



# Annual Report Highlights 2018-2019



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

**ROYAL GOVERNMENT OF BHUTAN**

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**Published by:**

Agriculture Resources Research & Development Centre-Bajo, Wangdue Phodrang,  
Department of Agriculture  
Ministry of Agriculture & Forests,  
Royal Government of Bhutan.

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## FIELD CROPS

The field crops research was implemented with the objectives to increase the productivity of different cereals. Research and development works were carried out both on station and on farm. Selection of elite lines and further testing under different agro ecological zones to suit under particular locations. During 2018-19, the following trial were conducted, assessed and reported.

### Rice Research and development

#### Evaluated 97 lines /germplasm (at various stages of evaluation)

- 13 at Advance Evaluation Trial. This trial is basically to identify the suitable varieties with high yield potential, medium height, optimum maturity and resistance to pest and diseases for mid altitude rice growing areas.
- 17 at Initial Evaluation trial. This trial is basically to identify the suitable varieties with high yield potential, medium height, optimum maturity and resistance to pest and diseases for mid altitude rice growing
- 17 at Observation Nursery. To evaluate the performance of the test lines in terms of yield, maturity period, adaptability, pest and diseases resistance.

#### Demonstration of released varieties

- 10 varieties. The purpose of this trial is for technology dissemination to farmers, extension, visitors and trainees who ever visit the centers
- Seed production and promotion of improved rice seeds: ARDC Bajo maintained and purify the released rice varieties and so supplied over 1.3MT seeds from on-station production. In total 10MT rice seed was produced at ARDC Bajo, ARDSC Menchuna and CRP, Chimipang as seed.
- Provide Technical support to large scale spring rice production in Wangdue, Zhengang and Trongsa Dzongkhag. 58.89 acres under spring rice cultivation in 2018-2019. Supported with seeds and plastics for spring rice production. In case of upland rice promotion four acres of upland rice was supported with technical and seed support to Wangdue Dzongkhag.
- A total of 34 accessions of traditional land races of rice for the phenotypic characterization and seed production were carried out in collaboration with National biodiversity centre, Serbithang.

#### On-farm rice trial

- Four gewogs under each dzongkhag has been identified for on farm rice trial. Three promising rice varieties were tested in each farmer's fields. A total of 24 households/sites were engaged in on farm rice trials. Each house hold was supplied with 4 kg of seeds.

**Table 1. On farm rice yield**

Sl No	Gewog/ Dzongkhag	Variety	Till /hill	Yield (Kg/acre)
1.	Kabesa, Punakha	TME-50518	7	2254.26
			9	3231.78
2.	Kabesa, Punakha	Ceres	8	2686.04
			7	2226.97
3.	Kabesa, Punakha	Zhanghan	8	2418.60
			10	2306.51
4.	Baarp, Punakha	Zhanghan	12	3282.94

			12	2830.93
5.	Baarp, Punakha	TME-50518	10	2878.29
			12	2403.10
6.	Baarp, Punakha	Ceres	11	2790.69
			9	2464.65
7.	Bjena, Wangdue	TME-50518	19	3970.54
			15	4177.44
8.	Bjena, Wangdue	Zhanghan	16	3665.11
9.	Bjena, Wangdue	Ceres	13	3103.87
			10	3046.35
10.	Daga, Wangdue	Ceres	11	940.93
			12	990.69
			12	1085.27
11.	Daga, Wangdue	Zhanghan	12	818.60
			14	933.02
			13	1085.27
12.	Daga, Wangdue	TME-50518	14	845.34
			15	897.98
			12	1100.77
13.	Kabesa, Punakha	TME-50518	7	2254.26
			9	3231.78
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			7	2226.97
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			10	2306.51
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			10	1085.27
24.	Daga, Wangdue	TME-50518	10	845.34
			14	897.98
			14	1100.77

### Field experiment/demonstration on direct seeding

Direct seeded using drum seeder was demonstrated in the centre. Under direct seeding, the rice seeds are directly sown to the well prepared main field. The seeds are soaked in water and kept

in dark for sprouting before sowing in wet rice cultivation. The sprouted seeds are sown in well puddled and levelled fields using drum seeders.

This method is adopted in areas where there is shortage of labourers or labour wages are very high and also where mechanical seeders are available. The crop matures 15-20 days earlier than normal transplanted rice. The seed rate is very low (7kg/acre) whereas the normal transplanted rice is 25-30 kg/acre.

Rice cultivation using drum seeder was demonstrated on station at ARDC Bajo, ARDSC Menchuna, and at farmers' field in Lhamoizingkha Dungkhag for three gewogs. A total of 60 farmers participated in the demonstration of drum seeder.

**Table 2. Agronomic traits of direct seeded rice**

Sample No	Plant height (cm)	Tillers / hill	Grains /panicle	Yield (kg/acre)
1	107	34	160	4400
2	101	35	177	3733
3	110	40	185	3666

### Upland Rice Varieties Research at Tsirang

The Field Crops sector conducts on station research for rice activity to come out with best suited rice cultivars to the agro ecological zone of Tsirang and Dagana Dzongkhags which ranges from 300 to 1500 masl. In the past, focus more research activity collecting crop characteristics data for IR 28 and Khangma Maap which were found promising in the fields. The sector usually does varietal cultivation periodically adding rice seeds from Centres. In addition to the prevalent cultivars the sector had received seeds nine rice varieties to conduct production evaluation trial (PET). The Agronomic data is collected as mentioned in the table below:

**Table 3. Agronomic traits of PET**

SL.No	Variety	Plant height (cm)	Yield t/ha
1.	Machapuchary	84	3.29
2.	Lumang local	88	2.92
3.	Zangthy	80	2.95
4.	Chandanath 3	62	0.86
5.	Chandanath 1	106	1.06
6.	Wengkhar Ray Kamja	96	3.82
7.	Khangma Maap	97	1.94
8.	IR 28 (check)	102	4.00
9.	Vietnam	76	0.30

Besides, on station rice evaluation, the sector seasonally go to the fields and collect varietal performance data with intention to help rice growing farmers to increase rice yield per unit by replacing their low yielding local variety by high yielding improved rice variety.

**Table 4. Yield of local rice varieties**

Sl.No	Variety	Plant height (cm)	Yield t/ha
1.	Local khamtey	97	3.16
2.	Chotay	89	3.00
3.	ARDSC Tsirang	47	3.00

### Maize seed varietal maintenance

The ARDSC Tsirang Field Crops sector could produce 1010 kg of improved maize seed from the on station and purchased 333kg of improved maize variety seed with fund from Royal Government of Bhutan in the financial year 2018-2019 and supplied free improved maize seeds of; Ganesh II, Yangtsipa, Chaskharpa ashom and Khangma ashom to the farmers of Tsirang and Dagana Dzongkhags as developmental activity in the fields in collaboration with Extension personnel. The distribution of free seeds supply is supported by our on station maize crop cut data.

**Table 5 On station maize crop cut data**

SN	Name of variety	Release year	Plant height in cm	Date of sowing	Date of harvesting	Yield t/ha
1.	Yangtsipa	1992	226	14.04.18	20.08.18	3.09
2.	Chaskharpa Ashom	2012	222	13.03.18	29.08.18	4.30
3.	Ganesh II	-	275	13.03.18	19.09.18	5.37
4.	Khangma Ashom	-	250	15.04.18	25.08.18	3.00

**Table 6 Maize seed distribution in 2018-19**

Tsirang Dzongkhag					
SN	Gewog	Varieties	Quantity in kg	No of HHs beneficiaries	Area in acre
1	Barshong	Yangtsipa, Khangma Ashom, Chaskarpa ashom and Ganesh -II	230	20	19.16
2	Kikhorthang	do	420	34	35.00
3	Rangthaling	do	23	2	1.91
4	Sergithang	do	100	56	8.33
5	Mendrelgang	Do	60	6	5.00
6	Goshiling	Do	40	4	3.33
7	Pachaling	Do	55	5	4.58
8	Tsirangdangra	Chaskarpa	15	1	1.25
Dagana Dzongkhag					
9	Drujeygang	Do	100	10	8.33
10	Khebasi	Do	300	25	25.00
	<b>Total</b>		<b>1343</b>	<b>163</b>	<b>134.38</b>



## Quinoa Research and Development

Quinoa research and development has given the most priority crop since its first introduction to the country in 2015. From a new crop in 2015, quinoa has already spread in all 20 Dzongkhags and across all agro-ecological zones with an estimated area of about 500 acres in 2018-2019. The production figures also capture on-station and on-farm seed produced by ARDC. Quinoa commodity has been mainstreamed into the 12<sup>th</sup> FYP targets of the Dzongkhags and is now being promoted in all 20 Dzongkhags

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 all five dzongkhags of West-Central Region. Quinoa seeds was supplied to farmers for seed production). The quinoa varieties included Ivory 123, *Amarilla marangani* and *Amarilla sacaca* which have been tried at different agro-ecological conditions.

In the FY 2018-19, under Dagana Dzongkhag, a total of 65 farmers from each geog of Lhamoizingkha, Karmaling and Nichula were give hands on training for cultivation packages of Quinoa. They were also brief on the nutrition content of the crop and post-harvest and by product development. After the training, certain quantity of seeds was distributed to all the participants. The Agriculture extension Officers including DAO of Wangdue Dzongkhag were also attended a day long training on cultivation Packages of Quinoa cultivation. A demonstration of seed sowing was done after the training and they were also briefed on product developments and post-harvest activities. A total of 100 kg of seeds were distributed to each geog for the cultivation of coming season.

Table 7. Status of quinoa cultivation in ARDC Bajo Region, 2018-2019

SN	Dzongkhag	Area (ac)	Seed Supplied (Kgs)	No. of HHs	Total Prodn. (Kgs)	No. of Milling Machine	Remarks
1	Wangdue	30	150	178	950	1 at ARDC Bajo	In some geogs, crop is still in the field
2	Punakha	3	10	25	50		
3	Gasa	2	10	15	0		No germination of seeds
	NSC Phobjikha	1	10		170		
	FMCL Bajo	2	12		0		
	On station		ARDC Bajo		595		
4	Tsirang	10		20	1720	1 at ARDSC Tsirang,	Sergithang=650kg Barshong=250kg Patsaling=300kg
5	Dagana	2		10	270		Drukjeygang=100kg Gozhi= 100kg L/zingkha= 70kg
	On station		ARDSC Tsirang		450		
<b>Total</b>					<b>4205</b>		

In total we have produced 4.2MT of quinoa seeds from on-station and from farmers' field during the FY 2018-19.

During the FY 2018-19, for ARDSC, Tsirang, RGoB had funded Nu.0.04m (Forty Thousand) only for the procurement of potential Quinoa varieties from the progressive farmers and supplied 400 kg of Quinoa seed to the farmers in the remote villages covering Tsirang and Dagana Dzongkhags.

The two Quinoa varieties DOA-1-PMB-2015 and Ivory 123 new Indian Quinoa cultivars (*Chenopodium quinoa* Willd) are in the farmers's field extending to 12 acres in Tsirang and Dagana Dzongkhags. In the fiscal year 2018-2019 the sector collected production data for both the cultivars from on station and on farms for evaluation.

**Table 8 Quinoa crop cut data of an on station and on farms**

SN	Characteristics	DoA-1-PMB-2015		Ivory 123	
		On station	On station	On station	On farm
1.	Plant height in cm	72cm	108 cm	71 cm	134 cm
2.	Area	6 m2	6 m2	6 m2	6 m2
3.	Yield per plot	1.8kg	0.533	1.5	0.97kg
4.	Yield/ha	3.00	1.33	2.5	1.62
5.	Date of sowing	1/10/2018	21/9/2018	1/10/2018	14/10/2018
6.	Date of harvesting	8/2/2019	20/2/2019	8/2/2019	2/12/2018

### Field day on Quinoa

For promotion of quinoa production field days were conducted during the harvesting time and they were also demonstrated on line sowing and broadcasting methods briefing them with advantages disadvantages of two methods. As to attract promotion of this crop varieties of quinoa products were developed for tasting during the field days.

**Table 9: Field Day**

Dates	Village/Geog	No participants	of Site
	Menchuna Kilkhorhang	11	On station ARDSC Tsirang
	Tsolingkar	9	On station ARDSC Tsirang
	Rangthaling	7	On station ARDSC Tsirang
02.12.2018	Sergithang toe	35	Sergithangmae
03.12.218	Sergithangmae/Tashithang	10	Tashithang
20.02.2019	Drukjeyang Dagana	25	Patala
10-06-2019	Wangdue and Punakha Extensions	26	On station ARDC, Bajo

### Oil Seed Research and Development:

During the FY 2018-19, five varieties of mustard was cultivated as evaluation trail at ARDSC, Tsirang. This also solve purpose of seed production and maintenance.

**Table 10: Crop cut data of different varieties of mustard**

SN	Variety	Date of sowing	Date of harvesting	Plant height (cm)	Yield (t/ha)
1	Pragati (trial plot)	11.10.2018	26.02.2019	72.86	1.81876
3	Unnati (trial plot)	11.10.2018	26.02.2019	65.56	1.85667
4	Bharshari	11.10.2018	26.02.2019	81.107	2.53334
5	Lumley	11.10.2018	26.02.2019	63.347	1.06112

At the end, the average weight and height was take out and known that Unnati was found out to be little productive than Pragati. This trial on mustard has been for the first time, the trial on these cultivars will be conducted for at least 3- 4 years till it is terminated. In total 500kg of seed is produced and maintained as seed at the centre.

## Wheat Research and Development

### Advance Evaluation Trial of Indian and 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 statistic report. Globally wheat is the leading source of vegetal 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 variety/lines were introduced and evaluated in different ecological zones in the country.

With the limited numbers of improved varieties in the country, the need for extra research effort and release of new variety is found to be important. Therefore, the National Wheat Program receive numbers of wheat varieties or lines from outside for its evaluation under Bhutanese conditions

In 2017-18 seasons, we received 3 wheat lines/ variety from Nepal for observation of its production and performance under Bhutanese conditions. The varieties are most popular released under wheat growing conditions in Nepal and are considered to be high yielding with wheat rusts resistant traits. 3 Nepal lines and 1 Indian line were evaluated under AET in 2018-19 seasons with Bumthangkadrukchu as local standard check.

**Table 11: Agronomic performance of Nepal and India lines**

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

### Advance Evaluation Trial of Biofortified wheat lines

Biofortification is a process to increase the bioavailability and the concentration of nutrients in crops through both conventional plant breeding (White and Broadley, 2005) and recombinant

DNA technology (genetic engineering) (Zimmermann and Hurrell, 2002). It is an idea of breeding crops to increase their nutritional value. It can be done through conventional selective breeding or genetic engineering. 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 increase people's intake of zinc and iron. The International Center for Wheat and Maize (CIMMYT) has developed numbers of biofortified wheat lines. For adaptability and performance observation, the lines were distributed in wheat growing countries. Bhutan being part of CIMMYT activity and global wheat network, we received 50 biofortified entries during 2014-15 seasons. 6 best performing lines underwent advance evaluation trial in 2018-19 seasons.

**Table 12. Agronomic performance of Biofortified lines**

SN	Treatments	Days to Heading	Days to Maturity	Plant height(cm)	Disease score (0-5)	Yield (ton/ha)
1	BF 450	93	145	89	0	2.72
2	BF 422	94	138	91	0	2.74
3	BF 411	98	135	89	0	2.48
4	BF 447	96	140	90	0	2.70
5	BF 412	92	140	91	0	3.33
6	BF 415	92	145	92	0	1.80
7	Bumthangkadrukchu (Local check)	94	155	94	0	2.10

### Wheat rust pathological study

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

**Table 13. Wheat rust pathological study**

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

### Seed production and maintenance of promising and released varieties

Considering the importance of varietal evaluation, elite germplasm from both regional and international centers are introduced and tested. 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. Three released variety seeds were produced and maintained. Since its released, Bumthang Kaa Drukchu gained much popularity among the wheat growers under mid and high altitude region. The National Seed Center (NSC) being the only center responsible for seed business in the country, NSC is not able to met seeds demand alone. Therefore, the field crops sector and the National Wheat Program thought to grow and produce more seeds of Bumthan Kaa Drukchu in order to meet the variety seeds demand. In 2017- 18, the seeds of following promising or released varieties were produced and maintained

**Table 14: Quantities of wheat seed produced in 2017-18**

Line/variety	Quantity (kg)
Bumthangkaa Drukchu	2250
Bajosokha kaa	200
Gumasokha kaa	180
<b>Total</b>	<b>2630</b>

### Observation of Durum wheat lines from ICARDA

Durum wheat, also called as pasta wheat or macaroni wheat (*Triticum durum* or *Triticum turgidum*) is a tetraploid species of wheat. It is the second most cultivated species of wheat after common wheat representing 5%-8% of global wheat production. It was developed by artificial selection of the domesticated emmer wheat strains. Durum wheat is awned with bristles. Durum wheat species are favorable for semolina and pasta making and less practical for flour.

Since there is no durum wheat varieties in Bhutan, field crops sector of ARDC Bajo and National Wheat Program requested for nursery germplasm from International Center for Agricultural Research in Dry land Areas (ICARDA). A total of 95 durum wheat lines were received from ICARDA international nursery request. The lines were evaluated under observation trial on station.

### Wheat seeds support

The following quantity of wheat seeds were supplied/distributed to farmers for conducting on farm production evaluation and support farmers for wheat production in the country. The National Wheat Program, field crops sector of ARDC-Bajo and involved projects/ contributors supported the program.

**Table 15: Wheat seed supply**

SN	Seeds supplied to	Qty supplied (MT)	Variety supplied
1.	ARDC Wengkharr	0.3	Bumthangkaadrukchu
2.	Natural Farm, CNR Lobesa	0.2	Bumthangkaadrukchu
3.	FMCL	0.6	Bumthangkaadrukchu
4.	Nahi gewog, Wangude	0.1	Bumthangkaadrukchu
5.	ARDC Wengkharr	0.1	Bajosokhaka
6.	ARDC wengkharr	0.045	Gumasokhaka
	<b>Total</b>	<b>1.345</b>	

**Seed support and released variety evaluation at ARDC Wengkharr**

As a part of wheat intensification program, a total of 250 kgs of wheat variety *Bumthang Ka Drukchu* was supplied to four households of Chumeey geog under Bumthang covering 6.25 acres. The intervention was mainly to promote the newly released variety for further seed multiplication. Moreover, two varieties *Gumasokha Kaa* and *BajosokhaKaa* are evaluated on station at ARDC Wengkharr and Khangma as an adaptation and performance trial.

**Wheat and Millet research & Development Activities at ARDC Samtenling**

Observation trial on two newly introduced wheat varieties (Swadagiri, BHU35 and Gumosokha as standard check) Swadagiri performed slightly better (Yield: 1.02 t/ha) as compared to BHU35 (1.0 t/ha) but there was no significant difference.

**Evaluation of promising finger millet varieties at on station**

Two promising finger millet lines IE4425 and IE4414 were evaluated on-station for yield and other agronomic traits with Samtening Memja-1 as standard check. On-farms trials to be carried out in the upcoming season (2019-2020).

**Promotion of local sweet buckwheat at Samtse**

100 kg of sweet buckwheat seeds were provided for Phuntsho Pelri geog, Samtse to enhance buckwheat production and to encourage effective utilization of fallow land after maize and rice cropping season. 1665 kg was produced from an area of 4 acres.

**Horticulture Research & Development Activities (2018-2019)****Evaluation of warm temperate and sub-tropical fruits and nuts germplasm**

ARDC-Bajo with full support from Integrated Horticulture Promotional Project (IHPP)-JICA established both warm temperate and sub-tropical fruit and nut orchards. The orchards will serve as management technology generation and demonstration sites for providing hands-on training for researchers and extension agents by the Project Experts. It is also to evaluate and identify superior cultivars for diversification of fruit cultivation.. Two varieties Wicheta and Western schelley released for commercial cultivation in June 2019. Established wine grape evaluation trial at ARDC-Bajo (9 varieties)

**Table 16: Fruit crop varieties established in the germplasm block**

Crops	Varieties
Peach	Kurataki, Nonomewase, Floridasan, Beauty cream

Apricot	Khasha, New Castle
Pear	Yakumo, Niitaka, Hosui, Kosui, Shinko, Chojuro
Kiwi	Hayward, Wengkar Yellow, Wengkar Green, Enza Red, Male
Grape	Steubin, Perlette, Campbell, Kyoho, Risamate, Nsehelena
Dragon fruit	Gewai ringa
Pomelo	R3P4,R4P5, R3P9, Banpeiyu
Lime	Seedless lime
Lemon	Frost Eureka
Loquat	Mogi, Tanaka
Avocado	Brogdown, Hass, Bacon, Zutano, T1, T2, T3, M1, M2, M3
Persimmon	Jiro, Fuyu, Yakumo, Zinjimaru, Taishu
Plum	Honey Rosa, Santa Rosa, Soldum, Kiyo, Oishi wase
Kumquat	Marumi
Pecan nut	Wichita, Western Schley
Wine grape	Cabernet Sauvignon 337, Syrah 470, Cot 598, Sauvignon Blanc 906, Chardonnay 96, Pinot Noir 72, Merlot 181, Petit Manseng 573
Guava	Pink Flesh, Thai Giant, Allahabad Safeda, Local
Pomegranate	Chaula, Bedana, K5, K3
Grape fruit	Star ruby

## Fruits and Nuts Development Activities

### Production of quality seeds and seedlings

Grafted and non-grafted seedlings of both released and promising cultivars of fruits and nuts are produced and maintained. Scion woods are collected from ARDC-Bajo and ARDC-Wengkar in the months of December and January. Grafting operations are done towards the end February (green house) and February-March (open field). In the fiscal year 2018-19, a total of 6762 grafted fruit crops, and more than 2000 seedlings were produced.

**Table 17: Production of quality seedlings**

Crops	Quantity Nos	Remarks
Citrus	1300	Grafted
Avocado	900	Non-grafted
Dragon fruit	42	Cuttings
Loquat	700	Non-grafted
Guava	400	Non-grafted
Pear	2500	Grafted
Persimmon	2000	Grafted
Peach	120	Grafted
Plum	100	Grafted
Apricot	100	Grafted
Kiwi	500	Grafted
Grape	100	Grafted
	<b>8762</b>	

### **Promotion of fruits and nuts through systematic training and orchard establishment**

ARDC-Bajo in close collaboration with Dzongkhag Agriculture Office established 23 demonstration orchards and 6 focus village orchards through systematic training in the west central region. In total, 3787 fruit plants were planted in about 40 acres of land.

### **Awareness and hands on training citrus canopy management conducted**

A total of 1137 interested clients of 7 Dzongkhags (Dagana, Punakha, Samtse, Sarpang, Chukha, Zhemgang and Pemagatshel) were provided awareness cum hands on training on; Citrus canopy management, application of Bordeaux paste/spray and nutrient management. The objectives of the program were to educate the citrus farmers on citrus orchard management aspect and its importance through awareness and hands on training.

Besides these National Citrus Repository has produced more than 10000 disease free citrus buds of 91 varieties.

### **Vegetable program**

#### **Evaluation of Red Tommy Toe both on-farm and on-station**

The adaptive research of new variety of Tomato is evaluated both on-station and on-farm. The three locations were selected for the on-farm trial at Dagana (Lower Gangzur, upper Gangzur and Thangna). The on-farm trial was started from September 2018 and completed in May end.

Further on-station research is on-going at the Centre with the released variety (CHT-160) as check.

#### **Evaluation of Tomato (Master)**

The adaptive research of new variety of Tomato is evaluated both on-station and on-farm. The three locations were selected for the on-farm trial at Dagana (Lower Gangzur, upper Gangzur and Thangna). The on-farm trial was started from September 2018 and completed in May end.

Further on-station research is on-going at the Centre with the released variety (Rattan as check).

#### **On-station Evaluation of the watermelon (Kabuki and blackball).**

The evaluation of two varieties is on-going with sugar baby as check. Further on-farm trial will be carried out in 2019-2020.

#### **Evaluation of four varieties of pumpkin (on-station).**

One variety from Japan (Kuri) and three lines from AVRDC are evaluated on-station with Wengkher Kakur as check. It will be taken to farmers' field in 2019-2020 for further evaluation.

#### **Evaluation of four varieties of Bitter melon (on-station) with local variety as check.**

The lines were obtained from the Department and AVRDC, Taiwan. The evaluation is on-going.

#### **Evaluation of pole beans and dwarf beans both on-farm and on-station.**



### Production of quality vegetable seeds and seedlings

In 2018-19, the horticulture sector produced more than 770kg seeds of different vegetable crops (winter and summer vegetable) on-station to maintain basic seeds and distributed to farmers through outreach program.

**Table 18: Summer vegetable seeds distributed to farmers in January 2019**

SN	Crop	Variety	Total (Kg)
1	Bean	Gray pole	101
		White	100
		Azuki	50
2	Ground nut	Small	58
		Large	46
3	Zucchini		13
4	Pumpkin		5.4
5	Brinjal		4.57
6	Carrot	Pure red	8.07
		Kurada	14.1
		Cuttings	3.25
7	Okra	short	17.8
		long	13.25
		Bajo	25.59
8	Sweet corn	Honey	4.5
		Peter	8.25
9	Tomato		0.4
10	Chili	Urka	0.7
11	Capsicum		0.06
12	Water melon	Kabuki & Black ball	0.626
			<b>474.566</b>

**Table 19: Summer Vegetable seeds distributed on 15/3/2019 to 5 Dzongkhag**

SN	Crop List	Quantity distributed (Kg)					Total
		Tsiran g	Dagana	Punakha	Wangd ue	Gasa	
	Okra, JPN						
1	Long	6	6	0	0	0	12
	Okra, JPN						
2	Short	2	0	8	8	10	28
3	Okra-Bajo	6	8	6	6	0	26
	White pole						
4	bean	14	14	14	14	8	64
	Grey pole						
5	bean	1.6	1.6	1.6	1.6	1.6	8
6	Peter Corn	2	1.5	0	1.5	0	5
7	Ebisu	0.7	0.7	0.7	0.7	4	6.8
8	Brinjal	0.56	0.56	0.56	0.56	0.3	2.54
9	Zucchini	1.5	1.5	1.5	2.1	1.2	7.8
10	Adzuki bean	8	8	2	10	4.6	32.6
11	Sweet corn	0	0.5	2	0.5	1.5	4.5

42.36	42.36	36.36	44.96	31.2	<b>197.24</b>
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**Table 20: Winter vegetable seeds distributed to farmers in August 2018**

SN	Crop	Variety	Pkts	Wt/Pkt	Total (Kg)
1	Mustard green	Mayuri Ryo	425	5	2.125
		Red Ryo	2000	5	10
2	Cauliflower	WMK I	1300	5	6.5
		WMK II	1000	5	5
		White top	250	10	2.5
3	Radish	Shogoun	260	100	26
		Sakurajima	130	100	13
		Minowase	1100	10	11
4	Carrot	Pure red	260	30	7.8
		Kurada	253	30	7.59
5	Broccoli		2600	10	26
		SP Green	460	10	4.6
		Ryokuri	352	5	1.7
6	Spiniach	Jiro maru	80	50	4
7	Onion	Bunching	250	10	2.5
		Bulb	3600	10	36
8	Pea	Long	190	50	9.5
		Flat	620	50	31
					<b>206.815</b>

**Table 21:Vegetable breeder seed maintenance**

Sl. no	Crop	Variety	Cultivar(breeding line name/original	Qty produced & maintained Kg)
1	Bean	Borloto	Borloto	9
2		Pusa Parvati	Pusa Parvati	9
3		Top Crop	Top Crop	9
4		Rasma	Rasma	9
5	Broccoli	Desico	Desico	1
6	Cauliflower	White Top	White Top	1
7	Chinese Cabbage	Kyoto 3	Kyoto 3	0.2
8	Carrot	Early Nantes	Early Nantes	2
9	Radish	Bajo Laphu 1	Hongkong White	1
10		Spring Tokanashi	Spring Tokanashi	0.2
11	Spinach	All Green	All Green	2
12	Tomato	Roma	Roma	1
13		Cherry Tomato	CHT160	1
14		Bajo Lambenda 1	Rattan	0.2
15	Watermelon	Sugar Baby	Sugar Baby	0.2

**Table 22: Promotion of water melon cultivation in the region**

Sl no	Names	Dzongkhag	Gewog	Chewog	Area (Ac)	Harvest (Kg)
1	San Man Subba	Tsirang	Sergithang	Tashithang	1.5	5500
2	Garab Dorji	Tsirang	Sergithang	Tashithang	0.3	2750
3	Lal Bdr Sanyasi	Tsirang	Sergithang	Tashithang	0.5	2600
4	Pema Dorji	Punakha	Toedwang	Samdingkha	0.6	700
						<b>11550</b>

## 2 Promotion and up scaling of Top-working techniques for improving local fruit trees

**Table 23: Topwork done**

Sl. No	Dzongkhag	Nos of trees top-worked								Total
		Pea r on	Persimm on	Peac h	Plu m	Apric ot	Waln ut	Appl e	Ki wi	
1	Punakha	178	162	78	91	5	65	0	1	580
2	Wangdue	85	36	82	0	0	0	5	0	208
		<b>263</b>	<b>198</b>	<b>160</b>	<b>91</b>	<b>5</b>	<b>65</b>	<b>5</b>	<b>1</b>	<b>788</b>

**Table 24: Beneficiaries list of onion(2018-2019)**

Sl.No	Village	Geog	Dzongkhag	Qty (Kg)	No.of HH
1	Omtékha	Limbukha	Punakha	1	6
2	Gumkarmo	limbukha	Punakha	1	6
3	Japhu	Rubesa	wangdue	0.5	12
4	Neyzergang	Rubesa	wangdue	0.25	1
5	Dochuzhur	Rubesa	Wangdue	0.25	1
6	Dubchugang	Tsholingkhor	Tsirang	7	28
7	tashithang	Asergithang	Tsirang	2	17
8	Bjijokha	Toewang	Punakha	2.5	8
9	Damchi	Kabjisa	Punakha	3	6
10	Dongkokha	Talo	Punakha	1	8
11	Gapalo	Chubu	Punakha	1.5	5
12	Wolakha	Guma	Punakha	1	4
13	Dalithang	Goshi	dagana	5	21
14	Goshi	Goshi	Dagana	1	1
15	Zawa	Athang	Wangdue	3	9
16	Tsendagang	Tsendagang	Dagana	2	3
17	on-station	ARDC,Bajo		3	
<b>Total</b>				<b>35</b>	<b>136</b>

## **Production assorted ornamental plants**

In 2018-19, ARDC Bajo and CRP has produced more than 30000 ornamental plants. 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).

## **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. During the FY 2018-19 total of 4900 bottles (750ml) of mushroom spawn were inoculated and produced. Materials used to produce spawn were wheat grains mixed with saw dust. During this FY the unit has trained 128 heads on mushroom production in the region.

## **RNR Engineering**

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. During the FY 2018-19 the main activities carried out was irrigation channel construction and agriculture infrastructures (handing taking notes).

ARDC Bajo also constructed 88 nos of low cost water harvesting ponds in the FY 2018-19 in the region.

## **Technical Support Services**

### **Plant Protection Unit Highlights**

#### **Rice weed management**

Shochum (*Potamogeton distinctus*), *Monochoria sp.*, and *Echinochloa sp.* are the three major weeds at ARDC Bajo rice field. The experiment was conducted to find a solution on controlling the rice weeds at ARDC Bajo condition. The experimental design was RCBD with three replications over time. Treatments are a) Sunrice, b) Sunrice + Butachlor, c) Butachlor and, d) Control.

The least mean weed biomass was recorded in sunrice applied fields. The highest weed biomass was recorded in control fields. Highest percent (%) weed reduction over control was recorded with 99.88% from Sunrice applied field followed by 98.03% from Butachlor +Sunrice treated field. The least was from Butachlor (single applied) treated field with 12.59%. From the three treatment methods, T3: Sunrice application is the most effective treatment from the experiment.

#### **Rice insect pests survey in Wangdue and Punakha**

A total of 10 rice growing gewogs (five each in Wangdue and Punakha) were randomly selected for the study. Pheromone traps (funnel-type) were used to catch the adult moths during the rice season with regular monitor. Lures used were from PheroChemicals and AmightyBio-organics. Four traps per acre was used for each pest. Target pests were

- a. Yellow stem borer (*Scirpophaga incertulas*)
- b. Paddy swarming caterpillar (*Spodoptera mauritia*)
- c. Rice leaf folder (*Cnaphalocrocis medinalis* Guenée)

### **Efficacy of Fenvelerate 0.4 DP against Red Ant of Potato**

Potato (*Solanum tuberosum* L.) is one of the main cash crops. However, red ant (*Dorylus orientalis*) was repeatedly reported as one of the major constraints for potato production in the west central region. Therefore, to control this pest, ARDC Bajo conducted a trial to evaluate the efficacy of Fenvelerate 0.4DP to control this pest. The trial was conducted at Semona (Village), Goenkha (Chiwog), Phangyul (Gewog) under Wangdue district 2019 potato season. Percent infestation and % reduction over control was calculated. Plot size was 3m x 2m and spacing of 60cm x 40cm was maintained. Recommended practices on fertilizer application, irrigation, and intercultural operations were kept uniform. The trial was laid out in RCBD with four replications. Treatments were; T1 = control and T2 = Fenvelerate 0.4DP @ 1g per hill during tuber formation.

When Fenvelerate 0.4DP was applied at tuber formation at the hill (@ 1g), it effectively controlled the red ants with 95.41 % reduction over control. The marketable yields of the experiment were 7.13 t/ac and 5.72 t/ac for fenvelerate 0.4 DP and control treatments. The net income and MCBR was calculated for the experiment. The net income of Nu.21, 930 per acre was revealed as monetary benefits of Fenvelerate application with MCBR 2.09. Therefore, it can be deduced that application of Fenevelerate 0.4DP during tuber formation @ 1g per hill will significantly reduce the red ant infestation thereby making the potato cultivation profitable.

### **HDPE posts as alternate posts for electric fencing**

Electric fencing has been one of the important tool to solve Human Wildlife Conflict (HWC), especially keeping away vertebrates. The current electric fence system uses wooden posts which needs to be replaced every two-to-three years. A kilometer of electric fence requires some 500 numbers of wooden posts. The constant replacement of wooden posts for the electric fencing is a labour intensive, involves high labour costs and environmentally unsustainable. Therefore, there is a need to find alternate or better posts for the electric fence system. This study aims to evaluate HDPE pipe posts as alternate to wooden posts of the electric fence system. Pungshi, Kana Gewog under Dagona district was identified for HDPE post Electric Fence. Intensity of proneness to depredation by animals and lower economic status of the recipient farmers were considered for the site selection. 2.6 Km HDPE fence was installed. The data on the different activities for electric fence installation was calculated as costs and compared with the costs data collected from Meri, Sephu (Wangdue) using a semi-structured questionnaire during 2016-2017 fiscal year.

Initial costs and maintenance costs were compared for both the systems. The HDPE pipe fence system although environment friendlier, it is very expensive for the marginal farmers. However, this fence system will last more than 50 years and is lot cheaper if all the cumulative costs of the wooden post fence system is calculated.

### **Mango Fruit fly Monitoring**

Mango fruit fly aka the Oriental Fruit Fly (*Bactrocera dorsalis* Hendel) is reported as important pest of mango in different parts of Asia. With minimal information on the pest population during the fruiting season, there was a need to study the population dynamics of this pest for development of the proper plans for control and management. This study was conducted in collaboration with NPPC and Dagana district to monitor the population of the flies.

The study was conducted during 2018 crop season (March to June) at Sunkosh, Tshankha under Dagana District. The elevation of the site is 488 masl and covered 2.5 acre. Five McPhail traps (manufactured by AMITY BIO-ORGANICS) with wooden lure impregnated with Methyl eugenol and insecticides were installed in the mango orchard. Four traps were placed at 4 peripheral points and one at the center of the orchard. Trap height of 1 m above ground surface was maintained. The traps were installed in late March and data collection was carried out every 10 days till harvest. Lures were replaced every 30 days. The flies were present during March in the orchards. The largest trap data was recorded in April month which coincides with the fruiting stage. It decreased in May month and again increased in the June month. However, the data was unreliable due to infestation on the trapped flies by weaver ants where some traps were left empty. Moreover, the study doesn't indicate the time of emergence of the flies. Therefore, the study needs to be carried as year round experiment to know the fly emergence time, and other relevant information for the development of proper control/management strategies.

### **Promotion of IPM Technologies (against pests of Rice, Citrus, Mango, Pear, Cucurbits, and Persimmon)**

**Rice stem borer management using pheromone traps** On-farm activity was demonstrated in Toewang, Dzomi, Kabesa, Baap, Bjena, Daga, Rubesa, Gasel Tshogom, and Uma. (Area: 25 acres on-farm and 10 HHs).

On-station stem borer management was carried out as well (Acreage: 30 ac)

#### **Armyworm monitoring using pheromone traps**

On-farm Sites: Toewang, Dzomi, Kabesa, Baap, Bjena, Daga, Rubesa, Gasel Tshogom, and Uma. (Area: 25 acres on-farm and 10 HHs).

On-station stem borer management was carried out as well (**Acreage: 30 ac**)

#### **Mango, Pear and Persimmon fruit fly control**

Mango fruit fly control at Sunkosh under Tsangkha gewog of Dagana district (**15 acres**)

Mango, Pear and Persimmon fruit fly control at Bajo (**50 acres**)

Citrus Pests: Bordeaux spray or paste application to control lichens and mosses and fungal infections

**Bordeaux paste** : (ratio = 1 kg Copper sulfate: 1 kg Lime : 10 L water) application on cut surfaces after pruning; if the cut surface is bigger than 2 inches and about 1 m height of the trunk; Area covered : **19 acres**

**Bordeaux spray**: (Ratio = 7g Copper sulfate: 7g Lime : 1 L water)

Application Branches and scaffolds and young shoots infected with powdery mildew.

□ Area covered : **19 acres**

- ✓ Kana, Drujeygang, Tsangkha, and Tashidhing under Dagana district (10 acres)
- ✓ Rimchu (Kabesa) under Punakha district (4 acres)

✓ Bai Kuenza (Bongo) under Chukha district (5 acres)

### **Promotion of Super Grain Bags**

Super grain bags which is based on hermetic principle to control grain storage was supplied to Tsangkha, Dagana district for maize and bean seed storage. Total households benefited is 31.

It was also supplied to two households of Bjibjokha, Toewang under Punakha district. The super grain bags were observed used for rice seed and zaw storage. Total household covered for Super Grain Bag promotion is 33. Super grain bags are also used for on-station rice and maize seed storage.

### **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 appropriate 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 purposes. The unit also carries out activities to promote organic farming in the region. Promotion of green manure, composting, vermicomposting, use of organic residue for mulching purpose, bio char, azolla, integrated nutrient management using trench in fruit crops and use of Effective Microorganisms solution were promoted in the region. The EM mother plant with capacity of 2000 liters was established at the Centre. Our Centre has now got the capacity to produce bio char and around 1000 kilograms were produced using rice husks.

The unit also promotes and carries out various SLM activities in the region in collaboration with Dzongkhags and National Soil Services Centre 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 a soil erosion measuring plot is maintained at ARDSC Menchuna. It will help us in building concrete national database regarding soil loss.

Some of the climate smart technologies promoted by the centre in FY 2018-19 are:

➤ **Effective Microorganism Technology**

➤ **Vermicomposting and Vermiculture**

The production and demonstration of earthworm composting is given to farmers when they visit our Centre. Around 100 kg of compost were produced using earthworms. It was used as a potting mix for horticultural crops. The research on the techniques of earthworm multiplication is also ongoing. The earthworm plays an important role in success of vermicomposting.

➤ **Green manure**

The uses of green manure in paddy and fruit orchards are done annually. It helps in addition of organic matters and Nitrogen to the soil. The seed production blocks are also maintained to meet the seeds demands of farmers and other interested clients.

➤ **Bio char**

The technique for production of biological charcoal is also being perfected at the Centre. Till date around 1000 kgs of bio char were produced and is still continued. The technology will be

➤ **Azolla**

The mother block for multiplying azolla has now been established at the Centre

➤ **Mulching Technology**

**Seed Testing for various parameters**

The National Seed Testing and Referral Laboratory at ARDC Bajo 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.