1 Citrus Leaf Miner:

The citrus leaf miner percent infestation ranged from 6% to 60% of leaves at Punakha district and 0.4% to 56% of leaves at Tsirang district. At Wangdue district the percent pest infestation ranged from 12 % to 59% of leaves.

1.2 Citrus Trunk Borer:

The percent infestation of citrus trunk borer at Tsirang district ranged from 8.3% to 24% per tree. The trunk borer percent infestation at Dagana district ranged from 3.1% to 16%.

1.3 Fruit Fly

At Tsirang, 100% of the lime fruits investigated was infested by fruit fly. Although mandarin (Citrus reticulata Blanco) is the most important citrus crop in Bhutan, no fruits were available during the survey period.

1.4 Other pests of citrus

Other pests like recorded during the study were scales (Aonidillae auranntii), swallowtail butterflies, Spodoptera litura, whiteflies, aphids, and snails. The percent infestation of these pests was at minimum.

1.5 Huanglongbing and its vector:

From a total of 16 mandarin orchards studied, nine orchards showed the disease symptoms. Ranging from 90% to 100% of the mandarin trees investigated in orchards at Dagana district was showing symptoms of Huanglongbing while it ranged from 22% to 100% at Tsirang district and 40% to 67% at Wangdue.

1.6 Sooty Mold

Sooty mold was observed in most of the citrus orchards. At Damphu, the most severe condition was observed with 100% of leaves covered with sooty mold. The other orchard trees ranged from 14% to 30% of leaves.

1.7 Other diseases of Citrus

At Tsirang, one orchard was observed with powdery mildew where 36% of the leaves investigated were covered with the mycelium of the fungus. At Toepisa under Punakha district, scab was observed in 20% of the fruits studied.

2. Mango

Incidence of mango pests and diseases in the region

Trunk borer was observed in 2 orchards out of four orchards surveyed. At Punakha, in two different orchards, an unidentified weevil and black spot disease were observed.

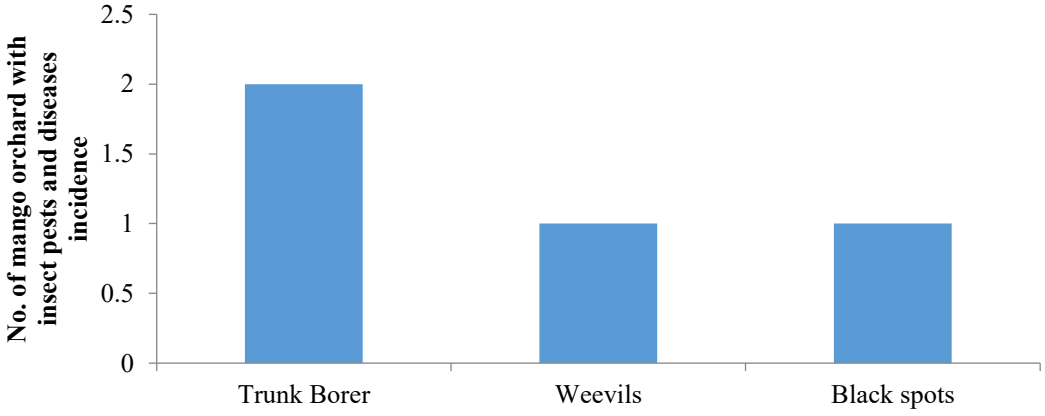


Figure 3-3: Incidence of mango pest and diseases in west central Bhutan (Sept-Oct. 2017)

Percent infestation of Pests and disease incidence on Mango in West Central region

2.1 Trunk borer:

Of the four orchards surveyed, trunk borer infestation was observed only at the Agriculture Research and Development Center, Bajo. About 4 % of the mango trees were observed infested by mango trunk borer (Batocera rufomaculata).

2.2 Fruit fly (*Bactrocera dorsalis*)

Although no fruits were available during the study period, there were adult flies trapped on the yellow sticky traps. An average of 4 flies was trapped in a week during the survey period.

2.3 Black spots

The mango trees at Phuntsho Pelri, Punakha was infected by black spots. The disease incidence was 68% of the leaves.

3. Pear

No major pest was detected during the study period. Minor pests such as aphids, red spider mites, oriental moths, and scales were observed. The highest aphid density or percent infestation was 5.4% per leaf at Talo, Punakha. The percentage infestation of other pests observed was less than 1%. The aphid infestation severity was all in grade 1 at all the pear orchards surveyed.

4. Grapes

At ARDC Bajo, the leaf beetle *(Scelodonta strigicollis*) was observed. The percent pest infestation was 50% leaves while the severity was scale 1 where 0-20% of the foliage was consumed by the beetles. No other pest was detected during the survey period.

5. Other fruit crops

Persimmon, walnut, guava, avocado, grapes are some of the minor fruits grown in Bhutan. Insect pests such as scales, scarab beetles, bagworm moths, leaf roller moths, leaf miners and longhorn beetles were observed in fruit trees during the study period. At Nahi (under Wangdue district) 73% of the walnut trees were infested by longhorn beetles.

B. Important Vegetable crops of West Central Bhutan and their pests and diseases

Chili, beans and radish are the top three vegetable crops grown in West central Bhutan. For the study; 14 chilli farms, 17 bean farms and 7 radish farms were surveyed. Other vegetables grown in the region are broccoli, cabbage, mustard green, eggplant and tomato.

1. Incidence of Chilli pests and diseases in west Central Bhutan

The most frequently observed disease of chilli was blight with 7 farms out of 14 farms surveyed infected by this disease. Although aphid infestation was observed only at one farm, viral disease symptoms were observed in 4 farms out of 14 farms.

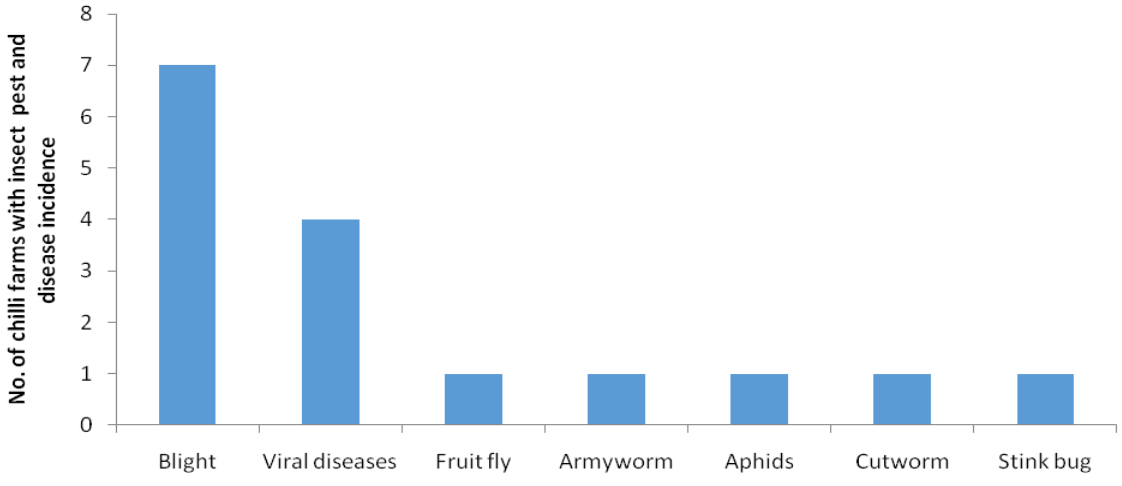


Figure 3-4: Incidence of chilli pest and diseases in west central Bhutan (Sept-Oct. 2017)

1.1 Solanum Fruit fly (*Bactrocera latifrons* Hendel)

The fruit fly percent infestation was highest at Wangdue district with 20% fruits infested (field condition) followed by Punakha (9%).

1.2 Armyworm (*Mythimnia separata*)

The chili crop at Sergithang, Tsirang was affected by Mythimnia separata. The percent infestation was 13% plants.

1.3 Other pests:

Other pests such as aphids, termites, ants and cutworms (Agrotis segetum) were observed during the study. The density of aphids, cutworms and termite was 1.5% per leaf, 2% per plant and 1% per plant respectively at Dagana.

1.4 Chilli blight; Damping off and foot rot symptoms

The chilli plants in the region were showing damping off and foot rot symptoms. The disease incidence ranged from 1% to 96% plants in the region. The disease was most severe at Bjaktoe, Kazhi under Wangdue district where 96% plants fully affected at a farm. At another farm at the same village, 90% of the small chilli (Indian) variety and 24% of the local chilli was affected.

1.5 Viral disease

The chilli crop in Wangdue district was affected by viral diseases with incidence ranging in the range 6% to 22% plants. No viral disease was observed at other farms during the study period.

2. Incidence of Bean pests and diseases in West Central Region

A total of 16 bean farms where surveyed for the study. The armyworm was observed only at Sergithang under Tsirang district. The bean pod borer was observed in two farms under Dagana district. There were several pests and diseases observed but only in one or two spots of the region with percent infestation and disease incidence less than 1%.

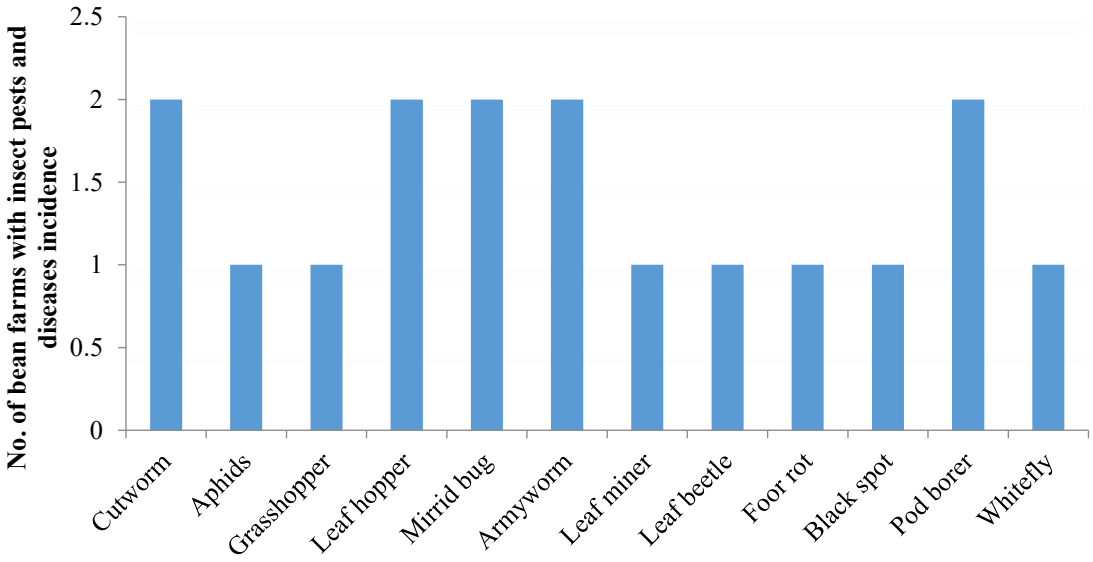


Figure 3-5: Incidence of bean pests and diseases in west central Bhutan (Sept-Oct. 2017)

Percent infestation of pests and disease incidence

2.1 Armyworms (*Mythimina separata*):

The beans at Sergithang were affected (10% of the pods) by armyworm. The beans at other places were not affected by armyworm.

2.2 Bean Pod Borer (*Muruca vitrata*):

The bean pod borer was observed only in two villages under Dagana district. The percent infestation of the pest was 8% of the pods surveyed at Tashidhing and 6.7% at lower Gozhi.

2.3 Other pests of beans:

The bean crop was infested by cutworms, mirid bugs, leafhoppers, grasshoppers, leaf miners, aphids and leaf beetles. However, the density of the pests was less than 1% at all the places surveyed.

2.4 Unidentified diseases

The beans at Bjaktey, Wangdue was affected by a kind of black spot disease while at Tashidhing, Dagana was showing foot rot symptoms. At Tashidhing, 2% of the beans were showing foot rot symptoms. The causal organism of the foot rot and black spots were unknown.

3. Radish

Incidence of Pests and diseases in Radish in the region

The most commonly observed pests were aphids and armyworms. However, the percent infestation of these pests was at minimal. A viral infection symptom on radish was observed only under Wangdue district.

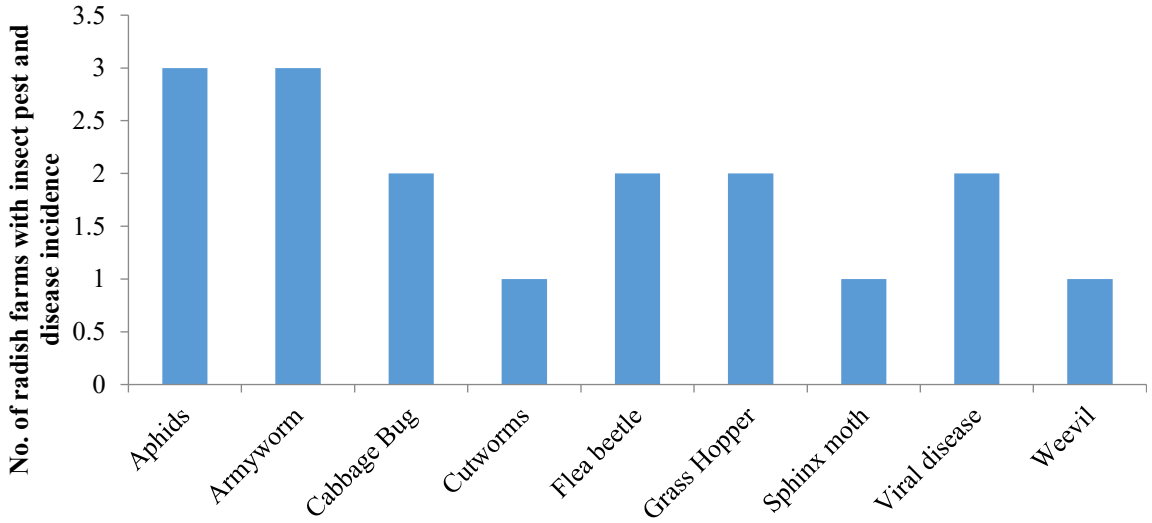


Figure 3-6: Incidence of radish pests and diseases in west central Bhutan (Sept-Oct. 2017)

Percent infestation of pests and disease incidences

At ARDC Bajo, the 3% of the radish seedlings transplanted were affected by cutworms (Agrotis segetum). At Kazhi, the radish crop was affected by flea beetles with percent

infestation 0.52% per leaves and 16% of plants affected by viral disease. The percent infestation of other pests was less than 1% in all the farms surveyed.

4. Other Vegetables

Other minor vegetable crops such as tomato, mung beans, and eggplants were also infested by several pests. At Tsirang and Dagana, the mung beans were heavily (94% and 94% of the plants) infested by armyworm (Mythimnia separata).

C. Major native natural enemies collected from fruit trees, vegetables and weeds in the cultivated fields

Although there may be much of beneficial insects that are natural enemies to different insect pests, only a few had been observed during the survey. The natural enemies observed during the survey were ladybird beetles, assassin bugs, parasitic wasps, parasitic flies, dragon flies, spiders, earwigs, praying mantis, hover flies and big-eyed bugs as tabulated against pests below:

Table 3-4: Natural enemies of insect pests in West Central Bhutan (Sept-Oct., 2017)

Insect Pests	Natural Enemy (ies)
Aphid	Lady beetles, parasitic wasps, predacious godflies, spiders, hoeverflies
Armyworms	Lady beetles, brachonidae wasps
Spider mite	Predacious mites
Cabbage bugs and weevils	Big eyed bugs
Tussock moth and Grasshoppers	Spider
Longhorn beetles	Spider
Bagworm moth	Spider
Stink bug	Assassin bugs

Discussion:

A: Important fruit crops of the West Central Region and their insect pests and diseases

NPPC (Bhutan) reports citrus leaf miner is present in all the mandarin orchards (NPPC, 2017). The citrus leaf miner is potentially a serious pest of citrus and related Rutaceae, and some related ornamental plants (Beattie 1989; Clausen 1993; Kalshoven 1981). Citrus leaf miner favours spread of citrus canker (Hill 1918; Ando et al. 1985) because of leaf damage from the mine. In this study, only in 11 of 16 citrus orchards surveyed were infested by citrus leaf miner. The highest percent infestation of this pest was 60% in the west central Bhutan during the study period. The information on spread of diseases by the pest in Bhutan is limited.

Citrus trunk borer is present in all the citrus growing regions and mainly problematic in poorly managed or neglected orchards (NPPC, 2017). The percent infestation of citrus trunk borer ranged from 3.1% to 24% per trees in our study. The adult females of mango trunk borer lay eggs upon dry shoots and dead barks. Upadhyay et al. (2013) recommends orchard sanitation followed by pruning of dry shoots and unwanted branches to manage the mango

stem borer. In this study, in two orchards of five were found infested by mango trunk borer. The percent infestation was just 4%.

NPPC reports that Chinese citrus fruit fly (Bactrocera minax) as the most serious insect pest of citrus causing losses up to 70% through late fruit drop (NPPC, HP). Two studies report that fruit fly densities are very high in Bhutan (Ghalley et al., 2014; Moriya et al., 2014). This Chinese citrus fly causes >50% fruit drop in mandarin (Dorji et al., 2006). However during this study, damage caused by fruit fly in mandarin was not studied as fruiting season was over during the study period. The study covered lime where 100% of the fruits studied was infested by fruit fly.

HLB is a severe and widespread disease in Asia and Africa caused by uncultured phloem restricted bacterium Candidatus Liberobacter asiaticus (Jagoueix et. al., 1996). The Candidatus Liberobacter asiaticus causes the Asian type HLB (Garnier et al, 2000). NPPC reports this disease is present in almost all citrus growing districts of Bhutan (NPPC, HP). In this study, we found ranging from 90% to 100% of the mandarin trees investigated in orchards at Dagana district was showing symptoms of HLB while it ranged from 22% to 100% at Tsirang district and 40% to 67% at Wangdue.

Diaphorina citri is a clarified vector of the citrus greening disease. Diaphorina communis is able to maintain the pathogen, Candidatus Liberobactor asiaticus. Donovan reported Diaphorina communis was inhabitated on curry leaf (Donovan et al., 2012). In this study, we also found Diaphorina communis inhabitated on curry leaf trees at Daga, Wangdue, but both Diaphorina citri and Diaphorina communis were not observed on citrus trees in the west central Bhutan.

Grapes are relatively a new crop cultivated in Bhutan and information on its pests and diseases in Bhutan is limited. The grape nursery at ARDC-Bajo was infested by the leaf beetle (Scelodonta strigicollis). The adults of the Scelodonta strigicollis feed on the foliage and sprouting buds while the larvae feed on the roots of the vine (Jeyseelan and Mikunthan, 2003). The damage on foliage initially began on the small netted veins and then to veins and midrib. The adult feeds first on the leaf veins from the lower side and later may feed on the other parts of the leaves. The females lay eggs in the soil or underneath the split bark. ARDC-Bajo with the current technical cooperation project (IHPP), there are numerous seedlings distributed as out-reach programs (ORP) in the region. The chances of eggs dispersal/transportation of the pest (eggs) with the distributed seedling plants is high in the split barks of the seedlings, although the seedlings distributed are pruned before distribution. With the percent hatchability of 95.0 ±2.4 (Jeyseelan and Mikunthan, 2003), S. strigicollis pose a threat to the relatively new crop in the country if not controlled at the earliest.

B. Important vegetable crops of the West Central Region and their insect pests and diseases

Moriya et al. (2014) reported that chili is infected by solanum fruit fly (*Bactrocera latifrons*). In our study, this pest was also found infesting tomato in September, 2017.

NPPC reports chili blight as the most serious disease of chili in Bhutan (NPPC, 2017). This study confirmed the disease as serious disease as the disease incidence was as high as 96% in the west central Bhutan. At Kazhi, the disease incidence on small the Jitsi ema (small Indian chili cultivar) was 90% while 24% on the local chili cultivar. Varietal resistance of other chili varieties against the disease is not known.

NPPC reported Mythimnia separata in outbreak conditions at several parts of Bhutan in maize and rice. In our study, we observed the mung beans were heavily (94% and 94% of the plants) infested by Mythimnia separata at Dagana.

C. Major native natural enemies collected from fruit trees, vegetables and weeds in the cultivated fields

Dorji et al. (2017) reported that as high as 33 species of lady beetles were observed in the Western region with 21 species in Wangdue Dzongkhag only. Ladybird beetles are well known for their predation for soft bodied arthropod pests (especially aphids and scales which are agriculture pests) and considered beneficial. In this study, two ladybird beetles belonging to Epilachninae subfamily (i.e., Henosepilachna indica and Henosepilachna vigintioctopunctata) were also observed. These Epilachnae beetles are rather leaf feeding herbivores than predators. Henosepilachna vigintioctopunctata, commonly known as 'Hadda beetle' cause damage to solanaceous crops.

The parasitoid wasps in Banchinae attack nearly the entire range of lepidopteran insects, and are used for biological control of agriculture lepidopteron pests (Whitefield, 2002). Namgay et al., reports that another kind of a wasp called Tamarixia drukyulensis, the parasitoid nymphs of Diaphorina communis was observed in Wangdue Phodrang Dzongkhag (Namgay et al., 2017). In Reunion Island, it is reported parasites (Tamarixia dryi & T. radiatus Waterson) significantly reduced the psyllid populations and lessened the damage of HLB (Gottwald et al., 2007). In our study, parasitoid wasps belonging to subfamily Banchinae and several others wasps were found in the west central Bhutan. The wasp Tamarixia drukyulensis was not observed in this study.

Conclusion:

The objective of this survey was to study the occurrence of insect pests, their natural enemies, diseases, and their vectors in fruits orchards and vegetables farms in the west central region of Bhutan. The major pests of fruit crops such as citrus, mango and pear are fruit flies and trunk borers. HLB and its vector, citrus psyllid (Diaphorina citri) are also major pests on citrus. The major insect pests of vegetable crops such as chili, beans and radish are armyworms. The phytopthora blight was a major disease on chili. The important natural enemies observed during the study period were ladybird beetles, assassin bugs, parasitic wasps, parasitic flies, dragon flies, spiders, earwigs, praying mantis, hover flies and big-eyed bugs.

3.2.2 The efficacy of Mixol 72 against chilli blight

3.2.2.1 I. Introduction

Chilli (Capsicum annum) is not only a spice but also a vegetable to Bhutanese. It is the main ingredient in most of the dishes. Chilli is a substantial crop to the farmers. However, farmers are challenged with diseases and insect pests. Phytopthora blight is the major disease of chilli in Bhutan. In the light of organic vision of the country, non-chemical managements are recommended to the chilli farmers. The non-chemical recommendation includes crop rotation and is impractical to farmers with small land holding. The marginal farmers grow same crops in the small land every time. Thus, non-chemical management practices are not feasible to most of the farms. Mono-cropping aggravates the crop loss due to decreased fertility and increased susceptibility to soil-borne diseases. The study was aimed to study the efficacy and dosage of Mixol 72 against chilli blight to use by farmers with small land holding.

3.2.2.2 II. Materials and Methods

1. Soil sampling field, sampling method and trial place

To carry out the trial, the soil samples from two farms at Bjaktey, Kazhi, Wangdue (elevation 2190 m and 2150 m) were randomly on 9 October, 2017. A total of five sub-samples were collected from each farm to form the sample of a farm. The farms were chilli crop cultivated fields which were severely affected by chilli blight (90% and 100% plants in the field affected by the disease). Similarly, healthy soil from research field of ARDC Bajo was collected on the same day.

2. Equipment and apparatuses

For the study trowels, plant pots (0.01 m3), watering can, fungicide (Mixol 71), scale (1g), measuring cup (1,000ml) and chili seedlings (Variety: 4884-C) were used.

3. Divisions for a trial

The plant pots were filled with soils collected from different sites as below:

A. Pots with soil from farm 1 (Disease history)

1. F1T1 (Farm 1-Treatment with Mixol 72-Replication 1)
2. F1T2 (Farm1-Treatment with Mixol 72-Replication 2)
3. F1T3 (Farm 1-Treatment with Mixol 72-Replication 3)
4. F1N1 (Farm1-No treatment - Replication 1)
5. F1N2 (Farm1-No treatment - Replication 2)
6. F1N3 (Farm 1-No treatment - Replication 3)

B. Pots with soil from farm 2 (Disease history)

1. F2T1 (Farm2-Treatment with Mixol 72-Replication 1)
2. F2T2 (Farm2-Treatment with Mixol 72-Replication 2)
3. F2T3 (Farm2-Treatment with Mixol 72-Replication 3)
4. F2N1 (Farm2-No treatment -Replication 1)
5. F2N2 (Farm2-No treatment -Replication 2)
6. F2N3 (Farm2-No treatment -Replication 3)

C. Pots with soil from ARDC Bajo (Healthy soil-control)

1. C1 (No treatment-Replication 1)
2. C2 (No treatment-Replication 2)
3. C3 (No treatment-Replication 3)

4. Planting of seedlings and the fungicide drenching

Two seedlings a pot were planted on 16 October, 2017. The treatments in FT series were drenched with the fungicide, Mixol 72 (Mancozeb 64% & Metalyxl 8% WP), immediately after the planting. The second drenching was carried out after seven days of the planting. The fungicide was diluted at 500 times (Mixol 72 2g / Water 1,000ml) with water. For every plant

pot, 1,000 ml of the diluted solution was applied. For the F1N, F2N and C series, 1,000 ml of water was applied when fungicide solution was applied to F1T and F2T series. The irrigations for the plants were kept constant for all the plant pots during the study period. No fertilizer was added to any of the pots. Fertility status of the soils collected was not studied.

5. Disease severity scoring

The disease severity was evaluated one month after transplant using a scale of 0-5, in which 0 = no visible symptom; 1= slightly wilted with brownish lesions on the stem; 2 = 30% of plant diseased; 3 = 50% of the plant diseased; 4 = 80% of the plant diseased; 5 = entire plant dead.

6. Yield data collection

The plants were observed for 8 months after the transplant. The fruits from the standing plants were harvested and the yield was measured.

3.2.2.3 Results and Discussion

1. Disease severity:

The disease severity on plants was 0 in C-series, F1T and F2T series. Disease severity of F1N series was 5 while 83% of plants in F2N series were 5 and rest 4.

2. Yield:

The average yields of the different divisions are graphed as below:

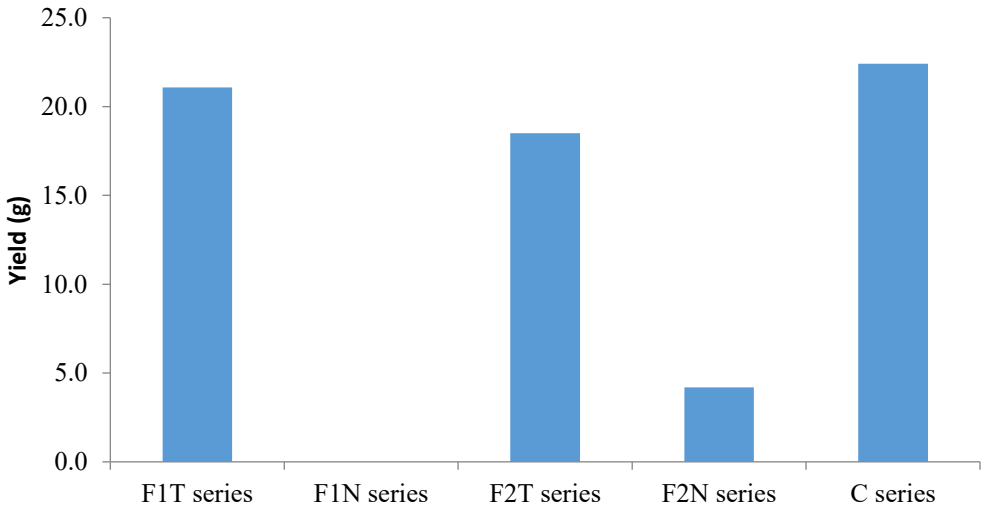


Figure 3-7: Average yield of different treatments/series

Healthy soil from ARDC Bajo field – control (C series):

The average yield of the C series was 22.4 g per plants.

Farmer 1: (F1T and F1N series)

The average yield difference between the F1T and F1N series was 100%. The average yield of the F1T series was 6% less than the C series.

Farmer 2: (F2N and F2T series)

The average yield of the F2N series was about 78% less than the F2T series while the average yield of the F2T series was about 17% less compared to that of C series.

The higher yield of the C series compared to F1T and F2T series maybe attributed to fertility status of the soils and differences between the performances of cultivar lines under different soils.

3.2.2.4 Efficacy of Mixol 72 and its dosage against chili blight

The Mixol 72 was found effective and completely controlled the phytopthora chilli blight when drenching the $0.01m^3$ plastic pots with 2g/l dosage first during transplant and 7 days after transplant (as second drenching). Mixol 72 required is estimated as 17 kg for one acre.

3.2.2.5 Conclusion

With 100% of the plants disease free in the F1T and F2 T series and yielding equivalent to the plants in the C series, the Mixol 72 was effective to control the phytopthora blight. Farmers are recommended to use non-chemical management practices described by NPPC, however farmers may use Mixol 72 (2g/l) onlyif no sufficient land to practice non-chemical methods and as a last resort for the disease management.

3.2.3 Electric Fencing Using HDPE Pipes

3.2.3.1 Introduction

Farmers traditionally use a range of methods for managing vertebrate pests. Recent development in the area is the use of electric fencing. It so far has proved very effective in keeping away most of the vertebrate pests. However, the sustainability of the system is questionable. The current electric fence system uses wooden posts which need to be replaced after every three to four years. The constant replacement of wooden posts for the electric fencing is a labour-intensive task that not only involves high labour costs but is environmentally unsustainable, which put an enormous pressure on the forest. The possibility of using HDPE posts instead of wooden posts would reduce post maintenance labor costs. It would also go a long way in conserving the environment through reduced demand for wooden posts. Therefore, this study was aimed to study the efficacy and feasibility of HDPE pipes in place of wooden posts for the electric fence system economically.

3.2.3.2 Methodology

ARDC Bajo consulted with the Dzongkhag Agriculture office, Wangdue and identified the trial site. Intensity of proneness to depredation by animals, lower economic status of the recipient farmer, crop grown and distance from the Center for timely monitoring of the trail were the factors considered for the site selection. Tools and equipments used were: GPS device, Driller and screws, Power chain and fuel, Electric fence materials:HDPE pipes (50 mm*3 m), Wooden posts (diameter 15cm, 3m height) and GI wire. Using a semi-structured questionnaire, data/information on installation/initial cost per unit fence (power chain operation, post preparation, insulator preparation, fuel costs, post erection costs, and transportation charges) and yearly maintenance costs of wooden post-electric fence system were collected from three pre-installed electric fence owners in the region. The collected data were used for preparing the standard costs for different quantities for a one-kilometer electric fence system.

For electric fence using HDPE pipes, the data on installation costs were collected during the trial set-up. The maintenance costs for HDPE post was estimated as per the durability stated by the manufacturer. The cost efficacy of the two electric fence system was compared based on the initial costs and maintenance costs. The costs for the common materials and devices

used were kept constant for the study. The post to post distance was kept constant (2m) for both the system.

3.2.3.3 Results and discussion

Initial costs comparison

A kilometer of electric fence requires 450 wooden posts (2m height) and to install them ready for the electric fence, it costs close to Nu.70, 000 on average. If the wooden posts were replaced by HDPE pipes, it costed a little more than three lakh ngultrums. The initial cost of electric fencing installation was comparatively cheaper using the wooden posts.

Table 3-5: Average initial costs of installation of 1km wooden post electric fence system

Quantity oractivity	Unit	Quantity	Unit cost	Total costs (Nu.)
Power chain operation	1 powerchain&1 man	5.1	1,500.00	7,602.90
Preparing post	Man days	7.8	500.00	3,882.40
Preparing insulator	Man days	12.0	500.00	6,000.00
Petrol	litre	27.2	58.64	1,594.80
Mobile	litre	22.5	230.00	5,181.80
HDPE Pipe- 32mm dia.	m	236.3	55.20	13,041.00
Nails	kg	30.0	70.00	2,100.00
Total costs				**39,402.80**
Post erecting	Man days	32.3	500.00	16,147.10
Transportation	Man days	26.6	500.00	13,323.50
Total initial costs				**68,873.40**

Table 3-6: Average initial costs of installation of 1km HDPE post electric fence system

Activity or Quantity	Unit	Quantity	Unit cost	Cost (Nu)
Driller charge	Man days	1.0		500.00
Energy Consumption				300.00
Post preparation cost				***800.00***
Post erecting cost	Man days	32.3	500	16,150.00
Transportation cost				3,000.00
Pipe cost	2	340.4	450	306,360.00
Total initial cost				**326,310.00**

Maintenance costs

The cumulative cost for replacement of wooden posts shoots up the cost of the fence later which is not sustainable. It is estimated to cost about Nu.23 lakh in 10 years and little more than Nu.45 lakhs in 20 years assuming that 20%, 30% and 50% of the posts need replacement after three years of installation. For the same length of electric fence using HDPE pipes considering its durability of more than 20 years, the maintenance cost is minimal in 20 years.

3.2.3.4 Conclusion

The wooden post electric fence system will be cheaper with minimal initial cost of establishment compared to the HDPE post electric fence system. However, with igher

cumulative expenses on maintenance, the HDPE post electric fence system will prove cost effective as compared to the wooden posts in a long run.

3.2.4 Bird Net Installation for Pear and Persimmon Orchard

Birds and bats were observed infesting the fruits in the orchards. To control these pests, bird nets were installed covering the orchards.

Materials use: -

- GI pipes: for main-frame posts
- GI wires: top truss to hold the net
- Bird net: 18x36 m2
- Nylon Threads: stitching nets
- Iron rods
- Welding rods

Tools and equipment/machines

- Excavator
- Ladders
- Crowbar
- Welding machine
- Pliers

Preparation and Installation:

- Hooks were made by welding iron rods on one end of GI pipes to run the GI wires.
- The GI pipes were installed as posts at 10m post-post distance to support the net as main-frame.
- The GI wires were run through the hooks on the GI pipe posts. The nets were installed covering the main-frame with no opening for birds to enter.

Target Pests:

Indian myna:

This bird is found a notorious pest of most of the fruits. The bird is found to peck and eat the fruits. The bird uses the beak to break apart and eat the fruit parts. The damaged part is exposed to different factors which could cause disease to the plant.

(a) (b)

Figure 3-8: (a) Red vented bulbul bird and (b) Trapped bats

Red vented bulbul: The bird has similar damage like the Indian myna.

Bats: Fruit bats were also observed infesting the pear fruits in the orchard. The damage observed was similar to that of birds except the markings were different. Unlike the birds, the bat damage was observed even when the fruits were not ripe.

Pest control/management recommendations: In the centre, IHPP and ARDC have successfully installed nets to control the bird and bat damages. Installing net to the whole

block/orchard was found effective to control these pests. However, at farmers' level the expense of installing such net facility would be high and economically may not feasible.

3.2.5 Large Promotion of IPM Technologies Scale

Rice is the staple food and Bhutanese strives for rice self sufficiency. However, different pests and diseases hinder the rice production through crops losses. To increase or enhance the rice production in the region, the centre had promoted the following technologies.

Comparative-demonstration on use of herbicides against shochum and other rice weeds (On-station: Weed management of rice was demonstrated using herbicides (Butachlor and sunrice). Use of different herbicides; individual, combined, hand weeded treatments were used for the demonstration. Shochum (Potamogeton distinctus), Monochoria sp., Cyperus sp., and Echinochloa spp. are the important rice weeds in the region. Current data shows that density of weeds was the least in sunrice applied field. Butachlor controlled most weeds except shochum. Farther study on the efficacy of the treatments based on yield differences and other parameters between the treatments is going on at the centre. (Area: 4.5 acres)

Rice stem borer management using pheromone traps (On-station and on-farm): Rice stem borer although a minor pest, sometimes are observed in severe conditions in the region. The management using insecticide spray was usually ineffective against the pest. In line with the organic vision, pheromone traps are promoted. The monitoring and control of the pest using pheromone traps were initiated on-station and on-farm. On-farm activity was demonstrated in four each gewogs under Punakha and Wangdue Phodrang districts. (Area: 4.5 acres on-station, 20 acres on-farm).

(a) (b)

Figure 3-9: (a) A farmer installing trap at Bjena, and (b) Installed pheromone trap (On-station)

Armyworm monitoring using pheromone traps (On-station and on-farm): Armyworms sometimes occur in outbreak condition and attack on crops affecting the yield severely. To monitor/control and study the emergence time of the pest f or future management plans, pheromone traps were installed at our centre and four each gewogs under Punakha and Wangdue Phodrang districts. (Area: 4.5 acres on-station, 20 acres on-farm).

3.3 Research Communication

3.3.1 Information management, publications extension material development

The Research Communication sector is mainly responsible for disseminating successful research results of all research disciplines of the Centre to the extension system of various

departments for their adoption and adaption. It is largely done through extension leaflet distribution, organizing study visits in the Centre, field days, review workshop and online information sharing. The sector is also responsible in coordinating the Annual Agriculture Sample Survey for the West-Central Region, data updating and maintaining the database for the Centre. In 2017-18 a total of 10 publications were developed and published. These publications consist of both technical and extension materials. The lists of publication materials developed are listed in the Table 41.

Table 3-7: Publication by the Centre in 2017-18

SN	Name of Publication	Type of Publication	Sector	Remarks
1	Baseline Survey Report	Book	IHPP/Horticulture	
2	IHPP Project Profile & Outreach Concept	Brochure	IHPP/Horticulture	
3	Temperate Fruits Nursery Management Calender	Brochure	IHPP/Horticulture	Brochure developed and ready to be printed
4	Temperate Fruit Management Calender	Brochure	IHPP/Horticulture	
5	Guideline for Ourreach Program	Pamphlet		
6	Guideline for fruits and vegetable nursery	Pamphlet		
7	Characteristics of Rice varieties	Poster	Field Crops	5 publications
8	Cultivation of Spring Rice for Food Security and Rural Livelihood	Poster	Field Crops	
9	Released Rice Varieties updates	Poster	Field Crops	
10	Annual Report 2016-17	Book		
11	IWP Progress			Bi-annual

Beside the development of extension materials, the Centre published a series of technical papers in both international and national papers as journal papers. Table 42 provides the list of technical publication with details.

Table 3-8: Technical journal paper produced by the Centre, 2017-18

Publication Title	Author	Publisher (in)	Date
Food Policy in Bhutan	Ngawang Chhogyel & Mahesh Ghimirey	https://www.elsevier.com Elsevier Inc.	2018
The importance and challenges of crop germplasm interdependence: the case of Bhutan	Mahesh Ghimirey & Ronnie Vernooy	Springerlink.com	2017
Value Chain Development and Technology of Large Cardamom and Ginger in Bhutan	Tanka Maya Pulami	SAARC Agriculture Centre, Dhaka, Bangaldesh Challenges and Opportunities in Value Chain of Spices in South Asia Regional Expert SAARC Countries, 11-13 Consultation Meeting on Technology sharing of spice crops	December, 2017
Crop suitability modelling for rice under future climate scenario in Bhutan	Ngawang Chhogyel, Mahesh Ghimiray & Kiran Sudedi	Bhutanese Journal of Bhutan, ARED, MoAF	February, 2018
Economic analysis of spring rice production at Rinchengang, Wangdue Phodrang	Thinley Gyem, Ngawang & Tanka Maya Pulami	Bhutanese Journal of Bhutan, ARED, MoAF	February, 2018

Graft Responses to three different techniques in Mango under Bhutanese nursery conditions	Sonam Chophel & Kinley Dorji	Bhutanese Journal of Bhutan, ARED, MoAF	February, 2018
Okra (Lady Finger) A Wonder Crop	Tanka Mya Pulami	Sanam Drupdrey, MoAF	February, 2018
Wheat threshers to reduce farm drudgery	Tanka Maya Pulami, Thinley Gyem & Legjay	Sanam Drupdrey, MoAF	February, 2018
Yarkey to the rescue – A success story of rice self-sufficiency after adopting new variety	Ngawang Chhogyel & Pema Dawa Ruepsia Gewog	Sanam Drupdrey, MoAF	February, 2018
Spring Rice for food security and rural livelihood	Ngawang Chhogyel	Sanam Drupdrey, MoAF	February, 2018
Technical assessment of rice research and development	Mahesh Ghimiray & Ngawang Chhogyel	Sanam Drupdrey, MoAF	February, 2018

RCO Unit has collected detailed lists of RNR publications produced by ARDC Bajo as well as publications shared by other sister RDCs, Central Agencies, Department and other relevant agencies and maintained in the library as reference. Library cataloguing has been maintained by the sector.

In line with information management articles and pictures are uploaded at the Centre webpage www.rcbajo.gov.bt, Agriculture Mover in Facebook and also shared at MoAF webpage www.moaf.gov.bt.

To maintain the historical records, the RCO Unit has carried out research on documentation of old pictures and photos of research activities of ARDC-Bajo into photos albums. More than 2500 pictures are categorized, levelled and maintained into photo album under various research activities.

3.3.2 Coordinate Centre visit by farmers, students and official delegates

During this fiscal year 2017-18, the Centre was visited by various groups of visitors comprising of farmers, students, youths, trainees from various schools and institutes, Dzongkhag RNR Extension staff and Research officials. Learning objectives of visitors varied from one group to another. It has been found that farmers are more interested in seeing new crop varieties, which are high yielding. Extension personnel are also keen on new technologies and information related to those technologies whereas trainees, outsider guests and other institution visitors have specific objectives visiting the Centre. In general, they are interested on the relevant technologies available in this research Centre. Altogether the sector has provided the protocol services to various groups who visited the Centre within the fiscal year as reflected in Table 3-9.

Table 3-9: Farmers study tour visit to the Centre, 2017- 18

SN	Farmers Group	Organizer Institute	No. of Farmers
1	RNR Farmers study tour	RNR Sector Dotey Gewog Paro	25
2	FSAPP Farmers study tour Dagana Dzongkhag (Project gewogs)	ARDC, Bajo	25
3	Farmers study tour (Agriculture)	Chudzom geog, Sarpang	22
4	RNR Farmers study tour	Doteng Gewog, Paro	36
5	Dairy Farming group	Bji Gewog, Haa	18
6	RNR Farmers study tour	Mewang geog, Thimphu	35

7	Livestock Farmers study tour	Samtse	18
8	Community Forestry Farmers group	Dogar Gewog, Paro	26
9	BDBL farmers exposure visit	BDBL, Wangdue	18
10	BDBL Eastern Farmers tour	BDBL, Thimphu	29
11	MHV Farmers Study tour, Dagana	Dagana	22
12	MHV Farmers StudyTour, Limithang	Limithang, Mongar	11
13	MHV Farmers Study Tour	Tsirang	20
14	Farmers study tour (Agriculture)	Phuentenchu Gewog, Tsirang	15

During 2017-18 fourteen groups of farmers visited the Centre on study tour organized by different sectors. These groups were shown various on-going activities at the station. Besides famers visit, there were guest from various institutional on official purposes (Table 3-10).

Table 3-10: Profile of visitors to the Centre in 2017-18

SN	Date	Name Designation	Organization Address	Purpose of the Visit
1	16.03.2018	SAP Coordinators (21 nos) Agriculture Staff (5)	Agriculture Sector, Wangdue Dzongkhag	Training on Improved Agriculture Technologies
2	07.02.2018	Minister, Secretary	Embassy of Japan to India	Official Visit
3	30.12.2017	Dasho Rinzin Dorji, Secretary Kinley Tshering, Director Tomoko Tanaka, Dy Director Masahiro Shioml, Advisior	MoAF DoA, MoAF J ICA HQ, Thimphu JICA HQ, Thimphu	To attend 2nd Joint Coordination Committee Workshop
4	18.05.2018	BSc. ECS students	CNR, Lobesa	Block day study program for BSc. ECS students, CNR, Lobesa on watershed management
5	15.09.2017	BSc. Agriculture Students	CNR, Lobesa	Block day program for horticulture research
6	15.03.2018	Agri. Extension Agents (8 nos)	West-Central Region	Training on Summer Vegetable Cultivation
7	18.07.2017	Delegates from IRRI-BRRI, Bangladesh	Delegates from IRRI-BRRI, Bangladesh	Discuss and strengthen on rice-based agriculture and food system focusing particularly on cold-tolerant rice varieties between Bangladesh and Bhutan
8	18.04.2018	Tshering Tobgay, Dy CAO with 8 EAS	DoA, MoAF, Thimphu	Professional Development Program
9	27.04.2018	Sonam Dargay with 37 participants	Mountain Hazelnut Venture, Gyelposing, Mongar	Awareness/training on Hazelnuts
10	14.05.2018	Kinley Tshering (Director) Wangda Dukpa (Chief ARED)	DoA, Thimphu	To strengthen the linkage between the department and RDCs, to discuss about the new intervention of DoA, and to discuss about field issues and problems.
11	14.06.2018	Regional Delegates	Bangladesh, Nepal and IRRI-India	Sustainable Intensification of Rice Based Cropping System in Bangladesh, Nepal and Bhutan
12	04.10.2017	Dr. KK Jena, Senior Rice Breeder	IRRI, Philippines	Interact with our rice scientists and policy makers and explore areas of collaboration.
13	04.07.2017	eight multi-disciplinary officials from Nepal Agriculture Research Centre	Nepal Agriculture Research Centre (NARC)	Exchange ideas and knowledge in regards to Agriculture Research between Nepal and Bhutan
14	06.07.2017	Eight delegates from SAARC member states	SAARC member Countries	Exposure visit to the Centre

15	27.03.2018	Dr. Dave Hodson, scientist with NPPC team	CIMMYT, Ethiopia	The program is part of wheat rust surveillance and to understand rust situation on farmers' field.
16	30.05.2018	Two officials from Nishima company	Nishima Electronics Industries Co. Ltd, Japan	NOP-JICA project for installation of field water level and temperature reading device on-station
17	17.08.2017	Program Director and Team	NSC, Paro	Familiarization tour.
18	28.06.2018	Delegates from Krygye Republic	Krygye Republic	Exposure visit
19	19.07.2017	Honorable Dasho Secretary, Dasho Rabgay Tobden Director, Directorial Services, Mr. Letho Wangchuk, Internal Aduit Unit, Ms Dechen Choden AFD, MoAF, Financial personnel from Divisional Forest Office, Lobesa and JNDP, PD, ARDC, Samtenling		Annual Audit Report Meeting on observation of audit memos pertaining to memos pertaining to RNR sectors of West-Central Region.
20	27.02.2018	His Excellency, Mr. Sone, Minister, Embassy of Japan to India and Mr. Aya (1st Secretary) and Chief Representative, Bhutan JICA office, Thimphu		Official visit to IHP Program
21	23.01.2018	The new recruits of 2018 Department of Agriculture		Exposure visit to the Centre
22	04.05.2018	Doley Tshering, Regional Technical Advisor, Regional Office UNDP Bangkok, Thailand Chimi Rinzin Portfolio Specialist, UNDP, Thimphu Nawara Chetri, Portfolio Manager, UNDP, Thimphu		Explore Climate resilient research opportunities in line with GEF-LDCF/BD Corridors Project UNDP-RGoB
23	27.04.2018	Sangay Dendup, Sr.H.O, DoA, MoAF, Thimphu with four participants		Professional Development Program.

(a)

(b)

Figure 3-10: (a) Delegetes from UNDP and (b)Ura, Bumthang farmers study tour

3.3.3 Regional Database Management

The RCO unit manages the database for the Region. To start up the unit has started with maintaining data base like crop cut data of important crops, rice, citrus data base, gewog information, electric fencing, farm machineries, gewog level problem and constraints. The sector also collects crop-cut data of important crops, validate in consultation with sector heads and submit to PPD along with the Centre Production data for analysis and Agriculture Statistics Publication. The database maintained with the sector

3.4 National Seed Testing and Referral Laboratory

National Seed Testing and Referral Laboratory at Bajo is responsible for carrying out necessary tests like Germination per cent, Purity per cent, Moisture per cent, etc. in samples submitted to them. It is the referral point for testing various parameters in seeds of various crops and caters its services all over the country. Currently, most of the clients include ARDCs, BAFRA, NSC, interested farmers and private seed companies. The laboratory was recently established as per the Organization Development program of RCSC and has two staff working in it. The laboratory is in serious need of Laboratory Officer to further strengthen the work and activities of the laboratory. In the past one year around 150 samples from vegetables and cereals crops were tested at the laboratory.

3.4.1 Seed samples tested for various parameters

The seed samples submitted through BAFRA are tested for germination percent, purity percent and moisture per cent. Whereas seed samples from interested farmers are usually tested for germination and purity percent only. The seed parameters to be tested depend on the interest of the clients and the capacity of the laboratory to perform the test. The results and recommendations are then provided to them. The seed samples collected are usually from vegetables and cereals crop and least from fruit crops. The table below (Table 3-11) shows the details of samples tested in the fiscal year 2017-18.

Table 3-11: Seed samples tested in 2017-18

SN	Crop	Beneficiary	SCB	TSN	Seeds	GR (%)	P (%)	MC (%)
1	Vegetables	Farmers, Tsirang	ARDC, Seed lab staff	2	Spinach	65	98	NT
				2	Lady finger	85	99	
				1	Broccoli	89	99	
				3	Tomato	84	98	
				3	Beans	92	99	
				3	Cabbage	93	99	
				1	Brinjal	75	99	
2	Cereal crops	ARDC, Tsirang	ARDC, Seed lab staff	3	Beans	92	99	NT
				4	Tomatoes	85	99	
				1	carrot	80	98	
				1	Chilli	78	98	
3	Vegetables	Farmers, Tsirang	BAFRA, Tsirang	2	Pea	94	99	9
				3	Radish	98.20	99	6
				5	Cauliflower	94.50	99	7
				2	Cabbage	92.30	99	6.50
				2	Chilli	95.30	99	12
				2	Beans	97	99	9
4	Vegetables	Farmers, Thimphu	ARDC, Seed lab staff	3	Chinese cabbage	92.50	99	6
				4	Beans	95	99.10	7
				1	Tomato	92	99.50	8
				2	radish	85	99	5.70
5	Cereal crops	Farmers, Thimphu	ARDC, Seed lab staff	2	Wheat	85	98	13
				6	Paddy	90	98	13.50
6	Vegetables	Farmers, Paro	ARDC, Seed lab staff	4	Beans	83	99	NT
				2	bulb onion	92	98	
				4	Cabbage	97	99	
				2	radish	80	99	
				3	Cauliflower	75	98	
				2	lettuce	84	97	
7	Cereal crops	Farmers, Paro	ARDC, Seed lab staff	6	Paddy	94	98	NT
				4	wheat	89	99	
				2	Maize	80	99.20	

8	Vegetables	NSC, Paro	BAFRA, Paro	1	Beans	92	100	8.70
				1	Pea	94	100	9
				2	Radish	97.50	100	6
				1	Cabbage	97.50	100	7
				1	Chinese cabbage	98	100	6.50
				1	Coriander	91	99.90	7
				1	Tomato	80.25	100	8
				1	Chilli	94.75	100	8
				1	Lettuce	96.75	99.80	8
				1	Beet root	75.75	99.90	6
9	Vegetables	Bhutan Alpine, Paro	BAFRA, Paro	1	Beans	93	100	9
				1	Pea	96	100	8.50
				1	Lady finger	90	100	10
				1	Radish	98.25	100	5.80
				1	Broccoli	96.25	100	6.50
				1	Cauliflower	94.50	100	7
				1	Bulb onion	97.75	100	8
				1	Cabbage	96.50	100	7
				1	chilli	94.75	100	8
				1	Tomato	93.75	100	8
10	Vegetables	ARDC, Wengkhar	BAFRA, Mongar	1	Pea	94	100	8
				1	Broccoli	86	99.90	7
				2	Cabbage	83	99.90	6.50
				3	beans	91	99.80	9
				1	Onion	89	100	7.50
				1	Spinach	82.50	99.90	6
				2	radish	89.25	100	6
				3	Cauliflower	87	100	6.50
				1	Chilli	90	99.90	9
11	Oil seed	ARDC, Wengkhar	BAFRA, Mongar	4	Mustard	84 to 91	99	9
12	Cereal crops	NSC, Wangdue	BAFRA, Wangdue	7	Wheat	86 to 95	99	14
13	Vegetables	Farmers, Punakha	ARDC, Seed lab staff	1	radish	90	99.80	NT
				2	Beans	86	99.80	
				1	Chilli	75	99.90	
				4	Tomato	84	99.80	
				3	Brinjal	87	99.90	
				2	Cabbage	92	99.90	
				2	Roy sag	90	99.90	
14	Cereal crops	Farmers, Punakha	ARDC, Seed lab staff	5	Paddy	85 to 94	99.90	13.30
				2	Wheat	87	99.70	13
				1	Maize	90	99.90	13.60
15	Cereal crops	Farmers, Wangdue	ARDC, Seed lab staff	7	Wheat	89 to 93	99.80	NT
				4	Maize	85 to 90	99.90	
				8	Paddy	80 to 91	99.90	

Note: SCB = Sample collected by, TSN = Total Sample Number, GP = Germination Rate, P = Purity, MC = Moisture Content, NT = Not Tested

The samples are tested as per the requirement mentioned in the letter by BAFRA but for farmers' germination and purity test is done.

4 ENGINEERING SERVICES

The main mandate of Engineering Sector is to provide irrigation engineering services to West-Central Region (Bumthang, Trongsa, Wangdue, Punakha, Dagana and Tsirang) to for the enhancement of food production through development of irrigation infrastructures. It provides general engineering services to sister agencies in the region under the ministry of Agriculture & Forests. Table 4-1 provides sector strength.

Table 4-1: ARDC Bajo Engineering Sector strength

SN	Name	Qualification	Designation	Position	Remark
1	Thinley Gyamtsho	BEng (Civil), MSc-NRM	Principal Agri. Officer	P1A	Sector Head
2	Thinley Gyeltshen	Diploma in Civil Eng.	Principal Engineer	P1A	
3	Puran Chhetri	Diploma in Civil Eng.	Assistant Engineer	SS4	
4	Nima Wangchuk	Diploma in Civil Eng.	Junior Engineer	S2A	
5	Indra Bdr Raika	Certificate in Electrical Eng.	Sr Tech-III	S2A	

4.1 Overview by sector mandate and agencies

Engineering services provided by the Engineering Sector included preliminary site visits, total station survey, preparation of designs, drawings, estimate, BoQ, tender document, tendering & awarding, implementation, passing of bills, and taking over of the work from the construction firms. In 2017-18 the sector provided services for 46 activities with estimated value of Nu697.636Million. This translates to average of 11.2 activities per engineer per year corresponding to average estimated value of Nu155.272M per engineers. The value of the work based on the bid price was Nu24.002M per engineer.

From a total of 56 activities 19 activities were related to irrigation infrastructure development while 37 were related to general construction works. These activities were implemented for six agencies (ADRC Bajo, ARDSC Tsirang, Royal Project Chimipang, NSC Bajo, NSC Phobjikha and DFO Dagapela) in the region under the Ministry of Agriculture & Forests and four Regional Client Dzongkhags (Dagana, Punakha, Tsirang & Wangdue).

Amongst the ten agencies the highest numbers of engineering services were provided to ARDC Bajo of 19 activities followed by Royal Project Chimipang, Divisional Forest Office-Dagapela, and Dzongkhag of 12, 9 and 8 activities respectively. In terms of estimated value of the work the highest was for Dzonkhag Administration Wangdue of Nu598.678M followed by Divisional Forest Office Dagapela of Nu38.635M, Dzongkhag Administration Punakha (Nu33.974M), DA Tsirang (Nu31.317M), DA Dagana (Nu29.499M), Royal Project Chimipang (Nu28.034M), ARDC Bajo (Nu13.594M) and rest were worth less than Nu3.0M. The details are presented in subsequent sections.

Table 4-2: Number of activities, estimated cost and bid price by service type and lead engineer

Agency	IES			GES			Both		
	NoA	EC(NuM)	BP(NuM)	NoA	EC(NuM)	BP(NuM)	NoA	EC(NuM)	BP(NuM)
ARDC-Bajo	4	1.183	1.183	15	12.411	0.984	19	13.594	2.167
ARDSC-Tsirang	-	-	-	1	0.047	0.050	1	0.047	0.050
RP-Chimipang	4	13.441	7.316	8	14.593	6.915	12	28.034	14.232
NSC-Bajo	1	1.719	1.115	1	0.650	-	2	2.369	1.115

NSC-Phobjikha	-	-	-	1	0.215	0.173	1	0.215	0.173
DFO-Dagapela	-	-	-	9	38.635	-	9	38.635	-
DA-Dagana	1	29.499	29.000	-	-	-	1	29.499	29.000
DA-Punakha	1	33.974	23.879	1	-	-	2	33.974	23.879
DA-Tsirang	1	31.317	29.806	-	-	-	1	31.317	29.806
DA-Wangdue	7	598.678	19.591	1	-	-	8	598.678	19.591
Total	**19**	**709.810**	**111.890**	**37**	**66.551**	**8.123**	**56**	**776.361**	**120.013**

Note: *IES = Irrigation Engineering Services, GES = General Engineering Services, NoA = Number of Activities, EC = Estimated Cost, BP = Bid Price, DA = Dzongkhag Administration, DFO = Divisional Forest Office*

4.2 Overview by nature of plan

Table 47 presents the overview of engineering services base on the nature of activity. The nature of is activity is defined whether the activity was in accordance with IWP coded as (PA) or adhoc (AA) or routine activity (RA) although foreseen but not reflected in IWP. In general, the sector implemented 10 planned activity, 5 routine activity and 41adhoc activities corresponding to estimated value of Nu126.782M, Nu3.811M and Nu645.768M respectively.

From a total of 18 irrigation related activities six activities worth Nu118.062M was per the IWP, two worth Nu3.714M was implemented as routine activity, and 11 activities with estimated value of Nu588.034M was implemented as an adhoc activity. Similarly, out of 37 general engineering activities only four activities worth Nu8.72Mwere as per IWP, three worth Nu0.097M was implemented as routine activity, and 30 activities with estimated value of Nu57.734M were implemented as an adhoc activity.

Table 4-3: Number of activities and estimated cost by activity type and lead engineer

Activity type code		**TG1**		**TG2**		**PC**		**NW**		**IBR**		**Eng. Sector**	
		NoA	C (MNu)	NoA	C (MNu)	NoA	C(MNu)	NoA	C(MNu)	NoA	C(MNu)	NoA	C(MNu)
IES	**PA**	1	18.356	-	-	4	95.715	1	3.991	-	-	6	118.062
	RA	1	3.699	-	-	-	-	-	-	1	0.015	2	3.714
	AA	7	587.212	-	-	-	-	1	-	3	0.823	11	588.034
GES	**PA**	-	-	2	1.475	1	3.450	1	3.795	-	-	4	8.720
	RA	-	-	-	-	-	-	-	-	3	0.097	3	0.097
	AA	-	-	12	14.267	11	38.635	7	4.832	-	-	30	57.734
Total	**IES**	9	609.267	-	-	4	95.715	2	3.991	4	0.838	19	709.810
	GES	-	-	14	15.742	12	42.085	8	8.627	3	0.097	37	66.551
Total	**PA**	1	18.356	2	1.475	5	99.165	2	7.786	-	-	10	126.782
	RA	1	3.699	-	-	-	-	-	-	4	0.112	5	3.811
	AA	7	587.212	12	14.267	11	38.635	8	4.832	3	0.823	41	645.768
Total		**9**	**609.267**	**14**	**15.742**	**16**	**137.800**	**10**	**12.617**	**7**	**0.935**	**56**	**776.361**

Note: *IES = Irrigation Engineering Services, GES = General Engineering Services, PA = Planned Activity, RA = Routine Activity, AA = Adhoc Activity, TG1 = Thinley Gyamtsho, TG2 = Thinley Gyeltshen, PC = PuranChhetri, NW = NimaWangchuk, IBR = IndraBdr. Raika, NoA = Number of Activities, C = Estimated Cost.*

4.3 Engineering Services provided by Thinley Gyamtsho (TG1)

4.3.1 Major Renovation Baychu Irrigation Channel

The work on the major renovation of 15.0km Baychu Irrigation Channel under Thedtsho Geog in Wangdue was started in 2014-15 financial year as part of the planned activity. The site survey, preparation of designs, drawings and estimate, and open tendering was completed in the same year. The cost of the work was estimated at Nu18.356M based on BSR-2015 with 20.08% cost index over Thimphu rates. In the following year the work was awarded to Ms Wangthang Construction for implementation through open tendering at contract price of Nu17.699M with net implementation duration of 16 months. The renovation works consist of improvement of intake structure, construction of sedimentation chamber, improvement of channel structures and capacities at critical sections, construction of cross-drains, provided channel-road crossing structures, lining of channels in high seepage section, increased channel capacities (350lps), provided gated channel outlet structures and realignment of three drinking water pipelines which are laid within the channel section obstruction the water flow in the channel.

The progress of the work was affected by the need to stop the work during paddy season (May to November). This has increased the cost of mobilization and demobilization of labour. Besides Wangdue-Trongsa Highway widening works has weakened the foundation of the channel starting from Chuzomsa to Gangthang (about 7.0km). Over the last two years the channel was completely damaged at three locations due to the failure of the slope triggered by widening works. The completed work was taken over from the contractor on 21 May 2018.

Mr Puran Chhetri (Assistant Engineer) and Indra Bdr Raika (Sr Tech-III) conducted the survey while Thinley Gyamtsho (PRO) served as site engineer in addition preparation of designs, drawings, estimate and BoQ. RNR Engineering Division under Department of Agriculture (DoA) carried out tendering and awarding of the work.

4.3.2 Construction of Lift Irrigation at NSC Bajo

DoA directed ARDC Bajo Engineering Sector to provide engineering services to Regional Seed Centre Bajo for the construction of Lift Irrigation for RSC Bajo Farm as an adhoc activity. Mr Indra and Thinley Gyamtsho jointly conducted the field survey. Subsequently, TG1 prepared design, drawings, estimate, BoQ and submitted to NSC Bajo. NSC Paro conducted open tendering of the work. The lift irrigation system was designed to irrigate 10 acres of NSC Farm at Bajo by pumping water from Punatshangchu to the upper most part of the farm area. The system is designed to pump water at 17 liters per second through 416m long 160mm HDPE pipe using 11kW (15HP) submersible pump mounted on float intake. The capital cost of the system was estimated at Nu1.719M based on DrukPipe price while for Indian suppliers was estimated at Nu1.440M. The cost of operation was estimated Nu84,631 per acre per year (Nu27,025 per acre in June, Nu18,632 per acre in July) based on the water requirement for prevailing cropping pattern in Wangdue.

Table 4-4: Design profile of proposed pumping system at NSC Farm Bajo

Command area	:	*10.47 acres (4.24 ha)*
Peak water requirement	:	*14 lps in June (13 lps-July, 8 lps-May)*
Pump operation hours	:	*20 hours per day*
Design flow	:	*17 lps*
Conveyance length- main	:	*416 m (HDPE Pipe- 160mm-PN6, Pump-Control House 30m of 110mm dia)*
Conveyance length-	:	*082 m (HDPE Pipe- 160mm-PN6)*

branch		
Dynamic pumping head	:	*42.34m (Static head- 31.37m, Residual head- 5.00m)*
Pump and Motor set type	:	*Submersible- 11kW (15HP) electricity powered*
Sump/Pump Intake type	:	*Float intake*
Control house/panel	:	*RCC Chamber (1.5x1.5x2.9m) with MS Door frame & Shutter*
Cost- capital	:	*DrukPipe-Nu1.719M, Duraline-Nu1.440M* *DrukPipe-Nu156,316 per acre, Duraline-Nu130,911 per acre*
Cost- operation (electricity) (*ref. design sheet for detail*)	:	*Nu886,058 per year (Nu282,955-June, Nu195,073-July, Nu103,713-May)* *Nu84,631/acre/year (Nu27,025/acre-June, Nu18,632/acre-July)* *Nu5.18/m^3 of water (Nu8.13/ m^3–June, Nu6.64/ m^3–July, Nu4.84/ m^3–May)*

4.3.3 Construction of Waste Water Harvesting System at ARDC Bajo

In accordance of the ARDC Bajo Management directed the Engineering Sector prepare drawings and estimate for the construction of Waste Water Harvesting System at ADRC Bajo Farm. The system is expected to help in the management of residential waste water flowing down from the Army area. The system is not only designed to separate solid waste and remove sediments, but also use as irrigation water for the lower part of the farm area. Besides this system will control waste entering into research plots and reduce health risk both for the Farm labours in particular and the farm product consumers in general.

The system consists pipelines (new), open channel (existing), waste screen chamber, irrigation water control chamber and valves, pipe outlet chambers, and two ponds with spillway, outlet and drain out pipes. The new pipelines are to be laid along existing open channel segregating fresh irrigation water and waste water. The irrigation water control chambers with gates to control flow into different branch channels. The first pond is designed to have storage capacity of 70cu.m. This pond is intended separate solid waste & sediments and to store water for irrigation. The pond has spillway with designed capacity of 305lps while the maximum emergency discharge capacity of 560lps. The pond has pipe outlet and drain out with gate valves housed in a concrete valve chamber. The second pond is designed to have storage capacity of over 800cubic meters. This pond is intended to store water for irrigation.

4.3.4 Feasibility study for Construction of Gaselo Irrigation Channel

Based on the command of the PM, Dzongkhag Administration Wangdue (DAW) initiated the feasibility study for the construction of Gaselo Irrigation Channel. DAW not only provided financial support but also facilitated discussion with the stakeholders, collection of data and visits to the sites. Engineering Sector under ARDC Bajo provided technical support in terms of analysis of the situation, feasibility assessment and prepared feasibility study report. Feasibility assessment were based on annual yield of the source, annual water requirement of the command area of respective sources, water sufficiency during the critical cropping season, cost of construction, and breakeven period. The following Table summarizes the findings.

Table 4-5: Feasibility parameters for proposed Gaselo Irrigation Channel

Descriptions	***Parameter***
Name of source	*Heso-tsham Chu & Chumistawa Chu*
Catchment area	*59.90 sq.km*
Catchment yield	*52.701 MCM (Million Cubic Meter)*
Channel length	*23.40 km*
Conveyance system	*Gravity flow open channel*
Command area	*1,270 acres (Gross CA = 1,596 acres)*

Water requirement	*20.769 MCM per year*	
Diversion requirement	*27.000 MCM (at 30% conveyance loss)*	
Design flow rate	*2,120 lps (liters per second)*	
Water sufficiency	*88% (Without storage), 254% (With storage)*	
Beneficiaries	*Gasetsho Gongm (5 villages, 346 HH, 849 acres)* *Gasetsho Wogm (4 villages, 186 HH, 417 acres)*	
Estimated cost	*Without access road* *Nu137.673M*	*With access road* *Nu159.004M*
Unit cost	*Nu5.883M per km* *Nu123,695.25 per acre* *Nu7.56 per cu.m*	*Nu6.883M per km* *Nu142,860.42 per acre* *Nu8.74 per cu.m*
Breakeven period	*3.3 years*	*3.8 years*
Feasibility score	*8.95 out of 10*	*8.94 out of 10*
Feasibility description	*Very highly feasible*	*Very highly feasible*

4.3.5 Feasibility study for Construction of Ruebisa Irrigation Channel

Based on the command of the PM, Dzongkhag Administration Wangdue (DAW) initiated the feasibility study for the construction of Ruebisa Irrigation Channel. DAW not only provided financial support but also facilitated discussion with the stakeholders, collection of data and visits to the sites. Engineering Sector under ARDC Bajo provided technical support in terms of analysis of the situation, feasibility assessment and prepared feasibility study report. Two options were considered for the feasibility assessment of the construction irrigation channel for Ruebisa. While the sources lay in the same catchment the two options were differentiated based on the location of channel intakes. Feasibility assessment were based on annual yield of the source, annual water requirement of the command area of respective sources, water sufficiency during the critical cropping season, cost of construction, and breakeven period. The following Table summarizes the findings.

Table 4-6: Feasibility parameters for proposed Ruebisa Irrigation Channel, Wangdue

Descriptions	***Parameter: Option-A***		***Parameter: Option-B***	
Name of source	Ngabay Chu, Lenda Chu, Pangza Chu&Draphu Chu		Jalla Chu	
Catchment area	20.10 sq.km		98.70 sq.km	
Catchment yield	8.472 MCM (Million Cubic Meter)		37.032 MCM	
Channel length	22.34 km		24.00 km	
Conveyance system	Gravity flow open channel		Gravity flow open channel	
Command area	860 acres (Gross CA = 1,641 acres)		1,120 acres (Gross CA = 1,905 acres)	
Water requirement	14.064 MCM per year		18.316 MCM per year	
Diversion requirement	18.283 MCM (at 30% conveyance loss)		23.811 MCM (at 30% conveyance loss)	
Design flow rate	1,440 lps (liters per second)		1,870 lps	
Water sufficiency	*46% (No storage), 60% (With storage)*		*82% (No storage), 202% (With storage)*	
Beneficiaries	*12V, 111HH, 505 acres- Ruebisa* *2V, 156HH, 354 acres- Bjena*		*14V, 171HH, 757 acres- Ruebisa* *2V, 156HH, 354 acres- Bjena*	
Estimated cost	*Without road* *Nu118.700M*	*With Road* *Nu137.178M*	*Without road* *Nu146.220M*	*With Road* *Nu168.875M*
Unit cost	*Nu5.313M per km* *Nu300,434 per acre* *Nu18.37 per cu.m*	*Nu6.140M per km* *Nu347,204 per acre* *Nu21.23 per cu.m*	*Nu6.092M per km* *Nu158,305 per acre* *Nu9.68 per cu.m*	*Nu7.036M per km* *Nu182,832 per acre* *Nu11.18 per cu.m*
Breakeven period	*7.9 years*	*9.1 years*	*4.2 years*	*4.8 years*
Feasibility score	*5.95 out of 10*	*5.90 out of 10*	*8.86 out of 10*	*8.86 out of 10*
Feasibility description	*Normal*	*Normal*	*Very highly feasible*	*Very highly feasible*

4.3.6 Pre-Feasibility study for Pump Irrigation Water as alternative to gravity channel

Based on the PM's command Dzongkhag Administration Wangdue directed Engineering Sector to explore options for providing irrigation to Phangyul through pumping as an alternative to construction of 34.0km long Baychu Irrigation channel passing through Kazhi geog. Accordingly, the sector carried out desktop pre-feasibility using existing information and the spatial information derived from Google Earth. The command area considered for pumping was only 300 acres against total 1000 acres considered for open channel. Based on the defined command water requirement pattern were established which in turn determined peak pumping rate of 385lps. Using Google Earth the location of intake and delivery points was determined. L-section data was also derived from Google Earth. Based on the above data hydraulic design of the pipeline was conducted and summary design result is presented in Table 51.

Table 4-7: Profile of pumping system for Phangyul with 10% supplement from existing channel

Command area	:	*300 acres (121.4 ha)*
Peak water requirement	:	*384.9lps in June (314.4 lps-July)*
Pump operation hours	:	*21.6 hours per day*
Design flow	:	*385lps*
Conveyance line	:	*4 lines (2,200m per line)*
Conveyance length	:	*2,200 m (HDPE Pipe- 400mm-PN6 to 25+)*
Static head	:	*625 m*
Residual head	:	*10 m*
Dynamic pumping head	:	*665 m*
Cost- capital (pipe only)	:	*DrukPipe-Nu132.785M, Duraline-Nu64.047M* *DrukPipe-Nu0.443M per acre, Duraline-Nu0.213M per acre*
Cost- operation (electricity) (*ref. design sheet for detail*)	:	*Nu2,048M per year (Nu168M-June, Nu174M-July, Nu173M-May)* *Nu6.827M/acre/year (Nu0.562/acre-June, Nu0.580/acre-July)* *Nu417/m^3 of water (Nu188/ m^3–June, Nu230/ m^3–July, Nu314/ m^3–May)*

4.3.7 Re-estimation for Construction of Baychu Irrigation Channel

Engineering Sector under ARDC Bajo prepared revised estimated for construction Baychu Irrigation Channel for Phangyul Geog based on the direction of DAW. The proposed 34.0km long irrigation channel with its intake located in Damchoethang village under Kazhi Geog was designed to convey 700lps of irrigation water to Phangyul Geog. The construction was estimated to cost Nu64.63M in 2011 which was without access road. The revised cost prepared in 2017 was estimated at Nu184.697M which included access road and revised channel section structure. Following table provides the summary of the cost.

Table 4-8: Design profile for proposed Baychu Irrigation Channel, Wangdue

Descriptions	***Parameter***
Name of project	*Construction of Baychu Irrigation Channel*
Name of source	*Baychu (Damchoethang)*
Length	*34 km*
Conveyance system	*Open channel gravity flow*
Command area	*1000 acres*
Design flow rate	*700 lit per second*
Beneficiaries geogs	*Phangyoul & KazhiGeog, Wangdue Dzongkhag*
Estimated cost	*Nu064.630M (Estimated in 2011)- without access road* *Nu184.697M (Estimated in 2017)- with access road + revised channel section structure.*

4.4 Engineering Services provided by Thinley Gyeltshen(TG2)

4.4.1 Construction of ESP Quarter at ARDC Bajo- 1 Block

The Engineering Sector constructed one block (double living units) of ESP Quarter at ARDC Bajo based on the plan and allocated budget. The sector prepared drawings, estimate, BoQ, and tender documents. Each living unit consisted of a sitting room, two bedrooms, kitchen and attached toilet. The cost was estimated at Nu1,120,158 per block base on BSR 2017 rates with 10% cost index over Thimphu rates. ARDC Bajo open tendering of the work and awarded to Ms Samphel Deendup Construction (CDB#4351) at the contract price of Nu887,299.12 and duration of 90 days for implementation. The work started on 20 January 2018 and was completed on 30 April 2018. The handing taking of work was done on 30 April 2018. The final valued of work done was Nu876,424.57. Mr Thinley Gyeltshen (Principal Engineer) not only prepared drawings, estimate, BoQ and Tender Documents for the civil engineering works but also served as site engineer for the work. Mr Indra Bdr Raika prepared drawings and estimate for electrical works. ARDC Bajo Tender Committee provided overall support for the implementation of the work.

4.4.2 Construction of Garage-cum-Workshop at ARDC Bajo

Base on the direction of the management Engineering Sector lead by Mr Thinley Gyeltshen prepared drawings, estimate and BoQ for the construction of Garage-cum-Workshop at ARDC Bajo for JICA Project. The cost for the construction work was estimated at Nu0.355M. The activity was implemented as per the plan but due to lack of budget the still remains unimplemented.

4.4.3 Construction of Strom Drain at ARDC Bajo

Mr Thinley Gyeltshen prepared drawings, estimate and BoQ for the construction of Strom water drainage system for ESP Colony at ARDC Bajo as an adhoc activity. About 250m long cut-off drain above the colony is going to prevent flooding of the colony generated due to surface runoff from the upper slope. The cost was estimated at Nu0.350M. The activity remains unimplemented due to the lack of budget.

4.4.4 Construction of Boundary Chain-link Fencing at ARDC Bajo

As part of an adhoc activity Mr Thinley Gyeltshen prepared drawings, estimate and BoQ for the construction of Boundary Chain-link Fencing at three sites within ARDC Bajo area. These sites lie along the highway passing through the farm area. Sealing of these opening will not only stop the entry of stray cattle into the farm but also minimize unauthorized public interference in the research plots. The total length of fencing required is 330m (50m at site first site, 30m at second site and 250 at third site). The estimated cost of the fencing work at first site is Nu0.350M, Nu0.25M at second site and Nu1.20M at third site. The work remains unimplemented due lack of budget.

4.4.5 Construction of Internal farm road basecourseat ARDC Bajo

Mr Thinley Gyeltshen prepared drawings, estimate and BoQ for the construction of 1400m long internal farm road bascourse at ARDC Bajo. The engineering service was provided based on the direction of the management as an adhoc activity. The work was estimated Nu1.50M. The work remains unimplemented as the budget is not secured yet.

4.4.6 Construction of Extension of National Seed Lab at ARDC Bajo

Base on the direction of the management Mr Thinley Gyeltshen prepared drawings, estimate and BoQ for the construction of National Seed Laboratory at Bajo as an adhoc activity. The work was estimated Nu1.30M. The work remains unimplemented as the budget is not secured yet.

4.4.7 Construction of Farm Toilets at ARDC Bajo

In accordance to the direction of the management Mr Thinley Gyeltshen prepared drawings, estimate and BoQ for the construction of Farm toilets at two locations within ARDC Bajo farm area. The work was estimated Nu0.76M. The work remains unimplemented as the budget is not secured yet. The activity was carried out as an adhoc activity.

4.4.8 Construction of ESP Quarterat ARDC Bajo- 4 Blocks

Based on the direction of the management Mr Thinley Gyeltshen prepared drawings, estimate and BoQ for the construction of four blocks OF ESP Quarter at ADRC Bajo. The work was estimated Nu4.00M. The work remains unimplemented as the budget is not secured yet. The activity was carried out as an adhoc activity.

4.4.9 Maintenance of Sewerage for Staff Quarter at ARDC Bajo

As part of an adhoc activity maintenance of sewerage system for Staff Quarter at ARDC Bajo was implemented departmentally by Engineering Sector. Over the time the flow in the sewerage line gradually decrease owing to differential settlement of the foundation. This caused the blockage of the flow and required to provide new bypass line.

4.5 Engineering Services provided by Puran Chhetri (PC)

4.5.1 Construction of Dreychu Irrigation Channel

The construction of new Dreychu Irrigation Channel was initiated in accordance with 11FYP. The scheme is situated in Kana Geog under Danaga Dzongkhag. This channel has a length of 7.20km with designed conveyance capacity of 360lps. This scheme is expected to irrigate about 400 acres of command area belonging to 77 households in Namzhigang Village.Engineering Sector under ARDC Bajo assigned Mr Puran Chhetri (Assistant Engineer) as the Site Engineer for the works. The sector with support from Dzongkhag, Geog and beneficiary farmers conducted preliminary feasibility study and field survey in 2015. Subsequently, the site engineer prepared designs, drawings, estimate, BoQ and Tender Documents with the guidance from senior colleagues within the sector. The cost of construction of the work was estimated at Nu29.0M with 23.4% cost index over Gelephu rates based BSR2013. The work included formation cutting, construction of gravity open channel (RRM) with plaster finish, construction of channel intake structures, sedimentation chambers, aqueducts (0.30km), cross-drainage structures, and channel outlet structures. The quoted price was stipulated to be inclusive of the construction of the approach road.

Department of Agriculture awarded the work to Ms PST Construction Ltd., for implementation at contract price of Nu29.0M (Nu28,999,998.10) and duration of 18 months through open tendering. The date of start was established on 10 October 2015.The work remains 90% completed by the end of 2017-18 financial years. The poor accessibility of the machineries and the need to stop works during the rainy season contributed to delay of works. The department recognized the constraints encountered at the field level and accordingly

awarded time extension. The delay was also attributed to slow mobilization in the early stages of the construction phased; hence construction firm was also made liable for the delay. Hence the work came under liquidity since 10 April 2017.

4.5.2 Construction of Jhatey Irrigation Pipeline

Jhatey Irrigation Conveyance pipeline is 7.2km long and located at Sergithang Geog under Tsirang Dzongkhag. The Engineering Sector surveyed the work in 2016 and subsequently prepared designs, drawings, estimates, tender documents and submitted to Department for Tendering. This irrigation scheme is designed to convey 220lps of irrigation water through 7.2km long pipeline (400mm HDPE pipe) from Jhatey Chu to the main command area in Sergithang Village. The scheme is designed to irrigate 224 acres of land owned by 64 households. The estimated cost of the work was Nu31.317million with 0% cost index over Gelephu rates based BSR2017. The work included formation cutting, construction of pipeline conveyance (400mm HDPE pipe), trenching of pipeline, areal pipeline construction, pipeline anchoring on the cliff face, construction of pipe intake structures, sedimentation chambers, and valve chambers. The quoted price was stipulated to be inclusive of the construction of the approach road. GEF-UNDP was proposed to be fund the project. DoA awarded the work to Ms Ghongphel Nima Construction Ltd., at contract price of Nu29,806,214.97 and duration of 12 months through open tendering. The start date of the work was established on 24 January 2018. Mr Puran who was engaged starting from the survey, till evaluation of tender documents was assigned as Site Engineer. The overall design of the system was carried out by Thinley Gyamtsho.

4.5.3 Major Renovation Phenday of Irrigation Channel (on-going)

The Engineering Sector conducted survey, prepared designs, estimates, BoQ and tender document in 2014 for the major renovation of Phenday Irrigation Channel. As per the survey data the length of the channel was determined to be 22.4km. The channel passes through three Geogs starting in Begana village (Topisa Geog), passing through Laptshakha (Talo Geog) and ending at Lunakha (Guma Geog). This scheme benefits 260 household irrigating 1000 acres of land. Designed conveyance capacity of 1000lps was considered based on the command area for determining the sizes of the channel structures. Owing to limited budget and priority of the beneficiary farmers out of 22.4km length only starting 3.0km and last 1.5km was proposed to be renovated. First stretch was proposed to be provided with new lining and protected with RCC slab cover to prevent frequent damage and blockage by falling boulders while last stretch was to be provided with cement lining works without cover. The cost of the work was estimated at Nu33.824M.

Open tendering and evaluation was conducted in June 2015, the work remained implemented till 2017 owing to the lack of budget. In 2017 DoA not only secured fund from GEF-UNDP but also decided to change the scope of the work from open channel to pipe conveyance system as justified hereafter. Unlike other civil engineering works the need to stop channel renovations works for paddy season (April to November) stands as major challenge for timely completion of the work. This leaves a very short time for actual (December to March) implementation of the work. For instance, net 12 months implementation duration translates to gross implementation period of 36 month spanning up to three paddy seasons. This not only delays the completion of the work, but also increase the construction cost in terms repeated remobilization and demobilization of the labour, plant and equipment. Besides it also delays the benefits the farmers can derive if the works are completed within a season or so. In consequence department directed to change the conveyance type from open channel to pipe conveyance type.

Although the pipe conveyance may be slightly expensive than open channel, the extra cost can be offset within few years due to increased production owing to the availability of additional water. Pipeline conveyance improves water availability up to 30 to 50% as pipe is able to control all conveyance losses. A typical conveyance loss observed in open channel in Bhutan ranges from 30 to 50% depending upon the extent and age of lining works and length of the channel. In extreme situation like Phangyul where the channel is long (18km) and source is relatively small (21lps dry season flow) the entire flow in the channel is lost in the conveyance. Water fails to reach command area. Hence pipe conveyance option remains only effective to convey all the water at the source to command area. The scope of revised proposal was to provide 2.0km long pipe conveyance line starting from the intake. Based on the design 560mm HDPE pipe was selected against initially proposed on 3.0km RCC slab cover channel. The last 1.5km long open channel to be completely replaced by 160mm HDPE pipe. The cost of the revised plan was estimated at Nu33.974M based on BSR2017 with 25.34% cost index over Thimphu rate. DoA supported by the Engineering Sector awarded the work to Ms Shambala Infra Pvt., Limited for implementation through open tendering at contract price of Nu23,879,083.20 with 12 months duration. The work was started on 28 January 2018. About 80% of the work is completed by end of June 2018. The work is currently stopped for paddy season and will resume at the end of the paddy season. Mr Puran Chhetri who was engaged starting from the survey was assigned as Site Engineer.

4.5.4 Construction of Irrigation Water Conveyance Pipeline for Royal Project Chimipang

As per the direction from management the Engineering Sector provided engineering services for the construction of irrigation water gravity conveyance pipeline for Royal Project Chimipang as an adhoc activity. Mr PuranChhetri with the support of Royal Project Chimipang conducted pre-feasibility studies. This was followed by conveyance alignment survey conducted by Indra Brd Raika. Mr Thinley Gyamtsho carried out the design of the pipeline conveyance system. Puran prepared drawings and estimate based on the design report. The overall cost of the construction was estimated Nu6.70M. The cost of pipe only was estimated at Nu5.132M based on Druk Pipe rates while based on Indian pipe rates at Nu2. 170M.This system will trap irrigation water from Tobay-rong-chu about 100m upstream of Lower Lobesa channel intake and convey to Royal Project Chimipang for irrigation of 63 acres of dryland under horticulture crop (fruits). The peak water requirement was determined at 15lps based on the area and cropping pattern. Hence 15lps was adopted as the design flow rate for the design of the pipe conveyance system. Based 15lps design flow and pipe alignment L-Section data the optimum pipe sizes (diameter) and pressure classes were determined as indicated in Figure 4-1.

The pipeline was designed with provision of providing gate valve at the delivery end to control flow without having to go to the source to control the flow. Further at the delivery point the residual head of about 46m were provided to enable the operation sprinklers.

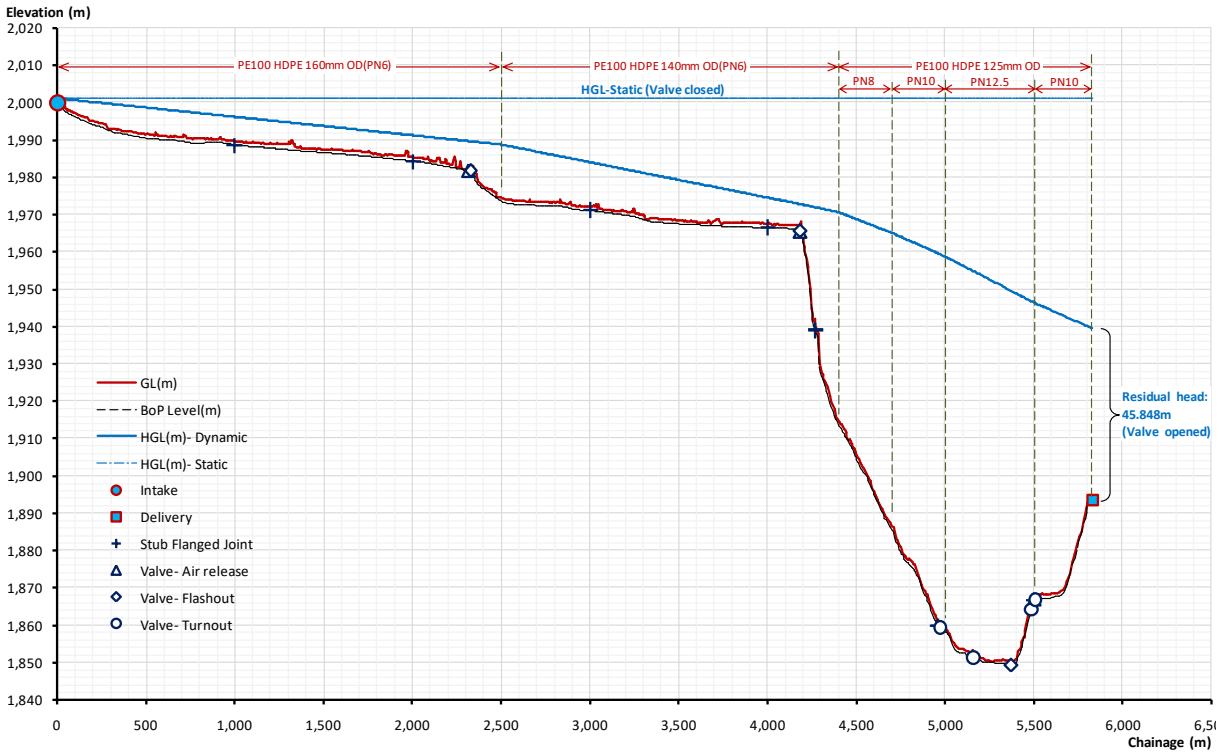


Figure 4-1: Pipeline L-Section profile with hydraulic design.

4.5.5 Construction of Farm road basecourse& Culverts at Royal Project Chimipang

Engineering Sector prepared design, drawings, estimate, BoQ, and Tender Documents for the construction of Farmroad basecourse and Culverts at Royal Project Chimipang. The work was estimate Nu3,449,662. ARDC Bajo awarded the work to Ms Dhuesum Construction for implementation at contract price of Nu 1,940,503.70 with construction duration of 150 days. The work was completed within the time frame including the additional work as per the specification laid in tender documents. The final value of the work done stands at Nu2,146,170.40.

4.5.6 Construction works for DFO at Dagapela

Based on the direction of the management the Engineering Sector prepared design, drawings, estimate and BoQ for following construction work for Divisional Forest Office at Dagapela.

Table 4-9: Cost of proposed construction worksfor DFO, Dagapela

SN	Name of work	Estimate Cost (Nu)	Remark
1	Construction of Entrance Gate	51,790	
2	Construction of Approach Gate	3,725,362	
3	Construction of Boundary Fencing	1,033,215	
4	Construction of External Water Supply	2,546,983	
5	Construction of Compound Lighting	665,500	
6	Construction of Office Building- Civil	14,178,094	
7	Construction of Office Building- Electrical	1,734,290	
8	Construction of Staff Quarter- Civil	13,792,161	
9	Construction of Staff Quarter- Electrical	907,853	
10	Total	38,635,248	

Total cost for the proposed construction works was estimated Nu38.635M.

4.6 Engineering Services provided by Nima Wangchuk (NW)

4.6.1 Construction of Irrigation Water Tank at Royal Project Chimipang

Engineering Sector provided engineering services for the construction of Water Tank at Royal Project Chimipang in terms of monitoring and passing of the bill. ARDC Bajo Tender Committee also served as the implementation monitoring committee. All the drawings, designs, estimates, tendering and award of work was done from AED and DoA. The work is executed by Ms Rinchen Dorji Construction at contract price of Nu679,488.20 with execution duration of 120days. The work completed within the stipulated time frameas per the technical specification. The final value of the work done was Nu805,900.41.

4.6.2 Construction of Farm Irrigation Network at Royal Project Chimipang

In accordance plan and allocated budget ES provided engineering services for the construction of farm irrigation channel network at Royal Project Chimipang. The sector visited the site along with Royal Project team and ARDC Bajo management for identification of site for laying channel networks. Subsequently, sector prepared the drawings, estimate, BoQ and Tender Documents. The cost was estimated at Nu3,990,541.50 based on BSR 2017 with 13.04% cost index over Gelephu rates. The work was awarded to Ms Aquarious Construction (CDB#8181) through open tendering at contract price of Nu2,636,825.94 with an implementation period of 90 days. The work was completed on 10 July 2018 and taken over by management on 13 July 2018. The final valued of work done was Nu2,636,845.11. Mr Puran Chhetri (Assistant Engineer) prepared drawings, estimate and BoQ and Nima Wangchuk (Junior Engineer) serve as sit engineer. ARDC Bajo Tender Committee and the manager of Royal Project Chimipang served as the Tender Committee for the work.

4.6.3 Construction of Rice Mill at Royal Project Chimipang

The Engineering Sector provided engineering services for the construction of Rice Mill House at Royal Project Chimipang as an adhoc activity based on the direction of ARDC Bajo Management. The sector in consultation with the Royal Project Chimipang team identified the location of the construction site. The sector made minor re-design of the mill house based on the feedback from the mill operators at ARDC Bajo and subsequently produced drawings, estimate, BoQ and tender document. The construction cost was estimated at Nu2,248,110. The work was awarded to Ms Tandin Wang Construction (CDB#7317) through open tendering at contract price of Nu1,814,450 with an implementation period of 120 days. The work was started from 29 December 2018 and completed on 11 May 2018. The work was delayed due to miss match of steel roof truss size which was fabricated in Phuntsholing. Since the trusses had to send back to market for the re-fabrication, the committee decided to extend the project duration by 15 days from actual completion date. The handing taking of work was done on 07 June 2018. The final value of work done was Nu 1,813,529.05.Mr Nima Wangchuk (Junior Engineer) who also prepared served as the site engineer for civil works and Mr Indra Bdr Raika (Sr Technician-III) served as the site engineer for the electrical works. ARDC Bajo Tender Committee and the manager of Royal Project Chimipang served as the Tender Committee for the work.

4.6.4 Construction of ESP Quarter and Compost Pit at Royal Project Chimipang

ARDC Bajo Management and Royal Project Chimipang team visited the site for the selection of construction for three blocks (double units) of ESP Quarter and one Compost Pit at Royal Project Chimipang based on the plan. The Engineering Sector prepared drawings, estimate, BoQ and tender documents for the work. The cost was estimated at Nu3,794,962. Through open tendering ARDC Bajo awarded the work to Ms Kurtoe Construction (CDB#3779) at contract price of Nu2,911,500.68 and duration of 120 days for implementation. As there was significant savings after tendering of the work the management decided construct one additional block as there was a dire need of ESP Quarters at Chimipang. The management also decided to award the work to the same contractor at the same rate subjected to the progress and quality of the work of the initially awarded package. As contractor made good progress and quality the management issued the work order for additional work based on the initial quoted rates valued at Nu875,825.05 including civil and electrical work with additional duration of 45 days. The work was completed on 25 June 2018 within stipulated time and was taken over by the management on 29 June 2018. The final value of work done was Nu3,914,700.24. Mr Nima Wangchuk (Junior Engineer) served as the site engineer for civil works and Mr Indra Bdr Raika (Sr Technician-III) served as the site engineer for the electrical works. ARDC Bajo Tender Committee and the manager of Royal Project Chimipang served as the Tender Committee for the work.

4.6.5 Construction of Office-cum-Quarter at Cheshithang FMCL Farm

In accordance to the direction of the management the Engineering Sector prepared the drawings, estimate and BoQ for the construction of Office-cum-Quarter at Cheshithang FMCL Farm under Dzomi Geog in Punakha as an adhoc activity. The cost was estimated at Nu984,046. Mr Indra Bdr Raika (Sr Technician-III) prepared the drawing and Mr Nima Wangchuk (Junior Engineer) prepared the estimate and BoQ for the work.

4.6.6 Surveyed for the construction of Sibjana-Lhachu Link Irrigation Channel

Based on the direction of Wangdue Dzongkhag, ARDC Bajo conducted survey for the construction of 7.0km Sibjana-Lhachu link irrigation channel. The construction of this link channel was one of the alternative options against the initially proposal 34.0km long irrigation channel from Baychu for Phangyul Geog via Kazhi Geog. By the time the survey was completed the Kazhi Geog had provided clearance to Phangyul Geog for construction 34.0km channel passing through Kazhi Geog on the condition that 30% of the flow from the channel can be used by Kazhi farmers. Hence, subsequent work on the link channel was not required.

4.6.7 Construction of Compost Pit at Kamichu Royal Orchard

As there were saving from the 2017-2018 capitals work of ARDC Bajo, the management decided to utilized budget for the construction of compost pit at Kamichu Royal Orchard in collaboration with Wangdue Dzongkhag Administration. ARDC Bajo agreed to bear the cost of materials and transportation of the project and labor charges by the Dzongkhang. Accordingly, the Engineering Sector visited the Royal Orchard to identify the locations, prepared drawings, estimate and BoQ. Total cost of the work was estimated at Nu192,947.74 of which Nu159,155.18 was materials & transportation and Nu33,792.56 for labour. Dzongkhag implemented the work departmentally owing the limited time and urgent need of

compost pit at Royal Orchard forging tendering process. Engineering Sector monitored implementation of the work.

4.6.8 Construction of Compost Pit at Sonagasa Royal Orchard

Engineering Sector prepared drawings, estimate and BoQ for the construction of Compost Pit at Sonagasa Royal Orchard as an adhoc activity upon the direction of the ARDC Bajo Management. The cost of work was estimated at Nu192,948. The capacity of the compost pit is 78. 75cu.m (26. 25CU.M X3).

4.6.9 Construction of Gates & Maintenance of NSC Farm Infrastructures at Phobjikha

As per the management direction, Engineering Sector along with the Officer-in-charge of NSC Phobjikha visited the proposed sites for the construction of gates and maintenance of farm infrastructure at NSC Phobjikha. Subsequently, Engineering Sector prepared drawings, estimates and BoQ. The cost of work was estimated at Nu214,670. NSC Paro awarded the work to Ms Othbar Construction (CDB#8249) at contract price of Nu172,831 with project duration of 30 days through limited bidding. Some maintenance items were missed in the initial proposal NSC Paro decided to award the additional work to same contractor. The firm accepted the additional work at 5% below the BSR estimate cost (Nu18,002) against the proposed of same variation for the initial awarded package. The work was started on 14 June 2018 and was completed on 13 July 2018 within stipulated time.

4.6.10 Construction of Cowshed at ARDC Bajo

The Engineering Sector prepared drawings and estimate for the construction of cowshed at ARDC Bajo based on the direction of the management. The cost was estimated at Nu269,066.53 for six cattle heads base on BSR 2017 rates with 10% cost index over Thimphu rates. This construction was proposed to be implemented through FSAPP Project funding but was dropped as the proposed construction works goes beyond the overall project scope.

4.7 Engineering Services provided by Indra Bdr Raika (IBR)

4.7.1 Maintenance of Pumps and Motors at ARDC Bajo

The old pumping system at ARDC Bajo which was installed in 1996 by JIC A Project breaks down frequently. The frequency of break down has increased over last few years disrupting reliable irrigation water supply to the research plots. Due to long operation period of over 20 years the moving parts are worn out overloading the motor and eventual breakdown. The sector repaired electrical motor several times for the last half of the year only.

4.7.2 Reinstallation of First Stage Pumping System at ARDC Bajo

Due to the frequent break down of First Stage Pumping Station at ARDC Bajo incurring high operation and maintenance cost. As a result, the management decided to provide new set of pumps, motors and associated parts. Accordingly, Engineering Sector prepared list of materials with specification for the procurement. The main list includes pumps, motor, control panel, flexible suction pipes, delivery pipes, NRVs, pipe fittings, pump & motor platforms, winching set, railing parts and power supply cables for two pumping lines. The cost of providing and fixing is estimated at Nu0.792M.

4.7.3 Installation of Second Stage Pumping System (Submersible pump) at ARDC Bajo

Engineering Sector provided support for the installation of Second Stage Pumping System to JICA Project. This pumping system will pump water from first stage delivery tank to second stage delivery tank located above the highway using submersible pump through 500m long 50mm HDPE pipe. The pump was procured at Nu30, 655.

4.7.4 Surveyed for the Construction of Lift Irrigation at RP Chimipang

Mr Indra Bdr Raika conducted survey for the construction of Lift Irrigation at Royal Project Chimmipang base on the direction of Engineering Division, Department of Agriculture. This lift irrigation was planned to provide irrigation water for the 63 acres of dryland at Chimipang farm. The survey data was submitted to Engineering Division for preparation of design, drawing & estimate.

4.7.5 Maintenance of Plumbing System at ARDC Bajo

Engineering Sector lead by Indra Bdr Raika also provides services for the maintenance of water supply pipeline networks at ARDC Bajo. The work Nu10,000 was implemented departmentally.

4.7.6 Maintenance of Electrical System at ARDC Bajo

Mr Indra Bdr Raika working under the Engineering Sector carried out all routine electrical system maintenance at ARDC Bajo Campus. The work includes identification and rectification of faultsall electrical system of the office building, compound lighting and staff quarter. All the rectification works are based on the drawings and estimate prepared by the sector. The annual value of the work done is estimated at Nu40,000. The other members of the engineering sector provided necessary support as when need arises.

4.7.7 Maintenance of Electrical System at ARDSC Tsirang

Mr Indra Bdr Raika provided services in carrying out the electrical system maintenance work at ARDSC Tsirang. The services include identification and rectification of faults all electrical system of the office building, compound lighting and staff quarter. All the rectification works are based on the drawings and estimate prepared by the sector. The annual value of the work done is estimated at Nu47,000. The other members of the engineering sector provided necessary support as when need arises.

6 FOOD SECURITY AND AGRICULTURE PRODUCTIVITY PROJECT

6.1 Background

The Royal Government of Bhutan (RGoB) has recently implemented the Food Security and Agriculture Productivity Project (FSAPP), a Global Agriculture and Food Security Program (GAFSP) financed project. The projectis implemented in Chhukha, Dagana, Haa, Samtse and Sarpang Dzongkhags. The project aims to increase agricultural productivity and enhance access to markets for farmers in selected gewogs in south-western Bhutan thus achieving the national policy of food and nutrition security. The project seeks to address inter-connected problems faced by farmers and rural households through a set of integrated, consolidated, area-specific interventions that respond to local constraints, potentials and priorities. For this, the project adopts a multipronged approach: (i) focusing on the farmer as - the primary beneficiary and lead player in food security, nutrition and commercialization of agriculture, (ii) productivity enhancement of food crops - rice, potato, vegetables, pulses, quinoa and high-value crops – spices (especially large cardamom & ginger) and citrus for improved food and nutritionsecurity, and (iii) linking farmers to agri-markets through a value chain approach. In the west-central region, the project covers the five gewogs viz. Drujeygang, Kana, Lamoijikha, Nichula and Karmalingunder Dagana Dzongkhag. The project will attempt to address the various needs of small and poor farmersthat make up almost the entire population of the selected five gewogsfor agriculture development. ARDC, Bajo is the Project Support Team (PST). During the financial year 2017-18 the following activities were carried out with the FASP Project support in the project sites Dagana.

6.2 Farmers Training on Improved Technologies

To work towards food self-sufficiency and fulfilling food security goal, a transfer technology was conducted at Lamoi dzingkha. The farmers of Nichula, Karmaling and Lamoidzingkha gewogs attended the training. The farmers were trained on rice seed selection, rice seed treatment using hot water, improved direct sowing of rice, soil& land management, protected cultivation, and tropical fruit canopy management.

Seed selection in rice: the farmers were trained on use of brine solution to select the healthy rice seeds by floating method. The benefits and precautions necessary for the method were explained.

Seed treatment: due to occurrence of different fungal diseases in the area, seed treatment of rice using hot water was demonstrated to the farmers. Since the availability of fungicides is a one of the constraints, the hot water treatment was advised and demonstrated accordingly. The seed treatment doesn't control the diseases fully however, it can increase the plant stand up to 30%. The hot water treatment was conducted at 60-650C for 10-15 minutes. Hot water treatment if practiced precisely can reduce the occurrence of the seedling diseases resulting from fungi and bacteria.

Improved direct seeding of rice: A rice drum seeder from AMC was demonstrated to farmers. The machine requires about 3 times lesser seed compared to transplant method.

Soil and land management: due to uneven contour during terracing, there are uneven distributions of water in the terraces leading to crop failures. Therefore, use of A-frame was demonstrated for use during terrace making. With the use of A-frame, the contour of the

terraces can be aligned to reduce unevenness. Even contour would distribute the water in a terrace evenly. Thus, it would reduce the crop failures.

Protected cultivation: certain crop requires protection from nature for a successful yield. The use of greenhouse and its advantages were explained to encourage protected agriculture. The methods for bed preparation for cultivation under playhouses were demonstrated.

Tropical fruit canopy management: the fruit trees were mostly observed with their natural canopy, which gives lesser yield compared to the trained trees. Therefore, to encourage the farmers on tree canopy management, training of mango tree was demonstrated. The advantages of the canopy management and training/pruning were explained during the demonstration. Besides, the use of right tools and safety tools were also explained.

6.3 Technical Training to Extension Workers of Dagana

The training was conducted for the Extension Officers of Dagana district with the following objectives:

- Sharing experiences and knowledge of researchers and extension officials.
- Mapping the capacities of extension agents and researchers
- Document the major field problems
- Sustainable land management: stripe plantation of Napier grass using slits, A-frame, contour, bund management
- Awareness on citrus rehabilitation activities and citrus repository
- Demonstration of different technologies at ARDC Bajo to extension agents.

The extension agents were trained on how to think about problems and the solutions; the differences between challenges and problems; and the characteristics of problems. This activity was aimed to instill the inquisitive methods on the Extension Agents to identify the problems and creating solution for the problems. Challenge is a "demanding task that one wishes to overcome" while problem is "something or someone that hinders the progress of a work". To get a solution to the problems, one must identify the core problem, the root cause, and its effects and impacts. The solutions may be targeted for reduction of effects and impacts. The participants were asked to highlight some of the major field problems faced in their own gewogs. The problems raised by them were:

- Wetland decline as a result of cardamom cultivation on wet lands.
- Pests and diseases: Citrus greening, cardamom wilt, rodents in paddy, red ants in potato, mango fruit cracking disorder, mango fruit drop and human wildlife conflicts were some of the major problems related to pests and diseases.
- Communication and road connectivity: EAs highlighted on the difficulties in their service delivery due to inaccessibility and poor mobile network coverage in the region.
- Price fluctuation of local produce
- Increasing demand of Greenhouses
- Non-effective buy-back policy in the locality
- In-effective service for the gewog power tillers: the spare parts are not readily available, and the hiring policy is in-effective.
- Irrigation water shortage

Farmers' feedbacks on Citrus Canopy Management

Feedbacks from the extension agents were collected for citrus canopy management carried out in the district. Extension agents of the district expressed on behalf of the orchards,

majority of the people have positive feedback on canopy management after the observing the result. However, some farmers were reluctant to cut off the branches during the canopy management program. The EAs extended the pride of farmers on knowledge and experiences gained in canopy management. They look forward to encourage youths to form a team who would learn Canopy Management and provide service to the people of the district. The right tools, right knowledge, right materials were suggested for the team to carry out follow up canopy management.

Rice Pests and diseases

The Extension agents were trained on symptoms and control management of the important rice pests and diseases. Pest management methods of different types of armyworms, rice ear bug, and stem borers were addressed. On the disease part, rice blast, sheath blight, and brown spots were presented. During the presentation, the participants shared their field experiences that Bhur Kamja 2 was affected severely by sheath blight at Dagana in the last season and expressed their interest for disease resistant varieties

Figure 6-1: Technical training participants with resource persons

Updates on National Citrus Repository

Mr. Phuntsho Wangdi presented on the location, mandates, and vision of the National Citrus Repository along with the activities carried out in the repository. He highlighted the challenges and future plans of the repository.

Practical on Greenhouse Installation for the Group at Drujeygang

Lead by the Program Director (ARDC-Bajo), the team and the participants installed the Greenhouse for the women's group. It was aimed as hands-on training for the Agriculture EAs of the district. Most of the participants were satisfied with the knowledge/experiences gained in the practical session. They expressed their interest in making use of their knowledge by installing more greenhouses in their gewog.

Figure 6-2: Training participants visit to ARDC Bajo

6.4 Farmers Study Tour

In the beginning of the project, the implementing agency(ARDC Bajo) has planned to organize a farmers' study tour for selected farmers from the project sites, with the aim to expose and demonstrate farmers on orchards management, winter vegetable production, smart climate technologies, emerging research and development technologies, and successful farmers groups. This study visit will provide farmers with first-hand information to appreciate and adopt the available technologies as an enterprise back in the community. Study tour was made from 19/01/2018 to 28/01/2018. The study visit were made to ARDC, Samteyling, ARDSC, Menchuna, ARDC, Bajo, Progressive farmer's fileds in Sarpang, Punakha and Tsirang Dzongkhags, Himilika Project, Barshong, Chimipang Royal Project and AMC, Bajo. Besides these they also had chance to take part in Southern Foothills Food Festival held at Gelephug.

The participants were expected to learn, understand and take back home some of the proven appropriate technologies and knowledge so that they will replicate in their farm with the support from the project. Through this study tour, farmers may be able to build their capacity on new climate smart technologies and other proven modern farming technologies. It will acquaint participants with successful experiences in the area of developing, promoting and implementing improved technology initiatives such as model FYM management Farm, Commercial Farming, Organic farming, Marketing Chains and Research and Development activities.

In total 25 farmers participated in the study tour five from each project Gewog. The group consisted of youth (school dropout), progressive farmers and out 36 % were female. The lists of participants are listed in Table 6-1.


Figure 6-3: FSAPP Farmers study tour to different sites

Table 6-1: FSAPP Farmers Study Tour (19 to 28 January 2018)

SN	Name	Village	Geog	Gender	CID No
1	Dhendup	Thangna	Drujegang	M	10302002457
2	Ram Lal Thapa	Thangna	Drujegang	M	10311001514
3	Cheni Lhamo	Youngsiji	Drujegang	F	10302001931
4	Ngawang Lhamo	Youngsiji	Drujegang	F	10302000349
5	Tashi Lhamo	Youngsiji	Drujegang	F	10302001349
6	Harka Maya Subba	Lhaling	Kana	F	10305001818
7	Kharka S. Chettri	Dalithang	Kana	M	20305000093
8	Dawala	Tangnaji	Kana	M	10305008025
9	Batka Bdr Singer	Pungshi	Kana	M	10305002647
10	Kadom	Kashithang	Kana	F	10305001329
11	Mongal Singh Tamang	Omchhu	Karmaling	M	11304000946
12	Sancha Raj Subba	Omchhu	Karmaling	M	11304000805
13	Passang Sherpa	Jemathang	Karmaling	M	11304000125
14	Thaji Maya Gurung	Jamathar	Karmaling	F	11304000172
15	Til Bhadur Sherpa	Karmiling	Karmaling	M	11304001690
16	Dawa Sherpa	Kuendrelthang	Lhamozingkha	M	11304001648
17	Tenzin Choki	Daragaon	Lhamozingkha	F	11309000268
18	Buddha Bir rai	Devitar	Lhamozingkha	M	10309000522
19	Madhu Sadan Koirala	Sibsoni	Lhamozingkha	M	21309000493
20	Bhim Nath Kafley	Yarpheling	Nichula	M	11310000688
21	Hari Prasad Pradhan	Farmgaun	Lhamozingkha	M	21309000234
22	Dadi Ram Adhikari	Katari	Nichula	M	11310000624
23	Tanka Bdr Chhetri	Gangtokha	Nichula	M	11310000156
24	Devika Battari	Vijgao	Nichula	F	11310000042
25	Uma Devi Vista	Damchuna	Nichula	F	11310000064

6.5 Soil sampling in Dagana

Under Food Security and Agriculture Productivity Project, the Soil and Land Management team went to do soil sampling at Durjaygang Gewog and Lhamoi D-Zingkha Dungkhag. A total of 25 samples were collected from Citrus orchard in Durjaygang and 18 samples from various crops were collected from Lhamoizingkha. The selection of crops to do soil sampling was based on farmers' interest. At Durjaygang, Citrus was selected as it was an important cash crop for them. On the other hand, Lhamoi D-Zingkha Dungkhag farmers were more into vegetables and maize crops. The details of soil sampling at Durjaygang are as follows. In total 43 soil samples were collected under FSAPP activities.

Table 6-2:Details soil sampling, Drujagang

SN	Name of farmer	Sample code	Sample type	Remark
1	Sonam Dhendup, Pangserbo, Durjagang [Citrus]	ARDCB007A	Top soil	
		ARDCB007B	Sub soil	
2	[Am Karchamo], Pangserbo, Durjagang [Citrus]	ARDCB008A	Top soil	
		ARDCB008B	Sub soil	
3	Pem Dorji, Pangserbo, Durjagang [Citrus]	ARDCB009A	Top soil	
		ARDCB009B	Sub soil	
4	Am Sermo, Pangserbo, Durjagang [Citrus]	ARDCB010A	Top soil	
		ARDCB010B	Sub soil	
5	Am Kadomo, Pangserbo, Durjagang [Citrus]	ARDCB011A	Top soil	
		ARDCB011B	Sub soil	
6	Ap Pakola, Pangserbo, Durjagang [Citrus]	ARDCB012A	Top soil	
		ARDCB012B	Sub soil	
7	Am Tshering Wangmo, Pangserbo, Durjagang [Citrus]	ARDCB013A	Top soil	
		ARDCB013B	Sub soil	
8	Sangay Choden, Pangserbo, Durjagang[Citrus]	ARDCB014A	Top soil	
		ARDCB014B	Sub soil	
9	Lhakpa, Pangserbo, Durjagang[Citrus]	ARDCB015A	Top soil	
		ARDCB015B	Sub soil	
10	Namgaymo, Pangserbo, Durjagang[Citrus]	ARDCB016A	Top soil	
		ARDCB016B	Sub soil	
11	Am Kuenzang Lhamo, Thangna, Durjagang[Citrus]	ARDCB017A	Top soil	
		ARDCB017B	Sub soil	
12	San Bahadur Monger, Thangna, Durjagang[Citrus]	ARDCB018A	Top soil	
		ARDCB018B	Sub soil	
13	Ap Tawla, Thangna, Durjagang[Citrus]	ARDCB019A	Top soil	
		ARDCB019B	Sub soil	
14	Ap Nalay, Thangna, Durjagang[Citrus]	ARDCB020A	Top soil	
		ARDCB020B	Sub soil	
15	Aum Gempo Lham, Thangna, Durjagang[Citrus]	ARDCB021A	Top soil	
		ARDCB021B	Sub soil	
16	Dongchenmo, Pangna, Durjagang[Citrus]	ARDCB022A	Top soil	
		ARDCB022B	Sub soil	
17	Aaochu, Pangna, Durjagang[Citrus]	ARDCB023A	Top soil	
		ARDCB023B	Sub soil	
18	Am Passang, Pangna, Durjagang[Citrus]	ARDCB024A	Top soil	
		ARDCB024B	Sub soil	
19	Ap Gangchu, Pangna, Durjagang[Citrus]	ARDCB025A	Top soil	
		ARDCB025B	Sub soil	
20	Am Karma, Pangna, Durjagang[Citrus]	ARDCB026A	Top soil	
		ARDCB026B	Sub soil	
21	Am Cheki, Pangna, Durjagang[Citrus]	ARDCB027A	Top soil	
		ARDCB027B	Sub soil	
22	Am Lengom, Pangna, Durjagang [Citrus]	ARDCB028A	Top soil	
		ARDCB028B	Sub soil	

23	Am Om, Pangna, Durjagang [Citrus]	ARDCB029A	Top soil
		ARDCB029B	Sub soil
24	Ap Phenchu, Pangna, Durjagang [Citrus]	ARDCB030A	Top soil
		ARDCB030B	Sub soil
25	Rohit Kumar Dahl, Pangna, Durjagang [Citrus]	ARDCB031A	Top soil
		ARDCB031B	Sub soil

The details of soil sampling at Lhamoi D-zingkha Dungkhag are as follows.

Table 6-3: Details of soil sampling at Lhamoizingkha D-Zingkha

SN	Name of farmer	Sample code	Sample type
1	Beechgaon, Nichula Gewog Extension, Dagana [Chilli]	ARDCB032	Top soil
2	Beechgaon, Nichula Gewog Extension, Dagana [Chilli]	ARDCB033	Top soil
3	Surya Bir Basnet, Beechgaon, Nichula [Maize]	ARDCB034	Top soil
4	Surya Bir Basnet, Beechgaon, Nichula [Maize]	ARDCB035	Top soil
5	M B Katwal, Beechgaon, Nichula	ARDCB036	Top soil
6	M B Katwal, Beechgaon, Nichula	ARDCB037	Top soil
7	Udar Singh Pradhan, near gewog office	ARDCB038	Top soil
8	Udar Singh Pradhan, near gewog office	ARDCB039	Top soil
9	Dal Bahadur Pradhan, near gewog office	ARDCB040	Top soil
10	Dal Bahadur Pradhan, near gewog office	ARDCB041	Top soil
11	Ganga Pradhan, near gewog office	ARDCB042	Top soil
12	Ganga Pradhan, near gewog office	ARDCB043	Top soil
13	Dik Bir Gurung, Jogigaon, Lhamoizingkha	ARDCB044	Top soil
14	Devi Jogi, Jogigaon, Lhamoizingkha	ARDCB045	Top soil
15	Tula Ram Tamang, Jogigaon, Lhamoizingkha	ARDCB046	Top soil
16	Tula Ram Tamang, Jogigaon, Lhamoizingkha	ARDCB047	Top soil
17	Tara Devi, Jogigaon, Lhamoizingkha	ARDCB048	Top soil
18	Mona Katwal, Jogigaon, Lhamoizingkha	ARDCB049	Top soil

6.6 Supply of improved seeds and seedlings

For productivity enhancement of food crops the supply of seeds and seedlings is done in consultation with Dzongkhag Agriculture, Dagana and farmers of the project gewogs. During the financial year 2017-18, ARDC Bajo has facilitated in sourcing out 14500 cardamom seedlings Seremna variety and supplied to Kana gewog for establishment of cardamom nursery orchard. Improved (hybrid) tomato seeds were procured and supplied to Lhamoi-D-Zingkha Dungkhag farmers for food security and rural livelihood improvement. The beneficiaries were also demonstrated on cultivation practices of these crops while distribution.

6.7 Protected Cultivation Demonstration

During the financial year 2017-18, three sets of green house were procured and set up for protected cultivation as demonstration with the aim to climate resilient production technologies. Two set were installed in Drujegang Gewog for vegetable production groups with. One set was provided to Nichula Gewog Centre to showcase improved cultivation practices of climate resilient production under protected cultivation to the farmers.

6.8 Citrus Canopy Management and Rehabilitation Program

Canopy management in Citrus was unheard a decade ago. In recent years Citrus canopy management is gaining popularity in our country among farmers. Most farmers in our country lack the technical know-how and benefits of canopy management in citrus. Most farmers hardly prune their trees because of the myth that trees will die when branches are removed.

When they do prune they do not make use of right tools and equipment and do not maintain tools and equipment before and after use. This results in decreased efficiency and effectiveness of pruning. Canopy management if done in right time with right tools using right techniques has many benefits. Some benefits are:

- To get good root-shoot ratio
- To get desired shape of fruit trees
- To minimize growth of undesirable or unwanted branches and
- To optimize use of available soil water and nutrient

Led by Program Director, ARDC, Bajo, the Centre has carried out the citrus canopy management in the West-Central Region from 2017. Table 6-4 details the canopy carried out in Dagana dzongkhag. In 2017-18 the Centre covered 56 orchards in three Dzongkhags with 8829 trees canopy managed.

Table 6-4: Citrus Canopy Management Details in Dagana

SN	Gewog	Village	No. of orchard covered	No. of tree canopy managed
1	Lajab	Compa	2	55
2	Lajab	Gelechu	1	10
3	Tsangkha	Zinchella	1	535
4	Tsangkha	Petakha	2	250
5	Tsangkha	Salmjii	2	920
6	Tsangkha	Tangji	1	81
7	Tsangkha	Goal Tan	2	228
8	Tsangkha	Bibithang	2	85
9	Tashiding	Shamdolay	5	700
10	Gozhi	Middle Gozhi	3	280
11	Gozhi	Dogak	1	50
12	Gozhi	Balakgang	1	130
13	Drukjegang	Phapherketi	1	210
14	Drukjegang	Pangserpo	10	1638
15	Drukjegang	Thangna	2	275
16	Drukjegang	Tshamkhanang	5	440
17	Drukjegang	Pangna	3	350
18	Kana	Khagochen	2	270
19	Kana	Lhaling	1	60
20	Kana	Pungzhi	3	1410
21	Kana	Dhaleythang	1	120
22	Tshendagang	Gangzur Maed	5	732
Total			**56**	**8829**

7 CHIMIPANG ROYAL PROJECT

7.1 Field crops program

Field crops sector focused more on land development and irrigation facilities. During this fiscal year, the sector also focused on soil improvement through cultivation of legume crop after stone collection in newly developed terraces. Paddy has been the main crop cultivated in large acreage, which generated the maximum revenue every year since 2013.

Land development

A total of 7.7 acres of wetlandhas been developed to standard terrace size. Collection and disposal of stone boulders and gravels in the developed terraces arekey challenges, which hamper the work progress. In consultation with the National Organic Program and JICA, about 5.3 acres of wetland was developed into standard terracesfor organic rice production through rotational cropping method. The aim is to demonstrate rice production using locally available materials such as compost combined with innovative technologies and cropping system to reduce the use of harmful chemicals and fertilizers. Forin conservation and demonstration of Dru-na-gu crops, 2 acres of dryland has been developed.

Stone collection

Stone collection is one of major and intensive activities after land development. Without removing the stones, the field situation and soil condition are not feasible for cultivation and use of farm machineries (high maintenance cost). Hand picking of stonesin 15 acres of newly developed terraces was done. Legume crops will be grown to improve the soil structure before paddy cultivation.

Production Output

We harvested eight different varieties of paddy and collected more than 20 truckloads of rice straw from 26 acres. The total paddy production was worth Nu. 550,100. Paddy straw was collected to use for mulching, supply to Lingkana, Thimphu and for mushroom production.

Table 7-1: Total production record

SN	Varieties	Quantity (kg)	Remarks
1	IR-64	9,420	Produce handed to marketing focal
2	Bonday	1,690	
3	Bajo Maap I	1,400	
4	Tan Tshering	1,260	
5	Ngapja	1,400	
6	Sticky Rice	680	
7	Shangana Maap	395	
8	Chumja Maap	2,300	
9	**Total**	**18,545**	

We also produced 860 kg of Mung Bean from seven acres of newly developed terraces. The cultivation was primarily for the purpose of soil improvement.

Crop Production

We have transplanted nine varieties of paddy, including both improvedand local varieties, in 25 acres of land. Of the total area newly developed terraces,9 acres is transplanted mainly to reclaim and improve soil structure and compaction.

Paddy cultivation of different varieties

Table 7-2: Paddy cultivation of different varieties

SN	Varieties	Area(acre)	Remark
1	IR-64	15.00	
2	Sticky Rice	3.00	
3	Ngapja	3.00	
4	Tan Tseri	2.00	
5	Bonday	0.50	
6	Khantey	0.50	
7	Chotey	0.50	
8	Shangana Maap	0.50	
9	Japhu Machum	0.25	
10	**Total**	**25.25**	

Maize is cultivated in small scale mainly for poultry feed. We have been supplying bird feed annually to Samtenling garden and Dechencholing. The cultivation trial of Sunflower is supportedby theNational OilseedsProgram for oil extraction. The OilseedsProgram also providedone Mini Oil Expeller.

In addition, two acres of Organic block is cultivated with Soybean for oil extraction. The crop residue will be used as organic manure/media for paddy nursery. A Joint Japan-Bhutan soybean plantation ceremony was conducted on 29 June 2018. Experts from JICA and stakeholders from different agencies participated in the program.

Land utilization

Currently, 24.7 acres of wetland is utilized through production of paddy, beans, cereals and legume crops from the total of 52.4 acres. More than 0.25 acres of vegetable block is utilized by Field crops program forthe production of sunflower and maize. Paddy fields measuring 7.7 acres, which are being developed into standard terraces will be utilized for cultivation of legume crops during 2018-19.

Other activities

The Field crop sector also supported in joint design, identification and completion of internal road network and construction of culvert and Hume pipes. The internal road is now connected to the boundary road. The contractor is now improving access to the wetland through the execution of work.

7.2 Horticulture program

Horticulture sector is sub-divided into vegetable, fruits, strawberry, mushroom, and floriculture programs. For producing different seasonal vegetables, 7 acres of land is utilized. Similarly, 10 acres of dryland are used for fruit orchard and two acres under floriculture production. The already planted different fruit trees are properly managed.

Vegetable Program

Vegetable program is implemented in 7 acres of field. The production is based on cropping calendar developed by Vegetable Program Chimipang. Various seasonal crops (refer Table below) are cultivated and fresh produce are marketed. The program targets to produce Solanaceous crops, cucurbits, root crops and crucifers to meet the market demand.

Table 7-3: Production record of vegetables

SN	Particulars	Production	Remark
1	Chili	212 kg	
2	Tomato	611 kg	
3	Brinjal	88 kg	
4	Broccoli	592 bundles	
5	Cabbage	325 kg	
6	Cauliflower	348 kg	
7	Carrot	321 kg	
8	Lettuce	905 bundles	
9	Bulb onion	10 bundles	
10	Beans	126 kg	
11	Water melon	347 kg	

Compost manure

The Vegetable program initiated compost making through locally available raw materials to reduce the cost of leaf mold and substitute the use of chemical fertilizers. During 2017-18, vegetable program produced 118 tons of compost manure in three different locations.

More than 6 tons of compost was supplied to Lingkana, Thimphu. The compost is utilized by Forestry and Horticulture sector in crop production and management.

Low Cost Green House Construction

A low cost ventilated greenhouse (36x6m) was constructed for the production of off-season crop. This ventilated new design greenhouse helps in maintaining the internal temperature and moisture.

Strawberry

Strawberry program multiplied and produced 10,000 runner plants and 215 boxes of fresh fruits as detailed below.

Table 7-4: Strawberry production record

SN	Particularser	No of Mother Plants	Production	Remark
1	Open field	3,000 Nos	65 boxes	
2	Green house	7,000 Nos	150 boxes	
3	**Total**	**10,000 Nos**	**215 boxes**	

Fruits

Three types of orchard: mixed orchard, kiwi block and citrus block are maintained with 975 trees. For effective utilization of space within the orchard, hybrid and wild asparagus and Pepino melon are intercropped.

Table 7-5: Fruit crop orchard maintained at CRP

SN	Particularser	Area	No of plants	Remark
1	Mixed orchard	*5.93* acres	597 Nos	Intercropped with asparagus & Pepino melon
2	Kiwi block	*1.20* acres	128 Nos	Developed kiwi trellis
3	Citrus block	*2.02* acres	250 Nos	Intercropped with Guava
4	**Total**	***9.15* acres**	**975 Nos**	

7.3 Mushroom program

The Mushroom program was initiated since 2016 and mandated to demonstrate and commercialize year round production of mushrooms. The Mushroom program is technically supported by Japanese Experts and National Mushroom Center in Thimphu.

Shiitake Mushroom Cultivation

During the 2017-18 financial year, the Mushroom program had surveyed the different potential areas for log collection and collected 3500 nos. of log for Shiitake mushroom cultivation. About 3000 billets were inoculated and kept under incubation.

Oyster Mushroom cultivation

We cultivated 815 bags and harvested 211 kgs of fresh Oyster Mushroom. The spawn are supported by ARDC-Bajo and National Mushroom Center. The fresh produce is marketed to high-end hotels.

Table 7-6: Oyster Mushroom production record

SN	Commodity	Quantity	Production	Remark
1	Oyster Mushroom	815 bags	65 kg	25 kg offered to VVIPs
2	**Total**	**815**	**65 kg**	

Developed Internal fencing

Fencing around the Mushroom and orchids block was done to protect from vandalism and safeguard the Mushroom house since the structure was made of glasses. Therefore, the sector has executed and developed more than 300 meters of internal fencing around Mushroom house and orchid block.

Procurement of Materials

The following materials were procured after obtaining approval of the RPCO, Thimphu. These materials are purposed for Mushroom production on sawdust-based media.

- Sawdust grinding machine
- Laminar air flow

Floriculture

The Floriculture Program is engaged with the production and maintenance of different potted flowers, ornamental trees and develop flower garden in the project area. The produced flowers are supplied to various important national events and Royal Bhutan Flower Exhibition.

Table 7-7: Flower production record

SN	Potted flowers	Quantity	Date of supply	Remark
1	Mixed potted flowers	1,575 pots	*11 Nov 2017*	
2	Mixed potted flowers	3,581 pots	*17 Dec 2017*	
3	Mixed potted flowers	3,295 pots	*05 Feb 2018*	
4	Mixed potted flowers	1,389 pots	*21 Feb 2018*	
5	Mixed potted flowers	32,020 pots	*25 April 2018*	
6	**Total**	**41,860 pots**		

Note: The value of potted flowers is estimated at Nu4,186,000 (= 41,860 pots x Nu100 per pot).

7.4 Forestry program

Forestry program implemented the activities related to irrigation supply, landscaping and beautification, forestry nursery production, plantation and windbreak. We rectified the existing water reservoir pond and irrigation supply to vegetables, floriculture and forestry plantation site. Irrigation reservoir pond was developed for organic rice production. Drinking water supply was initiated from Chasagang and Dashiding area, 7.1km and 3.6 km away from project site respectively.

Germplasm maintenance of both native and exotic orchid through propagation support from Royal Project Foundation, Thailand was continued. At present, the orchid houses 43 native species of orchid and 95 numbers of five varieties of orchids presented by Thai counterparts.

Forest nursery was developed to raise the ornamental and the forest tree species of both exotic and the native plants mainly for plantation as windbreak and for plantation at the barren areas of the project. About 60% of the developmental work is completed. The nursery is in operation with about 7000 plants of different species in two polyhouses.

Landscaping is implemented in various locations in consultation with RPCO and as per master plan. Landscaping is for beautification, development of fern garden and recreational site. The vetiver grass is propagated which will be used in sustainable land management program. Technical assistance in landscaping and beautification was provided to the Division staff, Lobesa. The project staff acted as focal for landscape and beautification, Choekhang area and Thai garden development, during the Flower show at Punakha.Technical support in developing rock garden for Green Bhutan Cooperation Limited was also provided.

7.5 Marketing

Table 7-8: Sale record for 2017-18 financial year

SN	Potted flowers	Quantity		Amount (Nu)	Remark
1	Rice	6,714.0	kg	324,860	
2	Mushroom	186.0	kg	37,200	
3	Mung Bean	700.0	kg	49,000	
4	Strawberry	107.0	boxes	31,110	
5	Water Melon	188.5	kg	7,540	
6	Vegetable	-		62,060	
7	**Total**	**-**		**511,770**	

8 ARDSC TSIRANG

8.1 Horticultural Research: Vegetables

8.1.1 Seed production of improved varieties

During the financial year 2017-18 the vegetable unit under ARDSC, Menchuna carried out various activities through IHPP/JICA. The main activities were production of winter and summer vegetables seeds of improved varieties introduced through IHPP/JICA from Japan and other sources. The seeds were produced to supply to the farmers for promotional purpose. In addition to seed production, the performance of the new varieties was also evaluated. Seeds of winter vegetables including radish (3 varieties), cabbage, Chinese cabbage (3 varieties), mustard green and spinach were produced. The seeds of only those varieties performing well in the sub-station were collected for supply. The total seed produced for winter vegetables are detailed in table 8-1.

Table 8-1: Winter vegetable seed produced

Crop	Variety	Quantity(kg)	Remark
Radish	Gensuke	1.420	
	Long foot	3.800	
	Aki no Irodori	0.041	
Chinese Cabbage	Neo Kyoto 3	0.500	
	Kyoshu 85	0.041	
	Kaga	1.964	
Mustard green	Nagajima	1.360	
Spinach	Jiromaru	5.440	
Total		**14.560**	

Summer vegetables like eggplant (5 Varieties), capsicum, chilli, bulb onion (3 varieties), bunching onion (3 varieties), tomato (7 varieties), zucchini, beans, water melon, and pumpkin are under production (Table 8-2).

Table 8-2: List of summer vegetable under cultivation for seed production

Crop	Variety	Status
Pumpkin	Ebisu	On-going
	KuriEbisu	On-going
Tomato	World one	On-going
	Ponte Rosa	On-going
	Fukuju	On-going
	Thai	On-going
	King-180	On-going
Yellow melon	Gold 9	On-going
Water melon	Neo yamato	On-going
	Black ball	On-going
	Black sweet	On-going
	Beni Kodama	On-going
Bean	White pole bean	On-going
	Grey pole beans	On-going
	Midori	On-going

8.1.2 Water melon production

Four varieties (Black Ball, Black Sweet, Beni Kodama and NeoYamato) of water melon were planted in the poly house in the sub-station which is at an elevation of 1600masl. Nursery was raised in March, transplanted in April and harvested from 1st week of June. Musk melons were also cultivated in open field for seed production.

8.1.3 On -farm Water melon promotion

Through the support of the IHPPJICA water melon was cultivated for the first time in Tsirang Dzongkhag. It was promoted in Tashiyangjong village under Kikorthanggewog which is located at an elevation of about 1200masl. Watermelon seedlings which were raised in IHPP/JICA vegetable nursery in the sub-station and thirteen household were selected and provided with Neo Yamato variety. It was very successful in the farmer's field and the participating farmers have already marketed their produce in Damphutown. There is good market for the local watermelon as it is without chemical and sweeter than the imported ones. About 250 kg of water melon was produced till date.

8.1.4 Horticultural research: Fruits and Nuts

There are four (20x 5M) poly houses dedicated to raising both vegetable and fruit nursery in ARDSC, Tsirang. In addition, fruits seedlings are also raised in open field in an area of about half an acre. A total of about 5000 fruit seedlings were produced out of which about 1000 seedlings were distributed to the farmers of Dagana and Tsirang districts.

8.1.5 Nursery production (fruits)

Production of quality fruit seedlings remains one of the main activities under horticulture sector. Seedlings are produced for establishment of demonstration orchards which is one of the most effective methods to promote promising and released varieties. The nursery and the mother blocks also serve as the ground for crops management and nursery establishment trainings for both farmers and extension officers. Moreover, ARDSC has been able to complement the private seedling nurseries in meeting the demand for quality seedlings. The objectives were to produce sufficient seedlings form establishment of demo orchards and research programs and conduct hands on training in nursery establishment and support the private nursery growers.

The nursery is managed following the recommended package of practices for quality seedling production. The scion wood is collected either from the germplasm block of the sub-station or from other ARDCs. Rootstocks are raised using both the local and improved varieties. Both grafted and un-grafted seedlings are produced (Table 8-3).

Table 8-3: Total no. of seedlings produced

SN	Fruit	Quantity	Remarks
1	Pomegranate	300	
2	Avocado	450	
3	Pear	2,000	Rootstock
4		200	Grafted
5	Kiwi	200	Rootstock
6	Peach	1,000	Rootstock
7		200	Grafted
8	**Total**	**4,350**	

Establishment of nursery has proved to be one of the most effective methods of promoting fruits crops. The nurseries are also the ideal training field for training of private nursery growers and extension officers on nursery establishment and management.

8.1.6 Establishment of demonstration orchards

Demonstration orchards play a key role in expanding the economic opportunities of the farmers and also disseminating the technology. The goal of the demonstration orchard is to provide the farmers with hands-on instruction in the establishment and management of fruits trees. The other objective is to serve as the orchard from where farmers in the surrounding area can adopt the improved practices and benefit. A new crop is also introduced through establishment of demonstration orchards and promoted. The objectives were to promote the promising and release varieties, demonstrate the management practices and serve as the source of planting materials for farmers in the vicinity.

Table 8-4: Total number of demo orchard and focus village established

SN	Fruit type	Demonstration orchard (HH)	Seedling supplied (HH)	Focus village (No)	Total seedlings (No)
1	Avocado	12	12	3	600
2	Persimmon	8	-	-	120
3	Kiwi	5	-	-	90
4	Walnut	6	-	-	60
5	**Total**	**31**	**12**	**3**	**870**

The farmers were selected jointly with district agriculture sector. The crop is identified according to the elevation and layout done jointly. The standard pits size of 1m deep and 1 m diameter is dug. Mixture of FYM and top soil at 1:1 ratio is mixed and filled to about 10-20cm above the ground level. The cultivation practices are demonstrated, based on the cropping calendar, to the farmers till third year. Establishment of demonstration orchards is one of the best approaches to promote fruit crops and demonstrate the standard management practices.

8.1.7 Fruits and nuts germplasm

ARDSC has germplasm collection of peach (5 varieties), plum (5 varieties) pear (4 varieties), Sub-tropical apple (1 variety), citrus (5 rootstock varieties) and persimmon (1 variety). The varieties of these fruit crops have been planted mainly for bud wood and fruit production. These varieties have been released or found to be promising and can be promoted for production in farmer's field. The scion woods are used for seedling production in the Sub-centre and also supplied to the private nursery growers.

There are in total about 4 trials in ARDSC, Tsirang.

1. Kiwi varietal evaluation trial (Re-established in 2018)
2. Pecan nut varietal evaluation trial (Established in 2008)
3. Citrus rootstock compatibility trial (Established in 2008)
4. Citrus varietal evaluation trial (Established in 2009)

As these trials are in initial stage of evaluation, no proper data are available currently. The trees are still small and yield is not significant. It might take a few more years before concrete data can be collected and solid conclusion drawn.

8.2 Horticultural Research: Medicinal and aromatic plants (MAPS)

8.2.1 Cardamom repository and research

The National Large Cardamom Repository at ARDSC, Tsirang comprises of 26 large cardamom accession that have been collected so far from Samtse, Zhemgang, Tsirang, Chhukha and Sarpang districts. These accessions were collected either from wild or from farmer's fields. It was collected with the objective to identify and characterize based on the morphological characteristics and also to main germplasm for breeding works in future. Besides these accessions, popular varieties like Ramsey, Seremna, Golsey and Varlangey have also been planted for performance evaluation. The total area under cardamom cultivation is about 2.8acres. The regular management practices are carried out based on the cropping calendar. Surprisingly, the yield was just about 1.5kg last season. No particular variety has been found to be performing well in Tsirang condition till date.

8.2.2 Support to the cardamom nursery

Technical and input support was provided to establish one cardamom nursery in Dagana. The support was provided to Mr. D.B. Waiba of lower Tashithang village under Tashithang gewog in Dagana district. More than 2000 seedlings were produced from this nursery.

Figure 8-1: Cardamom germplasm maintained in polyhouse and in the field

8.3 Horticultural Research: Citrus program

8.3.1 Citrus canopy management

Background

Citrus is the one of the main sources of income for the farmers of Dagana Dzongkhag. However, in recent years, its share in farmers income fell owning to decline is orchards because of factors like disease incidence (citrus greening), poor management practices (nutrient, irrigation and lack of canopy management) and aged unproductive trees. But it still contributes a substantial share in farmers income and there is potential for increasing the

yield and also improving the fruit quality through implementing improved management practices.

Therefore, meeting/hands on training on citrus canopy and nutrient management were organized in Tsangkhagewog, Dagana Dzongkhag. Tsangkhagewog was selected because the gewog has orchards with trees of varying age: orchards with young unbearing trees and trees over 30 years. The meeting/training was focused on building the capacity of the farmers on training/pruning of both young and old citrus trees, and on nutrient management through hands on practice.

Figure 8-2: Farmers participants in canopy management

Objectives

The broad objective was to sensitize the farmers on the importance and benefit of proper canopy and nutrient management, and make the farmers practice these management practices in their orchards. The main objectives were to

1. Build the capacity of the farmers in citrus pruning, rejuvenation of old unproductive trees and nutrient management through hands on training.
2. To build the capacity of the farmers in training and pruning of young citrus trees through hands on training.

Methodology
Target orchards

The orchards with trees of varying age were selected to provide a complete idea on different pruning practices practiced on citrus trees depending of the age. Three types of orchards were selected.

1. Orchards with trees over 30 years of age with no history of pruning in the past.
2. Orchards with trees in the range of 15-25 years of age.
3. Orchards with trees below 5 years of age.

This selection was done because the old trees over 30 years were needed rejuvenation and corrective pruning, orchards in between the age of 15-25 required just corrective pruning. The orchards with trees below the age of 5 years or young growing trees required both training and pruning.

Participants

The participants comprised of orchards owners and resource person from ARDSC-Tsirang, Gewog Extension Officers and trainees from College of Natural Resource (CNR), Lobesa. The participants were provided with tools (pruning saw and secateurs) on returnable basis. And a simple working lunch was provided to the participants. All the participants were trained for a day except for those who participated at royal orchard where the participants attended for two consecutive days.

Training method

The participants were briefed about the importance and other theoretical part for about two hours in the morning at the beginning of the training. Then a practical demonstration was shown to them on a tree on how to prune/ rejuvenate/train the tree. Each resource person was assigned a number of participants, depending of the total participants attending on that day. The resource person then guided the participants on how to properly prune the trees.

Table 8-5: No of citrus trees pruned

Name	Village	No of trees	Tree age
Dorji	Zinchulla	535	2-5 years(unbearing), <20 years
LakdhanRai	Salamji	60	<30 years
Tshomo	Salamji	25	<5 years and bearing
Kuenga Sangay	Goal Tar	200	3 years
Nar Bdr. Rai	Goal Tar	28	<30 years
MinduWangmo	Babaithang	15	<4 years(unbearing)
TsheringDorji	Babaithang	70	<20 years and <5 years(Bearing)
Dechen	Petakha	100	<20 years
Krishna Bdr. Rai	Petakha	150	<10 years
Royal Orchard	Tangji	85	< 30 years

Outcome of the training

A total of 81 farmers were trained. The participants included school drop outs residing in village, middle aged farmers and local citrus middle men. We are very confident that the farmers can now be able to practice these management practices properly in future on their own without further assistance. The farmers were very positive and forthcoming on the activity and we hope that the same spirit would be maintained and will continue to practice what they learned in their respective orchards every year. In total, 10 orchards were covered during the training. About 1268 trees were pruned and rejuvenated in total.

Follow up action

The follow up required are:

- The gewog extension officer to ensure that participating farmers carry out the canopy management in their respective orchard.
- The de-suckering and caring of the selected sprouts from the cut points is very important. Therefore, towards June-July, a follow up training is required to train them on how to selects the sprouts for making it the bearing branch in coming years.

8.4 Field Crops research

8.4.1 Rice initial evaluation of elite lines under rainfed conditions

In view of the changing climate and monsoon variability, water availability is one of the main constraints for rice farming. Research advocates that rice lines with drought tolerance or that can grow well under limi

ted irrigation would be desired if rice production is to be sustained. The main objective of this activity was to evaluate whether there exists any genotypic difference in the elite rice lines under rainfed or limited water conditions. The trial site, on-station of ARDSC Tsirang, is characterized by limited water particularly at transplanting as it has to depend entirely on monsoon.

A total of 5 lines including a standard check were evaluated in 2017-2018 season. Owing to small quantity of seed, trial was laid out in a single observation plot of 5 m x 3 m. The nursery raising, transplanting and other crop husbandry practices followed the standard packages, which are generally recommended for the location. During the growing season, none of the lines suffered from any pest incidence. At maturity, a crop cut was taken which indicated the potentiality of two new lines compared to others (Table 8-6). The selected lines will be further evaluated in the ensuing season to ascertain the performance.

Table 8-6: Agronomic traits of new rice lines

Line	Plant height (cm)	Leaf blade (cm)	Panicle length (cm)	Days to maturity	Grain yield (t/ha)
Shabhagi	75	41	25	157	3.07
IR05A235	72	42	19	170	3.05
IR09A220	40	39	21	150	3.70
CB08514	73	40	25	150	3.20
Attay (check)	110	37	25	180	3.10

8.4.2 Phenotypic characterization of traditional rice varieties

In collaboration with National Biodiversity Centre, 192 accessions of local rice varieties from the National Gene Bank were phenotypically characterized at ARDSC Tsirang on station. The accessions were laid out in a single observation block of 2m x 2munder the standard management conditions. Different agronomic and plant traits were collected as per the international protocols. These include leaf blade pubescence, leaf sheath colour, flag leaf angle, ligule colour, ligule type, culm habit, plant height, days to maturity, panicle length and number of grains per panicle to name some. As the National Biodiversity Center took the lead and have the designated professionals for such study, data were submitted for final synthesis and analysis.

8.4.3 Seed production and maintenance

The center continued to maintain seed of released and promising varieties for different research and developmental activities. In 2017, the center produced 300 kgs of Wengkhar Ray Kaap and 700 kgs of IR-28 basic seeds. While Wengkhar Ray Kaap 2 is a released variety with the proven success in certain part of Dagana, IR-28 is a promising variety demonstrating huge potential in tested sites in Tsirang and Dagana.

8.4.4 On-farm evaluation of new advanced rice lines

ARDC Bajo had advanced four lines (CB08514, IR09A220, IR05A235 and SAHABAGI) based on yield potential, maturity, and other desirable agronomic traits. As wider adaptability is often important for new variety to succeed, an on-farm evaluation was organized in two sites in Tsirang. The sites are Sunkosh (600 masl) and Zomlingzor (750 masl). The crops were entirely raised under farmers' agronomic management conditions from nursery till maturity. Though the importance of improved crop husbandry such as fertilization and weeding were shared, farmers seldom followed. At harvest, a field day was organized to jointly assess the yield potential of new lines and gather farmers' feedbacks. There was a genotype by environment interactions as observed in yield differences among varieties in different sites (Table 8-7). Farmers ultimately were considering the grain yield potential, and have affirmed to continue with the highest yielders.

Table 8-7: Performance of rice lines in different sites

Variety	Sunkosh		Zomlingzor	
	Plant height (cm)	Yield (t/ha)	Plant height (cm)	Yield (t/ha)
CB08514	89	3.0	90	2.45
IR-05A235	86	2.9	85	2.30
Shabagi	87	2.6	87	3.60
IR09A220	85	2.5	90	3.79
Locals Attey	110	2.4	160	3.10

8.4.5 On-farm evaluation of Khamtey rice variety

Rice is a main crop in Bharadhurey village (435 m), Barshong, Tsirang where the agro-ecological conditions are ideal for promotion of low altitude rice varieties. Considering the opportunity, ARDSC Tsirang had evaluated a number of improved varieties where Bhur Rey Kaap 2 had made a significant impact. However, opportunities still exist to further broaden the genetic diversity. Considering the success of Khamtey at a neighbouring village of Sunkosh (380 m), an observation trial was organized at Baradhurey in 2017 cropping season. Four farmers participated in this trial with an average cropping area of 0.3 acres. Crop was raised entirely under existing farmers' management practices.

A field day was conducted at harvest time to jointly assess the crop performance, gather farmers' feedbacks and plan future course of actions. Farmers, through the field visit, were convinced of its adaption in their locality. Farmers also appreciated the agronomic traits (tall height, grain size) of Khamtey which were comparable to their local dominant variety, Gauri. More importantly, the yield of Khamtey (1200 kgs per acre) was more than the Gauri (900 kgs per acre), which further proved its superiority and suitability. Apart from saving seed for ensuing season, one of the farmers could generate Nu. 4200 through sale of 60 kgs rice at the rate of Nu70/kg. As Khamtey has assured market and better palatability, the co-operative farmers would like to expand the area in the ensuing season. In addition, new farmers have also requested for seed, an indication of its preference. As envisaged, Khamtey cultivation will broaden the rice genetic base and contribute to cash generation of these needy farmers.

8.4.6 Maize seed production and maintenance

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. In the 2017 season too, a total of 1000 kgs of maize seed was produced in that station that could approximately cover 75 acres in the ensuing season.

8.4.7 Heat Resilience trial on maize

In collaboration with the National Maize Program of ARDC Wengkhar, 60 maize lines were tested at Sunkos (380 masl). The main aim was to select the best heat tolerant lines as the aerial temperature is expected to rise exponentially under the global warming phenomenon. Sunkosh being in a low lying area provide a conducive site where maximum aerial temperature and maize growing season coincide. Data were recorded as per the International Maize and Wheat Improvement Center protocol, and submitted to ARDC Wengkhar for final compilation and analysis. The initial observation indicated that there could be some genetic differences as signified by crop performance.

8.4.8 Maize Demonstration

The seed selection for maize crop was taken into our consideration since the maize is one of the major crops in their farming system. Maize crop is almost grown by the farmers in the localities. Therefore, the more research activities have to focus in promoting good yield. Objectives were to introduce Chaskhar Ashom in the village, gradually to replace the low yield maize variety, adapt in theagroecological zone and fit in their farming system and to compare the performance of improved maize variety with local maize. Three farmers participated in the program using large single plots. Seeds were sown in mid April and harvested in end August. Grain yields of 1.3 to 1.5 t/acre were recorded.

8.4.9 On station Quinoa trials

In 2017-18 season, three varieties (Amarilla Sacaca, DoA-1-PMB-2015 and Ivory-123) of quinoa were tested at Tsirang station (1500m) to assess their adaptability and performance. The crops were sown on 1st week of October 2017, and harvested in January, 2018 depending on the maturity of individual varieties. The basal dose of organic and inorganic fertilizations followed the standard application used in the station. Crop was entirely raised under rainfed conditions.

Table 8-8: Agronomic traits of quinoa varieties

Variety	Date of		Plant height	Grain yield	Milling recovery
	Sowing	Harvesting	(cm)	(t/ha)	(%)
Amarilla Sacaca	03.10.2017	28.01.2018	95	4.30	94.14
DoA-1-PMB-2015	03.10.2017	08.01.2018	101	2.77	90.57
Ivory-123	03.10.2017	08.01.2018	84	2.49	92.23

Among the three varieties, Amarilla Sacaca produced the highest yield (4.3 t/ha) at the tested site (Table 8-8). It also had the highest milling recovery. However, it is a late maturing variety, ~ 20 days as compared to other varieties. This may be a disadvantage if there are successive crops following immediately in the same land. However, the yield benefit from this variety is noteworthy if there is adequate time for the subsequent crop.

(a) (b) (c)

Figure 8-3: (a) Amarilla Sacaca, (b) Ivory 123, and (c) DOA-1-PMB-2015

8.4.10 On-farmQuinoa trials

The on-farm Quinoa trial was very new to be taken to the farmers' fields, and the farmers were not very willing to grow this crop because they have never seen and added in their daily

meal. Now the farmers are aware about the crop stand in the fields, and they are confident that this crop would easily adapt to their Agro ecological zone. During our field monitoring, we have seen farmers disinterested about the crop but in the time of harvest we have come across surprising yields from all three varieties, for example a farmer in Sergithang had received 175gm of DoA-1-PMB-2015 and grown in his field which gave 10kg so the Centre purchased the entire yield giving Nu100/kg to be given as seed to those farmers who have not cultivated in the first round.

In the future, we need investment in trials of different quinoa varieties, technical know-how on processing, marketing and more awareness on the crop. The crop has been successfully acclimatized and adapted to Tsirang conditions. Amarilla Sacaca and Amarilla Marangina for high altitude areas above 1500 masl and Ivory 123 below 1500 masl are recommended varieties. Identification and development of markets will be critical to upscale Quinoa production in the Tsirang and Dagana Dzongkhags.

Table 8-9: Perfromance of Quinoa varieties in Tsirang and Dagana

Variety	Place	Plant height (cm)	Sowing (date)	Harvesting (date)	Yield (t/ha)
Amarilla Sacaca	Drukjeygang	67.25	9.10.2018	20.01.2018	2.05
DoA-1-PMB-2015	Sergithang	109.00	15.10.2018	7.01.2018	2.25
Ivory 123	Barshong	39.00	2.10.1028	29.01.2018	2.50

8.4.11 Seed production of wheat and mustard

The center regularly receives and has to entertain ad-hoc request from farmers for the seed of winter crops. Therefore, center produced 515kgs of wheat seed and 115kgs of mustard in 2017-2018 season. In addition to the center production 50 kilograms of Yusi Peka-1 seed was procured from the selected seed grower of Drujeygang geog.

8.4.12 National Citrus Repository- Tsirang

The Agriculture Research and Development Sub-Centre (ARDSC) in Menchuna, houses the National Citrus Repository (NRC). NCR is located at an elevation of 1480m, under Tsirang district. Citrus is one of the main export crops of Bhutan. The crop has well established marketing chain although its cultivation method remains traditional and export markets are limited to two neighbouring countries (Bangladesh and India). On the contrary, Bhutan imports huge chunk of pulp (60-70%) for processing from outside country during the off-season. 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.

Objectives of NCR

- Maintain blocks of trees that serve as the primary source of disease-free, true to type bud wood of all important citrus fruits and rootstock varieties.
- Maintain superior quality germplasm of both local and exotic citrus cultivars

- Act as a repository for genetic resources and scientific information related to citrus.

Activities

Identification of potential varieties through introduction of different citrus varieties: Citrus crops/varieties which are not in the National citrus Repository (NCR) were collected from ARDC-Wengkhar in 2016. Otha ponkan, teishuponkan, tarku, Dorokha local and local 27/28 were the varieties/cultivars for the study. From each variety, 10 plants were planted at Foundation house of NCR for selection. The study is in process.

Minimise soil born disease using resistant citrus rootstocks: Citrus crops are often observed with soil borne diseases. To minimise the soil borne diseases, desired cultivars were grafted on different resistant rootstock in July 2017 to June 2018. 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.

Fast detection of disease using indicator plants: Orlando tangelo indicator plant was grafted on Otha ponkan, teishuponkan, tarku, Dorokha local and local 27/28 in February 2018 to detect HLB disease in the different varieties. Study on-going at NCR. Study success of only one percent due to poor facilities.

Provide clean planting materials to ARDCs and NSC for further propagation: To provide clean cultivars for cultivation, 6000 buds from 12 varieties (mother plants) are ready to deliver to different agencies.

Identify citrus varieties through complete phenological stages: Mixture of different cultivars of citrus plants was observed at NCR. To identify and characterize the plants, the plants were potted in protected house in July 2017 for the study. Records on phenological stages are maintained. With the record on phenological stages, plants will be categorised and identified. The study is under process.

Produce rootstock seeds for future propagation: A total of 15 varieties were planted randomly in open field at ARDSC Tsirang in February 2018. The production from the plants will be used for seed extraction to use as rootstocks in future propagation.

Awareness program on HLB management: To create awareness on HLB management and control, presentations were made to Extension Officers of Dagana district in April, 2018. The need for clean planting materials to control HLB was highlighted. A total of 12 Extension Officers attended for the program.

Performance Evaluation of different Citrus varieties: At areas under elevation 700-1500 masl in west central Bhutan, a set of 8 varieties were planted in May-June, 2018 to evaluate the performance among the different cultivars. Ryan, salustinia, bearss lime, othaponkan, okitsu wase, clementine, valencia, semjong lime were the varities/cultvars planted for the study. The best performing cultivar in the respective locality will be promoted in the future.

Establishment of Demo-orchard and Focus village to promote income generation through orchards: With support from IHPP, 4 demo-orchards were established in two gewogs under Dagan district. Based on the elevation and climatic condition of the locality, fruit trees suitable for the locality were planted at different orchards. Avocado, citrus, loquat, grapes, and dragon fruits were the fruit plants distributed. The technical and financial support on orchard management at different area is supported by IHPP/ARDC Bajo and ARDSC Tsirang. One focus village was established at Gangzor toe, Tsendagang gewog under Dagan district.

Establishment of windbreak: ARDSC Tsirang is a windy area where crops are damaged yearly. Jamuna is a broad leaf evergreen tree with massive biomass which can guard crops from heavy wind. Therefore, 144 saplings were planted along the periphery of research field at 6m plant to plant distance.

Infrastructure development: To provide efficient irrigation, drip irrigation set was installed at NCR station with supports from ACIAR/RGOB. Supported by IHPP, 2 each greenhouse with capacity of 5m by 10m and 7m by 20m were installed in February 2018.

9 METEROLOGICAL INFORMATION

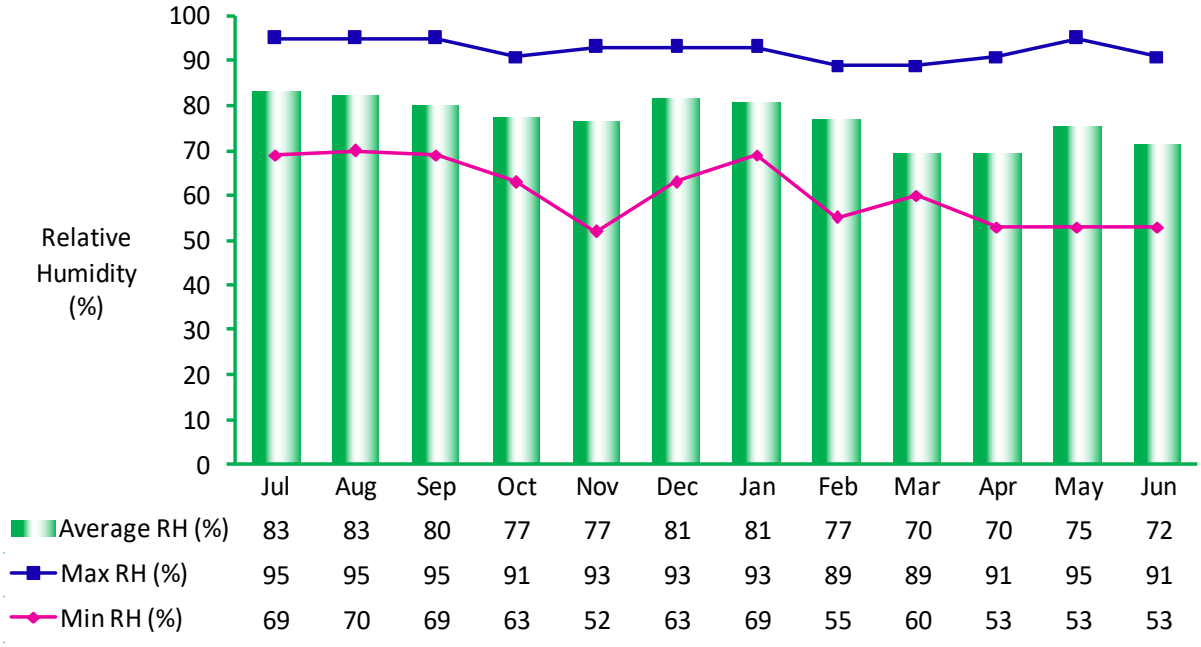


Figure 9-1: Relative humidity at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

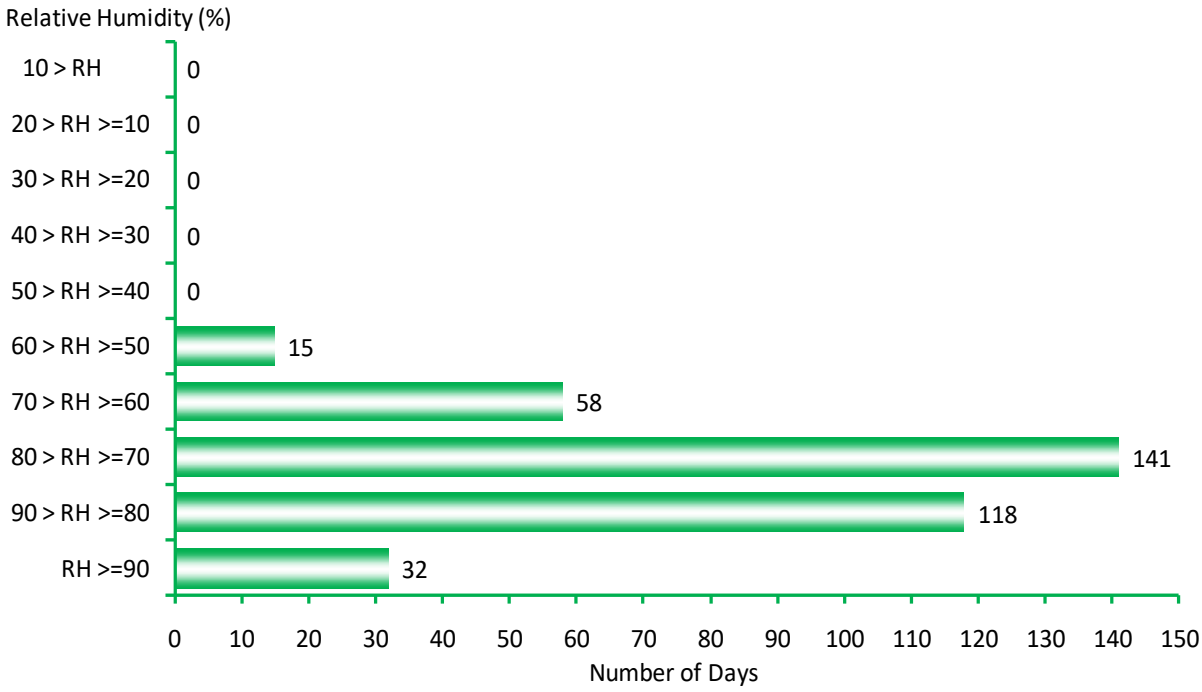
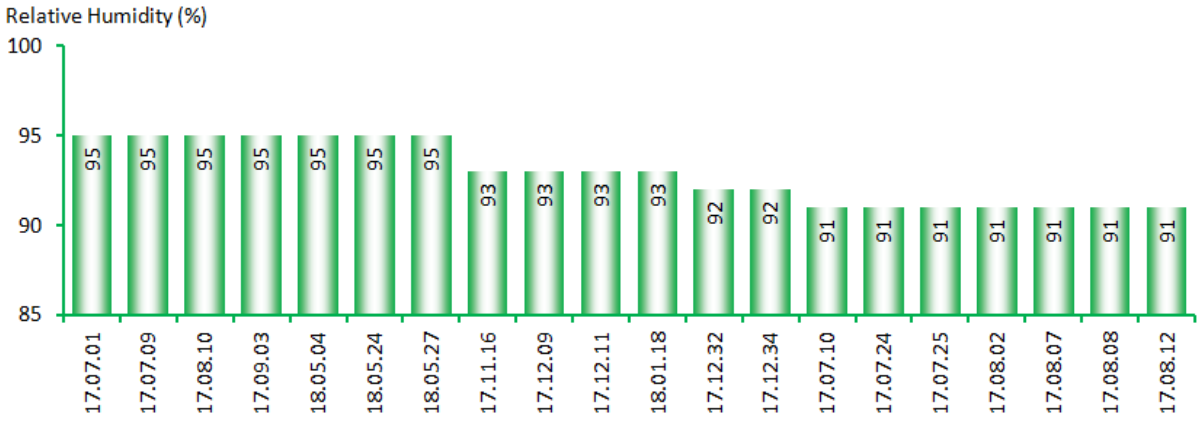
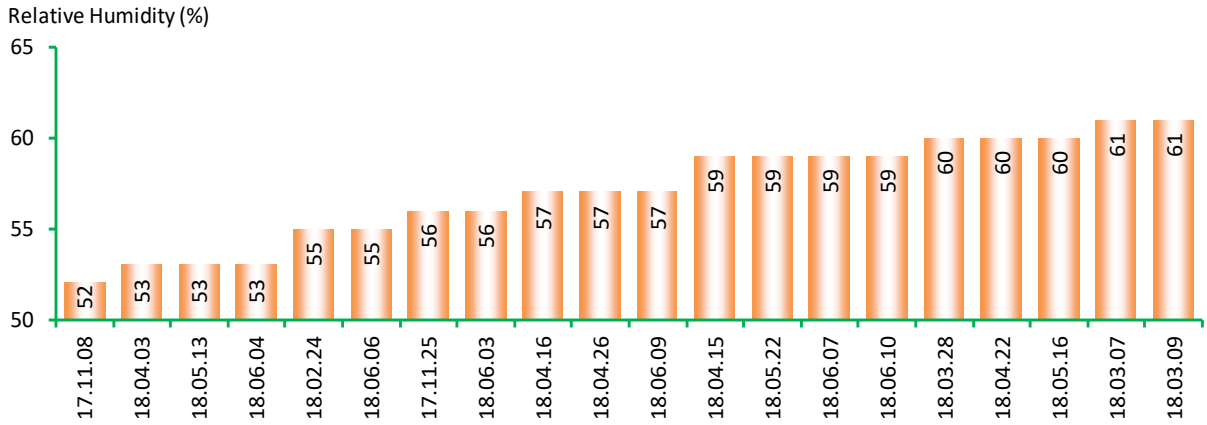


Figure 9-2: Relative humidity pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station



(a)



(b)

Figure 9-3: Relative Humidity: (a) highest & (b) lowest 20 days at ARDC Bajo

Source: Bajo Meteorology Station

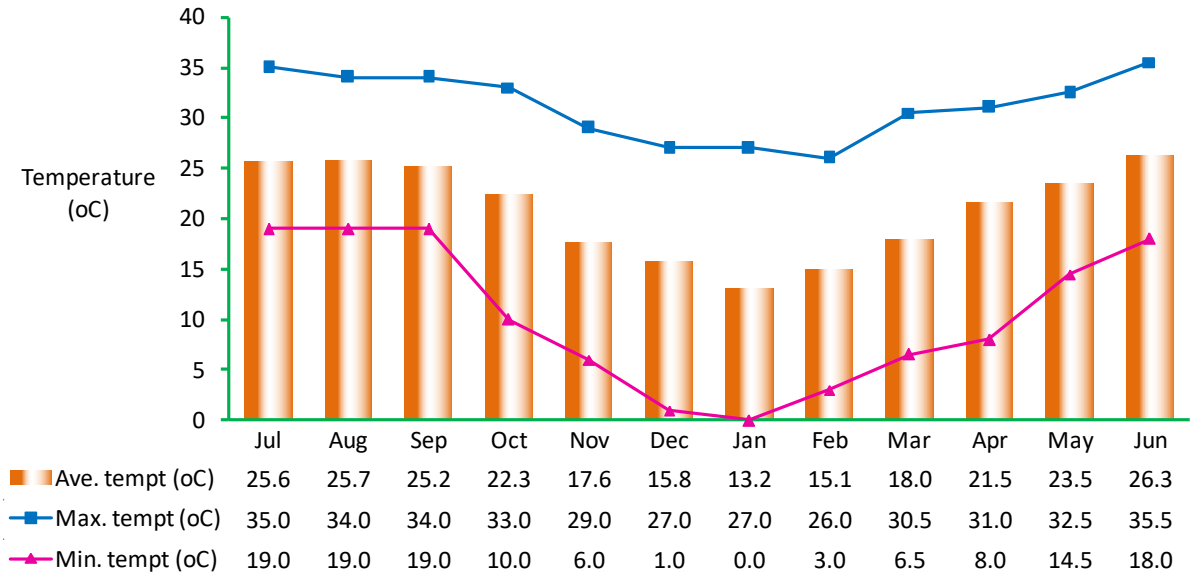


Figure 9-4: Temperature at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

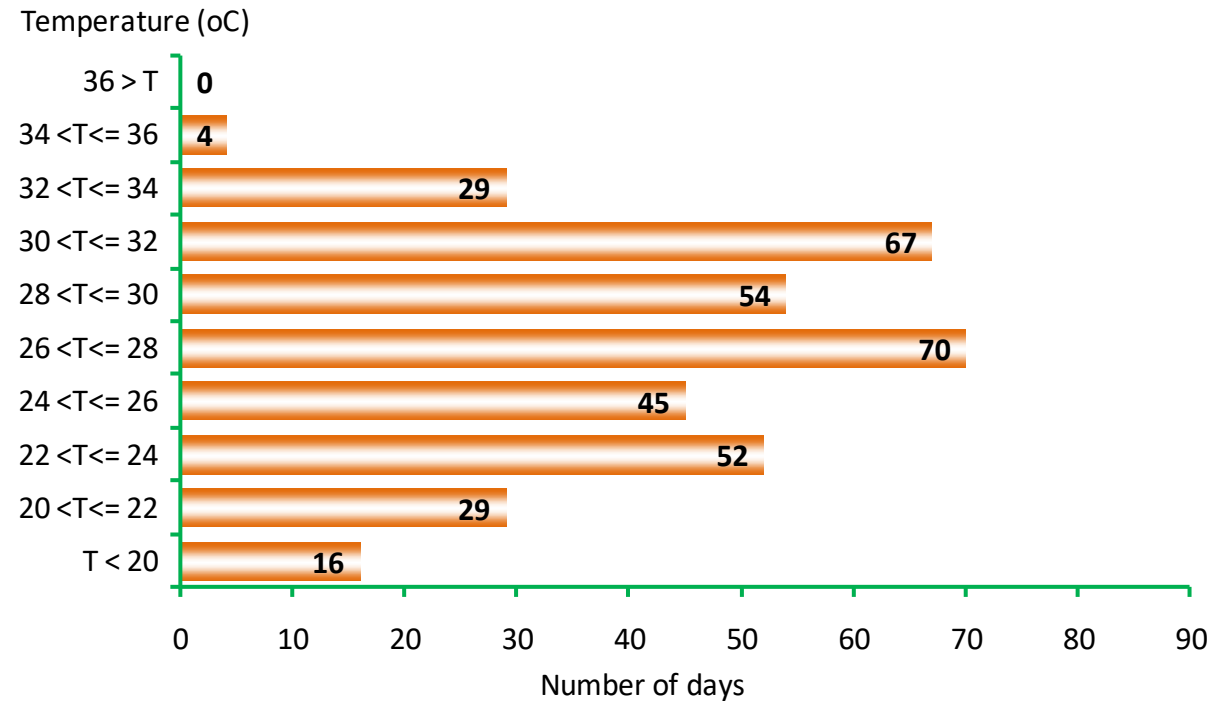


Figure 9-5: Temperature pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

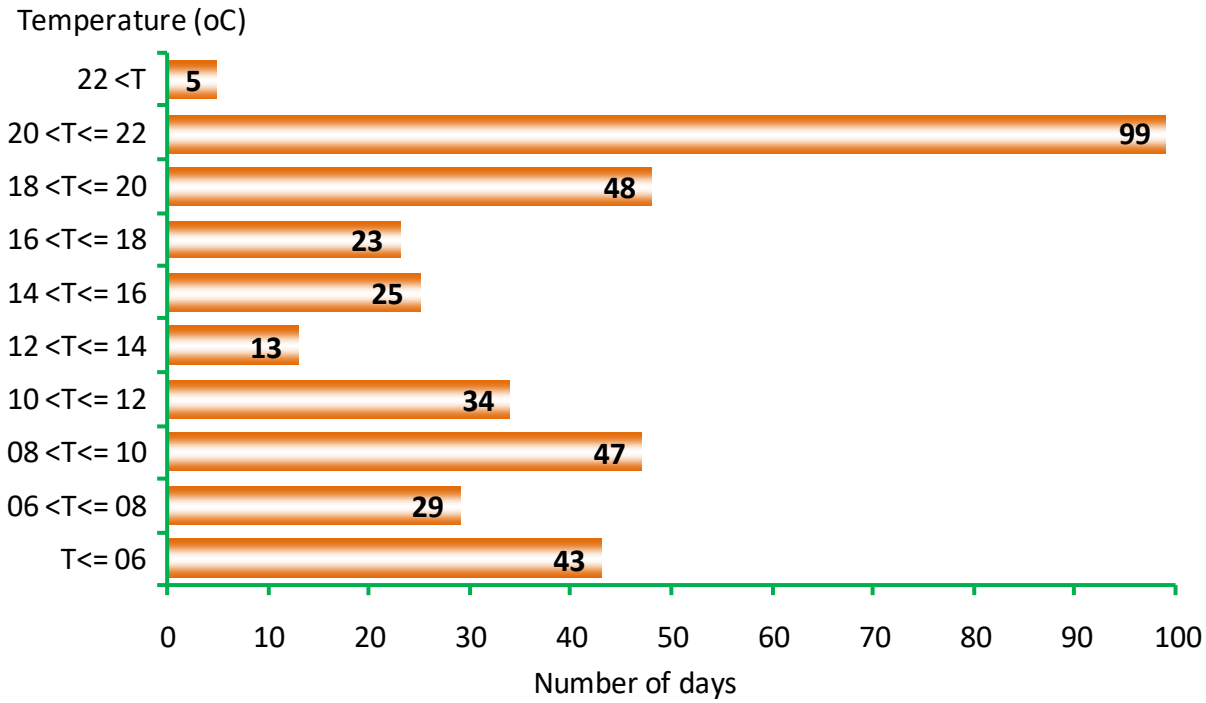


Figure 9-6: Minimum temperature pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

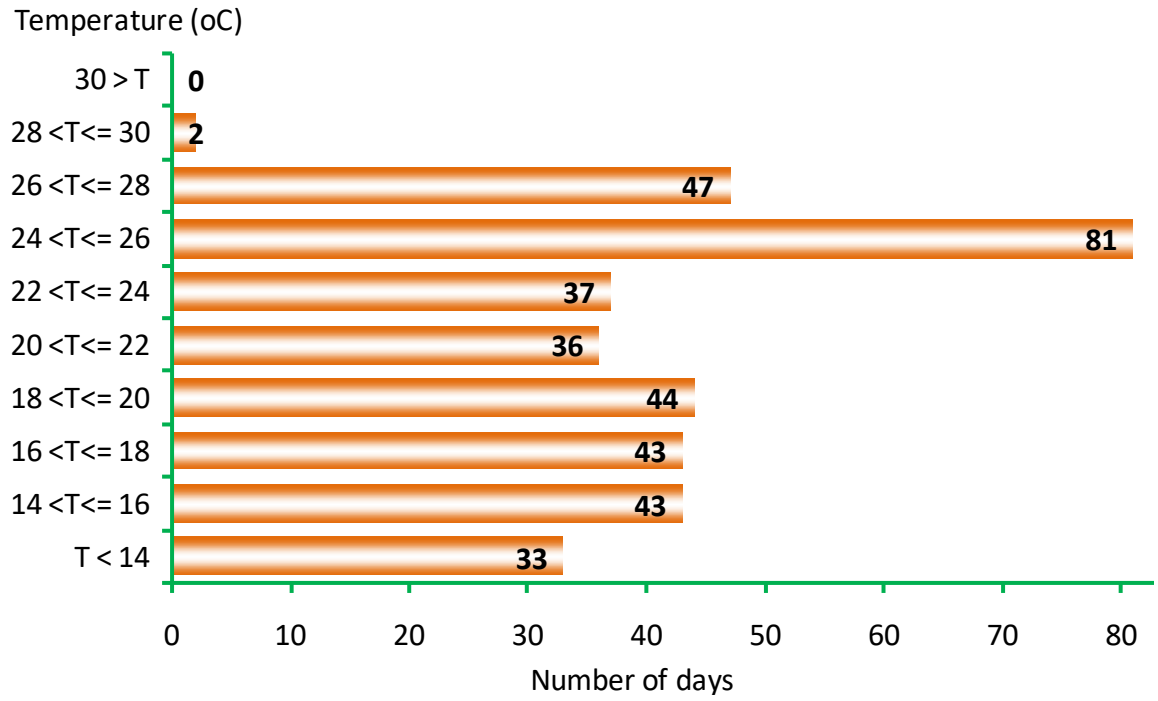


Figure 9-7: Average temperature distribution pattern at ARDC Bajo

Source: Bajo Meteorology Station

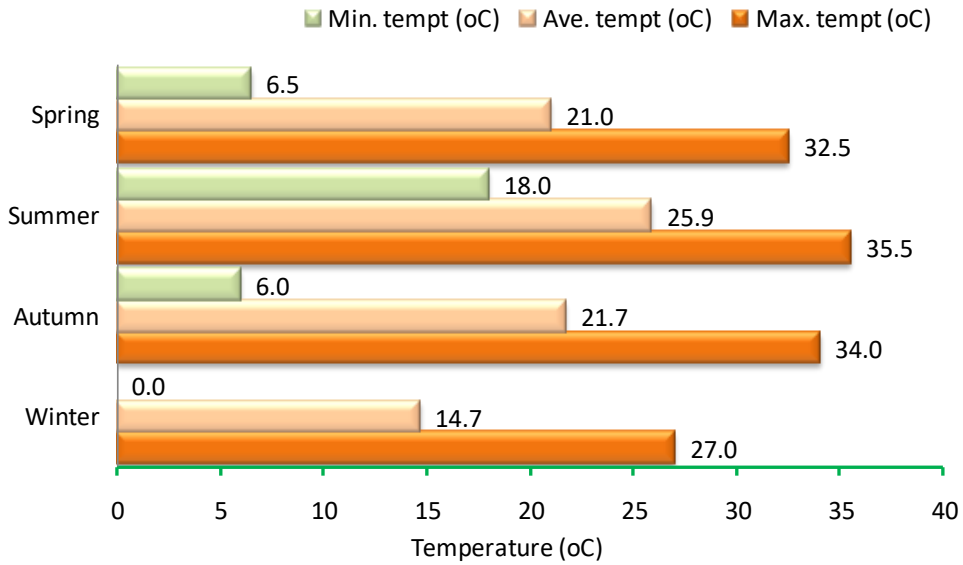


Figure 9-8: Seasonal temperature pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

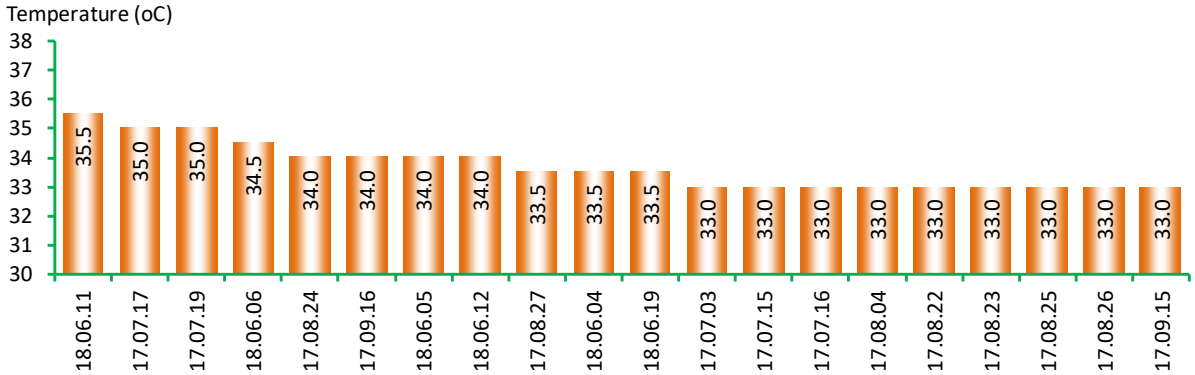


Figure 9-9: Twenty hottest days at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

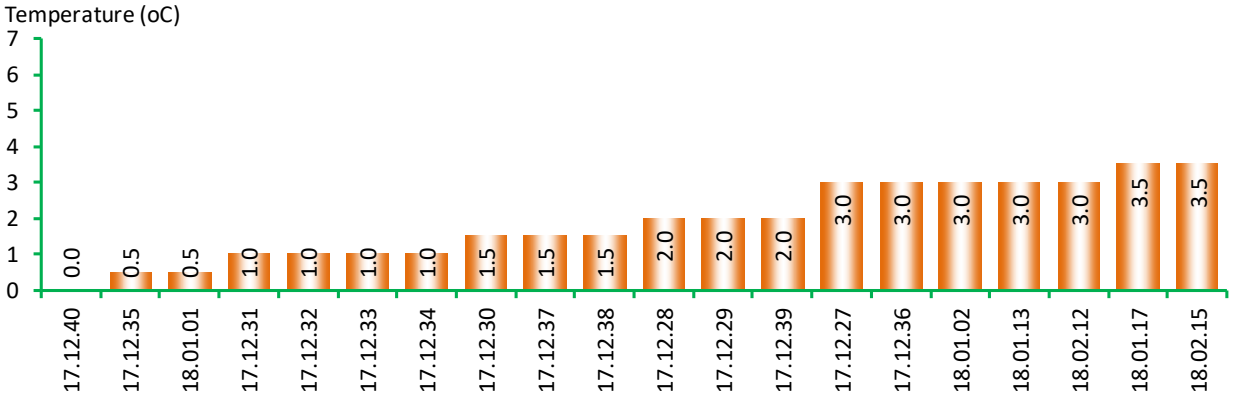


Figure 9-10: Twenty coldest days at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

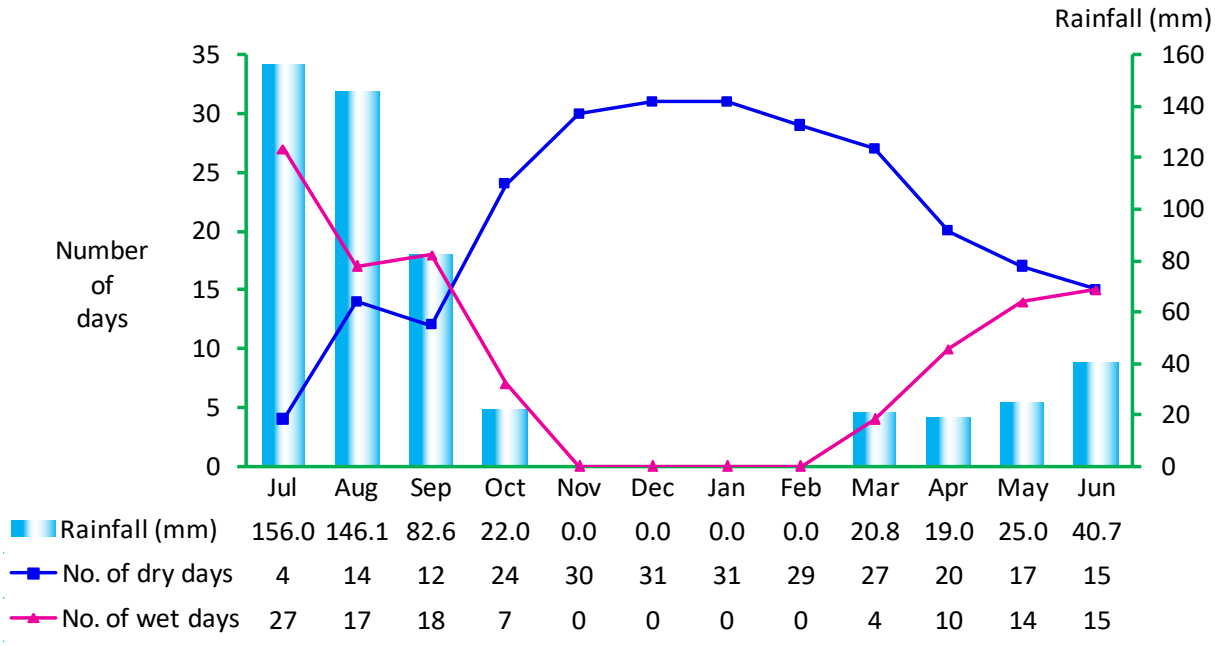


Figure 9-11: Rainfall and wet & dry events at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

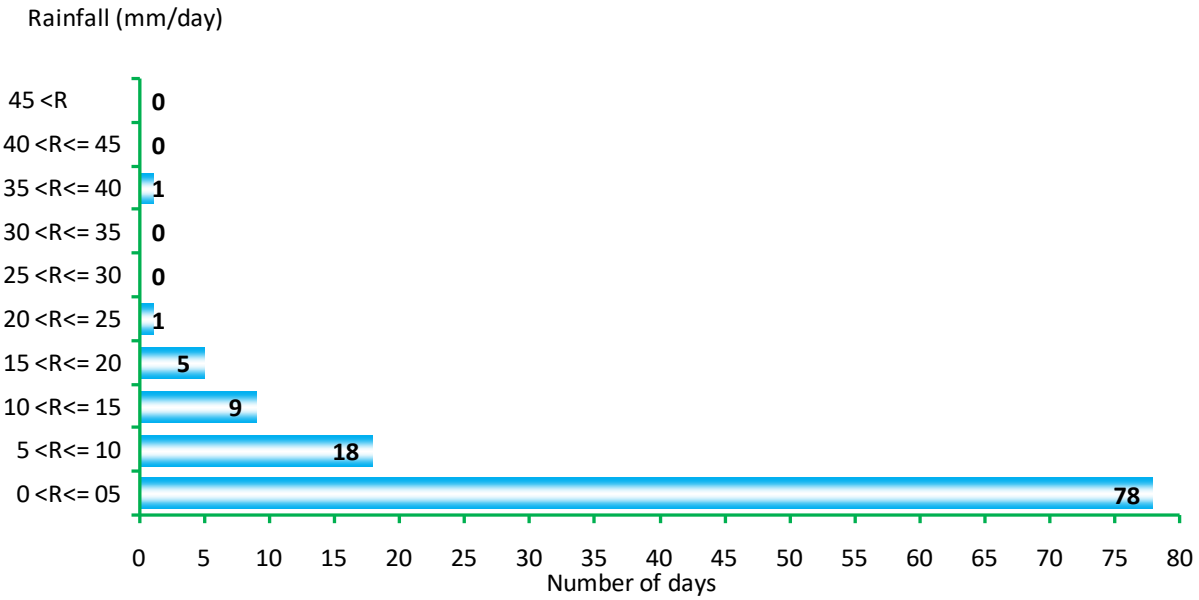


Figure 9-12: Rainfall intensity distribution at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

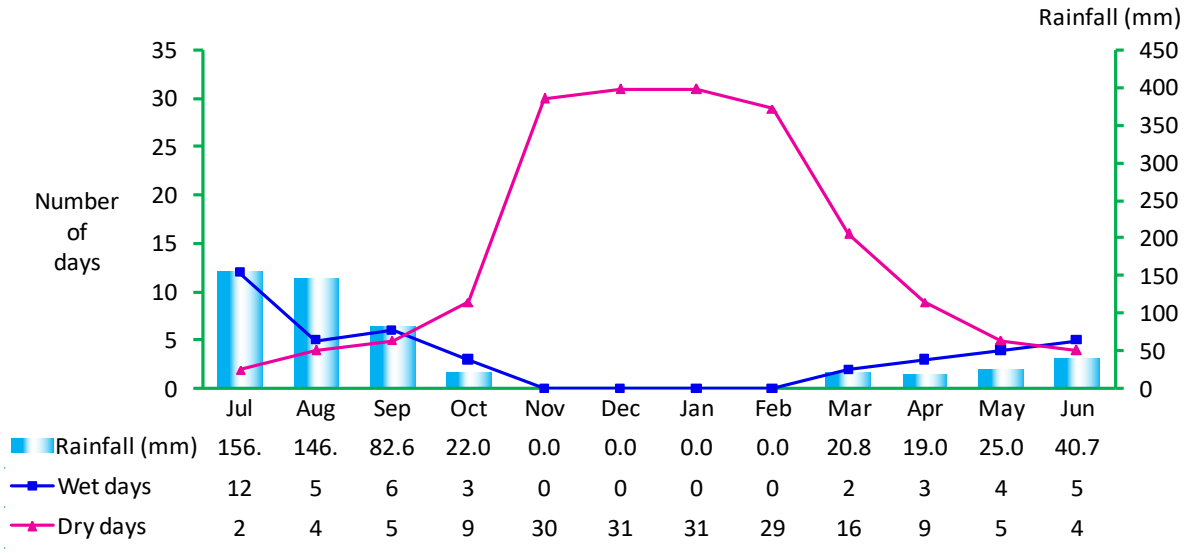


Figure 9-13: Duration of wet and dry days at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

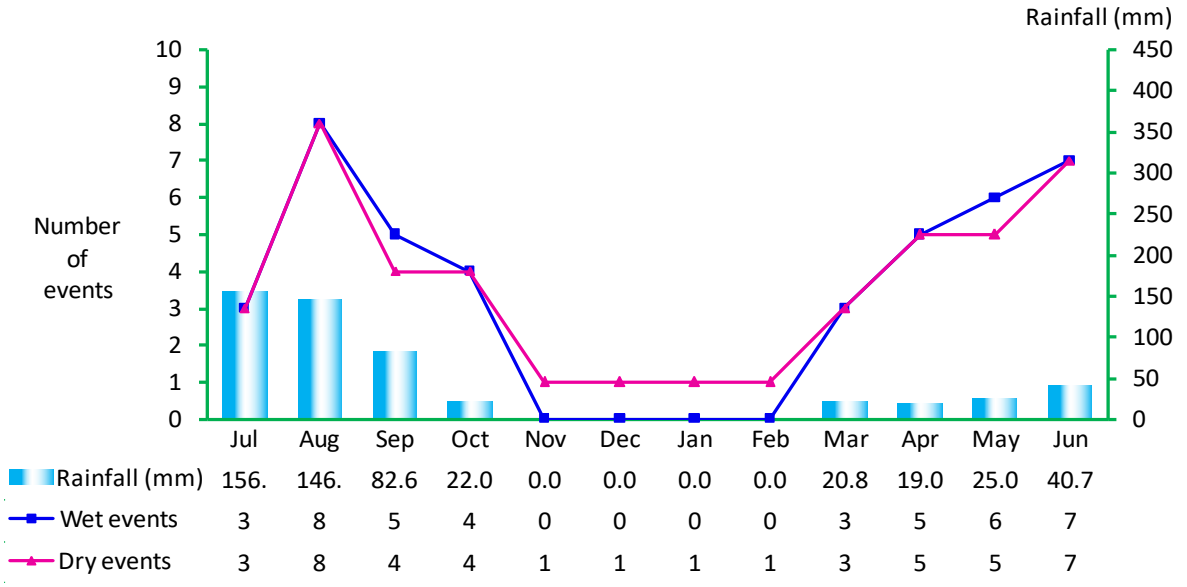


Figure 9-14: Monthly wet and dry events at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

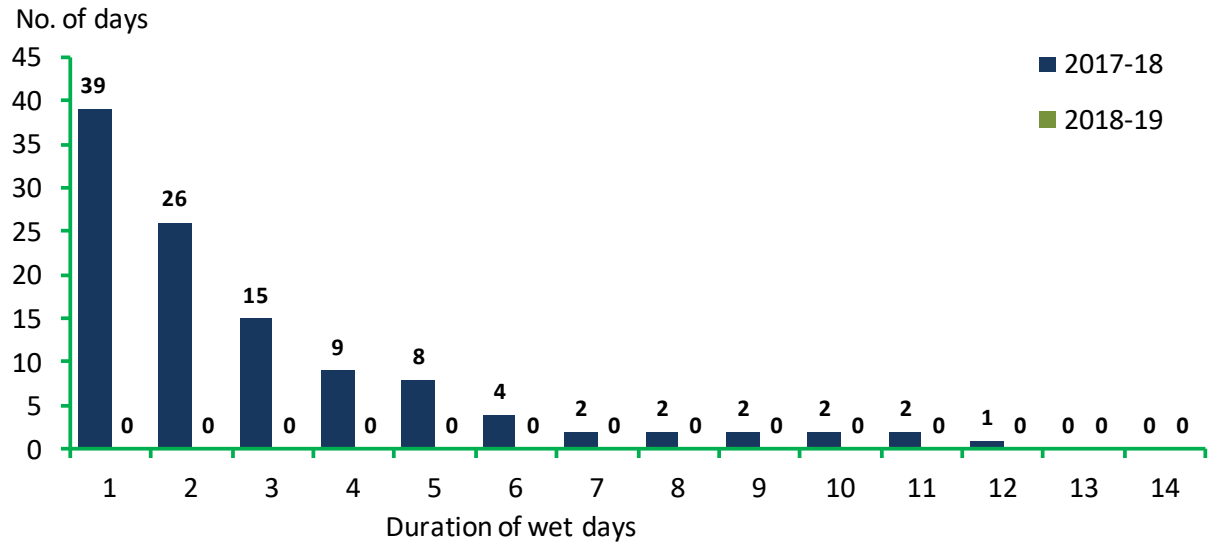


Figure 9-15: Pattern of rainfall events at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

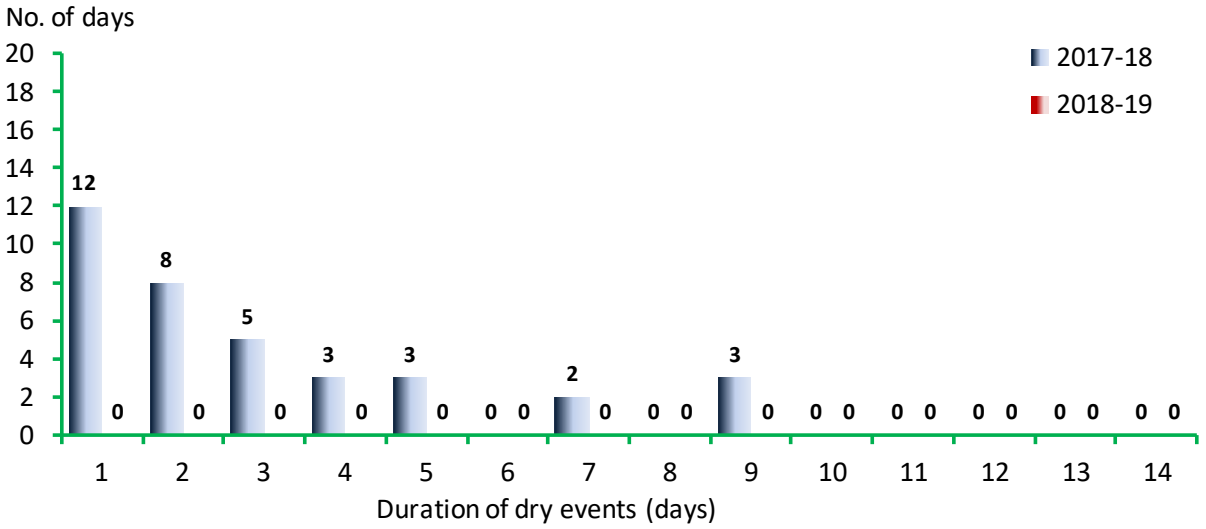


Figure 9-16: Pattern of dry events at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

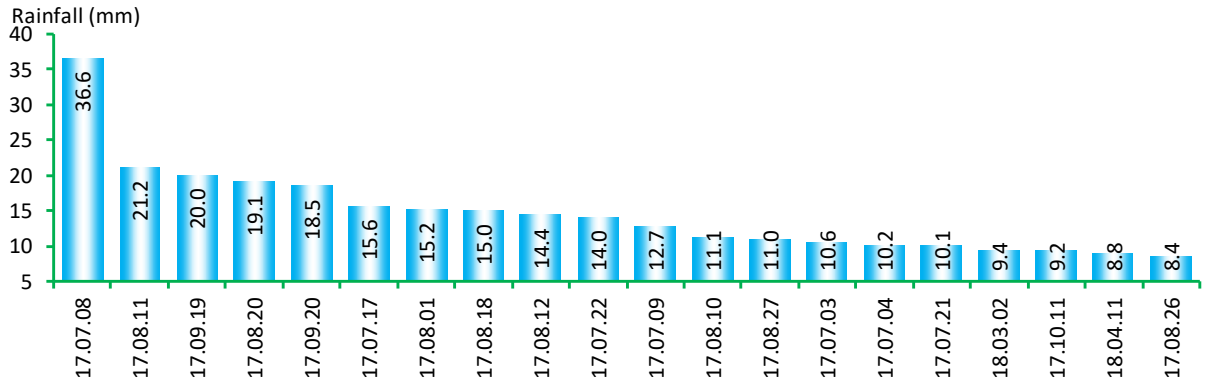


Figure 9-17: Twenty highest rainfall days at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

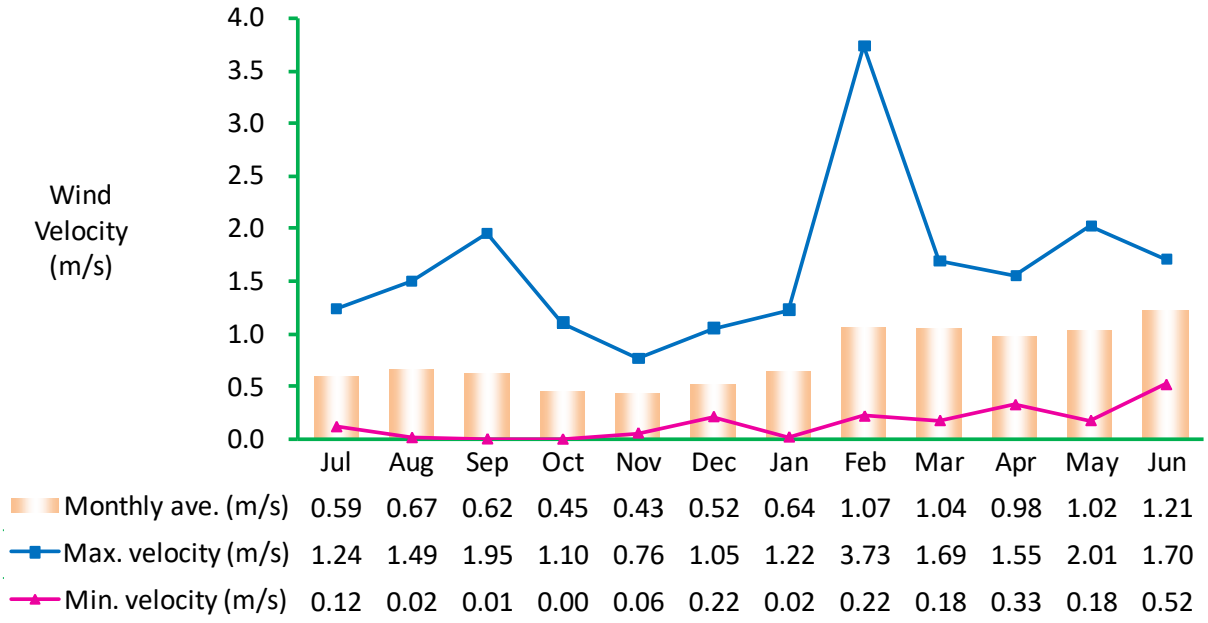


Figure 9-18: Wind speed at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

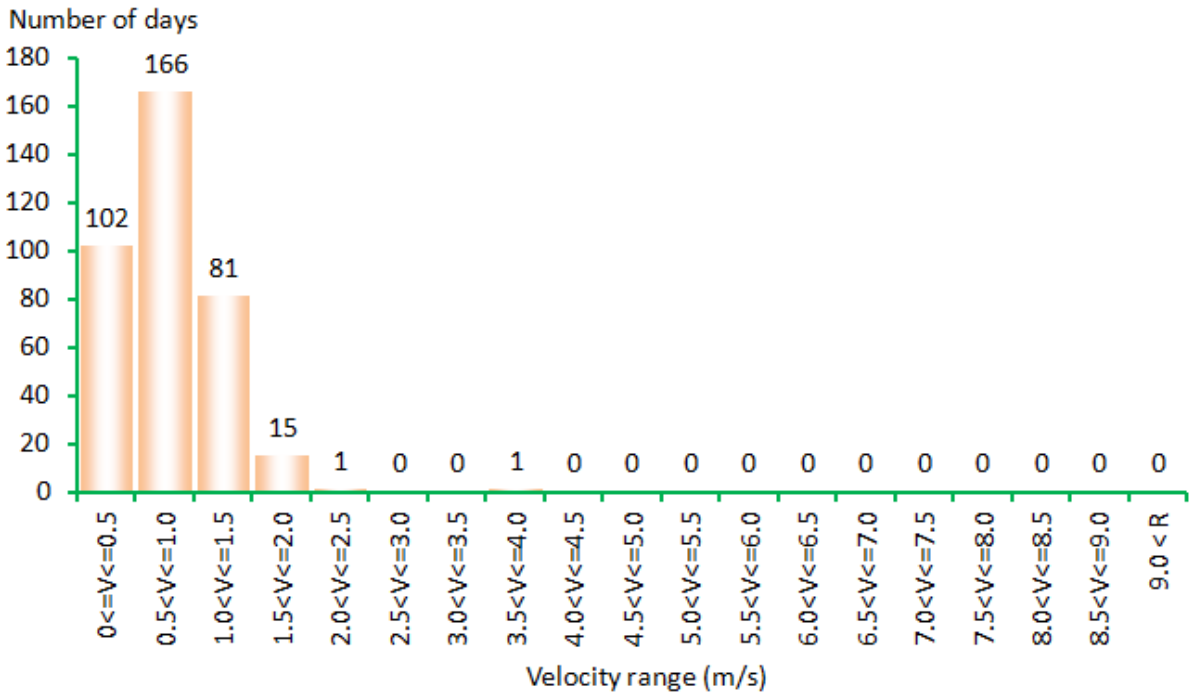


Figure 9-19: Wind speed pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

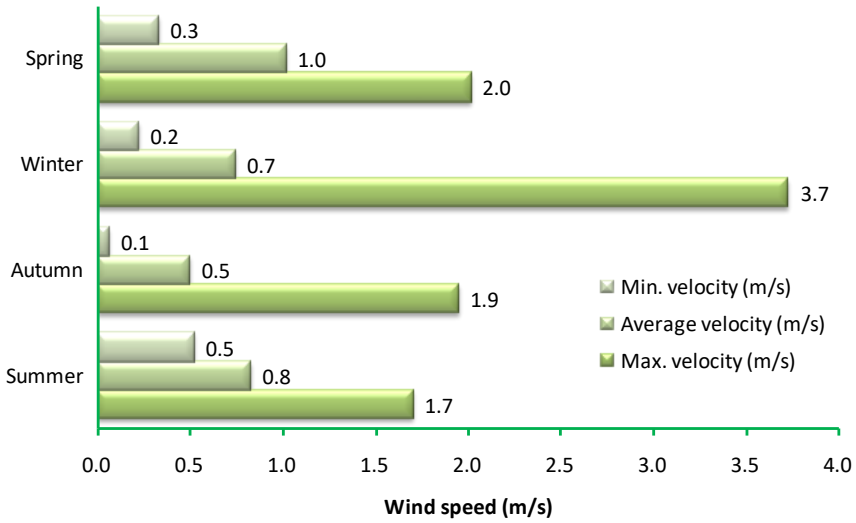


Figure 9-20: Seasonal wind speed pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

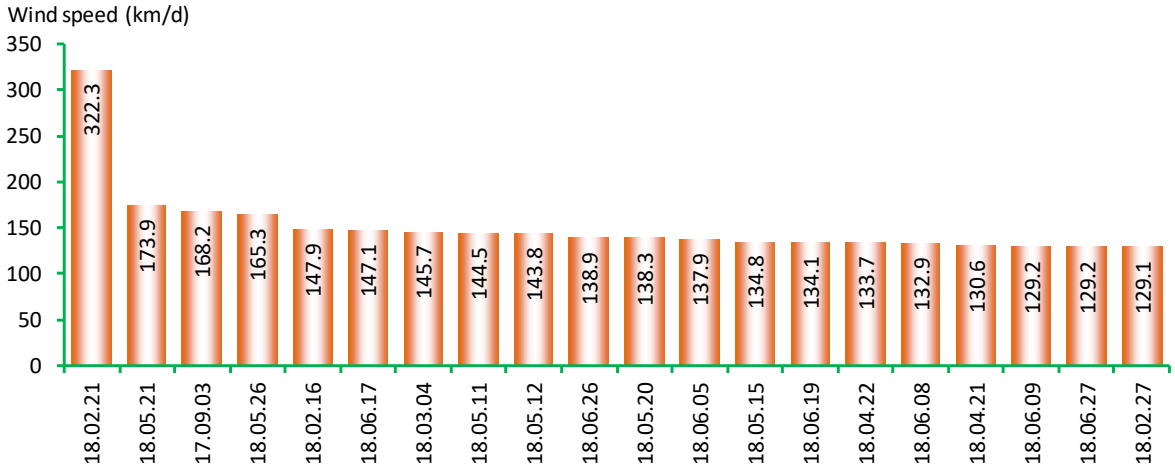


Figure 9-21: Twenty highest wind speed days at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

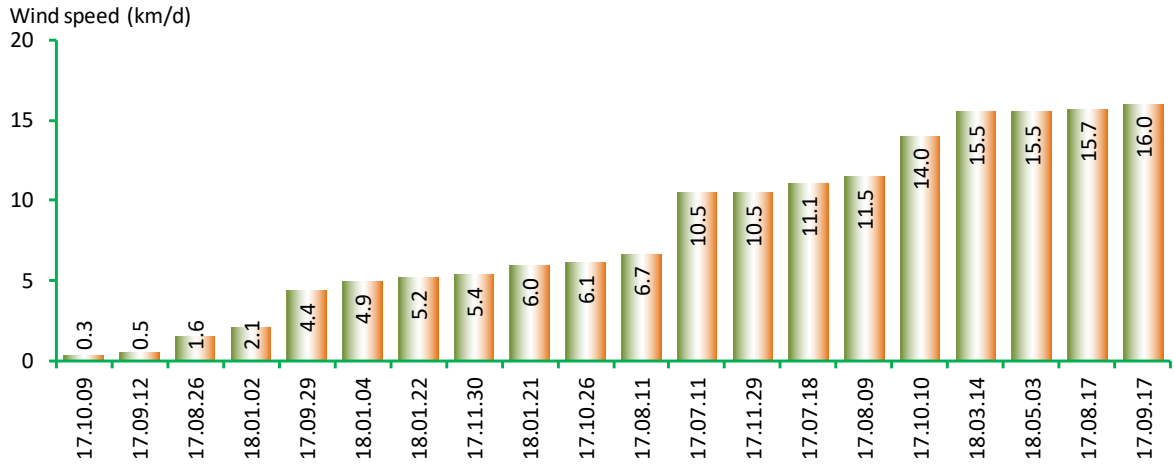


Figure 9-22: Twenty lowest wind speed days at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

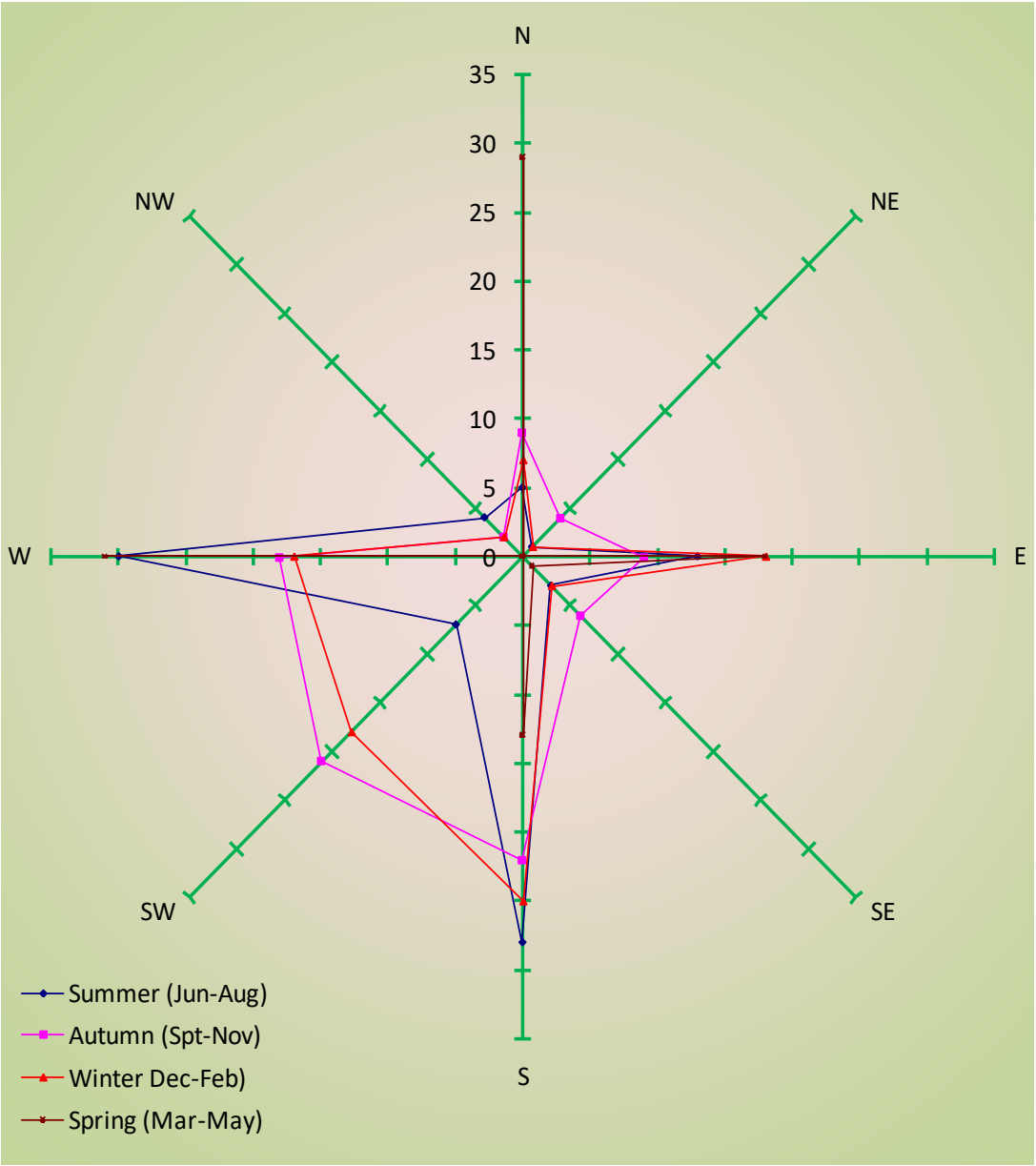


Figure 9-23: Seasonal wind direction pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

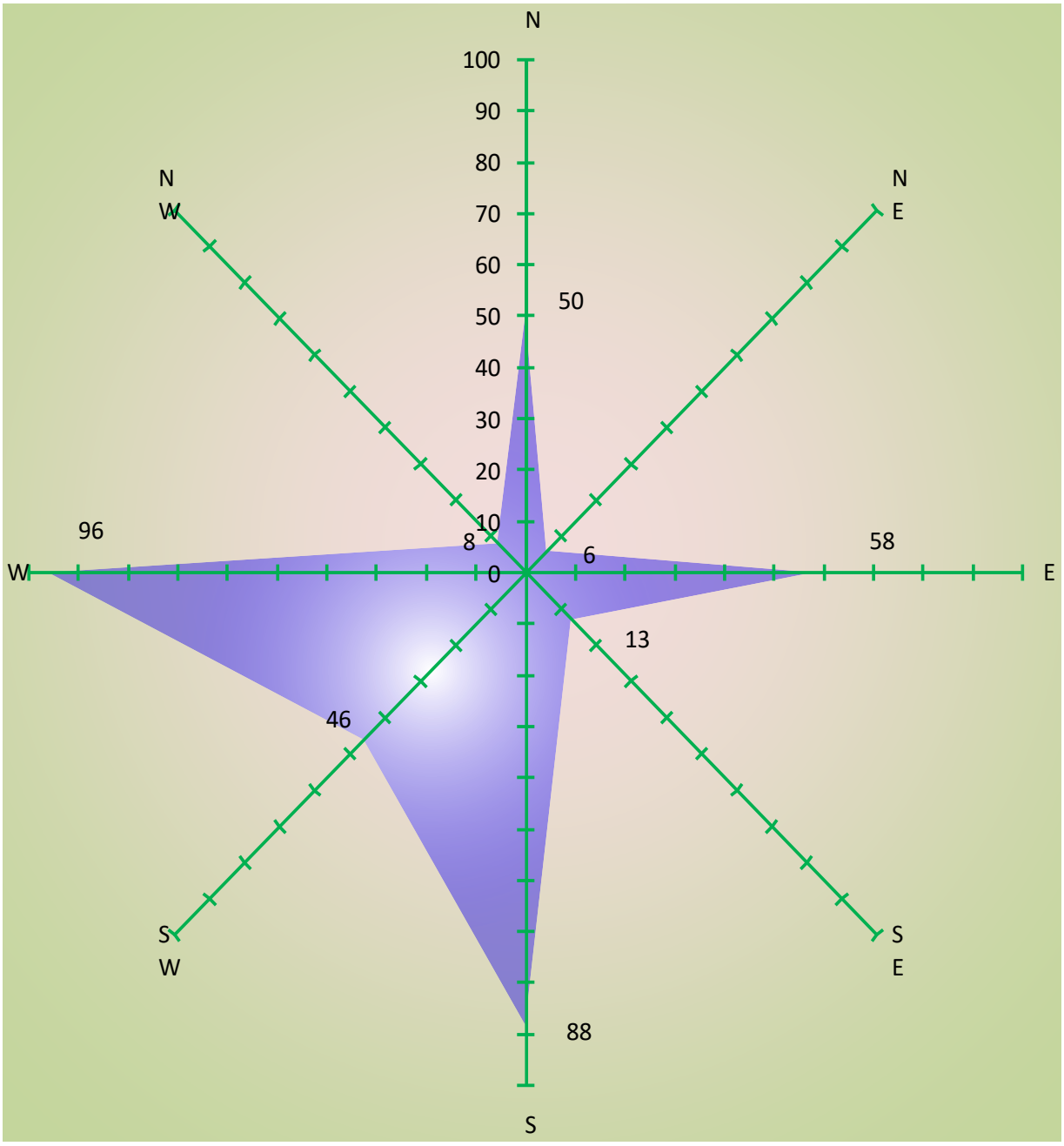


Figure 9-24: Annual wind direction pattern at ARDC Bajo (July 2017-June 2018).

Source: Bajo Meteorology Station

10 ANNEXURE

Annex 1: Information on plant qualitative characters of accessions (1-46)

Accessions	Plant characters					Accessions	Plant characters				
	Leaf pubsc	Leaf sheath colour	Flag leaf attitude	Ligule type	Ligule colour		Leaf pubsc.	Leaf sheath colour	Flag leaf attitude	Ligule type	Ligule colour
BTNC1011	glab	green	semi erect	2 cleft	whitish	**BTNC1104**	glab	green	semi erect	2 cleft	green
BTNC1020	glab	green	semi erect	2 cleft	whitish	**BTNC1302**	glab	green	semi erect	2 cleft	whitish
BTNC1021	glab	green	semi erect	2 cleft	whitish	**BTNC1303**	glab	green	semi erect	2 cleft	green
BTNC1022	glab	green	erect	2 cleft	whitish	**BTNC1375**	glab	green	erect	2 cleft	whitish
BTNC1024	glab	green	erect	2 cleft	whitish	**BTNC1376**	glab	green	semi erect	2 cleft	green
BTNC1025	glab	green	semi erect	2 cleft	greenish	**BTNC1439**	pubscent	redish	semi erect	2 cleft	green
BTNC1026	glab	green	semi erect	2 cleft	greenish	**BTNC1441**	glab	green	semi erect	2 cleft	green
BTNC1027	glab	green	semi erect	2 cleft	whitish	**BTNC1442**	pubscent	redish	erect	2 cleft	green
BTNC1029	glab	green	semi erect	2 cleft	whitish	**BTNC1443**	glab	whitish	semi erect	2 cleft	whitish
BTNC1030	glab	green	erect	2 cleft	greenish	**BTNC1445**	glab	green	semi erect	2 cleft	whitish
BTNC1036	glab	green	semi erect	3 cleft	whitish	**BTNC1447**	pubscent	green	semi erect	2 cleft	whitish
BTNC1037	pubscent	green	semi erect	4 cleft	whitish	**BTNC1453**	punscent	redish	semi erect	2 cleft	whitish
BTNC1039	glab	green	semi erect	5 cleft	greenish	**BTNC1455**	pubscent	green	erect	2 cleft	green
BTNC1044	glab	green	semi erect	6 cleft	whitish	**BTNC1459**	glab	whitish	semi erect	2 cleft	whitish
BTNC1045	glab	redish	descending	2 cleft	whitish	**BTNC1480**	glab	green	semi erect	2 cleft	green
BTNC1047	pubscent	green	erect	3 cleft	whitish	**BTNC1481**	glab	green	semi erect	2 cleft	whitish
BTNC1091	glab	green	semi erect	4 cleft	whitish	**BTNC1490**	glab	green	erect	2 cleft	whitish
BTNC1093	glab	redish	erect	2 cleft	whitish	**BTNC1506**	pubscent	green	semi erect	2 cleft	whitish
BTNC1098	glab	green	descending	3 cleft	greenish	**BTNC1522**	glab	green	erect	2 cleft	whitish
BTNC1103	pubscent	green	horizontal	4 cleft	whitish	**BTNC2302**	glab	green	horizontal	2 cleft	whitish

Annex 2: Information on plant qualitative characters of accessions (47-128)

Accessions	Plant characters					Accessions	Plant characters				
	Leaf pubsc	Leaf sheath colour	Flag leaf attitude	ligule type	ligule colour		Leaf pubsc.	Leaf sheath colour	Flag leaf attitude	ligule type	ligule colour
BTNC2303	glab	green	Descending	2 cleft	whitish	**BTNC985**	glab	green	S.errect	2 cleft	Whitish
BTNC2304	glab	green	errect	2 cleft	whitish	**BTNC997**	glab	green	errect	2 cleft	Whitish
BTNC2305	glab	Green	descending	2 cleft	whitish	**BTNC932**	glab	green	horizontal	2 cleft	whitish
BTNC2306	glab	Green	semi errect	Acuminate	whitish	**BTNC933**	glab	redish	horizontal	2 cleft	Whitish
BTNC2308	glab	Green	semi errect	Acuminate	whitish	**BTNC861**	glab	green	errect	2 cleft	Whitish
BTNC2311	glab	Green	semi errect	Acuminate	whitish	**BTNC100**	glab	green	horizontal	2 cleft	Whitish
BTNC2312	glab	green	semi errect	2 cleft	whitish	**IRGC323**	glab	green	errect	1 cleft	Whitish
BTNC2314	glab	Green	errect	2 cleft	whitish	**IRGC64934**	glab	redish	errect	2 cleft	Whitish
BTNC2319	glab	Green	descending	Acuminate	whitish	**IRGC64920**	glab	green	horizontal	2 cleft	Whitish
BTNC2333	glab	Green	hori	2 cleft	greenish	**IRGC72528**	glab	green	errect	2 cleft	Whitish
BTNC2347	glab	Green	semi errect	Acuminate	whitish	**IRGC72529**	glab	green	horizontal	2 cleft	Whitish
BTNC2349	glab	Green	semi errect	2 cleft	whitish	**IRGC62196**	glab	green	S.errect	2 cleft	Greenish
BTNC2350	glab	Green	errect	2 cleft	whitish	**IRGC18087**	glab	green	errect	2 cleft	Whitish
BTNC2351	glab	Green	errect	2 cleft	whitish	**IRGC20786**	glab	green	errect	1 cleft	Whitish
BTNC2352	glab	Green	semi errect	2 cleft	greenish	**IRGC67860**	pubscent	green	errect	2 cleft	Pure whitish
BTNC2353	glab	Green	hori	Acuminate	whitish	**IRGC86904**	glab	green	horizontal	2 cleft	Greenish
BTNC2354	glab	Green	errect	2 cleft	whitish	**IRGC86905**	pubscent	green	S.errect	2 cleft	Whitish
BTNC2355	glab	Redish	semi errect	2 cleft	whitish	**IRGC32406**	pubscent	redish	horizontal	2 cleft	Greenish
BTNC2356	pubscent	Green	hori	2 cleft	whitish	**IRGC111452**	glab	green	errect	2 cleft	Greenish
BTNC284	pubscent	Redish	hori	Acuminate	whitish	**11429**	glab	redish	descending	2 cleft	Whitish
BTNC327	glab	Green	semi errect	2 cleft	whitish	**2309**	glab	green	horizontal	2 cleft	Whitish
BTNC676	glab	Green	semi errect	2 cleft	greenish	**BTNC996**	glab	green	descending	2 cleft	Whitish
BTNC647	glab	Green	hori	2 cleft	whitish	**BTNC1444**	pubscent	green	S.errect	2 cleft	Whitish
BTNC929	glab	Green	errect		greenish	**IRGC86837**	glab	green	S.errect	2 cleft	Greenish
BTNC930	glab	Redish	semi errect	2 cleft	whitish	**IRGC111433**	glab	redish	S.errect	acuminate	Whitish
BTNC931	glab	Green	descending	Acuminate	whitish	**IRGC62179**	glab	green	errect	2 cleft	Whitish
BTNC938	glab	Green	hori	2 cleft	whitish	**IRGC67844**	pubscent	green	descending	3 cleft	whitish
BTNC985	glab	Green	errect	Acuminate	brownish white	**64917**	glab	green	horizontal	4 cleft	Whitish

Annex 3: Basic agronomic traits of the accessions (1-48)

Accessions	Plant height (cm)	Plant length (cm)	Grains per panicle	DTM	Estimated yield (kg/ac)	Accessions	Plant height (cm)	Plant length (cm)	Grains per panicle	DTM	Estimated yield (kg/ac)
BTNC1011	160	25.7	190-200	170-175	1115	**BTNC1104**	140	26	150-160	180-185	1089
BTNC1020	164	25	180-190	170-175	1120	**BTNC1302**	173	26	160-170	175-180	1006
BTNC1021	175	26	180-190	170-175	1135	**BTNC1303**	161	25.4	160-170	175-180	1115
BTNC1022	157	24.4	180-190	170-175	1098	**BTNC1375**	187	25	130-140	190-195	849
BTNC1024	146	25.4		165-170		**BTNC1376**	190	29	190-200	190-195	916
BTNC1025	180	25	160-170	165-170	978	**BTNC1439**	147	23.5	210-220	190-105	1243
BTNC1026	174	25.5	160-170	160-165	1112	**BTNC1441**	188	29.5	190-200	180-185	966
BTNC1027	182	25	170-180	160-175	1170	**BTNC1442**	180	24.3	180-190	180-185	1000
BTNC1029	171	27.8	170-180	160-165	1009	**BTNC1443**	96	25	160-170	175-180	898
BTNC1030	155	26.2	200-210	175-180	1150	**BTNC1445**	144	23.5	170-180	185-190	905
BTNC1036	153	22.5	190-200	175-180	1099	**BTNC1447**	192	30.5	220-230	175-180	990
BTNC1037	151	22.9	200-210	175-180	1200	**BTNC1453**	150	22.5	210-220	165-170	1085
BTNC1039	148		190-200	180-190	930	**BTNC1455**	172	24.5	190-200	195-200	1052
BTNC1044	144	25.5	120-130	175-180	1009	**BTNC1459**	165	25.5	180-190	195-200	1190
BTNC1045	168	24	150-160	180-190	997	**BTNC1480**	140	23	240-250	180-185	1236
BTNC1047	183	26	170-180	170-175	1094	**BTNC1481**	101	22	140-150	180-185	1000
BTNC1091	138	25	170-180	175-180	1154	**BTNC1490**	153	22.5	190-200	190-195	1200
BTNC1093	136	28	180-190	175-180	1090	**BTNC1506**	138	25.5	120-130	180-185	1000
BTNC1098	195	23	140-150	175-180	898	**BTNC1522**	162	27.5	180-190	170-175	1236
BTNC1103	200	27	140-150	180-185	815	**BTNC2302**	174	27	140-150	175-180	900

Annex 4: Basic agronomic traits of accessions (50-128)

Accessions	Plant height (cm)	Plant length (cm)	Grains per panicle	DTM	Estimated yield(kg/ac)	Accessions	Plant height (cm)	Plant length (cm)	Grains per panicle	DTM	Estimated yield (kg/ac)
BTNC2306	170	26.5	160-170	170-175	1221	**BTNC100**	130	27	130-140	185-190	875
BTNC2308	146	25	180-190	170-175	984	**1435**	186	25.5	190-200	170-175	1025
BTNC2311	141	25.5	140-150	170-175	960	**IRGC61181**	160	26	150-160	170-175	1122
BTNC2312	157	26.5	250-160	175-180	1301	**IRGC62183**	173	27.5	140-150	170-175	1084
BTNC2314	148	23	180-190	175-180	1304	**IRGC32387**	125	21	130-140	190-195	800
BTNC2319	119	23	140-150	195-200	890	**IRGC64934**	147	27	160-170	175-180	850
BTNC2333	181	27.5	150-160	165-170	854	**IRGC64920**	191	28.6	170-180	180-185	850
BTNC2347	180	24.5	170-180	170-175	976	**IRGC72528**	181	27.5	170-180	180-185	850
BTNC2349	146		170-180	175-180	990	**IRGC72529**	140	23.5	230-240	185-190	1220
BTNC2350	177	25	120-130	190-195	800	**IRGC62196**	146	23	130-140	180-185	898
BTNC2351	196	25	130-140	195-200	798	IRGC648980	165	30	200-210	190-195	1012
BTNC2352	184	30	190-200	200-205	1201	**IRGC67860**	146	25	200-21-	190-195	1229
BTNC2353	170	24	140-150	165-170	979	**IRGC86904**	182	27	210-220	190-195	1211
BTNC2354	168	25.5	150-160	190-195	983	**IRGC86905**	172	27	200-210	180-185	1214
BTNC2355	170	27	180-190	170-175	998	**IRGC32406**	196	26	170-180	195-200	910
BTNC2356	164	22	130-140	195-200	928	**IRGC111452**	190	25	170-180	195-200	1010
BTNC284	165	27.5	150-160	190-95	985	**111424**	191	24.5	150-160	175-180	869
BTNC327	175	27.5	160-170	165-170	900	**2309**	183	24	150-160	175-180	900
BTNC676	170	25.5	210-220	185-190	1190	**BTNC996**	180	25	140-150	180-185	950
BTNC647	124	23.5	180-190	195-200	1096	**BTNC1444**	156	24.6	170-180	190-195	1197
BTNC929	189	26	180-190	190-195	900	**IRGC86837**	187	26	170-180	170-175	1050
BTNC930	191	29.5	150-160	190-195	902	**IRGC62162**	185	26.5	160-170	175-180	1071
BTNC931	177	27	160-170	190-195	888	**IRGC62179**	163	25.5	160-170	175-180	1100
BTNC938	175	26	230-240	195-200	1053	**IRGC67844**	180	23	200-210	195-200	1197
BTNC985	165	25	220-230	195-200	1141	**64917**	177	13.5	200-210	195-200	1176

Annex 5: Analysis of grains for shape, size and colour

Accessions	Paddy grains (mm)			Hull colour (codes)	Dehulled grains (mm)			Kernel colour	Grain categorization	
	Length	Width	L/W ratio		Length	Width	L/W ratio		Shape	Size
BTNC1011	9.61	2.90	3.31	0	6.97	2.18	3.20	white	slender	long grain
BTNC1020	8.60	3.25	2.65	10	6.28	2.91	2.16	white	medium	medium
BTNC1021	7.81	3.38	2.31	0	5.61	3.01	1.86	red	bold	medium
BTNC1022	8.47	2.59	3.27	0	6.53	2.49	2.62	white	medium	medium
BTNC1024	8.76	3.03	2.89	0	6.04	2.70	2.24	white	medium	medium
BTNC1025	7.51	3.55	2.12	10	3.37	3.03	1.11	red	bold	short grain
BTNC1033	7.85	3.33	2.36	0	6.38	2.80	2.28	white	medium	medium
BTNC1036	7.74	2.96	2.61	0	5.68	2.67	2.13	white	medium	medium
BTNC1037	8.62	3.27	2.64	0	6.30	2.64	2.39	white	medium	medium
BTNC1042	8.37	3.17	2.64	10	5.72	2.65	2.16	red	medium	medium
BTNC1044	9.75	2.80	3.48	10	6.99	2.26	3.09	white	slender	long grain
BTNC1045	9.29	3.70	2.51	7	5.96	3.17	1.88	red	bold	medium
BTNC1079	8.70	3.05	2.85	0	6.27	2.30	2.73	red	medium	medium
BTNC1086	8.70	3.36	2.59	0	6.57	2.94	2.23	white	medium	medium
BTNC1089	9.67	2.63	3.68	0	6.97	2.34	2.98	white	medium	long grain
BTNC1093	7.92	3.29	2.41	3	5.85	2.86	2.05	white	medium	medium
BTNC1103	8.20	3.34	2.46	0	5.48	2.55	2.15	white	medium	short grain
BTNC1302	6.51	3.10	2.10	0	4.25	2.91	1.46	white	bold	short grain
BTNC1376	7.86	3.60	2.18	10	6.03	3.07	1.96	red	bold	medium
BTNC1439	8.06	2.91	2.77	7	5.73	2.30	2.49	white	medium	medium
BTNC1441	7.86	3.06	2.57	10	5.63	2.65	2.12	white	medium	medium
BTNC1442	7.98	2.48	3.22	7	5.77	2.17	2.66	white	medium	medium
BTNC1445	9.93	2.78	3.57	0	7.49	2.51	2.98	white	medium	long grain
BTNC1447	8.56	3.41	2.51	1	6.02	2.89	2.08	white	medium	medium
BTNC1453	7.41	2.80	2.65	7	6.23	2.41	2.59	white	medium	medium
BTNC1455	7.96	3.12	2.55	10	5.45	2.66	2.05	white	medium	short grain
BTNC1459	8.73	3.04	2.87	0	6.07	2.78	2.18	white	medium	medium
BTNC1480	9.07	3.15	2.88	0	6.47	2.69	2.41	white	medium	medium
BTNC1481	7.81	3.05	2.56	0	5.19	2.74	1.89	white	bold	short grain
BTNC1490	8.83	2.96	2.98	0	6.36	2.54	2.50	red	medium	medium
BTNC1506	7.81	3.18	2.46	10	5.41	2.71	2.00	white	bold	short grain
BTNC1522	9.05	2.22	4.08	0	7.09	1.91	3.71	white	slender	long grain
BTNC2302	8.04	3.33	2.41	0	6.11	2.92	2.09	red	medium	medium
BTNC2304	7.73	2.99	2.59	10	5.95	2.87	2.07	red	medium	medium
BTNC2305	7.48	3.13	2.39	7	5.67	2.90	1.96	red	bold	medium
BTNC2306	7.83	3.49	2.24	10	6.04	2.77	2.18	red	medium	medium
BTNC2308	7.96	3.34	2.38	10	6.00	2.79	2.15	red	medium	medium
BTNC2312	8.08	2.85	2.84	0	6.04	2.63	2.30	white	medium	medium
BTNC2314	8.01	3.00	2.67	7	6.35	2.66	2.39	white	medium	medium
BTNC2333	6.68	2.92	2.29	1	4.33	2.50	1.73	white	bold	short grain
BTNC2347	7.96	3.00	2.65	7	6.32	2.45	2.58	white	medium	medium

Accessions	Paddy grains (mm)			Hull colour (codes)	Dehulled grains (mm)			Kernel colour	Grain categorization	
	Length	Width	L/W ratio		Length	Width	L/W ratio		Shape	Size
BTNC2349	5.15	2.72	1.89	5	4.35	2.41	1.80	white	bold	short grain
BTNC2350	8.15	2.73	2.99	4	6.41	2.47	2.60	white	medium	medium
BTNC2352	7.82	3.43	2.28	0	5.69	2.91	1.96	red	bold	medium
BTNC2353	7.56	3.15	2.40	3	5.68	2.82	2.01	white	medium	medium
BTNC2354	8.89	2.71	3.28	0	7.00	2.00	3.50	white	slender	long grain
BTNC2355	7.75	2.92	2.65	7	6.16	2.36	2.61	white	medium	medium
BTNC2356	8.51	2.80	3.04	0	5.57	2.36	2.36	white	medium	medium
BTNC747	7.25	3.20	2.27	0	5.31	2.94	1.81	red	bold	short grain
BTNC929	8.45	2.97	2.85	0	6.00	2.44	2.46	red	medium	medium
BTNC930	8.12	3.26	2.49	10	6.13	2.83	2.17	red	medium	medium
BTNC938	9.00	3.27	2.75	0	6.52	2.78	2.35	white	medium	medium
BTNC985	7.09	3.50	2.03	0	5.17	2.98	1.73	white	bold	short grain
BTNC990	5.99	3.00	2.00	0	3.78	2.67	1.42	white	bold	short grain
BTNC997	7.27	3.08	2.36	0	5.23	2.79	1.87	white	bold	short grain
BTNC932	9.88	2.68	3.69	0	7.04	2.17	3.24	white	slender	long grain
BTNC933	8.80	3.25	2.71	0	6.50	2.74	2.37	white	medium	medium
BTNC100	8.07	2.89	2.79	0	6.98	2.12	3.29	white	slender	long grain
1435.00	7.73	3.30	2.34	7	5.56	2.83	1.96	red	bold	medium
IRGC62181	8.39	2.87	2.92	0	6.21	2.31	2.69	white	medium	medium
IRGC62183	7.84	3.17	2.47	0	5.90	2.79	2.11	red	medium	medium
IRGC32387	7.52	3.07	2.45	10	5.42	2.90	1.87	red	bold	short grain
IRGC64934	8.35	3.29	2.54	0	6.21	2.62	2.37	white	medium	medium
IRGC64920	6.74	3.19	2.11	9	4.63	2.94	1.57	red	bold	short grain
IRGC72528	8.33	2.94	2.83	0	6.14	2.48	2.48	white	medium	medium
IRGC72529	7.53	2.98	2.53	10	5.41	2.72	1.99	white	bold	short grain
IRGC62103	7.52	9.19	0.82	0	5.51	2.70	2.04	red	medium	medium
IRGC64890	7.79	2.91	2.68	0	5.97	2.72	2.19	red	medium	medium
IRGC207862	8.65	3.25	2.66	0	6.75	2.81	2.40	white	medium	long grain
IRGC86827	8.24	3.27	2.52	0	5.95	2.76	2.16	white	medium	medium
IRGC67860	8.17	2.66	3.07	0	6.14	3.07	2.00	white	bold	medium
IRGC86890	7.13	3.04	2.35	0	5.30	2.66	1.99	white	bold	short grain
IRGC86904	9.32	2.77	3.36	0	6.52	2.43	2.68	white	medium	medium
IRGC86905	9.73	2.73	3.56	0	7.18	2.40	2.99	white	medium	long grain
IRGC11452	8.37	2.98	2.81	0	5.93	2.55	2.33	white	medium	medium
BTNC1444	7.52	3.26	2.31	10	5.84	2.65	2.20	white	medium	medium
IRGC86837	6.96	3.27	2.13	0	5.18	2.82	1.84	white	bold	short grain
IRGC62179	7.72	3.07	2.51	3	5.64	2.68	2.10	white	medium	medium
IRGC67844	8.08	2.95	2.74	0	6.03	2.80	2.15	red	medium	medium
64917.00	8.01	2.79	2.87	0	5.41	2.62	2.06	white	medium	short grain

Annex 6: Local fruit trees top-worked in Punakha Dzongkhag 2017-18

SN	Name	Dzonkhag	Geog	Peach	Pear	Persimmon	Plum	Apricot	Walnut	Kiwi
1	Kinley	Punakha	Shangana	4	14	15				
2	Pemba	Punakha	Kabjisa	2	1	1		1		
3	Pem	Punakha	Kabjisa			3				
4	Kencho	Punakha	Kabjisa		1	2			1	
5	Karma Thukten	Punakha	Kabjisa	1		2				
6	Tandin	Punakha	Kabjisa		1				2	
7	Kinley Zam	Punakha	Kabjisa	3		1		1	2	
8	Kinley Dem	Punakha	Kabjisa	1	1			1		
9	Kinley Dorji	Punakha	Kabjisa			1			1	
10	Chnaglo	Punakha	Kabjisa	1		3				
11	Kinley Wangchuk	Punakha	Kabjisa			1			1	
12	Yangden	Punakha	Kabjisa	2		1			1	
13	Dechen Pelden	Punakha	Kabjisa	3	3	-				
14	Kinley Om	Punakha	Kabjisa	5		4			5	
			Total	**22**	**21**	**34**		**3**	**13**	
1	Bongkho	Punakha	Guma	2	7	1	1	1	9	
2	Naku	Punakha	Guma	5						
3	Dorji Om	Punakha	Guma	5	1	1				
4	Lhaki	Punakha	Guma	1			1		3	
5	Namgay	Punakha	Guma	1	3					
6	Om	Punakha	Guma	3	1	2		2	3	
7	Sangay Om	Punakha	Guma	4	1	2			4	
8	Yeshey Tshering	Punakha	Guma	4	4	13			16	
			Total	**25**	**17**	**19**	**2**	**3**	**35**	
1	Lhap Dorji	Punakha	Toedwang		1	2	2		2	
2	Ugyen Pem	Punakha	Toedwang	5	5	4	4	3	5	
			Total	**5**	**6**	**6**	**6**	**3**	**7**	
1	Am Sangay	Punakha	Toepisa	2		3		2		
2	Youzer	Punakha	Toepisa	3	1	1	5			
3	Tshagay	Punakha	Tiepisa	5	1	1	4		10	10
			Total	**10**	**2**	**5**	**9**	**2**	**10**	**10**
1	Dechen	Punakha	Talo		2					
2	Denka	Punakha	Talo		1				5	
3	Karma Dema	Punakha	Talo	1	1					
4	Wangmoli	Punakha	Talo		2					
5	Wanngchu	Punakha	Talo	1	8					
6	Dawa	Punakha	Talo		5					
7	Jigme Lham	Punakha	Talo	6	6		1		1	
8	Namgay Tshering	Punakha	Talo	2	1					
9	Kinzang Pem	Punakha	Talo	1	5					
10	Kencho Tenzin	Punakha	Talo		4					
11	Daw Dem	Punakha	Talo	1	4					
12	Ugyen Dema	Punakha	Talo	2	1					
13	Kinley Om	Punakha	Talo	3	6					
14	Pema	Punakha	Talo		1					
15	Zangmo	Punakha	Talo	3	2					
16	Lham	Punakha	Talo	2	1					
17	Yangkam	Punakha	Talo	2	3					
18	Pema Khandu	Punakha	Talo	1	1					
19	Kinzang	Punakha	Talo		5					
20	Kinley	Punakha	Talo		3					
21	Tashi Tshering	Punakha	Talo	1	2					
22	Tshering Dendup	Punakha	Talo						9	
23	Thukten Sonam	Punakha	Talo	2	5	6	1		2	
		Total		**28**	**69**	**6**			**17**	
1	Tshering	Punakha	Barp	1			2		3	
2	Kiley	Punakha	Barp	3		2				
		Total		**4**		**2**	**2**		**3**	

Annex 7: Profile of Engineering Activities

SN	*Name of work*	*Agency*	*ST*	*AT*	*LE*	*SB*	*Implemented by*	*Estimated*	*Quoted*	*Status*
1	Construction: Waste Water Harvesting System	ARDC-Bajo	IES	AA	TG1	NW	ARDC Bajo	344,951	344,951	OG
2	Installation: 2nd Stage Pumping-submersible	ARDC-Bajo	IES	AA	IBR		ARDC Bajo	30,655	30,655	C
3	Maintenance: Pumps & Motors	ARDC-Bajo	IES	RA	IBR		ARDC Bajo	15,000	15,000	C
4	Reinstallation: First Stage Pumping System	ARDC-Bajo	IES	AA	IBR		ARDC Bajo	792,000	792,000	C
5	Construction: Cowshed	ARDC-Bajo	GES	AA	NW		D	269,067	-	D
6	Construction: ESP Quarter- One block-double units	ARDC-Bajo	GES	PA	TG2	IBR	MsSaamphelDhuendup C.	1,120,158	887,299	C
7	Construction: Garage-cum-Workshop	ARDC-Bajo	GES	PA	TG2		NIY	355,000	-	NIY
8	Construction: Strom drainage-250m	ARDC-Bajo	GES	AA	TG2		NIY	350,000	-	NIY
9	Construction: Boundary chain-link fencing-Part-01_50m	ARDC-Bajo	GES	AA	TG2		NIY	350,000	-	NIY
10	Construction: Boundary chain-link fencing-Part-02_30m	ARDC-Bajo	GES	AA	TG2		NIY	325,000	-	NIY
11	Construction: Boundary chain-link fencing-Part-03_250m	ARDC-Bajo	GES	AA	TG2		NIY	1,200,000	-	NIY
12	Construction: Farm road basecourse-1400m	ARDC-Bajo	GES	AA	TG2		NIY	1,500,000	-	NIY
13	Construction: Farm toilet	ARDC-Bajo	GES	AA	TG2		NIY	760,000	-	NIY
14	Construction: Parking basecourse	ARDC-Bajo	GES	AA	TG2		NIY	785,000	-	NIY
15	Construction: National Seed Lab Extension	ARDC-Bajo	GES	AA	TG2		NIY	1,300,000	-	NIY
16	Construction: ESP Quarter (4blocks)	ARDC-Bajo	GES	AA	TG2		NIY	4,000,000	-	NIY
17	Maintenance: Electrical System	ARDC-Bajo	GES	RA	IBR		ARDC Bajo	40,000	40,000	C
18	Maintenance: Plumbing System	ARDC-Bajo	GES	RA	IBR		ARDC Bajo	10,000	10,000	C
19	Maintenance: Staff Quarter Sewerage System+drink water	ARDC-Bajo	GES	AA	TG2		ARDC Bajo	47,000	47,000	C
20	Maintenance: Electrical System	ARDSC-Tsirang	GES	RA	IBR		ARDC Bajo	47,000	50,000	C
21	Construction: Dreychu IS- 7.20km	DA-Dagana	IES	PA	PC		Ms PST Const. Pvt., Ltd	29,498,993	28,999,998	OG
22	Renovation: Phenday IS- 22.48km	DA-Punakha	IES	PA	PC		MsShambala Infra Pvt., Ltd	33,974,000	23,879,083	OG
23	Construction: Compost Pit at Sonagasa Royal Orchard	DA-Punakha	GES	AA	NW		NIY	192, 947.74	-	NIY
24	Construction: Jhatey IS- 7.20km	DA-Tsirang	IES	PA	PC		MsGhongphelNimaC.P.Ltd	31,317,000	29,806,215	OG
25	Feasibility Study: Construction of Baychu IS- Re.estimation	DA-Wangdue	IES	AA	TG1	DAW	NIY	184,697,000	-	NIY
26	Feasibility Study: Construction of Gaselo IS	DA-Wangdue	IES	AA	TG1	DAW	NIY	159,004,000	-	NIY
27	Feasibility Study: Construction of Ruebisa IS	DA-Wangdue	IES	AA	TG1	DAW	NIY	168,875,000	-	NIY
28	Feasibility Study: Phangyul pumping	DA-Wangdue	IES	AA	TG1	DAW	NIY	64,046,565	-	NIY
29	Maintenance: Baychu IS- 14.50km	DA-Wangdue	IES	RA	TG1		DAW	3,699,044	1,891,934	C
30	Renovation: Baychu IS- 14.50km	DA-Wangdue	IES	PA	TG1		MsWangthang Const., Ltd.	18,356,000	17,699,000	C
31	Survey: Construction of Sibjana-Lhachu Link Channel 7km	DA-Wangdue	IES	AA	NW		D	-	-	C

SN	*Name of work*	*Agency*	*ST*	*AT*	*LE*	*SB*	*Implemented by*	*Estimated*	*Quoted*	*Status*
32	Construction: Compost Pit at Kamichu Royal Orchard	DA-Wangdue	GES	AA	NW		DAW	192, 947.74	-	C
33	Construction: Approach Gate	DFO-Dagapela	GES	AA	PC		NIY	3,725,362	-	NIY
34	Construction: Boundary Fencing	-do-	GES	AA	PC		NIY	1,033,215	-	NIY
35	Construction: Compound Lighting	-do-	GES	AA	PC		NIY	665,500	-	NIY
36	Construction: Entrance Gate	-do-	GES	AA	PC		NIY	51,790	-	NIY
37	Construction: External Water Supply	-do-	GES	AA	PC		NIY	2,546,983	-	NIY
38	Construction: Office Building-Civil	-do-	GES	AA	PC		NIY	14,178,094	-	NIY
39	Construction: Office Building-Electrical	-do-	GES	AA	PC		NIY	1,734,290	-	NIY
40	Construction: Staff Quarter- Civil	-do-	GES	AA	PC		NIY	13,792,161	-	NIY
41	Construction: Staff Quarter-Electrical	-do-	GES	AA	PC		NIY	907,853	-	NIY
42	Construction: Lift Irrigation	NSC-Bajo	IES	AA	TG1	IBR	MsNayab Construction	1,719,000	1,115,054	OG
43	Construction: Concertina fencing	NSC-Bajo	GES	AA	TG2		NIY	650,000	-	OG
44	Construction: Gates/Maintenance of Farm Infrastructures	NSC-Phobjikha	GES	AA	NW		MsOthbar Construction	214,670	172,831	C
45	Construction: Drain	RP-Chimipang	IES	PA	NW		Ms Aquarius Construction	3,990,542	2,636,826	C
46	Construction: Water Storage Tank	RP-Chimipang	IES	PA	PC		MsRinchenDorji Const.	925,487	679,488	C
47	Survey: Construction of Irrigation Pipeline Conveyance	RP-Chimipang	IES	AA	TG1	PC,IBR	DI-RPC	8,525,079	4,000,000	C
48	Survey: Construction of Lift Irrigation	RP-Chimipang	IES	AA	IBR		NIY	-	-	C
49	Construction: Chain-link fencing 1800m	RP-Chimipang	GES	AA	TG2		NIY	3,000,000	-	NIY
50	Construction: Compost pit	RP-Chimipang	GES	AA	NW		MsKurtoe Construction	2,100,000	248,926	C
51	Construction: ESP Quarter (3blocks) & compost pit	RP-Chimipang	GES	PA	NW	IBR	MsKurtoe Construction	3,794,962	2,911,501	C
52	Construction: Farm road basecourse& culverts	RP-Chimipang	GES	PA	PC		MsDhuesum Construction	3,449,662	1,940,504	OG
53	Construction: Gazebo- prepared drawings	RP-Chimipang	GES	AA	PC		D	-	-	D
54	Construction: Market Outlet House- prepared drawings	RP-Chimipang	GES	AA	PC		D	-	-	D
55	Construction: Rice Mill House	RP-Chimipang	GES	AA	NW	IBR	MsTandin Wang Const.	2,248,110	1,814,450	C
56	Maintenance: Granary Store House	RP-Chimipang	GES	AA	NW		D	-	-	D
Total								**776,361,192**	**120,012,715**	

Note: IES = Irrigation Engineering Services, GES = General Engineering Services, DFO = Divisional Forest Office, DA = Dzongkhag Administration,
ST = Engineering Service Type, AT = Activity Type, RA = Routine Activity, PA = Planned Activity, AA = Adhoc Activity, NIY = Not implemented Yet, OG = On-going, C = Completed, D = Dropped
LE = Lead Engineer, SE = Supported Engineer, TG1 = Thinley Gyamtsho, TG2 = Thinley Gyeltshen, PC = PuranChhetri, NW = NimaWangchuk, IBR = IndraBdr. Raika

Annex 8: Summary of BUP of ARDC, Bajo for Fiscal Year 2017-2018

SN	Financial Insituation Code	Approved (M)	Expenditur (M)	Balance (M)	Utilized (%)	Underutilized (%)
1	0001 RGOB	54.085	53.050	1.035	98.1	1.9
2	3057 GOI	3.910	2.225	1.685	56.9	43.1
3	4519 TCP	3.730	2.132	1.598	57.2	42.8
4	4584 FSSAP	4.949	3.324	1.625	67.2	32.8
Total approved		**66.674**	**60.730**	**5.944**	**91.08**	**8.92**

Annex 9: Research and support staff

SN	Name	Qualification	Position Title
1	Pema Chofil	MSc. Community & Health	Program Director
Field Crops Sector			
2	Mahesh Ghimiray	MPhil. Plant Breeding	Rice Specialist II
3	Ngawang Chhogyel	MSc. Rice	Dy. Chief Agriculture Officer
4	Sangay Tshewang	MSc. Rural Science	Dy. Chief Agriculture Officer
5	Thinley Gyem**	MSc. Agri-Bussiness	Senior Agriculture Officer
6	Cheku Dorji	BSc. Agriculture	Senior Agriculture Officer
7	Passang Tshering	BSc. Agriculture	Agriculture Officer
8	Legjay	Diploma in Agriculture	Sr. Agriculture Supervisor-II
9	Doley	Diploma in Agriculture	Sr. Agriculture Supervisor-II
10	Lhab Gyem*	Diploma in Agriculture	Sr. Agriculture Supervisor-III
11	Rabgay Dukpa	Diploma in Agriculture	Dy. Chief Agriculture Officer
12	Yeshey Dema	BSc. In Agriculture	Agriculture Supervisor-I
Horticulture Sector			
13	Kinley Dorji	MSc. Horticulture	Dy. Chief Agriculture Officer
14	Jigme	MSc. Horticulture	Principal Agriculture Officer
15	Sonam Chophel	BSc. Agriculture	Senior Agriculture Officer
16	Gyeltshen Tshering	BSc. Agriculture	Senior Horticulture Officer
17	Arjun Kumar Ghallay	BSc. Agriculture	Senior Agriculture Officer
18	Dawa Delma	Diploma in Agriculture	Agriculture Officer
19	Duptho Wangmo	BSc. Horticulture	Horticulture Officer
20	Tshering Dema	BSc. Agriculture	Sr. Agriculture Supervisor-III
21	Karma Dema	Diploma in Agriculture	Sr. Agriculture Supervisor-I
22	Phuntsho Wangdi	Diploma in Agriculture	Sr. Agriculture Supervisor-I
23	Pasang Dorji	Diploma in Agriculture	Mushroom Supervisor-III
Soil &Plant Nutrients and Plant Protection			
24	Tashi Dorji	BSc. Agriculture	Agriculture Officer
25	Ugyen Dorji	BSc. Agriculture	Plant Protection Officer
26	Kinley Tshering	BSc. Agriculture	SFPN Officer
27	Yeshi Zangpo	Diploma in Agriculture	Agriculture Supervisor-III
Engineering Sector			
28	Thinley Gyamtsho	MSc Natural Resource Mgt.	Principal Research Officer
29	Thinley Gyeltshen	Diploma in Civil Engineering	Dy. Executive Engineer
30	Puran Chhetri	Diploma in Civil Engineering	Assistant Engineer-III
31	Nima Wangchuk	Diploma in Civil Engineering	Jr. Engineer
32	Indra Bdr.Raika	Electrical Engineering	Sr. Tech-III
RRCO			
33	Tanka Maya Pulami	BSc. Agriculture	Senior Research Officer
34	Pema Lhamo*	Certificate (XII)	Library Asst-III
Laboratory Sector			
35	Karma Yozer	Certificate in Basic Lab	Lab.Assistant-IV
36	Loday Jamtsho	Certificate	Lab. Assistant-I
37	Tshering Yangdon	Certificate in Seed testing	Sr. Lab Assistant-V

ADTC / Royal Project			
38	Dophu Namgyel	Diploma in Agriculture	Sr. Agriculture Supervisor-II
39	Tshering Dorji	Diploma in Agriculture	Agriculture Supervisor-II
40	Dorji Khandu	Diploma in Agriculture	Agriculture Supervisor-II
41	Karma Thinley	Diploma in Agriculture	Mushroom Supervisor-III
Administration Sector			
42	Dawa Zangpo	Diploma in VSc & AH	Dy. Chief ADM.Officer
43	Sherub Dorji	Diploma in Finance Mgt.	Accounts Assistant-II
44	Deki Pelzom	BBA	Accounts Assistant-IV
45	Tashi Tshering	Diploma in Information Mgt.	Sr. ICT-III
46	Lhamo	Certificate (XII)	Adm Assistant-II
47	Gyem Lham	Certificate (XII)	Sr. Despatcher
48	Gyembo Lham	Diploma in Finance Management	Store Assistant -II
49	Ugyen Tashi	Certificate in Driving	Driver- I
50	Nidup	Certificate in Driving	Driver- I
51	Tenzin Loday	Certificate in Driving	Driver- I
52	Mon Bdr. Rai	Certificate in Driving	Driver- I
53	Deo Raj Pradhan	Certificate in Driving	Driver- II
54	Dorji Choden	Certificate (X)	PABX Operator
55	Bago	Certificate (VI)	Messanger
56	Nedup	Certificate in Driving	Tractor Driver
57	Farm Attendants (ARDC Bajo)		25 Nos
58	Farm Attendants (ADT Chimipang)		44 Nos
59	Farm Attendants (ARDSC Tsirang)		18 Nos
60	Night Guard		1 No

*Transferred; **Resigined

Annex 10: Training and workshops for July 2017- June 2018

SN	Date	Name	Place	Purpose
1	11-13/09/2017	Tanka Maya Pulami	Kerala, India	Meeting on Technology sharing of spice crops in SAARC, Countries.
2	3-9/09/2017	Sonam Chophel	Nepal	Training on Horticulture cultivation at Nepal Agriculture Research centre.
3	10-19/09/2017	Mahesh Ghimiray, Ngawang Chhogyel	Vietnam	Study visit on Rice Research & Development.
4	19-22/09/2017	Passang Tshering	Dharward, India	Study visit to the University of Agricultural Sciences.
5	03-31/10/2017	Pema Lhamo	IMS, Thimphu	Training on Basic Office Management & Operational skill Development.
6	12-20/10/2017	Pasang Dorji	Thailand	Training on mushroom Spawn production and cultivation practices.
7	13-15/10/2017	Pema Chofil (PD)	Nepal	Workshop
8	26/10/2017 – 3/11/2018	Tanka Maya Pulami	FITI, Thimphu	Priority Sector Lending training
9	01-10/11/2017	Tshering Dorji	Thailand	Study Tour
10	29/11/2017-07/12/2017	Indra Bdr. Raika	Ladakh & Mumbai, India	Consultation meeting & visit of solar Pump irrigation system installed by Rain irrigation system limited.
11	16-18/12/2017	Phuntsho Wangdi	Nagpur, India	To attend "World orange festival" at Nagpur, India.
12	20-26/01/2018	Dophu Namgyel	Thailand	Planning meeting
13	17/01/2018-16/02/2018	Pema Chofil (PD)	Japan	Training on Horticulture Research.
14	17/01/2018-17/03/2018	Gyeltshen Tshering	Japan	Training on Fruit Cultivation.
15	17/01/2018-17/03/2018	Karma Dema	Japan	Training on vegetable Cultivation.
16	5-11/02/2018	Phuntsho Wangdi	MJU, Chaing Mai, Thailand	Training on "Plant propagation and repository"
17	04-10/03/2018	Doley	MJU, Chaing Mai, Thailand	Field Crops production & management Training.
18	07-18/03/2018	Cheku Dorji	Noida, New Delhi, India	Quinoa Cultivation & post production Training.
19	07-18/03/2018	Rabgyal Drukpa	Noida, New Delhi, India	Quinoa Cultivation & post production Training.
20	09-14/03/2018	Kinley Tshering, Nima Wangchuk & Yeshey Dema	AMC-Training Centre, Paro	Training on Scientific paper writing
21	11-17/03/2018	Dawa Delma	Maejo university, Chaingmai, Thailand	Training on vegetable production & post harvest management.

22	12-24/03/2018	Deki Pelzom	Jaipur, Rajasthan, India	Training on management development program on government budgeting, accounting and expenditure control.
23	18-24/03/2018	Arjun Kumar/ Tshering Yangdon	Maejo university, Chaingmai, Thailand	Horticulture production & management.
24	25/03/2018-7/04/2018	Tanka Maya Pulami	Maejo university, Chaingmai, Thailand	Organic Agriculture & Management.
25	18-24/03/2018	Tashi Gyeltshen	Bangkok. Thailand	Horticulture Production & Management.
26	25-31/03/2018	Ugyen Dorji	Maejo university, Chaingmai, Thailand	Plant Protection & Management Training.
27	14-17/04/2018	Passang Tshering	Marrakech, Morocco, India	Attend workshop on "Borlaug global Rust initiative at India.
28	10-24/04/2018	Tashi Dorji	Bejing & Sinchuan Province, China	Attend seminar on Protected Agriculture.
29	03-04/05/2018	Cheku Dorji	Bangkok, Thailand	WFP Asia Regional meeting on Rice Fortification.
30	06-15/05/2018	Tashi Phuntsho	Nepal	Study Tour on Advance climate smart citrus production technology in National Agriculture Cooperation Central Federation Ltd in Nepal.
31	07-09/05/2018	Sherub Dorji	Samdrupjongkhar	Attend meeting for RNR Accounts personnel.
32	09-11/04/2018	Sherub Dorji, Gempo Lham & Tshering Tashi	Hotel Taj Tashi, Thimphu	Participants for procurement Training.
33	23-25/04/2018	Deki Pelzom	Phuntsholing	Meeting for RNR Accounts Personnel
34	15-28/05/2018	Tshering Tashi	Maejo university, Chaingmai, Thailand	Training on Digital publishing and trasmedia.
35	21-29/05/2018	Nima Wangchuk & Puran Chhetri	Bangkok, Thailand	Training on Climate Smart Irrigation Technology at International Centre for Development communication.
36	01-30/06/2018	Gyem Lham, Dorji Choden & Bago Dukpa	IMS, Serbithang, Thimphu	Basic office management& operational skill Development.

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, 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 CitrusRepository 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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