ANNUAL REPORT
2013-14

Renewable Natural Resources Research and Development Center
Bajothang, Wangduephodrang
Department of Agriculture
Ministry of Agriculture and Forests

ROYAL GOVERNMENT OF BHUTAN

Published by:
Renewable Natural Resources Research & Development Centre-Bajothang,
Wangdue Phodrang,
Department of Agriculture
Ministry of Agriculture & Forests,
Royal Government of Bhutan.

Editors:
Mahesh Ghimiray, Cheku and Thinlay Gyamtsho

Suggested Citation:
RNR-RDC Bajo. 2014. **Annual Report 2013-2014**, Department of Agriculture, Ministry of Agriculture and Forests, Wangdue Phodrang

Layout and design:
Thinlay Gyamtsho

For a copy of the report, contact:
Program Director
RNR-RDC, Bajothang
Post Box: 1263
Wangdue Phodrang
Bhutan
Tel: +975-2-481361 Fax: 481311
Email: ybajgai@moaf.gov.bt

FOREWORD

It is a pleasure to publish the 29th Annual Technical Report of RNR RDC Bajo for the financial year 2013-14. The report format follows the earlier format for standardized reporting across RNRRDCs.

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 research carried out in field crops, horticulture, forestry, farming systems and engineering sector. The report also provides highlights of activities implemented at Chimipang Royal Project/Frontline Agriculture Demonstration and Training Centre. Further, the report presents the human resources, financial progress and visitors to the centre in addition to the technical findings.

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. It is believed that 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 as a cyclical process. We continue to build and strengthened 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.

Dr Yadunath Bajgai
Offtg 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 technologies.

This publication highlights the annual research and development work carried out from 1st July till 30th June of the financial year. After Research Centres became Research and Development Centres, equal importance is given to promoting and disseminating proven technologies. Starting last year, we are pleased to report research activities and development activities in separate sections to emphasize their equal importance.

Research component includes mainly varietal evaluation trials of field and horticulture crops. In addition, research activities on soil fertility management and pest (insect, disease, weed) management are important. This report includes work on optimum nutrient management of major crops like rice and wheat. In pest management, work on citrus fruit fly is reported. The development section highlights activities mainly given in the form of support services, including engineering services that the sector provides not only to the Centre but also to a larger RNR familiy. It also includes provision of improved agricultural inputs such as seeds and seedlings of improved varieties, fertilizers and farming tools. 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.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

REASEARCH AND SUPPORT STAFF

SN	Name	Qualification	Position Title
1	Dr. Yadunath Bajgai	PhD in Agriculture	DyCRO/Offtg. PD
		Field Crops Sector	
2	Mahesh Ghimiray	MPhil.Plant Breeding	Rice Specialist
3	Ngawang Chhogyel	MSc. Rice	Sr. Research Officer
4	Sangay Tshewang	MSc. Rural Science	Sr. Research Officer
5	Tshering Wangchen	BSc. Agriculture	Research Officer
6	Cheku Dorji	BSc. Agriculture	Research Officer
7	Legjay	Diploma in Agriculture	Sr.Research Asstt-II
8	Doley	Diploma in Agriculture	Sr.Research Assist-II
9	Lhab Gyem	Diploma in Agriculture	Sr.Research assist-III
10	D.B Rana	Certificate in Agriculture	Research Assist -I
11	Yeshey Dema	Diploma in Agriculture	Research Assist -I
		Horticulture Sector	
12	Jigme	MSc. Horticulture	Dy. Chief Res Officer
13	Kinley Dorji	MSc. Horticulture	Sr. Research Officer
14	Sonam Chophel	BSc. Agriculture	Research Officer
15	Gyeltshen Tshering	BSc. Agriculture	Research Officer
16	Neten Drukpa	BSc. Agriculture	Sr.Research Assistt-III
17	Dawa Delma	Diploma in Agriculture	Sr.Research assistt-III
18	Dawa Drukpa	Certificate in Agriculture	Sr.Research Assistt-III
19	Lungki	Diploma in Agriculture	Sr.Research assistt-III
20	Birkha Bdr. Tamang	Diploma in Agriculture	Research Assistt -I
21	Pasang Dorji	Diploma in Agriculture	Research Assistt -I
		Farming Systems Sector	
22	Tanka Maya Pulami	BSc. Agriculture	Research Officer
23	Karma Dema	Diploma in Agriculture	Sr.Research Assistt-II
24	Yeshi Zangpo	Diploma in Agriculture	Research Assistant -I
25	L.N Sharma	Certificate in Agriculture	Research Assistant-II

		Engineering Sector	
26	Thinley Gyamtsho	MSc. In Natural Resource Mgt.	Principle Res Officer
27	Thinley Gyeltshen	Diploma in Civil Engg.	Dy.Executive Engineer
28	Puran Chhetri	Diploma in Civil Engg.	Assistant Engineer I
29	Indra Bdr.Raika	Electrical Engineering	Technician-I
		RRCO Sector	
30	Singye Phub	MSc. Agriculture	Principle Res Officer
31	Pema Lhamo	Certificate(XII)	Library Asst-III
		Forestry Sector	
32	Purna Bdr. Gurung	BSc. Forestey	Research Officer
33	Kinzang Dorji	Diploma In Forestry	Sr.Research Assistt -III
		Laboratory Sector	
34	Karma Yozer	Certificate in Basic Laboratory	Sr. Lab.Assistant-IV
35	Loday Jamtsho	Certificate	Lab Assitant-II
36	Tshering Yangdon	Certificate in Seed testing	Sr. Lab Assistant-III
		ADTC/Royal Project	
37	Dophu Namgyel	Diploma in Agriculture	Sr.Research Assist. -III
38	Tshering Dorji	Diploma in Agriculture	Research Assistant -II
39	Dorji Khandu	Diploma in Agriculture	Research Assistant -II
		Administration Sector	
40	Dawa Zangpo	Diploma in VSc & AH	Sr. ADM.Officer
41	Tenzin	Diploma in Finance Mgt.	Accounts Assistant-II
42	Sangay Gyeltshen	Certificate in Store Mgt.	Sr.Store Keepeer
43	Thinley Norbu	Diploma in Information Mgt.	Sr.ICT-III
44	Lhamo	Certificate(XII)	Adm Assistant-III
45	Gyem Lham	Certificate(XII)	Sr.Despatcher
46	Ugyen Tashi	Certificate in Driving	Driver- I
47	Nidup	Certificate in Driving	Driver- I
48	Tenzin Loday	Certificate in Driving	Driver- I
49	Mon Bdr. Rai	Certificate in Driving	Driver- I
50	Deo Raj Pradhan	Certificate in Driving	Driver- II
51	Dorji Choden	Certificate (X)	PABX Operator

52	Bago	Certificate (VI)	Messanger
53	Bikash Rai	Certificate in Driving	Tractor Driver
54	Nedup	Certificate in Driving	Tractor Driver
55	Farm Attendants (Bajo)		34 numbers
56	Farm Attendants (Chimipang)		30 numbers
57	Night Guard		1 number

EXECUTIVE SUMMARY

Field Crops

The main objective of implementing the Field Crops research is to increase the productivity of different cereals, oilseeds and pulses. Research and Development works were equally emphasized both on station and on farm. The center continued to evaluate elite lines and commercial varieties received through international research institutes. About 58 varieties of rice underwent various stages of evaluation. Assessment of green super rice materials received from IRRI was an area of interest since the varieties are said to perform well with limited inputs. We are still pursuing the validation of SRI technology and will continue even in the coming years. The center over the years played a crucial role in coordination and implementation of rice commercialization program.

Evaluation of high yielding varieties of wheat started gaining momentum with good number of materials received from ICARDA, CIMMYT regional office based in Nepal and CIMMYT Mexico. Seed production of promising varieties of wheat was taken as a parallel activity to the evaluation trial of various materials which will further be up-scaled in the ensuing season.

Two extra early maize varieties were promoted to the farmers of Toeb geog in order to capitalize on the blooming roadside market along the highway. Seed production of these two varieties along with Yangtsipa was carried out. The materials of pulses that were received through the pulse shuttle breeding project completed the advanced evaluation phase. Hence promising varieties that were selected were promoted in selected areas of Tsirang and Dagana. Small scale seed production of these pulses was carried out on station. Along with the seed production of BSA and PT 30, Indian mustard lines were tested. Field crops research will continue to find high yielding varieties and agronomic practices that suit our farm conditions.

Horticulture

The core objective of horticulture crops research is to improve rural livelihood and also to achieve vegetable and fruit self sufficiency in the region and at the national level. The research activities of the horticulture sector include crop management technology, post-harvest practices,

improved seeds, plant propagation techniques and maintenance of mother plants and breeder seeds of released crops besides varietal evaluation. The sector also focuses on broadening the genetic base of the prioritized horticultural crops through either introduction or selection from local diversity. The on-station research comprises of research on fruits and nuts, vegetables, and medicinal and aromatic plants at both Bajo and sub-station Tsirang.

The horticulture sector also gives equal importance to outreach programs wherein demonstration of superior varieties over the existing ones and alternative cash crops options are implemented based on location specific farming systems in collaboration with extension officials. Furthermore, the sector provides technical support to the farmers and also carries out capacity development of farmers and extension agents.

Farming Systems

Farming System Sector consists of three research programs on Soils, IPM, and Agriculture economics. The sector gears towards studying the existing farming systems, planning and evaluating the process and generation of appropriate technologies involving the technology users, the rural farmers. This is vital as the decision to introduce changes or adopt any innovation depends entirely on how a household assesses the relative advantages and disadvantages in terms of its own perceptions and priorities. Because of these considerations, we have adopted a problem-oriented and farmer-centered approach.

During 2013-14, the soils research and development focus was on developing strategies to improve land productivity mainly through improving farmers' soil fertility management practices and through promoting sustainable land management practices. The program serves as an interface between research-extension and farmers and demonstrates different land and soil fertility management technologies. Similarly, the IPM research unit catered mainly to the insect, pest and disease issues in the important crops such as rice, citrus and mango in the region. The unit also participated in the wheat rust survey conducted during the month of April and May, 2013 along with the NPPC team and the scientists from the International Maize and Wheat Improvement Center (CIMMYT). In order to update and upgrade the knowledge and skills of the farmers, farmers training were also conducted on IPM on major pests/diseases of

major crops like rice, wheat, mustard and citrus under Punakha and Dagana dzongkhag.

Under the agriculture economics research program, during, research and development focus was on organic farming through research out-reach program site at Gasa. Commercial vegetable production, mustard production, pear, asparagus, garlic and potato production and marketing programs were the main activities implemented. SRI Rice economics study has been carried out by the unit. Irrigation channel construction feasibility studies, renovation and new construction of channels are the main activities under water management program.

Forestry

The activities of the Forest Research Program include management of on-station multipurpose tree species (MPTS) nursery and solving the on-farm regional needs of the client farmers. Owing to limited staff in the sector, the activities undertaken were very few, namely the management of the MPTS nursery and *in situ* resource sustainability assessment-documentation of people's perception about Jala Yangka (a bamboo under Genus *Yushania*). The sector continued evaluation of species in the nursery and seedlings produced were distributed to schools and institutions. The sector also carried out plantations at Chimipang with avenue species for developing a recreational area below the *Lhakhang*. The findings from the *in situ* resource sustainability assessment and documentation of the people's perceptions about Jala Yangka are summarized in this report.

FIELD CROPS RESEARCH

1 FIELD CROPS

1.1 Rice

1.1.1 Advance Evaluation Trial

In advanced evaluation trial, 9 entries including a standard check (Bajo Kaap 2) were assessed for grain yield, medium growth duration (140-150 days), medium stature (90-100 cm) and disease (s) resistance. The entries are the selections from the previous season's trial. The trial was laid out in a RCB design with three replications. Twenty five days aged seedlings were transplanted in an area of 10 m^2 with a spacing of 20 cm x 20 cm. Chemical fertilizer of 70:40:20 NPK kg ha^{-1} was used with half of N, and whole P and K applied as basal dose. The other half N was top-dressed at panicle initiation. The sources for N, P and K were urea, single super phosphate (P_2O_5) and muriate of potash (MoP) respectively. Butachlor 5G was applied at 1.5 kg a.i ha^{-1} three days after transplanting which controlled mostly the grassy weeds. Other broadleaved weeds such as pondweed (*Potamageton distinctus*), monochoria (*Monochoria vaginalis*) were managed through mechanical method of hand pulling. Irrigation was provided when needed. There was no incidence of diseases occurrence or pests infestations, and hence did not apply any plant protection measures. At maturity, crop was harvested from an area of 5.04 m^2, and grain moisture standardized at 14%. Results are in Table 1.

Table 1: Agronomic traits of different rice entries in Advance Evaluation Trial

Entries	50% flowering days	No of tillers $hill^{-1}$	Plant height (cm)	Grain yield (t ha^{-1})
CT16658-4-1-15R-	126	9.2	96.3	4.02
OMCS 2009	115	11.3	87.3	4.95
IR 71701-28-1-4	129	12	91	4.95
IR 75288-144-1-3	131	12	90	4.95
IR72	127	15	76	5.01
GANZAOXIAN 49	128	11.3	89	5.02
IR 80905-50-1-3-2	124	10	96	5.02
YN 3109-23-1-2	129	11	92.6	4.17
BAJO KAAP 2	128	10	95.3	5.51

1.1.2 Initial Evaluation Trial

A total of 15 lines including a standard check (Bajo Kaap 2) were tested under this study. The lines were the selections from the observation nursery of 2012 season, and as with other trials intend to identify promising lines with higher grain yield, medium growth duration, medium height, and resistance to pests and diseases. Trial was laid out in a RCB design with 3 replications. Fertilizer application, weed management and other agronomic practices were same as that of Advanced Evaluation Trial. At maturity, crop was harvested from an area of 5.04 m^2, and grain moisture standardized at 14%.

Majority of the entries had the same maturity period with standard check though their plant heights were shorter than Bajo Kaap 2 (Table 2). None of the new lines produced grain yield higher than the check. However, five entries possessing the similar agronomic traits and yield potential to standard check were selected to evaluate in Advanced Evaluation Trial in 2014 season.

Table 2 : Agronomic traits of different rice entries in Initial Evaluation Trial

Entries	50% flw Days	No of tillers $hill^{-1}$	Plant height (cm)	Grain yield (t ha^{-1})
3147728	109	11	84	1.71
3147732	116	9	94	4.25
3147733	108	8	74	2.36
3147735	109	8	94	2.55
3147737	112	12	65	2.41
3147738	114	8	82	3.66
3147739	116	9	79	3.75
3147740	111	10	83	3.00
3147741	116	8	81	2.04
3147742	110	12	83	4.43
BK -2	128	9	85	5.39

1.1.3 Rice Observation Nursery

A total of 20 lines were evaluated for various agronomic traits such as yield, maturity days, pest and disease resistance and plant height. The design was a single observation plot of 10 m^2 with the spacing of 20 cm x 20 cm. All the nutrient and other agronomic management practices were followed as similar to other trials.

Of the 20 lines, only 8 were promoted for further evaluation based on the desirable agronomic characters. The rejected lines were very tall in height and susceptible to lodging indicating their inferiority in our Bhutanese farming system particularly in the mid altitude regions.

Table 3: Agronomic traits of different entries in observation trial

Entries	50%Flw days	Plant height	Tillers/hill	Grain Yield t ha^{-1}
Wanxian 7777	124	94	11	5.1
Tme 80518	134	83	11	5.1
P 35	127	89	10	5
HUA 564	135	104	7	5
HUA 565	127	86	10	5.2
Huanghuazhan	126	81	11	5.4
SAG 64	129	83	11	5.2
Zhonghua 1	128	81	11	3.2
Weed tolerant rice	124	88	11	6.3
RC8	130	92	10	6
D4098	130	87	12	5.4
IR 84678-25-5-13	129	85	9	5.3
HHZ 5-sal-10-DT1-Dt	127	88	12	6.1
HHA-5-sal-10-DT2-Dt	125	87	13	7.1
HAH-17-Dt6sal3-Dt	130	82	13	8
IR 64	127	87	13	6.5
SAG-05	136	91	12	5.1

6S27	133	87	15	5.2
PSBRC 18	133	90	10	4.4
Nabja	160	123	15	4.5

1.1.4 Observation of SRI

The system of rice intensification (SRI) which is guided by a set of agronomic principle (transplanting young seedlings of 8–12 days old, transplanting single seedling hill^{-1}, wide spacing, intermittent wetting and drying of soil during vegetative stage) was tested in the on station. The main objective of the study was to showcase the visitors particularly the farmers about the field situation and reality of this rice cultivation system.

The trial was laid out in a single large observation plot. An improved rice variety IR 64 was tested. The agronomic management practices as recommended in the SRI protocol were followed to the best possibility. At maturity, different agronomic traits such as effective tillers, plant height and grain yield were measured.

Nabja, a local cultivar, is a low yielder and taller while other varieties are improved with shorter plant heights. However, the study had several limitations such as lack of conventional system for comparison, and lack of irrigation water control due to seepage from the newly constructed canals. Due to improper water management, pondweed incidence was severe, and this could possibly have affected the yield as the grain yield was low.

Table 4: Agronomic traits of different rice varieties under SRI

Variety	No of tillers Per hill	P height (cm)	Grain yield (t ha^{-1})
Bajo Kaap 1	17	95	4.00
IR 64 (SRI)	15	82	6.31
IR 64 (Non SRI)	14	83	5.25
Nabja	14	135	2.60

1.1.5 Demonstration of released varieties

The centre entertained number of visitors such as farmers, students and extension staff who came on an educational visit. The visitors were showcased and explained with the physical characteristics of released rice varieties through demonstration plot. Improved varieties of different agro-ecological zone were established as in Table 5. The design was a single large plot, and received the same management practices as that of other trials.

Table 5: List of released rice varieties for demonstration

Variety	Recommended agro ecology	
	Altitude (m)	Crop
IR 64	600-1500	Main single
Bajo Kaap 1	600-1500	Main single
Bajo Kaap 2	600-1500	Main single
Bajo Maap 1	600-1500	Main single
Bajo Maap 2	600-1500	Main single
IR 20913	600-1500	Second double
Wengkhar Rey Kaap 2	600-1500	Main single
Khangma Maap	Above 1500	Main single
Kamja	Up to 600	Main single
Karjat	Up to 600	Main single
Guojing 4	600-1500	Main single

1.1.6 Seed production and maintenance of released varieties

The centre maintained basic seeds of both released and pipeline varieties in the station. These seeds are used for various on station and on farm trials particularly for production evaluation and demonstration in the new sites. The seed stock also served the ad hoc request from extension. In 2010 season, a total of 7301 kgs of rice were produced and maintained (Table 6). From this harvest, a total of 5172 kgs were distributed to extension for production evaluation (Table 7).

Table 6: List of rice varieties with quantity of seed produced

Variety	Status	Quantity (kg)
IR 64	Released variety	1600
Bajo Kaap I	Released variety	630
Bajo Kaap II	Released variety	450
Bajo Maap I	Released variety	1300
Bajo Maap II	Released variety	1000
IR 20913	Released variety	210
Khangma Maap	Released variety	311
Wengkhar Ray Kaap 1	Released variety	200
Wengkhar Ray Kaap 2	Released variety	245
No 11	Released variety	275
IR 28	Pipeline variety	350
B2983B	Pipeline variety	330
BP176	Pipeline variety	400
Total		**7301**

Table 7: List of rice varieties with quantity of seed distributed

Variety	Quantity (kg)
IR 64	1188
Bajo Kaap I	468
Bajo Kaap II	298
Bajo Maap I	1215
Bajo Maap II	210
IR 20913	140
Khangma Maap	239
IR28	315
Wengkhar Ray Kaap 1	200
Wengkhar Ray Kaap 2	245
B2983B	140
BP 1767	239
NO 11	275
Total	**5172**

1.1.7 On-farm evaluation of Mid-altitude rice varieties

In continuation to the previous year's production evaluation trial, two mid-altitude rice varieties namely IR28 and BP176 were further evaluated in 2013 to ascertain their adaptability and yield performance in the mid altitude rice growing regions. Two sites each in Punakha and Wangdue Dzongkhag under Kabesa and Rupesa Geog respectively were used. The trial was laid out in a single large plot without any randomization. All

management practices were done as per farmers management practices. The monitoring and data recording were done jointly by extension agent and researchers.

Crop cut was taken from an area of $6m^2$ during the harvest time to measure the yield. IR 28 yielded the highest with the mean yield of 6.19 t ha^{-1} and it is preferred by the farmers. The other variety were also equally doing well and there has been a good demand of seeds for those new varieties and more and more farmers will be covered in the coming season.

Table 8: Performance of mid altitude on- farm rice trial

Variety	Location	Plant height (cm)	Tillers /hill	Yield (t/ha)
IR 28	Wangdue	96.66	9.33	7.21
BP176	Wangdue	102.66	8.0	4.81
IR28	Punakha	100	14.6	5.37
BP176	Punakha	96	9.66	5.88
IR 28	On-station	96	17	6.01
BP176	On-station	104	11	5.67

1.1.8 Production Evaluation Trial of improved rice varieties in Tsirang

The main objective of this activity was to increase the rice productivity through introduction of adaptability and high yielding rice varieties. Additional aim was also to widen the genetic diversity as narrow genetic base is undesirable from biodiversity perspective. Three improved rice cultivars along with their dominant local checks were evaluated at Pemashong, Mindrelgang during 2013 cropping season. Pemashong lies at an elevation of 1000 masl, and the tested varieties were ideally recommended for this altitude range.

The agronomic management practices provided to crops were entirely of existing farmers' practices. The research and extension only provided necessary technical support. The crops did not record any pests or diseases in any of its growth stage. The recommended rate of inorganic fertilizers was suggested, owing to more responsiveness from improved cultivars, but farmer did not apply due to various circumstances.

A field day was organized during the harvest time where both the co-operating and non beneficiary farmers participated for the selection. Bhur

Rey Kaap 2 was unanimously selected as the best variety, and crop cut result also confirm the yield difference (Table 9). With the yield benefits that this improved variety provides, farmers would like to continue cultivating in the ensuing seasons. The non-cooperative farmers after the field day asked for seed support in the 2014 cropping season, and hence were supported with 40 kgs of Bhur Rey Kaap 2 seed.

Table 9: Grain yield of improved and local rice cultivars at Pemashong, Tsirang

Variety	Grain yield (t ha^{-1})
Bajo Kaap 2	4.0
Bhur Rey Kaap 2	5.4
IR 64	4.1
Attey (Local)	3.5
Choti (Local)	3.1

1.1.9 Production Evaluation Trial of improved rice varieties in Dagana

This activity is in continuation of the previous season which was implemented as part of the Biodiversity Use and Conservation in Asia Program (BUCAP) project at Drujeygang, Dagana. As farmers in the locality had more preference towards red variety, another improved red variety, Bajo Map II was added to the Participatory Varietal Selection list. All the management practices were carried out by the farmers in participatory approach within the given project norms.

During the harvest time, farmers selected their best variety participatory. Their main criteria of selection were high yield, biomass and disease resistant. Being the highest yielder, Bajo Maap II was selected by the farmers (Table 10). Farmers were supported with additional seed, and the crop performance will be monitored during the successive season.

Table 10: Grain yield of improved and local rice cultivars at Drujeygang, Dagana

Variety	Grain yield (t ha^{-1})
Bajo Maap 1	3.3
Bajo Maap 2	3.6
Attey (Local)	2.9

1.2 Maize Research (On-station)

1.2.1 Seed Production and Maintenance of released varieties

The sector has carried out the seed production and maintained sufficient quantities of maize seeds for future use. The table below shows the varieties of maize produced during the fiscal year 2013-2014.

Table 11: Quantity of maize seed produced in 2013-14

Variety	Quantity (kg)
Yangtsipa	250
Khangma Ashom 1	150
Pop Corn	3
Sweet Corn	30
Arun 2	90
Arun 4	65
Total	588

1.2.2 Community based seed production of released cultivars

The main activity in maize research and development was the technical backstopping to the community based seed production groups in Tsirang and Dagana. Four groups (two in each Dzongkhag) were formed to produce quality maize seed production of recently released maize varieties, Chaskarpa Ashom and Shafangma Ashom. If this expectation is to be realized, technical support has to be rendered to these groups consistently, at least for three cropping seasons.

The 2013 crop season also recorded greater emphasis on technical enhancement of the seed growers. Farmers of all the groups were imparted on improved agronomic management practices from sowing till post harvest management. To express full genetic potential, farmers were sensitized and recommended of fertilizer usage including the dosage, especially urea. The following quantities of seed were produced which were promoted in newer and disease affected areas in Tsirang and Dagana (Table 12).

Table 12: Maize grain yield and seed quantity in 2013 season

Dzongkhag	Site	Variety	Grain Yield (t ha^{-1}) *	Quantity of seed produced (kg)
Tsirang	Dunglagang	Chaskarpa Ashom	2.98	1665
		Local	1.93	
	Gagaling	Chaskarpa Ashom	3.40	500
		Local	2.75	
Dagana	Tsangkha	Entry # 33	3.30	1000
		Local	2.35	
	Shamdolay	Chaskarpa Ashom	3.0	1000
		Local	2.0	

*****Means are average of 3 samples

1.2.3 Production Evaluation Trial of new maize variety

The main aim of this activity was to evaluate the performance of new maize variety at Barshong, Tsirang in terms of yield and disease resistance. Maize farmers of the locality reported a significant loss of crop yield to fungal diseases annually. Since the study was an observatory one, trial was laid out in a non randomized plot. To avoid varietal contamination through crossing, distance isolation of 300 m was suggested but was not practical to follow in the farmer's field. However, crop cut were taken from the representative plots which are generally located in the middle of the field.

The crop cut result showed a yield advantage of improved varieties when compared to local (Table 13). The disease resistant trait of improved cultivar could have attributed to this yield difference as local variety was susceptible to fungal disease, GLS. The farmer also appreciated its agronomic characters, and hence would continue growing this new variety in the ensuing season (s).

Table 13: Maize grain yield at Barshong in 2013 season

Variety	Grain Yield (t ha^{-1}) *
Chaskarpa Ashom	1.91
Local	1.45

* Means are average of 3 samples

1.3 Wheat Research

1.3.1 Initial Evaluation of elite spring wheat lines under maize-based system

The purpose of this activity was to assess the suitability of elite genotypes under maize based system. In this system, the crop is entirely grown under rain-fed conditions in dry land without any supplementary irrigation. If the overall wheat production has to increase, this ecosystem has a great potential owing to huge area under maize.

Three lines from International Maize and Wheat Improvement Center (CIMMYT), and five lines from Nepal were evaluated at Tsirang on station in a large observation plot. Sowing was done soon after maize harvesting which happened to be last week of September. No irrigations were provided, and crops survived on soil residual moisture. The crop matured in late February, which provided adequate time for land preparation for maize planting.

A field day was conducted during harvest time with participation from nearby maize farmers. The participants on evaluating the overall crop performance promoted three best lines from eight lines for further on farm evaluations (Table 14). Farmers expressed their interest for wheat under this system as it is easy to cultivate without requiring irrigation or additional investments. In the ensuing season, a parallel seed production and on-farm evaluations of these selected lines are planned.

Table 14: Grain yield of three besting performing wheat lines in 2013-2014

Line	Plant height (cm)	Grain Yield (t ha^{-1})
BL3235	105	3.2
NL 1073	106	2.9
BL3503	106	2.6

1.3.2 Participatory Varietal Selection cum Advanced Evaluation of 32nd Elite Spring Wheat Yield Trial (ESWYT)

The selected lines from previous season were further tested in a large non randomized block to ascertain their performance before promoting to on-farm evaluation. The crop was nourished with 80:40:30 N: P_2O_5: K_2O kg ha^{-1}, respectively with urea as a source for nitrogen, SSP for phosphorus and MoP for potassium. 50% of N and full dose of P and K were applied as basal during final land preparation, while the remaining N was applied at maximum tillering stage, a month and half after planting. The crop received four irrigations during its entire crop period, and hand weeding were done when required.

At maturity, the selections were done jointly with researchers and extension officials. The varieties were examined for yield potential, maturity, height, and spike length. Of the six lines, four fulfilled the above selection criteria (ESWYT 104, ESWYT 125, ESWYT 130 and ESWYT 133), and hence were promoted for seed multiplication program in the successive season.

1.3.3 Production Evaluation Trial of two improved spring wheat varieties

The two spring wheat varieties advanced from on-station trials were evaluated in multi-locations in 2013 season. The main objective of this was to gather comprehensive and reliable crop performance data before varietal notification is proposed and mass commercialization program is organized.

The crops were raised under farmers' management practices. Majority of the farmers reported of top dressing urea at 50 kg N ha^{-1} at two months after planting which is desirable in stimulating the yield production. The crop cut result showed a great yield difference between the new varieties, and existing Sonalika (Table 15) in all the trial sites.

Table 15 Grain yield of new wheat lines and Sonalika across sites in 2013-2014

Dzongkhag	Site	Line/Variety	Yield (t ha^{-1})	Remarks
	Phongme	BSBW2013B	4.0	
Trashigang		BSBW2013A	3.3	
		Sonalika	2.2	Crop affected by yellow rust
	Thangu	BSBW2013A	2.3	
Wangdue	Thangu	BSBW2013B	3.0	
	Wangjukha	BSBW2013A	2.3	
	Thangu	Sonalika	0.7	Crop affected by yellow rust
	Bap	BSBW2013A	1.9	
		Sonalika	1.3	Crop affected by yellow rust
Punakha				
	Guma	BSBW2013A	2.5	
		Sonalika	1.4	Crop affected by yellow rust
	Lower Bara	BSBW2013B	3.0	
		BSBW2013A	2.6	
Samtse		Sonalika	2.1	Crop affected by yellow rust
	Karmaling	BSBW2013B	3.1	
		BSBW2013A	2.4	
		Sonalika	1.9	Crop affected by yellow rust
Trongsa	Korphu	BSBW2013B	2.5	
		BSBW2013A	3.0	

1.3.4 Disease survey and surveillance

To monitor the wheat rusts situation, surveys were conducted in April – June, 2014 using the standard BGRI survey methodology. Wheat growing districts of west (Paro, Haa, Punakha and Wangdue), central (Bumthang), south central (Tsirang and Dagana) and eastern (Trashigang) were covered during the period. In total, 27 sites were covered which is an appreciable representation of the rusts scenario in Bhutan.


Figure 1a: Infected Sonalika variety

Yellow rust was the main disease spotted in most of the surveyed areas. Of the 27 sites surveyed, 11 sites were found to be infected by yellow rust. In Wangdue and Punakha districts where Sonalika is widely grown, yellow rust was found to be severe with incidence showing even up to 50S (Figure 1a). On the other hand, the two newly introduced materials from CIMMYT (Bajoka2013A and Bajoka2013B) exhibited resistance to yellow rust (Figure 1b).


Figure 1b: Healthy Bajoka2013A

Leaf rust, as in previous years, was the second most prevalent disease. However, the incidence was lower than the yellow rust. Leaf rust was observed to be prevalent in warmer wheat growing areas of Punakha, Wangdue, Tsirang and Dagana. Bajoka2013A and Bajoka2013B here too showed resistance to brown rust. The incidence of stem rust was not

observed in any of the surveyed site. This concurs with the findings of previous reports.

The recurrent problem of yellow and leaf rusts in Bhutan provides an opportunity to fast track the commercialization and promotion of resistant cultivars to replace the susceptible variety, Sonalika. This will not only avert rust epidemic in the country, but also will play an important role in rust management in the whole South Asia region. A remarkable progress has been made towards this varietal improvement to displace the obsolete cultivar.

HORTICULTURE RESEARCH

2 HORTICULTURE

2.1 Fruits and nuts

2.1.1 Pecan nut variety evaluation trial

Five pecan nut cultivars were introduced from Australia (Desirable, Cheyenne, Wichita, Kiowa and Western Shelley) in the year 2002 with the objective to assess and select suitable cultivars for mid altitude region. Two plants per variety were planted with spacing of 3m x 3m between plant and rows. The trees were trained into modified centre leader system. Weeding, basin preparation and mulching are carried out in February-March every year and manure and fertilizer application are also carried out during this period. The fields are irrigated regularly, on an average of once per month, during the dry months which stretch from December till May in Bajo.

Table 16: Morphological characteristics of four pecan nut cultivars

Cultivars	Tree appearance	Bloom time	Leafing	Harvest time
Wichita	Vigorous	April	April	October
Western Shelly	Vigorous	April	April	October
Kiowa	Vigorous	April	April	October
Desirable	Vigorous	April	April	October

No major pest and disease were observed except for minor incidence of trunk borer during the initials years. However, severe incidence of twig borer and the scab occurred in 2009 and insecticides were applied. Cypermethrin was very effective in control of twig borer while scab was managed with other chemicals. In the same year, there was severe incidence of trunk borer too and consequently there was drop in the yield. Since then, we have been spraying insecticides on schedule basis to prevent such incidence every year. The trees of Cheyenne variety have died as a result of pest, mainly trunk borer, and could not be replaced.

The growths of all the remaining varieties are vigorous and the trees are healthy. Wichita and Desirable started to bear fruits from the third year while the rest did so from the fourth year. The performance parameters recorded are on vegetative growth, yield, nut and kernel qualities, shell thickness, nut size and weight, and pest and diseases incidences.

In September the trees are mechanically shaken and the nuts picked up from each tree by hand. Twenty nuts are taken from each tree to determine nuts weight and they are measured for size (length and diameter). These nuts are then shelled to determine kernel percentages and the kernels are inspected for quality. In terms of nut size, Kiowa has the biggest nuts followed by Western Shelly (medium size) and Wichita has the smallest nuts among these varieties. In terms of yield, Wichita produced the highest yield followed by Western Shelly with Desirable giving the lowest yield. The details are mentioned in Table 17.

Table 17: Nut characteristics, yield and quality of pecan nut cultivars

		Wt.	Dia.	Length	Percent	Yield (kg tree^{-1})			
Cultivars	Shape	(gm)	(Cm)	(cm)	kernal	2009	2010	2011	2013
Wichita	Oblong	6.2	1.8	3.3	57	0.3	0.9	1.4	3.75
Western Shelly	Oblong	7.6	2.2	3.7	58	1.2	1.2	1.2	3.80
Kiowa	Oblong	8.9	2.6	4.9	55	Nil	0		1.40
Desirable	Oblong	6.4	2.1	3.1	54	0.65	0.6	1.2	0.95

The trees have not yet reached their yield potential but the yield is increasing year by year. However, all the four varieties are found promising and producing standard yield. All varieties have demonstrated vigorous physical growth which is one of the indications that it is favorable in Bajo climatic condition. The nuts are also of good quality with kernel percent ranging from 58% of Western Shelly to 54% of Desirable which are similar to that of nuts grown in other countries. The kernels are all golden brown in color.

Figure 2a: Western Shelly

Figure 2b: Wichita

Figure 2c: Kiowa

Figure 2d: Desirable

2.1.2 Persimmon varietal evaluation trial

The persimmon variety trial was established in the year 2003. The objective of the trial was to identify suitable non-astringent varieties and provide alternative variety option to the persimmon growers. The single plot design was adopted for the trial layout with three plants for each treatment with planting distance of 4mx 4m. No systematic pruning was practiced and only the removal of dead wood and thinning of overcrowded and misshapen branches were carried out as and when required. No irrigation was provided during the rainy season but during the dry season, particularly in the winter and spring or at the time of flowering, irrigation

was provided. Weeding was done when required and basin preparation was done twice i.e. once in spring and another in autumn after crop harvest. FYM application and mulching was carried out right after harvest. Chemical fertilizer of varying dosage in accordance with the age of the tree was applied in the spring prior to flowering. Top-dressing of nitrogen fertilizer was carried out in autumn, after crop harvest.

Table 18: Morphological characteristics of five persimmon cultivars

Cultivar	Tree appearance	Bloom time	Leafing	Harvest time
Fuyu	Spreading	May	End March	Mid September
Jiro	Spreading	April	Early March	Mid September
Z- Maru	Spreading	May	March	--
Hanagosho	Spreading	April	April	Mid September

Performance parameters like vegetative growth, precocity, cropping habit, fruit quality, yield, and pests and diseases incidences were also studied (Tables 18 and 19). Under Bajo climatic condition, the plant growth is slow and stunted. The climatic factors and the soil condition may be the reason for slow growth of the plants. Two persimmon cultivars, viz. Fuyu and Jiro had started bearing fruit by 2007 and Hanagosho started to produce fruits from 2009 while Z-Maru has not yet fruited. Three varieties- Fuyu, Jiro and Hanagosho have orange flesh color, are non-astringent or table type varieties with smooth pericarp texture. We have not observed major pest and diseases as of now, except for damage from birds and wasps at the time of fruit maturity. However, this is easily prevented by covering the trees with nets in right time.

Table 19: Fruit characteristics and quality of persimmon cultivars

Variety	Shape	Fruit wt.	Dia	Length	Yield (kg tree -1)				
		(gm)	cm	Cm	2009	2010	2011	2012	2013
Fuyu	Flat	150	7.01	4.50	4.00	2.8	8.5	11.7	12
Jiro	Flat	125	6.9	4.60	0.65	4.6	8.0	9.0	9
Z-Maru	--	--	--	--	--	--	--	--	
Hanagosho	Flat	250	5	3.75	0	2.6	4	11	11

Fuyu, Jiro and Hanagosho varieties have already been released while Zenji Maru has been put up for release by other centres where parallel research is being carried out. After the release of Zenji Maru, the trial block will be maintained as the mother block for promotion in the field through NSC and other promotional program.

2.1.3 Citrus varietal evaluation trial

The citrus yield in Bhutan is far below the international average as the yield of local mandarin is quite low when compared with other citrus types. Although low yield could be attributed to existing poor management, the varietal factor also plays an important role as most of the citrus such as sweet orange varieties and Pummello gives higher yield than the mandarin groups. Therefore, identifying citrus types specific for both table/ or fresh fruit and for processing function would not only diversify citrus fruit basket but also help to increase yield and production.

The citrus varietal trial was established in the year 2008 with 12 varieties (Otha Ponken, Teshu Ponken, Freemont, Washington Naval, Clementine, Valencia, Mineola, Fortune, Tsennucarddi, Hayaka, Kinnow and Local mandarin). Similar trial has also been set up in RDSC Tsirang for parallel evaluation. The varieties started bearing fruits from the year 2011. The parameters like yield, fruit weight, and fruit size and quality of the fruits harvested during last season i.e. 2013 were assessed as shown in Table 20.

Table 20: Fruit characteristics and quality of citrus cultivars

Variety	Length (cm)	Diameter (cm)	Brix %	Seeds (No)	Weight (g)	Locule (No)	Peel thickness (mm)
Fremont	5.71	6.23	12.03	13.07	120.73	12.40	1.3
Hayaka	6.40	7.64	8.75	16.10	211.40	10.90	1
Minola	7.98	7.63	9.93	20.00	240.60	12.40	3
Tshonokadari	6.48	7.19	10.41	17.80	170.60	12.90	1
Clementine	6.69	7.71	12.00	13.70	191.80	11.30	2
Othaponkan	8.88	8.64	10.16	10.20	265.00	8.60	1
Fortune	4.74	6.02	11.40	5.60	100.98	11.80	1
Valencia	6.18	6.26	10.75	5.50	284.30	11.30	3

Since planting, a few trees have been affected by pest and disease which has resulted in low yield which is not significant fruit for evaluation. From each tree, a total of ten fruits were collected for determining the fruit weight, size and quality.

Clementine and Mineola produced good yield and it will be assessed in the coming season (2014) as few plants or varieties have yet to bear fruits. Fremont was found susceptible to red scales and sooty mould. Minor

incidence of citrus trunk borer (*Anoplophora versteegi*) was also observed. The flowering was uniform for all the mandarin varieties (March) except for Clementine (late March to early April). Othaponkan matured earlier to all other varieties. However, it had relatively low juice content and the total soluble solids (TSS) content was just 10.16 (Brix %). Fremont and Clementine varieties demonstrated the highest TSS values with 12.03% (Brix) and 12 % respectively. TSS is directly related with the sweetness and more the TSS, more sweet the variety. In terms of fruit weight, Valencia had the largest fruit with average fruit weight of 284 g and the smallest fruit was of Tshonokadari with average fruit weight of 170g. However, all the fruits were of standard size that is preferred by the customers. Developing of seedless variety is also one of the priority breeding objectives in citrus. Valencia had the lowest number of seeds with only about 5.5 seeds per fruit (average) while Minola had the highest with 20 seeds per fruit. The evaluation of these citrus varieties will be continued for another few years till it attends the economic potential yield.

Figure 3: Differebt varieties of citrus under evaluation

2.2 Vegetable Research

2.2.1 Evaluation of high β-carotene tomato lines

The demand for safer and more nutritive food is increasing year by year. β-carotene is associated with many health benefits including antioxidant functions and cardio-vascular health. Six tomato lines (CLN2070A, CLN2071C, CLN2366A, CLN2366B, CLN2366C and CLN1314G) having high beta-carotene content were provided in 2010 to the centre by Asian Vegetable Research and Development Center (AVDRC) in Taiwan. The evaluation of these lines started in May, 2011 with the objective to evaluate mainly yield and other characteristics like fruit size and weight and to subsequently promote the promising lines.

The seeds were sown in nursery in May which was ready for transplantation in June A local check (Rattan) was included and laid out in RCB design with three replications. Each plot contained 20 plants. The data was collected for total yield, average fruit weight, fruit length and fruit diameter. As shown in the table, the fruit weights of all the lines are statistically similar to that of the check except for CLN2070A (32g). This line is very small (cherry size) though the total yield is very high. Rest of the lines have literally similar weight to that of check (67.3g). In terms of yield, there was decline in 2014 because of late blight incidence. However, the relative yield trend among the lines has more or less remained the same. In both the years i.e. 2013 and 2014, the line CLN2070A gave the highest yield and is the year 2014, its yield (14.7 T/ha) is statistically different from other varieties except with the line CLN2366B (11.1T/ha) ($P<0.001$). The control Roma gave the lowest yield (6.5T/ha) in 2014.

Table 21: Yield and other fruit characteristics

Variety	Fruit length (cm)	Fruit width (cm)	Weight (gm)	Yield (T/ha)	
				2013	2014
CLN2070A	3.1ab	2.4a	32.0a	24.93a	14.7b
CLN2366A	3.8b	3.9c	68.6b	18.66a	7.0a
CLN2366B	5.0c	3.8c	65.0b	23.26a	11.1ab
CLN2366C	3.6b	4.2c	64.3b	22.36a	9.4a
Roma	3.6b	4.2c	67.3b	23.80a	6.5a
P	0.001	0.001	0.001	0.92	0.001

The means followed by same letters within the columns are not significantly different by 95% Confidence interval

2.2.2 Evaluation of Late Blight Resistant (LBR) tomato lines

The trial on late blight resistant tomato lines was continued. All the seven Late Blight Resistant (LBR) tomato lines (LBR-6, LBR-7, LBR-9, LBR-10, LBR-11, LBR-16 and LBR-17), received in 2010 from Asian Vegetable Research and Development Center (AVDRC) in Taiwan, and were evaluated for their yield in the centre. The Ratan variety was used as the check. The seeds were sown in the nursery trays by end of May and transplanted in the last week of June in the vegetable research plot of RNRRDC-Bajo. RCB design was adopted with three replications and each plot had 20 plants each. The recommended practices of crop management were followed. The trial field was irrigated and weeded on as and when required basis.

Table 22: Characteristics evaluated for Late Blight Resistant lines

Variety	Fruit length	Fruit width	Weight	Yield (T/ha)	
				2013	2014
LBR-10	4.8a	6.1ab	89.6ab	35.00a	17.8ab
LBR-11	4.7a	5.4ab	104.3ab	14.60ab	21.8ac
LBR-16	5.6a	6.7b	137.0b	28.10 ab	26.5bc
LBR-17	5.0a	6.3b	102.0ab	5.20 b	12.3a
LBR-6	5.3a	6.2b	103.3ab	23.00 ab	27.6c
LBR-7	5.0a	5.8ab	103.3ab	5.90 b	18.4ac
LBR-9	4.9a	6.7b	80.3ab	26.50 ab	20.5ac
Ratan	4.5a	4.7a	67.6a	14.90 ab	14.0a
P	0.24	0.004	0.045	0.01	0.001

The means followed by same letters within the columns are not significantly different by 95% Confidence interval

The data was collected were on fruit length, fruit width, fruit weight and the yield. No scoring on disease resistance was carried out. However, all the lines exhibited some degree of resistance to the late blight disease in Bajo condition. In fact, the effect of late blight on the lines was not significant through visual observation and in terms of fruits harvested. From the coming season, we will be scoring the lines for their late blight disease resistance.

The fruits of all the lines are bigger in size to that of the control. However, the difference in fruit weight is not significantly different from the control ($P<0.045$) except for LBR-17. The fruit weight of LBR-17 is almost

double to that of control and might not be preferred by the consumer. In terms of size, the line LBR-10 is of ideal size.

In terms of yield, all the lines has statistically similar yield to that of control except for LBR-6 (P<0.001) in year 2014. The line LBR-17 has the lowest yield (12.3 t/ ha) in both the season and the yield in lower yield than the check variety Ratan (14.t/ha) in both the years. There are not much difference in yield obtained in the year 2013 and 2014 for LBR-16, LBR-6 and LBR-9, but difference of at least 7 T/ha is observed for other lines. The inconsistency in yield of some of the lines will be verified in the coming seasons. This trial will be continued for two more years for obtaining a reliable data and selecting the suitable line for release.

2.2.3 Evaluation of Heat Tolerant varieties of hot pepper (NCT)

Eleven varieties of heat tolerant hot pepper were received from AVRDC, Taiwan in 2011. The objective of the trial is to find out the performance of the exotic heat tolerant varieties of hot pepper and assess their adaptability to increase the germplasm of hot pepper suitable for cultivation in local climatic condition.

Table 23: Agronomic traits for various hot pepper lines

Variety	Pt . height (cm)	Fruit length (cm)	Fruit width (cm)	Weight (g)	Yield (t/ha)
AVPP0303	55.6a	9.8c	0.93ac	3.3ac	10.5ac
AVPP0903	61.7ab	4.9a	0.80ab	2.3ab	6.5a
AVPP0904	54.3a	4.6a	0.76ab	2.0a	6.9a
AVPP0905	59.9a	8.8bc	0.96ac	4.0cd	8.6a
AVPP0906	66.4ab	8.8bc	1.0ac	4.6cd	16.9c
AVPP0907	64.3ab	4.8a	1.2cd	5.0d	10.1ab
AVPP0908	61ab	7.7b	1.06bc	4.0cd	11.4ac
AVPP9905	61ab	8.5bc	1.55d	9.0e	11.6ac
CO7753	60a	8.8bc	1.2cd	3.6bcd	15.3bc
G4	77b	7.2b	0.70a	2.0a	6.5a
P	0.009	0.001	0.001	0.001	0.001

The means followed by same letters within the columns are not significantly different by 95% Confidence interval

The trial started in March, 2012. The seeds were sown in the nursery trays by end of May and transplanted in the first week of June in the vegetable research plot. RCB design was adopted with three replications and each plot had 20 plants each. The recommended practices of crop management

were followed. The trial field was irrigated and weeded on as and when required basis.

As indicated in the above table, the tallest plant was that of the control i.e (G4) with mean plant height of 77cm which is significantly different to some of the varieties. In terms of fruit weight, AVPP9905 gave the highest yield and is found to be significantly different from other lines including control ($P<0.001$). The lowest fruit weight was that of line no. AVPP0904 and control G4 having mean fruit weight of 2g and is found to be significantly different from AVPP0905, AVPP0906, AVPP0907, AVPP0908, AVPP09905 an CO7753 and similar to AVPP0303 and AVPP0903 ($P<0.001$).

In terms of yield, the highest yield was obtained from line no. AVPP0906 with a mean yield of 16.9 t/ha and is found to be statistically similar to CO7753, AVPP0908, AVPP09905 and AVP0303 ($P<0.001$). The lowest yield was obtained from control G4 and line AVPP0903 with a mean yield of 6.5t/ha.

No scoring of hotness was carried out and only the physical performances of the lines were carried out this season. However, we will be scoring the lines based on their hotness in the coming season.

2.2.4 Vegetable breeder seed maintenance

RNR-RDCs are mandated to maintain the breeder seed of various crop released from the respective centre. The RNRRDC-Bajo maintains the breeder seed of various vegetable crop cultivars/ varieties released from the centre. However, maintaining of all 22 cultivars released from the centre is impossible in the centre due to specific climate requirement of crop. The vegetable seeds produced and maintained in the centre from July 2013 to June 2014 in RNRRDC, Bajo are given in Table 24.

Table 24: Vegetable breeder seeds produced in RNR-RC, Bajo

Sl.no.	Crop	Variety	Quantity (Kg)
1	Bean	Top crop	8
2	Bean	Broloto	10
3	Brinjal	PPlong	1.5
4	Broccoli	Desico	5
5	Bitter gourd	Kaiti	2
6	Cauliflower	White top	1
7	Carrot	Early nantes	0.5
8	Pea	Usui	10
9	Tomato	Ratan	0.5
10	Tomato	Roma	1
11	Water melon	Sugar baby	0.1

2.3 Medicinal and Aromatic plants

2.3.1 Asparagus land races evaluation trial

The wild asparagus land race trial was established in the year 2009. It was established with the objective to domesticate wild asparagus and to generate appropriate technology for its cultivation and germplasm maintenance. Asparagus is one of high value vegetables with very high demand in the local market but no detailed study on its cultivation has been done so far in Bhutan. Bhutan is home to three prominent wild asparagus species which are found in altitudes ranging from 200-2150 m i.e. from tropical to subtropical regions.

A total of seven land races were collected from different agro-ecological sites which comprises of places in Tsirang, Punakha and Wangdiphodrang districts. The accessions were gathered after carrying out reconnaissance survey and informal interview with the local people. The natural habitat has been replicated in the centre and the crop's growing habit is under study. Experimental trial was conducted in a lattice design with single plot at centre's station. 45 plants of each landrace were maintained in each plot. Asparagus crown were planted directly in trench with application of 2-3 kg of well decomposed compost. The following planting methods were used: row to row = 90cm, plant to plant = 60cm and planting depth of 15-20cm. Roots/crowns were spread out in trench with buds pointing upward covered with soil. Weeding was

done at 3-4 months intervals depending upon weeds intensity. No major pest and disease problem has been observed and the plants rooted well.

The growth of asparagus racemosus crowns were quite good and promising in the first year of the plantation but as the field was accidentally flooded which lead to wilting of more than half of the total plants, no data could be collected so far. The plants have been replaced and we are letting the plants to root well before data will be collected. The data on tuber yield per plant will be collected. No spear will be harvested but will be cut off when it attains about 75cm.

Table 25: Collection sites of A. racemosus landraces

Sl. No.	Local name	Accession	Location	Altitude
1	Nyekhagchu	A. racemosus	Gaselowom, Wangdue	1200 masl
2	Nyekhagchu	A. racemosus	Nahi, Wangdue	1780 masl
3	Nyekhagchu	A. racemosus	Nahi, Wangdue	1700 masl
4	Nyekhagchu	A. racemosus	Nahi, Wangdue	1450 masl
5	Nyekhagchu	A. racemosus	Tshokhana, Tsirang	700 masl
6	Nyekhagchu	A. racemosus	Toeb, Punakha	1300 masl
7	Nyekhagchu	A. racemosus	Kabji, Punakha	1340 masl

2.3.2 Prickly ash (*Zanthoxylum*) land races evaluation trial

Zanthoxylum land races evaluation trial was established in the year 2009. It was established to study the wild and the cultivated species of *Zanthoxylum* which are found in the country. It was undertaken to also document wild and cultivated *Zanthoxylum* species and races, identify potential races suitable for commercial production. Though the seed and bark of *Zanthoxylum* has been used in our Bhutanese cuisine since long time back and is culturally associated with Bhutanese culinary, no detailed study on *Zanthoxylum* species has been carried out so far.

Table 26: *Zanthoxylum* land races and their yields.

Sl . No.	Cultivars (Land race)	Yield (g/tree)		
		2012	2013	2014
1	Kaba	3.09	102.28	65.96
2	Daba	2.08	108.15	99.21
3	Sinphu	1.56	5.15	22.55
4	Pang	4.54	17.78	59.6

5	Bemjee	10.61	27.86	65
6	Tshokathang	7.07	42.18	6,08
7	Isogwom		13.1	49.72
8	Isogum			7.32
9	Sunkosh			18.28
10	Teobrungchu			5.14
11	Kabesa		4.45	16.35
12	Wangsesena*			
13	Kabesa			10.04

**Zanthoxylum armatum* seedlings from Wangsesena was planted in 2014

There are nine *Zanthoxylum* species found growing naturally in Bhutan. The seeds were stratified and sown in green house in January and February. Seedlings were transferred into individual pots after one month and planted in the field by June. Two plants per variety/land race were planted with spacing of 3m x 3m between plant and rows. The trees were trained into modified centre leader system. Basin preparation and mulching are carried out in February-March every year and manure and fertilizer application are also carried out during this period. The fields are irrigated regularly, on an average of once per month, during the dry months which stretch from December till May in Bajo. Weeding is carried out when required depending on the intensity of the weeds which comes to about 3-4 times of weeding in a year. The watershoots are removed every winter and irrigation is provided as and when required. Some of the landraces started to produce fruit and fruit yield/ tree of different land races are shown in Table 26.

2.4 Mushroom Program

The farmers of the region were provided full support from the centre on mushroom cultivation ever since the mandate to provide support for mushroom program was delegated to the RNRRDCs for the respective region during the 5th PCCM meeting. The centre now produces spawns for oyster mushroom and provides technical support for both oyster and shiitake mushroom cultivation in the region.

The demand for both oyster and shiitake mushroom cultivation support has increased sharply. The spawn for shiitake mushroom is still supplied by NMC owing to lack of production equipments in the centre while spawn for oyster mushroom, the spawns are multiplied in the centre from the mother spawn supplied from NMC.

2.4.1 Shiitake Mushroom Program

The number of shiitake billets inoculated in this financial year was almost double to that of the previous year i.e. from 5276 billets in last season to 9933 billets this year. The demand for support was based on the OGTP (one geog three product) or from interested farmers. With the success in last season, more farmers came forward seeking support. The total numbers of billets inoculated in every district in indicated in Table 27.

Table 27: Total number of billets inoculated

Sl.no	Dzongkhag	Households	No. of billets
1	Punakha	10	5460
2	Gasa	5	3075
3	Tsirang	2	798
4	Wangdiphodrang	1	600
	Total		9933

2.4.2 Oyster Mushroom Program

Oyster mushroom can be grown easily with the available of raw materials like paddy and wheat straw, grass and other plant residues. In order to provide proper nutrients, an additive has to be added. The only additional nutrient available in our context is rice bran. Four different types of oyster mushroom spawn namely Wo-I, PBN, PJ and Thai II were multiplied in the centre from the mother spawn supplied by NMC. However, lack of enough space like separate incubation room, joint room etc. hindered in spawn production and the production could not meet the demand. This is also due to high incidence of spawn infection making the spawn produced unusable. Out of 1449 bottles of spawn produced, 550 bottles were infected i.e about 38% of the total spawn produced were infected with other fungus. Other problem is the lack of adequate budget for seed and materials required for spawn production as no separate budget has been provided mushroom program.

The demand for both technical support and spawn of oyster mushroom also increased from last season. Like in the case of shiitake mushroom, demand for support was based on the OGTP (one geog three product) or from interested farmers. The total number of spawn supplied is Table 28.

Table 28: Oyster spawn distributed

Sl.no.	Dzongkhag	House hold	Varieties	Spawn supplied (in bottles).
1	Punakha	9	Wo-I	122
			PBN	80
2	Wangdiphodrang	7	Wo-I	118
			PBN	95
3	Gasa	3	Wo-I	15
			PBN	10
4	Tsirang	3	Wo-i	33
			PBN	29
5	Dagana	1	Wo-i	11
			PBN	19
	Total			532

Figure 4: Oyster and shiitake mushroom cultivation in villages

2.5 Horticulture Research in RDSC Tsirang

2.5.1 Citrus rootstock-scion compatibility trials

Citrus rootstocks induce variation in bud wood characters when grafted. This variation affects growth, yield, and fruit quality (taste and fruit size) of the grafted bud wood. Therefore, to identify ideal roots stock for local mandarin (*Citrus reticulata* Blanco), on station trial was set up in 2008. The site is located at 1460 meters above mean sea level. A total of five different rootstocks with a check (local mandarin) is included in the study.

Table 29: Type of rootstocks used and number of plants grafted

Rootstock	Scion wood cultivar	Nos. of plants
Troyer	Local mandarin	5
Carrizo	Local mandarin	5
Volkameriana	Local mandarin	5
Cleopatra	Local mandarin	5
Local mandarin (Check)	Local mandarin	5
Ranpur lime	Local mandarin	5

The plants started fruiting since 2013 and as of now, no major insect pests and diseases are observed. Wild animal damage especially deer is the main problem in winter due to lack of fence. Despite providing appropriate management, the growth among plants varies.

2.5.2 Citrus variety evaluation trial

Local mandarin (*Citrus reticulata* Blanco) is the only cultivar that is commercially cultivated in Bhutan. The cultivar has desirable characters both for fresh fruits and processing purposes but the yield is low when compared with other citrus varieties (Pumello, grape fruit, sweet oranges etc). This trial aims to evaluate the suitability of exotic varieties to diversify citrus varieties specific to purpose (table and processing) and provide options.

The trial was established in June 2008. The single plots design was used for lay out with 5 plants per variety at spacing of 4m x 4m plant to plant. The performance parameters of citrus varieties such as plant growth, phonological stages, fruits quality and yield aspects, market acceptance and pest and diseases incidences will be assessed. Fruiting started in last season. No major pests were observed except for little case of fruit drop

due to Chinese fruit fly (*Bactocera minax*). Similarly, little incidence of powdery mildew was found to control by sulphur dusting.

Table 30: Citrus type and varieties

Varieties	Rootstocks	Nos. of plants
Washington Naval	Trifoliate	5
Valencia	Trifoliate	5
Encore	Trifoliate	5
Minneola	Trifoliate	5
Local (T8)	Trifoliate	5
Local (13)	Trifoliate	5
Teishu ponkan	Trifoliate	5
Kinow	Trifoliate	5
Local (T6)	Trifoliate	5
Encore	Trifoliate	5
Otha ponkan	Trifoliate	5
L.Eira	Trifoliate	5
Clementine	Trifoliate	5
Hayana	Trifoliate	5
Fortune	Trifoliate	5
Tsunokari	Trifoliate	5
Local (T13)	Trifoliate	5
Thai trangerine	Trifoliate	5

2.5.3 Citrus rootstock production block

The citrus root stock block was established in July 2008. It was layout in single plot design with the spacing of 3m x 3m plants to plant 3m x 3m row to row. The block consists of 30 plants; 5 plants each for 6 varieties (Cleopatra, Volkamariania, Troyer, Carrizo, Ranpur lime and local rootstock).

The objectives of this study are to generate greening free citrus root stock in sufficient quantity to cater the need for west central region and to initiate citrus certification system. The growth of plants seems good compared to grafted saplings. No major pests and diseases observed except powdery mildew in local rootstocks. Rangur lime started fruiting since 2012.

Figure 5: Rootstock mother block and Rangpur fruiting

2.5.4 Persimmon varietal evaluation trial

The persimmon is a new fruit in Tsirang region although the climatic conditions are congenial for its cultivation. The trial was set up to study the yield performance on station. The trial was established in 2007 planting the local persimmon rootstock (astringent type). In 2009 improved variety non- astringent type (Fuyu variety) was grafted on local rootstocks. The trial consists of 15 plants. The trial was layout maintaining 4mx4m plants to plants.

The growth of the plants is slow: it may be due to cold. No major pests and diseases were observed except for minor incidence of beetles. Adults feed on the upper surface of foliage, chewing out tissue between the veins. This gives the leaf a lacelike appearance if timely spray was not done. The plant started bearing fruits from last season (2013) and matures towards September end. Birds (bulbul) damage the fruits if harvest is delayed.

2.5.5 Kiwi variety evaluation trial

The kiwi variety trial was established in 2007 in RDSC, Tsirang. The trial consists of 15 plants with 3 plants in each variety. 3 varieties namely Thimphu 1, Thimphu 2 and Thimphu 3 were plant with the spacing of 5x5m. The layouts were done in single plot design. The vines are trained in permanent trellis framework adopting pergola system.

The growth of the kiwi plant seems quite poor although it is 5th year of its growing period. The plant starts fruiting only from last year in Thimphu 1 variety. Since it is their first year of fruiting with limited fruit, data could not be collected. The kiwi fruit in the Tsirang condition matured in last week of the October. Until now no major pests were observed except for white grub damaging tap roots, fibrous roots and collar regions.

Figure 6: Kiwi onstation trial

2.5.6 Large Cardamom (*Amomum subutalum*) germplasm collection

Large cardamom is territorially confined to Himalayan range (India, Nepal and Bhutan). It is one of the important cash crops that is devastated by viral diseases almost two decades back. The annual income from export of cardamom amounted to Nu. 384.28 million in 2011. Therefore, it is still a priority crop that requires attention from all the stakeholders.

Of late, the acreage under cardamom is increasing annually. With very limited technology at shelf, this increase in area is cause of concern to policy makers, researchers and extension officials. Therefore, to generate technology, large cardamom germplasm was collected and maintained. The purpose is to produce disease free seedlings resistant to common diseases.

2.5.7 Cardamom performance evaluation

Cardamom cultivation was completely wiped out by diseases few decades back. It is imperative that best management practices are evaluated to keep abreast with risk of disease epidemics. Therefore, to generate management technology, a production demonstration plantation is established on station.

2.5.8 Banana germplasm collection

Banana is economically important fruit worldwide. However, its cultivation is limited to altitude below 1300 meters above sea level. Therefore, to increase the production zone, high altitude banana germplasm was collected from higher elevations to evaluate adaptability and production feasibility.

2.5.9 Maintenance of released fruit and nut cultivars

The released fruit and nuts cultivars block was established in 2006 with the spacing of 3mx3m plants to plant. The Block consists of 8 varieties of released fruit and nuts cultivars with 5 plants each. The variety are avocado (Hass), promogranate (Chowla), peach (July Elberta & Shani Punjab), Pear (Flemish beauty), Apple (Anna), Walnut (kanthal selection and B15). In total the block consist of 40 plants.

The released fruit and nuts cultivars block was established with the objectives to collect scion for nursery grafting and for top working for the region from the centre. Both the varieties of peach (July Elberta and Shani Pubjab) have started fruiting from 2008. For top working peaches and pears in interested farmers of the Dzongkhag, the scion wood was collected from the centre. The growth pomegranates are very poor and seems to be not to suitable for Tsirang condition. The growth of other varieties are also affecting because of wild animal damage. Here we have initiated individual fencing of plants. The walnuts have been grafted this year with 2 varieties and 5 plants each and the growth is quite good.

2.5.10 Top working of improved fruit on local varieties

Although mandarin is the main cash crop for the Dzongkhag in general but in some villages mandarin cannot be cultivated due to higher

elevation. Therefore, to support those farmers to earn some cash income, the RNR-RDSC, Mithun has top worked their local pear, peach, apricot and walnut rootstock with improved best quality scion woods. The scion woods for top working were collected from fruit and nuts released block of RDC, Bajo and RDSC Tsirang. The main objective of this program was to reach the released technology to farmer's field through on farm demonstration. The top working was carried out last week of January 2009 in the field of interested farmers in 8 villages of Shemjong, Rangthangling, Tsolingkhar and Dunglagang geogs. A total of 226 fruit trees were top worked; 93 (pear), 83 (peach), 36 (apricot), 12 (sub-tropical apple) and 2 (walnuts). Regular monitoring and after care services enabled 100% graft success. So far no major pests and diseases were observed. The fruiting has started 2011 by all top worked trees.

2.5.11 Breeder Seed Maintenance

RDSC, Tsirang is also maintaining the breeder seeds of various vegetable crop cultivars released from RNR-RC, Bajo.

FORESTRY RESEARCH

3 FORESTRY

3.1 On Station Research

3.1.1 Evaluation of multipurpose tree species

The evaluation of Multi-purpose tree species (MPTS) is one of the on-going activities carried out by the sector in the on-station nursery. Different forest trees and other woody species including bamboo are evaluated in the nursery with different propagation techniques. Species selected for developing propagation techniques are based on the farmers' preference and some are based on their important multiple uses. Priorities was focused to develop propagation techniques for native tree species which have multiple uses and can be promoted in agro-forestry, private and community forestry programs.

Figure 7: *Jacaranda mimosifolia* seedling in the mother bed

One of the best preferred methods is through vegetative cuttings, it is a science of producing true to true plants by selecting healthy stems from healthy tree and/or plant from disease free tree and/or plants for producing healthy offspring. Though a large numbers of seedling can be produced through seeds but loss their trait due to cross pollution, due to this vegetative propagation is preferred over seed.

Figure 8: *Melia azedarach* seedlings inside screen house

3.1.2 Fresh seeds germination study

Various seeds germination studies were conducted in the nursery on-station, seeds were sown immediately after collection and some quantities were stored in the room temperature, this was basically done to study the

seed viability. The stored seeds will be sown in 2015 seed sowing and compare the fresh and stored seeds viability. The bigger size seeds were directly sown in the polytube, some in mother beds, while minutes seeds were broadcasted in the mother beds. Data collection is ongoing.

Table 31: Seed germination trial

Species	Local name	Collection/ sowing period	Collection site	Germination %
Cupressus corneyana	Tsenden	Jan-April	Bajo	
Meliaazedarach	Jashing	Jan-April	Bajo	
Phyllanthusemblica	Amla	Jan-Feb	Phayual	
Jacaranda mimosifolia	Jakashing	Jan-Feb	Punakha and Bajo	
Quercus griffithii	Oak	Dec-Jan	Dagana	
Callistemon citrinus	Bottle Brush	August-Dec	Bajo	
Leucaena leucocephala	IpilIpil	Jan-Feb	Bajo complex	
Thuja occidentalis	Thuja	Jan-Feb	Bajo NSC	
Albizi aprocera	Sekpalashing	March	Dagana D/gang	

Vegetative cuttings

Various economic trees and plants have been tried between February to May in 2014, the numbers by species, their mortality with success rate is presented in the Table 32. The following tips were followed while preparing cuttings. Some figures of cuttings planted are presented above as an as an example.

Figure 9: *Ficus religoisa* stem cuttings

Stems cutting, treatment and after care

General

- Stem cutting should be taken during early morning hours – stock plants are to be hydrated
- Insert least one node below the media surface, two to three is better
- Place cutting in a bucket of water to prevent desiccation immediately after collecting
- Always use sharp pruners/secature

Figure 10: *Ficus benghalensis* stem cuttings

- For most species, terminal cutting work best (depends on species)
- Always select cutting materials with good diameter (about thumb size but depends on species) – terminal cuttings are usually small.
- Select cuttings of 1-2 years old from a health mother plant

Some general steps to follow

- Cut the woody stem at an angle
- Make the angled cut on the side of the closest bud
- Scratch/scrape the stem on the other side (wounding help better root initiation)
- Remove bottom leaves and/or cut bottom leaves in half to reduce transpiration
- Always use healthy, pest-free plants
- Maintain clean environment

Table 32: A list of MPTspropagatedthrough stem cutting

Species	Local Name	Qty.	Uses	Planting season	Survival
Ficus benghalensis	*Ficus*	140	Fodder/ornamental	Feb-April	80
Ficus benjamina,	Rubber plant	160	-do-	Feb-April	80
	Cactus plant	15	Ornamental	Feb-April	99
Ficus elastica	Rubber plant	400	-do-	Feb-April	90
Ficus religious	Bodhi tree	200	Fodder/ornamental	Feb-April	90
Bougainvillea	Paper flower	190	Ornamental, used	Feb-March	65

(white)			for making bonsai.		
Bougainvillea (Red)	Paper flower	180	-do-	Feb-March	70
Zanthozylum	Prickly-ash	300	Medicinal	Feb-April	80
Dendrocalamus spp.	Bamboo	150	Ornamental	May	90
Duranta erecta	Golden Dewdrop, Pigeonberry	150	Hedges, ornamental	Feb-June	95
Duranta repens	Golden Dewdrop, Pigeonberry	500	Ornamental	Feb-June	90

Table 33: Seedlings supplied to School/Institution, Dratshang and Individuals in 2014

Species	Local/common name	Qty	Puropose
Cupressus corneyana	Cypress	630	• For school seedlings were supplied on 2nd June for planting around the school campus. • For Dartshang seedlings were supplied for planting around the campus. • For individuals to plant on waste land (which cannot be cultivated. • For Institution (CNR) it was basically supplied for landscaping.
Meliaazedarach	Persian lilac	145	
Phylanthusemblica	Indian gooseberry		
Jacaranda mimosifolia	Jakashing	460	
Quercus semicarpifolia	Oak		
Callistemon citrinus	Bottle Brush		
Leucaena leucocephala	IpilIpil	115	
Thuja occidentalis	Thuja		
Albizia procera	Sekpalashing	20	
Benthamedia capitata	Dogwood	50	
Thevisa	Lucky nut	90	
Duranta repens	Hedge	630	
Silver oak	Australian Silver oak	400	
Syzygiumcumini	Ngatsi (Dz.)	250	

Dendrocalamus species	Bamboo	52	
Choerospondias axillaris	Labsi (Lh.)		
Tamarind	Titiri		
Thuja orientalis	Thuja		
Delonix regia	Gul mohar	400	
Saraca indica	Ashoka	120	
Araucaria columnaries	Christmas	50	
Olneya tesota	Iron Wood	450	
Schefflera actinophylla	Umbrella	450	
Quercus glauca	Oak	50	
		4342	

3.1.3 Maintenannce of centre plantation and mini arboretum

Starting from year 1996, RNR-RDC Bajo led by forestry sector initiated forest tree saplings plantation around the campus. When viewed from other side of Punatshang Chu, the area used to look very barren except for a few Eucalyptus trees. In 1995 Punakha-Wangdue Valley Projected (PWVP) provided monetary support of Nu 50,000.00 to establish screen house and nursery shed using bamboo mats. The project support was of great help, due to which the center could establish shed house and nursery shed. After this establishment, multipurpose tree species (MPTs) seedling of different species were raised particularly focusing on broadleaf species which have multiple values. The actual broadleaf and ornamental plants plantation started from 2nd June 1996 and this program was kept as an annual event. The excess seedlings were planted in Lingmutey Chhu watershed community forestry area. Currently the sector is maintaining 36 different trees, ornamental and 12 bamboo species. The centre still maintains the nursery to develop different propagation methods of MPTS. Table 34 indicates the different species maintained and managed.

Table 34: Maintenance of Centre Plantation and Mini Arboretum

SN	Species	Local name	Uses	Remarks
1	*12 species of bamboo*			
2	*Albizia procera*	Tall albizia		
3	*Phylanthus emlica*	Amala (Lh.)	Medicinal	Contains Vati.c
4	*Acrocarpus*	Mandanay (Lh.)	Timber species	Fast growing

	fraxinifolious			
5	*Araucaria spp.*	Monkey puzzle	Ornamental around farm household	
6	*Bougainvillea Red*		Ornamental	
7	*Bougainvillea White*		Ornamental	
8	Cassia Siamea	Siam Cassia	ornamental	a genus of shrubs in the beans family Fabaceae
9	*Callistemon citrinus*	Bottle brush	Ornamental	Evergreen and thrives in dry condition
10	*Cassis fistula*		Ornamental	
11	*Choerospondias axillaris*	Lapsi (Lh.), Nepali Hog Plum .	Fruits are eaten by human and deer mostly, timber	
12	*Cupressus*	Cypress	Timber	Have wide altitudinal growing range, fairly grow fast.
13	*Duranta spp.*	Hedge	Ornamental	Maintenance of soil moisture during dry season is critical.
14	*Eucalyptus spp.*	Tobdhashing (Sh.)	Medicinal, fuel-wood, timber	Fast growing, thrive well in dry and harsh condition.
15	*Ficus elastic*	Rubber plant	Fodder, avenue plantation, evergreen.	
16	*Ficus bengalensis*	Bar (Lh.),Indian banyan tree	Has Medicinal uses properties	
17	*Ficus religiosa*	Peepal	Used in traditional medicine	
18	*Ficus roxburghii*	Fodder		
19	*Terminalia bellerica*	Bahera,(Lh.)	Medicinal	
20	*Jacaranda minosifolia*		Ornamental, fuel-wood	
21	*Ficus cunia*	*Khanyu* (Lh.)	Fodder	
22	*Morus alba*	Kimbu (Lh.)	Fodder, fruits	
23	*Euphorbia pulchemeria*	Poinsettia, Christmas star,	Ornamental	

		Christmas flower		
24	*Leucaena diversifolia*	IpilIpil	Fodder	Leguminous
25	*Leucaena leucocephala*	IpilIpil, White Leadtree	Fodder	Leguminous
26	*Meliaazedarach*	Jashing (Dz.)	Fuel-wood, fodder	Fast growing
27	Poplar tree		Fuel-wood	Fast growing
28	*Paulownia tomentosa*	Empress, Princess, or Foxglove tree		Paulownia tomentosa is the fastest-growing tree in the world
29	*Purnus*	Cherry	Ornamental	Good for agriculture tools handles.
30	*Robiniapseudoacacia*	black locust	Fodder	Leguminous
	Thujaoccidentalis		Ornamental	Planted as hedges
31	*Schefflera actinophylla*	Queensland umbrella tree, octopus tree and amate	Fodder, land management, ornamental even as drugs for animals	Evergreen can be potted and use as indoor plant.
32	Salixbabylonica			
33	*Thevisa*			
34	*Thysanolaenalatifolia*	Broom grass	Used for sweeping floor	Good for land stabilization, winder fodder
35	*unknown spp. around veg field*			
36	*Wild cane*	Cane	Used for making ropes, as vegetables.	

Ficus religiosa is used in traditional medicine for about 50 types of disorders including asthma, diabetes, diarrhea, epilepsy, gastric problems, and inflammatory disorders, infectious and sexual disorders. Peepal tree is of great medicinal value. Its leaves serve as a wonderful laxative as well as tonic for the body. It is especially useful for patients suffering from Jaundice. It helps to control the excessive amount of urine released during jaundice. The leaves of Peepal are highly effective in treating heart disorders. It helps to control the palpitation of heart and thereby combat the cardiac weakness. Ayurveda makes an extensive use of the leaves of peepal due to the numerous benefits it provides.

FARMING SYSTEMS RESEARCH

4 FARMING SYSTEMS

4.1 Soils Research

4.1.1 Mineral fertilizers enhance rice productivity in Wangdue-Punakha Valley

Rice is the most important food crop in Bhutan, further to cultural, traditional and religious significances. During the 10th Five Year Plan (FYP) rice self-sufficiency target was at 65%, however the self-sufficiency stands only at 51.3%. So to make up for the rice deficit, imports from India range from 50,000 to 60,000 MT every year. Currently, rice is cultivated in 59,609 acres of land with a national productivity of 1,312 kg/acre. In tandem with the growing population, rice production should further be increased. However, declining soil fertility coupled with shortage of irrigation water are the two most constraining factors. Use of mineral fertilizers is inevitable to optimize rice production particularly for improved varieties. Though the use of mineral fertilizers in rice is widespread, the imbalanced usage (only nitrogen-fertiliser) and poor timing of applications (insufficient in critical crop growth stages) remain as the main issues. While mineral fertilizer recommendation rates existed both for local and improved varieties, adoption of the same is limited. Most farmers use lower than the recommended rates. Lack of awareness on adoption of the recommended rate among the farmers is the other issue.

Despite the limited number of farmers using recommended fertilizers, there is an increasing trend of its usage. To maintain crop productivity in the face of declining soil fertility, farmers have resorted to increased use of mineral fertilisers because farmyard manure availability has been decreasing over the years. Hence, balance and proper timing of application of the recommended mineral fertilizer rates were demonstrated to farmer at different sites. Irrespective of the sites, recommended practice out-performed the farmers' practice in both grain and straw. Recommended fertilizer rates are not only sustainable but also economically feasible. The cost benefit analysis indicated that expenditure incurred on buying fertilizers can easily generate a reasonable net benefit even with the cultivation of local rice varieties due to the incremental yield brought about by the mineral fertilisers.

4.1.2 An assessment of glyphosate use and its cost effectiveness as a substitute for farm labour on paddy terrace bunds

Glyphosate is a broad spectrum systemic herbicide used to control annual broadleaf and grass weeds. It was discovered in 1970s and introduced in the market under the trade name Roundup®. The herbicide is used for both agricultural and non-agricultural land. In Bhutan it is one of the registered herbicides and its use was generally restricted to managing pre-harvest in potato fields. However, recently some farmers in a few geogs under Tsirang Dzongkhag have started using the herbicide on paddy terrace bunds to control weeds to cope with the decreasing farm labour.

So far no study has been conducted to validate the general perception that some farmers use glyphosate on paddy terrace bunds. This study was, therefore, an attempt to confirm the general perception, evaluate the trend, and compare the cost involved in controlling weeds on paddy terrace bunds through use of glyphosate and manually. A representative and structured household survey was conducted with 130 households covering 30% of the population from each geog.

In all the surveyed geogs of Dunglagang, Kekhorthang and Gosiling, majority of the respondents reported using glyphosate. The data of the number of farmers using glyphosate over last four years exhibited a clear increasing trend, and so was the national trend. The findings also revealed that the use of glyphosate for controlling weeds on paddy terrace bunds is comparatively cheaper than done manually. On average a farmer spends Nu. 2005/acre (excluding the cost of two meals) to clear weeds manually. However, a farmer spends only Nu. 702/acre for purchasing and spraying glyphosate to control weeds. Therefore, using glyphosate saves a farmer 65% the cost of employing farm labours. The household labour availability and the size of wetland holding did not affect the use of glyphosate, but the availability of the information did. Although glyphosate may be a short-term solution to decreasing farm labour, the potentially undesired consequences may follow in the long-term.

4.1.3 Soil fertility as a possible cause of citrus decline in Drukjegang

In Bhutan citrus is grown in 17 districts out of 20 and it is the highest value export crop of the country. It is an important primary source of livelihood and income for a majority of the subsistence and small farmers.

However, the citrus industry is currently at stake due to many factors, of which soil nutrient management is one of them. While soil nutrient management is decisive in successful citrus production, the only source of replenishing soil fertility is through tethering. The amount of manure added through such practice is not much and only few farmers mentioned supplementing with mineral fertilizers.

Therefore, soil fertility was evaluated for 45 orchards to see if soil fertility as a cause of citrus decline. A better understanding of the soil fertility status of our citrus orchards will guide us in streamlining our strategy towards addressing the citrus decline problem in the country. However so far, little or no study has been conducted to assess soil fertility as a factor to the declining of citrus industry in the country. In light of this need, this study was therefore an attempt towards investigating soil fertility as a possible factor for declining citrus industry. The study was done in Drujeygang geog of Dagana Dzongkhag. A total of 45 soil samples collected from 45 orchards randomly selected covering three chewogs. Two composite samples, top soil at the depth of 0-20 cm and sub-soil at the depth of 20-50 com were collected from the basins of the trees. The two samples from each orchard were composed of 8-10 sub samples representing the whole orchard. These samples were submitted to the Soil and Plant Analytical Laboratory (SPAL) for research package analysis. The data entry, analysis and reporting were done by using Microsoft Excel.

The results indicated that, low soil fertility is one of the major, if not the primary, factors for citrus decline. Important soil variables such soil pH, organic matter, % N, available P and K and CEC are of great concern. About (11.1%) have lower soil pH (>5) while for greater citrus growth and productivity; the most ideal soil pH is around 5.5 to 6.5. More than (50%) of the orchards have organic matter within very low to medium. About (50%) of the orchards have percent N, (25%) orchards have available P and (20%) orchards have available K within very low to low ranges. The CEC of (20%) orchards is in low range. Other possible factor is lack of irrigation water as almost all orchards do not have irrigation water sources. Without adequate irrigation water, orchards are more susceptible to nutrient deficiencies, physiological disorders, pests and diseases.

4.1.4 Responses of wheat to varying rates of N-fertilizer application

Wheat is one of the cereal crops first domesticated and its cultivation reaches far back into history. It is the most important cereal crop in the

world and it is grown on more than 240 million ha, larger than for any other crop. Its production leads all crops, including rice, maize and potato and continues to be the most important food grain source for human. Similarly, wheat is an important crop next to rice and maize as staple food grains in Bhutan. In the wetland system it is grown after paddy and as spring crop in the dry-land system. However according to RNR Statistics 2012, area under wheat production has decreased from 21,907 acres in 2005 to 5,802 acres in 2011 and production has reduced from 11,306 MT in 2005 to 6,266 MT in 2011. The reduction in area under wheat cultivation and its production is mainly because of many constraints impeding wheat production. Of the constraints, inadequate soil nutrient management is the main factor.

As with other crops, opportunities to increase wheat yield exist if fertility management is improved. The response of wheat yield to different rates of nitrogenous fertilizer was examined for two consecutive years of 2012 and 2013. The experiment was laid out in randomized complete block design (RCBD) with three replications. Nitrogen rates ranged from 0 to 100 kg N ha^{-1}. Data were analyzed using ANOVA and for both the years; among the treatments, 100 kg N ha^{-1} have significant effect on grain, biomass yields and plant height. Correlation analysis was performed to determine association and measure the strength of the association. The correlation is significant both at the 0.05 and 0.01 levels (2-tailed). The test showed significant relationship between the rates of nitrogen and the grain yield ($r=1$, $n=12$), biomass yield ($r=0.683$, $n=12$, $p=0.014$) and plant height ($r=0.553$, $n=12$, $p=0.062$). Furthermore, the treatments had significant effect both on soil N nutrient content and CN ratio. Results led to the conclusion that with the application of 100 kg N ha^{-1}, wheat farmers can increase their wheat productivity and improve the production sustainably.

4.2 Gasa Organic Outreach Program

Gasa dzongkhag was adopted as research out-reach site of RDC Bajo for organic farming, focusing on alternatives and best practices of organic farming particularly on pest, diseases and crop nutrient management since 2012. Relevant stakeholders and partners were identified as NOP, DoA, NPHC, DAMC and Dzongkhag Agriculture extension to work for the organic program with the mission to enhance income and livelihood of farmers. The following activities were initiated and carried out during the fiscal year 2013-2014.

4.2.1 Upland Rice Demonstration

Upland rice (Kambja) is grown in rainfed fields prepared and seeded when dry, much like wheat or maize. As demonstration and on-farm trials, it was tried at Gasa in small areas in 2012 with three farmers at Zamina and Baychu under Khatoe geog (2600 masl). The objective was to evaluate the performance and adaptability of upland rice in this area. The result of the first year trial was promising and the performance was well accepted by the farmers. Thus it encouraged more farmers to try at larger areas. So in 2013, the upland rice program was up-scaled to seven farmers cultivating upland rice on small areas with an average of half langdo land.

The land preparation began in February and March with the clearing of area, followed by application of FYM in half langdo land which was spread evenly in the field. The land was then ploughed and prepared by removing the vegetative matters. After the land preparation, the Kamja seeds were broadcasted at rate of 30 kg per acre at the beginning of March. The first weeding was done when the seedling attained three to four leaves stage during the month of May. Due to prolonged monsoon and weed pressure, subsequently additional three hand weeding was done. Upon maturity, the crop was harvested in the month of November and yield assessment was done through crop-cut. Result of the yield assessment is presented in Table 35.

Table 35: Grain yield and other parameters of upland rice

Farmer's Name	Shena Zam			Choden			Tshering Om			Mean	SD
Samples	I	II	III	I	II	III	I	II	III		
Crop cut result (kg)	0.55	1.50	0.85	2.60	1.90	1.40	1.30	1.40	1.12	1.40	0.59
No. of tillers	4.90	4.40	4.60	7.40	5.10	8.60	9.40	7.00	6.80	6.47	1.82
Straw weight (kg)	18.00	10.50	11.00	17.00	14.00	11.00	16.00	12.50	13.50	13.72	2.76
Crop height (m)	1.14	0.83	0.98	0.90	1.00	1.20	1.30	1.40	0.75	1.06	0.22

The average yield computed based on the crop-cut result is 0.94 tons/acre and the average number of tillers counted is 6.47 per hill. Although the yield is lower than in Eastern Bhutan which is 1.80 tons/acre, yet the technology is quite promising and farmers showed interest to go for larger promotion of upland rice. Although in smaller quantity, farmers are convinced that they have their own red rice produced from their field. Apart from its yield, farmers are more interested on the straw production which is very necessary for their livestock that includes cattle and horse. The result showed an average of 9.25 tons/acre of straw was produced to supplement the livestock feed during winter. Further it reduces the cost of purchasing paddy straw and transport it all the way from Punakha which was their usual practice earlier.

Some of the constraints in upland rice production according to the farmers were during the early tillering stage there was an outbreak of army worm infection in the entire rice fields. As an intermediate measure, Neem oil was issued through NOP and farmers were advised to spray it to control army worm, which solved the problem besides the onset of monsoon which helped to control the outbreak. Since farmers had sown the Kamja seed densely, the effect of army worm was very negligible.

The other constraint was during the time of crop maturity when farmers faced problem of wild animal invasion and crop damage. It was reported that among the test farmers, the field of two farmers was totally damaged by wild boar. Even there was report of bear and rodents attacking the crop during the maturity stage.

The demonstration concludes that the farmers were very satisfied with the crop performance and its yield. The feedback from

farmers indicated that more farmers from the localities are interested in upland rice and would like to continue in the coming season covering more areas. This upland rice production program will ultimately contribute towards increased rice production in the area besides making availability of the paddy straw for their livestock.

4.2.2 Mustard Production Program

Mustard is a major oilseed crop grown in the country. However, there is an indication that the area and production of mustard in the country has declined over the years, which resulted in increasing import of cooking oil in the country from India. Technically and ecologically, Bhutan has the potential of achieving self-sufficiency in oil crops without displacing other crops. Khamae geog under Gasa has favourable agro-ecological conditions for mustard production considering the traditional practice of the farmers. Further, mustard plant releases biotoxic compounds or metabolic byproducts that exhibit broad activity against bacteria, fungi, insects, nematodes and weeds. It is also least preferred by pests and can be grown organically. Therefore, mustard production program was initiated at Khamae geog to evaluate mustard production through improved management practice to up-scale production with the long term objective of marketing organic mustard oil in the local market.

During the first cropping season, 65 households were involved in mustard production covering 30 acres of wetland. The mustard seed was locally sourced and supplied to farmers for mass production for the first time. Subsequently, farmers were advised to keep their own seed for the following year. Constant monitoring for pest and disease attack was carried out. The crop matured after three months and yield assessment through crop cuts were taken from three villages with an area measuring 6 m^2. Table 36 presents the comparative result of crop cuts.

Table 36: Mustard crop-cut result

Village	Farmer	No. of sample			Average yield	
		I	II	III	Per plot	Per acre
Khalio	1	0.4	0.5	0.2	0.4	247.3
	2	0.5	0.6	0.3	0.5	314.8
	3	0.7	0.6	0.4	0.6	382.2
Damji	1	1.2	1.2	1.4	1.3	854.4
	2	1.4	1.2	1.1	1.2	831.9
	3	1.6	1.2	1.3	1.4	921.8
Yemina	1	0.2	0.3	0.4	0.2	134.9
	2	0.3	0.5	0.4	0.4	269.8
	3	0.2	0.5	0.3	0.3	224.8
		Average			**0.7**	**464.7**

The average yield computed is 464.7 kg per acre which is lower than the previous years. This is attributed due of the frost damage at seed formation and also the improved seed supplied by Department of Agriculture did not perform well in comparison to the local varieties of the area.

There was no major pest and disease incidences observed during monitoring, only negligible incidences of aphid were observed. Farmers reported that they would further continue with the mustard production program and RDC, Bajo will continue to provide technical support. In addition, The NOP has supported the community by providing oil expeller for collective use. RDC Bajo will facilitate in developing the group by-laws for efficient and sustainable use of the oil expeller. It is estimated that in the coming season, the area of mustard production will increase as per the consultative meeting held with the farmers. Further, in the coming year, RDC Bajo in collaboration with NOP and Dzongkag administration will facilitate in packaging and marketing of organic mustard oil.

4.2.3 SRI trial

System of Rice Intensification (SRI) is a set of improved practices in plant, water, soil and nutrient management developed originally in Madagascar which brings out rice natural growth potential. It is said that the average yield of SRI is 8-9 t/ha with some farmers even getting 10-15 t/ha. SRI does not require external inputs like chemical fertilizer and it emphasizes more on use of organic manure. The results and experiences had shown higher production with organic manure. As such, this technology exactly fits with organic farming practices; it was recommended that SRI can be done in any rice varieties with 2 weeding using rotary weeder for good soil aeration. Therefore, with the objective to evaluate the feasibility of SRI on Organic Agriculture, two trials were conducted at Damji and Yemina villages, Khamae geog in Gasa dzongkhag. RNR RDC Bajo implemented the trials in collaboration with NOP, Simtokha and the Dzongkhag Extension during 2013 rice season.

SRI trial was conducted in a single large observation plot at Khailo and Yemina with an area of one langdo each. The basic principles of SRI were followed throughout the experiment. Seedling of 20 days old or at 2-3 leaf stage were transplanted immediately without removing soil particles attached to the roots upon removal from nursery. To maintain uniform spacing between the seedlings, line transplanting using rope was carried out in a square pattern of at least 25 cm X 25 cm. The wide spacing will expose plants to more sunlight, air and nutrients resulting in more root growth and tillering. Seedlings were transplanted individually rather than in clumps of 2 or more to facilitate individual plants to spread their roots and prevent competing with other plants for space, light and nutrients.

Water management in SRI does not require continuous flooding as in the traditional practice rather the soil is kept moist for about 10-12 days after transplanting. As per the literature, the fields were allowed to slightly crack once in a week which allows air movement in the soil. As such, alternative drying and wetting method of irrigation is recommended but Gasa had adequate rainfall during the cropping time, the soil were never

allowed to crack rather farmers had to drain out water from their field most of the time.

As recommended, weed management was done at least twice by using rotary weeder in 2-3 weeks interval after transplanting, the weeding will disturb the soil and helps in supplying air to the growing roots as well it smothering the germinating weeds. Timely monitoring and data collection were carried out from the very beginning of the trial establishment. The SRI field at Yemina was damaged by wild animal and the data was not available. The data collection for traditional method was based on the data collection form and yield data was collected through crop cuts from SRI adjacent fields during harvest. Table 37 shows the crop cut result conducted from 6 m^2 area at Damji.

Table 37: Grain yield comparison from SRI and farmers' practice

Technology Method	Sample No.			Average yield/ plot (kg)	Kg/acre
	I	II	III		
SRI Method	0.90	1.00	1.20	1.03	696.98
Farmer's practice	1.22	1.80	1.90	1.64	1106.18

The result shows that SRI did not perform well at both sites. The yield was low and the labour inputs were higher and it may not be feasible for high altitude. Farmers describe SRI having high tillers but it takes time to mature and takes longer time at vegetative growth. Although the SRI trial was transplanted on the same date with the conventional method, but it took longer time to mature resulting to heavy bird attack in the field. Even the climatic condition did not favour SRI since the area received heavy rainfall during the vegetative growth and it was not possible to keep the soil dry as the technology demands. It was concluded that SRI is not feasible for higher altitude wetland rice and the activity will be discontinued.

4.2.4 Garlic Production and Marketing

Garlic production and marketing program was initated in the year 2012 with the objective to diversify organic crop production and enhance rural income. Garlic is a crop of low volume and high value that has long

duribility or shelf life for off-season marketing. It is adopted as one of the major cash crops by the farmers of Khamae and Khatoe geogs. At the beginning of the program, garlic cloves were purchased locally by RDC, Bajo from Khailo and Damji and distributed to 22 farmers of Khamae and Khatoe during September 2012. In addition, farmers having their own seeds were encouraged to cultivate for marketing. The activity was continued in the year 2013 with more farmers encouraged on large scale production. The farmers arranged their own seed by saving either from their last harvest or sourcing from neighbours. RDC Bajo facilitated in monitoring, yield assessment and marketing of the produce. The major garlic growing areas are Khailo, Yemina, Damji at Khame geog and Bauchu, Tshirna and Remi at Khatoe geog. The total area of garlic cultivation was estimated about 5.8 acres. The yield assessment was done through crop-cut in three different villages. In each village, three garlic growing farmers were randomly selected and three sample crop cuts were taken from an area of 2 x 3 m^2. The samples were properly dried and measured, the result showed that the average yield was 861.9 kg/acre as presented in Table 38.

Table 38: Yield performance of garlic in Gasa

Village	Farmer	Crop-cut yield (kg)			Average yield per plot (kg)	Yield Kg/acre
		Sample I	Sample II	Sample III		
Khalio	1	1.4	1.2	1	1.2	809.4
	2	1.5	1.7	1.3	1.5	1011.8
	3	0.8	1.6	1.2	1.2	809.4
Damji	1	1.2	1.2	1.4	1.3	854.4
	2	1.4	1.2	1.1	1.2	831.9
	3	1.6	1.2	1.3	1.4	921.8
Yemina	1	1.3	1.2	1.1	1.2	809.4
	2	1.3	1.4	1.2	1.3	876.9
	3	0.9	1.5	1.3	1.2	831.9
Average						861.9

Based on the total land area of 5.8 acres, the total garlic production in 2013 was estimated at 5 MT. The garlic cloves were checked and sorted for approperiate quality and size to meet the market preferances. From the total production, RDC Bajo in collabaration with Horticulture Division facilitated in marketing 3.5 MT of garlic as seed for distribution to other dzongkhags at the rate of Nu. 100 per kilogram generating a revenue of Nu. 0.35 million. The remaining 1.5 MT were sold by farmers in small quantity at the local market in Punakha and Damji weekend markets. The remaining stock was kept for home consumption and as seed for next season.

4.2.5 Commercial vegetable production and marketing program

With the inception of organic program in Gasa dzongkhag since 2004, farmers had reported that there are diverse vegetable crops produced and it has solved problem of winter vegetable scarcity and increased self-sufficiency at household level. Owing to fertile soil and higher elevation, Gasa has advantage of producing summer vegetable and potential to capture good market when there is no import of Indian vegetable in the country. Therefore, the vegetable production program was initiated by RDC Bajo in collaboration with NOP and Dzongkhag Agriculture sector with the objective to enhance income through semi-commercial vegetable production.

The program was initiated in both Khatoe and Khamae geogs in May, 2012. It was started with a joint consultative meeting among stakeholders to develop a joint activity plan for semi-commercial vegetable production. In total, 53 households were identified to start vegetable production in 20 acres of land. The potential market identified for marketing the vegetable were the local market, weekend market in Punakha and Wangdue, Centenary Farmers market in Thimphu and the Punatsangchu Hydro-power Projects.

To begin with the program, capacity building of farmers was done by providing basic training on vegetable production by the dzongkhag

extension. Following the training, vegetable seeds were supplied by RDC Bajo for large scale production along with demonstration on nursery raising, transplanting, spacing and other management practices. The main vegetables crops promoted were cole crops (cabbage, cauliflower, and broccoli), root crops like radish and carrot, beans and pea seeds were also supplied for dual purpose to generate income and improve soil fertility. Besides, leafy green vegetables and garlic were also prioritized for commercial production since these crops are grown abundantly in the geogs.

Routine monitoring and field visits were done jointly by researchers and extension. Farmers reported the problem of crop damage by pest infestation especially the cutworm. To control the pest problem organically, hand picking of pest was practiced, in addition use of cow urine solution at the ratio of 1:10 was recommended. Other pests like hopper and caterpillar also damaged nurseries, and bio-pesticides like neem oil, last straw and Jeevatu were provided by NOP as an intermediate measures to control. Liquid manure and Jeevatu solution were also made available at farms for pest/disease control.

The produce from this semi-commercial vegetable program was sold at weekend market in Punakha and some farmers even took their produce to Farmers Centenary Market in Thimphu. With the increased vegetable production in the locality, farmers also have an option to sell their fresh vegetables at the weekend vegetable market established at Damji to supply vegetable to dzongkhag staff, boarding school, and other visitors in the locality. The weekend vegetable market was started in August 2014 by Dzonkhag in collaboration with RDC, Bajo.

In future, there is the need to facilitate and establish marketing link between the producers and different consumers like Punatshangchu hydro-power projects and other potential buyers to sustain the program.

4.2.6 Others

The other on-going activities include Pear Production, Asparagus Production, Potato Production and Marketing. These are the continued activities where researchers provide technical support and carry out routine monitoring and data collection. Bio-pesticides were supplied to control pest and diseases. In addition, to formulate bio-pesticides locally, technical assistance and relevant material were supplied in collaboration with NOP.

DEVELOPMENT ACTIVITIES

5 DEVELOPMENT ACTIVITIES

5.1 Rice

5.1.1 Highlights of rice commercialization activities and achievements

In 2013-2014, the national rice program has been able to realize some tangible achievements due to increased budgetary outlay. The program continued with various interventions like promotion of improved rice varieties, demonstration and promotion of plant nutrient management, farm mechanization, capacity building of farmers and extension agents, establishment of modern rice processing units towards improving post harvest and marketing aspects of rice commodity. The progress has been good and the crop performance, especially in the southern belt is assessed to be increasing. Of some notable achievements, the installation and commissioning of three modern rice processing units were noteworthy and will go a long way in improving post harvest and marketing aspects of this particular commodity. As per the initial targets of rice commercialization program which started in late 10th Five Year Plan period, rice potential dzongkhags of Wangdue-Punakha valley, Samtse, Sarpang, Samdrup Jongkhar and Tsirang-Dagana clusters are being targeted. The highlights of achievements are presented in the following paragraphs.

Promotion of improved rice varieties

As one of the major interventions, the rice commercialization program continued with promotion of improved higher yielding varieties of rice. Over 50 tons of improved rice varieties comprising of ten varieties have been supplied to the farmers of Samtse, Sarpang, amd SarupJongkhar, Wangdue-Punakha valley, Tsirang - Dagana, and Trongsa. These dzongkhags were the target dzongkhags of rice commercialization program as well as the beneficiary dzongkhags of Decentralized Rural Development Project (funded by Work Bank). Table 39 shows information on quantities of seed supply.

As presented in Table 39, the major rice growing dzongkhags like Samtse, Sarpang, Samdrup Jongkhar and Wangdue – Punakha received the maximum seed support. Among the improved rice varieties, Bhur Kambja 1 & 2, and Bhur Rey Kaap 1 & 2 were promoted more vigorously based on their yield potential and feedback received from the farmers. For mid-altitude region, IR-64 and Bajo Maap continued to gain farmers'

preference and so were supplied in larger quantities. The yield assessed from these improved rice varieties were about 1/3rd higher as compared to the local varieties under farmers condition.

Table 39: Supply of improved seeds in different dzongkhags

Varieties	DRDP Dzongkhags					Non DRDP Dzongkhags			Total
	W/due	P/kha	Tsirang	Dagana	Trongsa	Sarpang	S/J	Samtse	
IR-64	2000	1500	1000	1000	1000	0	260	0	6760
Bajo Maap 1	1800	1800	0	0	600	0	0	0	4200
Bajo Maap 2	900	1000	0	0	160	0	0	0	2060
Bajo Kaap 2	1000	1190	0	0	0	0	0	0	2190
No.11	800	100	0	0	100	0	0	0	1000
Khangma Maap	200	250	0	150	400	0	0	0	1000
Bhur Kambja 1	0	0	0	0	0	2600	2000	3800	8400
Bhur Kambja 2	0	0	100	100	0	2700	1900	4000	8800
Bhur Ray Kaap 1	0	0	1500	1500	200	2300	1800	1700	9000
Bhur Ray Kaap 2	0	0	1100	1200	0	1500	1300	1500	6600
	6700	5840	3700	3950	2460	9100	7260	11000	50010

Plant nutrient management

To boost yield potential of improved rice varieties, on-farm demonstration on balanced fertilizer application and pre-rice sesbania green manuring technologies were promoted. Crop cuts conducted during the farmers' field days in areas where such technologies were promoted showed encouraging results. However, with not many farmers taking up proper nutrient management, vigorous demonstrations and all out awareness will have to be continued for some more years. In the Dzongkhags of Samtse and Sarpang, there were as many as 22 and 20 numbers of balanced fertilizer demonstrations respectively. Similarly, there were a couple of integrated nutrient management demonstrations in Samtse Dzongkhag which used pre-rice green manure and fertilizers. In Samdrup Jongkhar, the use of pre-rice green manure is in full swing and many farmers have adopted it as part of Samdrup Jongkhar Initiative (SJI) to brand the

dzongkhag as organic. According to Table 40, the improved varieties have shown yield increase of about 30-40% and with the spread of these varieties, there stands a chance to double the stagnating yield in the southern belt of the country.

Table 40: Yield report from Samtse and Sarpang Dzongkhag

Site/Dzongkhag	Variety	Grain Yield (kg.ac)
Lingthang, Samtse	Bhur Ray Kaap 2	2040
	Bhur Kambja 1	2146
	Local variety	1360
Sipsoo, Samtse	Bhur Kambja 1	1766
	local	924
Beru, Samtse	Bhur Rey Kaap 2	2015
	Bhur Kambja 1	1850
	Bhur Kambja 2	1746
	local	1071
Sershong, Sarpang	Bhur Rey Kaap 2	1552
	Bhur Kambja 1	1282
	Local	905
Tarathang, Sarpang	Bhur Rey Kaap 1	1141
	local	802
Chuzargang, Sarpang	Bhur Kambja 1	1859
	local	1255
Shompangkha, Sarpang	Bhur Kambja 1	1719
	Bhur Kambja 2	1954
	local	900

Capacity building

To promote improved management practices, the rice program targeted training of both farmers and extension agents. Extension agents were provided a refresher course on basic rice production as well on seed systems. Altogether 41 extension agents have availed these trainings and plans are in place to at least training 100 extension agents and researchers in the next few years. Additionally, 60 extension agents have received ToT on group formation and farmer mobilization, taking up the number of extension agents trained to 101.

As regards training of farmers, 20 farmers were trained on nursery management and use of reaper harvesting at Lhamoizingkha under Dagana Dzongkhag. This training was packaged as part of spring rice production and plans are in place to bring more area under this cropping and train more farmers.

Spring rice production (rice double cropping)

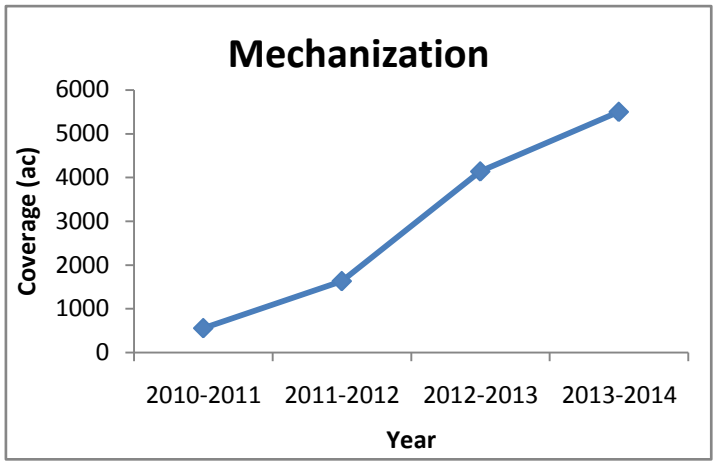
As part of crop intensification program, spring rice production is being targeted in potential areas. Spring rice production, in 2014 was done at Rinchengang (Wangdue Phordang) and Lhamoizingkha (Dagana) on about 30 ac and 6 ac area respectively. Rice double cropping has been emphasized and is one of the means to increase total production in the country. As a follow up activity, plans are under way to scale up rice double cropping to about 150 to 200 ac in the 2015 season. This year's total production from double cropping is 61.8 MT paddy which is worth Nu. 1.20 M as shown in Table 41.

Table 41: Area, production and productivity of rice double cropping

Location	Yield	Area coverage (ac)	Production (kg)	Remarks
Rinchengang (No.11)	1.9 t/ac	30	57000	Farmers selling a drey of No.11 rice @ Nu.150/kg
Lhamizingkhag (IR-20913)	0.80 t/ac	6	4800	Planning to scale up to about 50 ac in the upcoming 2015 season
		36	61800	~ 30900 kg milled rice=Nu.1.2 to 1.5 M (at Nu. 40-50/kg)

Farm mechanization

Farm mechanization has become one of the main components of rice commercialization program which is aimed to ease farm labor shortage, reduce cost of production, reduce drudgery of rice farming, make rice farming more attractive and improve the efficiency of rice farming. The machinery hiring services initiated by AMC has gained attention and publicity. Though it is being viewed as very important but an expensive government under taking, machinery hiring system has helped farmers in overcoming farm labour shortage. Farmers in some of the dzongkhags were able to bring back huge area to cultivation, thus contributing immensely to total rice production of the country. Farm mechanization services also provided employment opportunities to unemployed village lads by recruiting as machinery operators and many farmers were also trained on machinery operation and maintenance. The figure shows area coverage under mechanization program.



Post harvest and marketing

To improve quality of milled rice and marketing of local rice, several interventions have been undertaken including the installation of modern rice mills in potential clusters or dzongkhags. Apart from the 1.5 MT per hour capacity rice mill installed at Chuzargang in Sarpang (in 2008-2009), the DoA has completed installation of 3 other rice mills of 0.5 MT per hour capacity for Wangdue-Punakha (at RDC Bajo), Tsirang –Dagana (at Mithun, Damphu) and Samdrup Jongkhar (at Phuntshothang).

While there is some success on the rice processing and marketing front, going by the experience of Chuzargang, our existing farmers cooperatives and groups do not function satisfactorily and lack capacity. CAFCo of Chuzargang, for instance was not able to utilize the mill properly due to

inadequate working capitals and inefficient management. Therefore, the new rice mills are going to be operated and managed by FCBL that has adequate expertise, experience and working capital. In the face of many problems plaguing our farmers' cooperatives, there is an urgent need to entrust the rice mill for professional management to an entity that has adequate expertise, experience and working capital. It must, however be noted that such an arrangement to engage FCB is only an interim step until CAFCO (and other upcoming cooperatives) become fully capable to run the operations. With about 5-10% paddy collection, there stands a chance to have about 2000 – 4000 tons of local rice in the market.

Other support

Other support from the rice commercialization program included the following very important activities which has direct or indirect linkage with the production and cropping system:

- Land development and terracing at Tsirang: Re-terraced and developed about 2 ac land at Tsirang research sub centre. The objectives were to make the research farm ideal for machinery

use, more convenient for research activities and enhance work efficiency.

- Procurement and distribution of grain moisture meter: 80 sets of grain moisture were procured and supplied to the potential rice growing dzongkhsgs to be used genuinely for measuring grain yield. This is going to improve the quality of field data.
- Evaluation of rice germplasm: This is a continuous program of RDC and additionally, emphasis was also placed on screening of germplasm for earliness to be used for rice-rice cropping system
- Sample survey: A sample survey to make quick assessment of rice program impact in wangdue-Punakha valley. It basically focussed on use of rice varieties and allied interventions.

5.2 Agriculture and Demonstration Training Centre, Chimipang

5.2.1 Farm Road Construction

As per the proposed plan for farm road construction and also within the purview of approved budget a farm road boundary ring road construction has been completed. The actual work started from 2nd April 2014. The priority for excavation of farm road has been taken along the farm

Figure 11. An overview of farm boundary road

boundary basically to provide easy access to farm machineries and other amenities. With large area of 168 acres, with 30 ESP to bring the land under cultivation and plantation is a great challenge. Presently the center has managed to procure four powertillers but most of the paddy field terrace is narrow the terrace bunds are very deep and vertical which hinder the movement of machine from terrace to terrace. Given the difficulties engineering section of RDC Bajo has long term master plan for land development to bring the land under mechanization. With the support of CMU CAT machine a farm ring road is completed but there are still major

works to be executed. It is a long term plan and major activities will be done on phase wise basis.

5.2.2 Site development for office cum ESPs shed construction and plastic house

Figure 12. Site development for ESP shed

With only eight units of ESPs shed accommodating 30 ESPs is really a big problem, due to the housing problem few of the ESPs are still retained at Bajo but now with current budget of Nu 800,000 the center has tendered out work for two units and the works are currently under progress**. A** chain-link fencing and farm road pavement works have been contracted out and works are completed.

Table 42. Works tendered out and completed

Items	Unit
Construction of Office and ESP Shed	2 blocks
Chain link fencing	217 meters
Farm development	
	270

5.2.3 Rice production and demonstration

On 16th June 2014 RDC Bajo conducted a practical demonstration of rice transplanting to diploma students of College of Natural Resources (CNR, Lobesa), new Elementary Service Personnel of Agriculture Demonstration and Training Centre (ADTC), Chimipang and staff volunteers of RDC Bajo. It served as helping hand in terms of manpower support of CNR Agriculture faculty students and practical engagement. In total 150 members took part in the program. The program was organized to

Different methods of nursery establishnemt (1) inside plastic house & this can be planted by nachine (2) open wet bed nursery (3) seedlings are uprootted made into bundle & placed in he prepared field (4) planting

facilitate students in learning the work by doing as ADTC has the mandate to showcase RNR technologies and provide hands-on training to RNR trainees, field staff and farmers. Towards this end and to get manpower to cultivate larger area with rice, such program will be strengthened and will be continued further for benefit of learning purpose. Given the large targeted area of 50 acres in 2014 season, another program was also held on 24th June 2014 with the staff and ESPs of RDC, Bajo and Chimipang. National food security is our highest priority and with this concern RDC Bajo will continue to demonstrate and disseminate available RNR technologies to increase food production. Roughly about 50 acres paddy field has been brought under cultivation with different rice varieties (Table 43).

Table 43: Paddy varieties planted in 2014 at Chimipang

SN		Acres
1	Ngapja (Local variety)	10
2	Tan Tshering *(variety)	5
3	Bajo Kaap 1 (improved variety)	3
4	Bajo Maap 1 (improved variety)	2
5	IR-64 (improved variety)	30

5.2.4 Initiation of Fruits and Vegetable Crops Demonstration

Horticultural crops be it fruit crops or vegetables crops are gaining wide popularity both in rural and urban communities as a subsidiary diet long with meals, since almost all the fruits and vegetables crops are major source of minerals and vitamins. ADTC is mandated to train and

demonstrate technologies to farmers, students, University students, extension agents and civil servant from other Ministries as well. Therefore,

fruit plant and vegetable crop plantation and demonstration has started especially with the ones not popularly grown in Lobesa and Chimipang area. Initially the following crops and vegetables crops are tried.

Table 44: Fruits plants and vegetables planted in 2013-2014 Fiscal Year

SN.	Crops	Variety	Area/Quantity	Remarks
Fruits plants				
1	Citrus	Wengkhar tshalu 1	200 numbers	
2	Citrus	Wengkhar tshalu 2		
3	Guava	Red flesh	50	
4	Pecan		7 numbers	2 dead
5	Pomegranate	Bedana.	105	
Vegetables				
1	Asparagus	UC 157	14500 Nos.	
2	Bean	Top Crop		
3	Bean	Broloto	1 langdo	
4	Bean	Rajma		
5	Tomato	Roma	1/4	

5.2.5 Wheat production

World economic role of wheat production is significant both in terms of cultivated land and food supply, feeding and commerce. Population growth, climate change and unsustainable use of natural resources have already a negative impact on food security in some regions of the world. In the absence of global commitment to build food systems adapted to climate change and ensuring food security while minimizing greenhouse gases emissions and sustaining natural resource base, this negative impact is likely to increase and lead to global food shortfall and food price rises in the coming decades, resulting in undernourishment and poverty increase in the world's more vulnerable populations. Expanded investments in sustainable agriculture to increase agricultural productivity per land area and to avoid losses in productive capacity, as well as promotion of

healthier food diets and food waste reduction, are required to avoid an increasing gap between food supply and demand. To this front seed production of about 14 varieties, mainly the Nepalese and Indian lines has been initiated at Chimipang. This is basically pre-production trial/studies to find out the best varieties for release to farmers. The following were the varieties tested in 2014 and it will be continued to find the best varieties for grain yield and agronomic traits.

Table 45: Seed production of Wheat varieties

SN.	Varieties	Seed produced (kgs)
1	ADITYA	50
2	NL 1050	63
3	NL 1073 Ug99)	53
	NL 1053	20
4	NL 1054	32
5	NL 6040 (Ug99)	20
5	BL 3235	28
6	BL 1054	32
7	BAJ	
8	AGREM	
	Total	417

5.2.6 Demonstration and Promotion of Winter Fodder Production

Chimipang Crown property under Baap geog in Lobesa has an area of approximately 168 acres which encompass the area around the Chimi Lhakhang including the adjacent paddy fields. The crown property was proposed with the Royal Command to develop into a frontline agriculture and training project. RNR RDC Bajo is mandated with the production and developmental initiatives in the area. In the initial phase, RDC Bajo has started some basic production of cereal and vegetable crops. The overall development plan is in the process of finalization to execute and transform the area into a model agriculture project. The area development plan includes the integrated farming system model with agriculture, horticulture, forestry, fishery and livestock farming. The areas are divided into commodity-based production plan based on the feasibility study of the area. The site will also have infrastructure development including the offices, training hall, residential quarters and recreational areas.

As a part of livestock sector development activities, promotion of winter fodder production through cultivation of Oat *(Avena sativa)* mixed with

pea (*Pisum sativum*) to maintain soil fertility and demonstration on fodder maize *(Zea mays)* production was the initial activities during the fall season. These activities were to ensure green fodder production during the fodder shortage winter season. Although the technology on oat as winter fodder production was promoted in the past, this activity was intended to further demonstrate incorporation of legumes with fodder oat to better maintain soil fertility.

Livestock production in Bhutan is constrained by fodder shortage especially in winter period. Early on it was recognized that any improvement in livestock production depended on improving the quantity and quality of fodder resources. Yet today, nutritional limitations of the available livestock feed and fodder still remains to be the single most important constraint that needs to be addressed to enhance animal production. Besides, to make ends meet, Bhutanese farmers have adopted a mixed farming system whereby livestock farming systems are well integrated with that of the agriculture farming systems. During the 11th Five Year Plan, fodder development and animal nutrition will be the main leverage to achieve higher production levels.

Oat grain has always been an important form of livestock feed. Oats are a good source of protein, fiber, and minerals. Oats remain an important grain crop for people in marginal ecologies throughout the developing world, and in developed economies for specialist uses. In many parts of the world oats are grown for use as grain as well as for forage and fodder, straw for bedding, hay, silage and chaff. Livestock grain feed is still the primary use of oat crops, accounting for an average of around 74% of the world's total usage. Oats are better adapted to variable soil types and can perform better on acid soils than other small grain cereals crops. They are mostly grown in cool moist climates and they can be sensitive to hot, dry weather from head emergence through to maturity.

Besides, maize crop has an important place in the food grain basket of our country and is the one of the most important versatile food grain crops due to its importance in food, feed, specialty corn, starch etc. with wider adaptability under varied agro-climatic conditions. As it has yield potential far higher than any other cereal, it is sometimes referred to as the miracle crop or the 'Queen of Cereals'. Maize is an excellent crop in terms of biomass production. Since the production as well as productivity of maize is increasing in the country, the availability of biomass from maize is also increasing at the same magnitude. Maize straw is used as animal fodder

since the ancient times. Besides, the fodder quality of green maize is excellent. Amongst the non-legume cultivated fodders, maize is the only fodder which produces better nutritional quality along with good quantity of biomass.

Objectives

The objectives of this activity were to:

- Assessment of fodder oat and maize as winter fodder in wetland based farming system
- Demonstrate promotion of winter fodder to provide better nutritional quality and quantity biomass during winter season

Methodologies

The demonstration trial was conducted in a field measuring approximately four acres. The demonstration plot was located adjacent to Punatshang Chu river, the allocated land was divided into two plots, the large plot of 3 acres was sown with Oat mixed with pea (1.5 acre line sowing and 2 acres broadcasting) followed by the remaining 0.5 acre land that was sown with fodder maize as winter fodder. The standard seeding rate of oat seed was 150 kg per hectare (60 kg per acre), pea seeds at the rate of 30 kg per acre (broadcasting) and fodder maize at the seed rate of 40 kg per hectare (16 kg per acre). The land preparation and time of sowing was done as per the activity plan. Seed purity and germination tests were also conducted in the lab prior to sowing. Data on Green biomass yield and dry matter content was taken two times at 45 and 85 DAS. The samples were also used for dry matter (DM) assessment in the laboratory, the sample were oven dried at 75^{o}C for 48 hours and the dried sample weight are recorded for analysis. Other data on the number of cuts for oat and legumes, total biomass production and farmers' feedback on the adoption of winter fodder technology will be collected. In order to

Figure 13: Land prepared for winter fodder production

demonstrate the winter fodder production trial at the crown property area in Chimipang, the following materials were used.

Table 46: Resources used for winter fodder production

Sl. No.	Particulars	Quantity	Remarks
A	Seeds		
1	Oat seeds	240 kgs	
2	Pea	600 packetsx20 gm	
3	Fodder maize seeds	20 kgs	
B	Fertilizers		
1	Urea	3 bag (50 kgs)	
2	Suphala	2 bag (50 kgs)	
C	Farm machineries		10 days for land preparation and 2 days for sowing
1	Labor	4 men x 12 days	
2	Power-tiller	2 x 12 days	

Results of Seed Germination Test

Prior to the sowing of winter fodder, seeds of both oat and pea were tested for its purity and germination at the Regional referral seed testing laboratory at Bajo. The tests methods were based on ISTA rules and regulation and the finding of the test results are presented in Table 47.

Table 47: Purity and Germination test result

Seed type	Pure Seed	Inert matter	Other seeds	Normal seedling	Abnormal seedling	Dead seeds	Hard seeds	Fresh seeds
Oat	99.9%	0.1%	-	68.25%	2.5%	1.5%	12.25%	15.5%
Pea	100%	-	-	82.5%	2%	3%	3%	9.5%

The laboratory test result shows that the pea seed had better purity and germination percent as compared to the oat seeds with 82.5% normal seedling rate of pea as compared to 68.25% in oat.

Plant growth rate and height

Timely monitoring and data were recorded on plant growth rate and height. Based on the data of 45 and 85 days after sowing (DAS), following data were recorded:

Plant height at different harvest dates

Fodder type	Date of Harvest	DAS	Plant height (cm)
Oat	27/12/2013	45 days	27.00
	11/02/2014	85 days	36.60

Pea	27/12/2013	45 days	23.25
	11/02/2014	85 days	45.60

The growth rate was not very promising since the field was very dry and

Figure 14: Plant growth rate at 45 DAS and 85 DAS

the soil temperature was also low. There were also incidences of stray animals (cattle and horse) grazing in the fields since the area was not fenced. However, with timely irrigation and application of fertilizer (urea), the plant growth had improved however there is a need for further recording at 120 DAS.

Yield assessment : Biomass production and Biological composition

Biomass yield was assessed during the growth stages by cutting five samples randomly using a quadrant and over the period of 45 days, and there was an increase in the overall biomass production. There was huge increase in the biomass weight of pea at 85 DAS (358 gms) compared to 45 DAS (33 gms). This was attributed to the biological composition of the fodder plants. At the 45 DAS, the composition of pea was only 5.82% whereas oat was 94.18%. However, at 85 DAS the composition of pea was 31.96% compared to oat with 68.04%.

Figure 15: Biomass assessment at 45 DAS

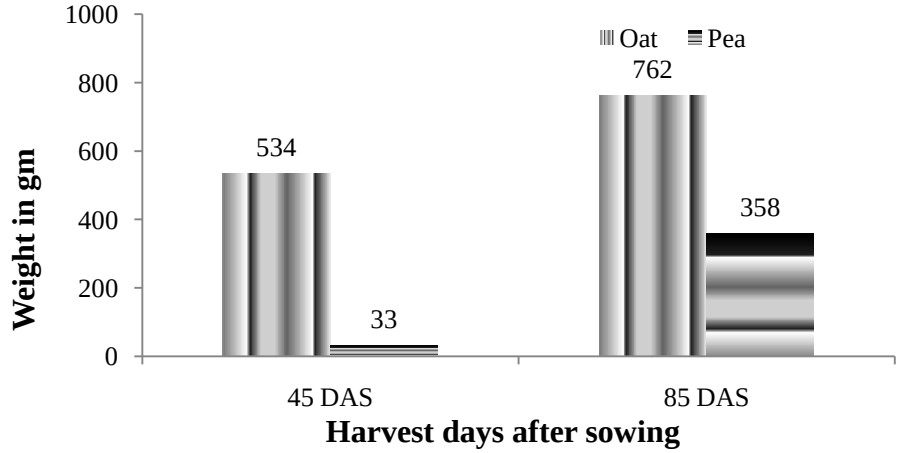


Figure 16: Biomass production at different harvest dates

The yield assessment shows that at 45 DAS, the total average biomass production was 567.03 gm from an area of 1 m^2 which computes to 2.3 tons per acre. Similarly at 85 DAS, the average biomass production increased to 1120 gm which was equivalent to 4.5 tons per acre. The result shows that within 40 days interval and with the additional inputs of irrigation and fertilizer application, there was 49% increase in the biomass production.

Dry matter production

The fresh biomass was converted into dry matter (DM) by oven drying in the laboratory and it was found that at 45 DAS, the DM content was 40.80% of which 16.25% was from oat and 24.55% was from pea. On an average, the total biomass during the first harvest was 384 kg per acre. Similarly,

during the second harvest at 85 DAS, the DM content slightly increased to 50.90% of which 22.90% from oat and the remaining 28% was from pea. The DM production during the second harvest was 1112.5 kg per acre. The DM content during the second harvest has increased by three folds while comparing to the first harvest.

Table 48: Biomass and dry matter production at different harvest

	Date of Harvest	Biomass (gm)	Biological composition (%)	DM%	Yield (kg/acre)	DM (kg/acre)
Oat	27/12/2013	534.01	94.18	16.25	2161.66	351.24
Pea	27/12/2013	33.02	5.82	24.55	133.65	32.82
Total		567.03	100.00	40.80	2295.32	384.06
Oat	11/2/2014	762.00	68.04	22.925	3084.58	707.13
Pea	11/2/2014	358.00	31.96	27.973	1449.18	405.38
Total		1120.00	100.00	50.898	4533.76	1112.51

Further continuation of activity

With the transfer of the concerned staff from the research centre, the activity was not completed. The activity needs further continuation for yield assessment at 120 DAS and the final data need to be analyzed for reporting. In addition, the winter fodder produced from the area may be shared and provided among the farmers in the locality to provide supplementary nutrition during the lean and dry months. Some portion of the fodder may be kept for seed production to ensure continuity of winter fodder production in the next season.

5.3 Engineering Sector

5.3.1 Construction of Park Head Office at Chokhortoe Bumthang

The Engineering Sector (ES) of RDC Bajo provided site supervision services for the construction of Park Head Office at Chokhortoe, Dekiling Geog under Bumthang for Wangchuck Centennial Park, DoFPS, MoAF. The work was awarded to M/s National Builder at cost of Nu7.740 million. The work was started on 22 April 2011 and completed on 22 April 2012. The final value of the work was Nu 9.729.

5.3.2 Construction of Double Unit Staff Quarter at Sephu

The Engineering Sector (ES) of RDC Bajo provided site supervision services for the construction of Double-Unit Staff Quarter at Sephu for Wangchuck Centennial Park, DoFPS, MoAF, Bumthang. The work was awarded to M/s Wangdicholing Construction at a contract of Nu 2.755million. The work started on 28 August 2013 and was scheduled to complete on 28 March 2013. The project duration was extended and actual completion was on 30 June 2013 as the work could not be completed on stipulated duration. The final value of the work stands at Nu 2.235 million.

5.3.3 Infrastructure development for Eco-tourism Camp at Tang

The sector provided site supervision for the construction of various infrastructure development for Eco-tourism Camp at Tang for Wangchuck Centennial Park, DoFPS, MoAF, Bumthang. The work was awarded to M/s Haapa Construction, Bumthang at a contract of Nu1.514 The implementation started on 29 August 2013 and completed on 01 March 2014. The final amount of the work stands at Nu 1.514.

5.3.4 Maintenance of approach road at WPRO

The site supervision for maintenance of approach road at WPRO at Sephu for Wangchuck Centennial Park, Bumthang was provided by the Engineering Sector at RDC Bajo. The work was implemented through Community Contract mechanism at a contract price of Nu 0.206 million. The work started on 01 March 2013 and was completed on 20 June 2013. The final amount of the work done was Nu 0.206 million.

5.3.5 Infrastructure development for Beat Office at Kurkubithang

The Engineering Sector provided the services for infrastructure development works for Beat Office at Kurkubithang under the Divisional Forest Office at Deliking, Bumthang. The works included the construction of Beat Office, Check Post, 3-unit Staff Quarters and site development works. The work was implemented by M/s Legsho Construction at a contract price of Nu 2.752 million. The scheduled implementation duration was from 01 March 2012 to 01 December 2012. As the work could not be completed on time, the project duration was extended the work was completed by 25 July 2013. The final value of the work stands at Nu 4.848 million.

5.3.6 Construction of Office cum Residence at Bumthang

The site supervision for the construction of Office-cum-Residence at Bumthang for BAFRA was provided by the sector. The work was awarded to M/s UP Construction, Thimphu at a contract price of Nu 5.738 million. The final amount was Nu 5.325 million. The work started on 13 March 2013 and completed on 13 Dec 2013 as scheduled.

5.3.7 Construction of PD Residence at Khangma

The site supervision for the construction of Program Director Residence at Khangma, Trashigang for Regional Livestock Development Centre at Khangma was provided by the sector. M/s Namsel Construction implemented the work at a contract price of Nu 6.793 million. The final amount of the work stands at Nu 7.302 million. The work started on 27 July 2012 and was scheduled to be completed by 27 May 2013. As the project could not be completed on schedule the work duration was extended and was completed on 30 September 2013.

5.3.8 Renovation and Extension of Staff Quarters at Khangma

The sector provided site supervision for major renovation and extension of Staff Quarter at RLDC at Khangma, Tashigang. The work was awarded to M/s Tshongdrup Construction at a contract price of Nu 2.332 million. The work started on 25 July 2012 and was scheduled to be completed by 31 December 2012. The work was actually completed on 30 June 2013 at a final cost of Nu 3.131 million.

5.3.9 Rice Mill Construction at RDC Bajo

The site supervision services for construction of Rice Mill at RDC Bajo, Wangdue for Department of Agriculture was provided by the sector. The work was awarded to M/s T Yangdon Construction at a contract price of Nu 2.368 million. The works started on 20 September 2013 and completed on 19 April 2014 as scheduled and final amount was Nu 2.296 million.

5.3.10 Rice Mill Construction at RDSC Tsirang

The sector provided the site supervision service for construction of Rice Mill at RDSC Tsirang for the Department of Agriculture. The work was awarded to M/s X Construction at a contract price of Nu 1.980 million. The works started on 19 October 2013 and completed on 19 April 2014 as scheduled. The final value of the work was Nu 2.296 million.

5.3.11 Land Development Work at RDSC Tsirang

The sector prepared drawings and estimate for research farmland development work at RDSC Tsirang. The work was awarded to M/s Urung Construction through limited bidding owing to limited time for open tendering process. The work was initially planned to be implemented departmentally through the use of CUM excavator. But owing to the busy engagement of the excavator for other priority activities, this land development work had to be tendered out finally. The work was completed in stipulated time frame. However, owing to the difference in the interpretation of the specification of the earthwork item (EW0046), the contractor has not accepted the final bill amount of Nu 0.198927 million passed by the Engineering Sector.

5.3.12 Renovation of Second Stage Pump Station at RSC Bajo

The Engineering Sector conducted survey, prepared drawings and estimate for the Second Stage Pump Station construction work at RSC Bajo. The work included construction of pump house, pump, and gravity irrigation pipeline system. Engineering Division under the Department of Agriculture has awarded the work to M/s Kenrab Construction for the implementation of the work. Site supervision and bill verification responsibility were provided by ES at RDC Bajo. The work was completed on stipulated time and the value of the work is Nu 0.914 million.

5.3.13 Back topping of parking & approach road and Maintenance work at RSC Bajo

The Engineering Sector prepared drawings and estimate for the Black topping of parking & road, and Maintenance of Buildings at RSC Bajo. The work included construction RCC Gate, Cattle Guard, and Signboard. The implementation of work was awarded to M/s Sonam Construction by NSC Paro at a contract price of Nu 2.599 million which was stipulated to be completed within five months. Apart from signboard all other works were completed on scheduled time.

5.3.14 Re-electrification work at RSC Bajo

The Engineering Sector prepared drawings and estimate for re-electrification of farm buildings at RSC Bajo. The implementation of the work was awarded to M/s KWSS Construction on 22 October 2013 at contract amount of Nu 0.151 million with implementation period of two months. The total value of the work done was Nu 0.150million. The work was delayed by 180 days resulting in penalty reduction of Nu 13,513.33 from the final bill.

5.3.15 Farm infrastructure improvement work at RSC Farm in Phobjeekha

The engineering sector prepared proposal for major farm infrastructure improvement proposal for RSC Farm in Phobjikha. The sector conducted site surveying of existing farm infrastructures, made assessment of the functionality of these structures and accordingly proposed for renovation, major modification or completely new infrastructures. Based on theses decision drawings and estimates were prepared for various types of works which included (1) major modification of office block, (2) renovation of two staff residences, (3) renovation of three stores, (4) construction of night guard residence, (5) electrification work for all buildings, (6) compound fencing with gate for two stores, and (7) GI chain-link fencing with gate for two farms. The total costs of implementing above activities were estimated at Nu 6.171 million.

The NSC Paro awarded the implementation of the work to M/s Sonam Construction at contract price of Nu 4.184 million with stipulated project duration of 5.5 months starting from 06 December 2012. Owing to the

cold climate in Phobjikha, the work was suspended for two months (December 2013 and January 2014). Further additional work requiring additional time of 1.5 months was awarded pushing the completion date to 10 July 2014. The work was completed on time and the final bill amounted Nu 4.104 million.

5.3.16 Construction of Lift Irrigation for Lobesa Rice Commercialization

The sector devoted substantial amount of time for preparation of proposal for lift irrigation for the Rice Commercialization and Chimmipang Farm in Lobesa. The activity included L-section surveying for pipeline alignment, designing, preparation of drawings and estimate, consultation of the proposal with the beneficiary farmers, drawing up cost sharing mechanism for capital works, finalizing model of managing the recurrent cost, and land allocation agreement for pipeline laying. Initially, entirely separate project for above two farms were designed. Since the two farms are adjacent to each other, there was huge potential to reduce the cost if the pipeline trenching, the pump and the control houses were combined. However, it requires redesigning of the project demanding more time. Finally, re-design, preparations of drawing & estimates were completed, and the work was tendered out. Upon opening of the tender quoted prices were 22.55% above the estimated cost. Hence, there allocated budget for Chimipang Farm was not adequate and hence decided not to award the Chimmipang Farm part. As a result only the Rice Commercialization component was awarded to M/s Chimmi RD Construction at contract price of Nu 7.687 million.

As the allocated budget was limited, it was decided that the pipe trenching work will be implemented departmentally; trenching and refilling will be done by beneficiary farmers, besides many other items of works although necessary were removed to minimize the cost before awarding the work. Currently about the 70 percent of the work is completed.

5.3.17 Construction of Bajo-Trashigang irrigation channel siphon link at Wangjokha

The sector conducted survey, prepared designs, drawings and estimate (Nu1.991 million) for the construction of siphon pipeline linking Bajo and Trashigang Irrigation Channel at Wangjokha. The implementation of the work was awarded to M/s Solution Builders at contract price of Nu 2.254

million with implementation duration of 59 days starting from 19 April 2014. At present 60 percent of the work is completed. This siphon consisting of 280mm diameter HDPE pipeline with a total length of 606m can convey 140 lps (maximum designed capacity) of irrigation water from Bajo Irrigation Channel to Trashigang Irrigation Channel. About 72 acres of wetland owned by 40 households can be irrigated from this siphon link system. At present 70 percent of the area are left fallow owing to water shortage problem. The WACREP project through Bhutan Water Partnership Project based in RSPN will finance 76 percent of the project cost while the RGoB will cover the remaining cost.

5.3.18 Construction of FMU Office/Residence at Phobjeekha

The sector provided the site supervision services for construction of Office cum Residence for Forest Management Unit at Phobjikha. The service included monitoring of construction, verification and passing of bills.

5.3.19 ATDC Physical Infrastructure Development Master Plan

The sector devoted substantial time for preparation of ADTC Farm Physical Infrastructure Development Master Plan. The component of this master plan included construction of (1) primary farm road, (2) internal farm link roads, (3) irrigation and drainage networks, (4) farm land development works, (5) farm protection (fencing), and (6) temporary office, store and ESP Quarters. The work included planning of farm infrastructures, surveying, designing of structures, preparation of drawings and estimate, and getting the approval (Table 49).

Table 49: Summary of quantity of work and cost estimate

SN	Budget Code	Expenditure on description	Quantity	Cost (Nu.Million)	Remark
1	51.01.01	Building- ESP Quarters	15 .000 Blocks	5.882	(Double units per block)
2	51.01.02	Roads- Farmroad	8.666 km	38.310	
3	51.01.04	Irrigation channels	4.100 km	9.600	
4	51.01.08	Others- Fencing	4.300 km	7.729	
5	51.01.08	Others- Land development	117.000 ac	3.307	
Total				64.828	

Further, the sector also provided support for the Thai counter parts entrusted with the master plan preparation for water resources management infrastructure development for the farm. This preliminary master plan envisages the construction of two irrigation water storage ponds to store irrigation water when the water is freely available before paddy cultivation season. For this about 12 acres of farmland has to be utilized for water pond construction which amount to about 8 percent of the farm area. Based on Bhutanese conventional thinking it is a complete waste of land, however, based on the new farming concepts that are being promoted in Thailand, depending on the degree of water scarcity as much as 30% farmland can be used as water storage area and can be still be profitable. The sector provided soil sampling reports, conducting irrigation water conveyance alignment survey, and provided preliminary conveyance design for conveying irrigation from Lower Lobesa channel to the proposed ponds in the farm.

5.3.20 Farm road formation cutting works

The farm road formation cutting for the farm ring road was implemented by the sector departmentally using the CMU excavator. From a total of 8.666 km farm road construction planned, formation cutting for 4.10 km was completed in the fiscal year.

5.3.21 Construction of ESP Residence at ADTC Chimipang

The sector prepared designs, drawings and estimate for second phase construction of two blocks of Double-unit ESP Quarters at ADTC Chimipang Farm, Lobesa. Although this work was planned to be implemented completed by the end of the fiscal year, the sector could only manage to conduct open tender and award the work by end of June 2014 owing to the late release of budget. The work was awarded to M/s Thongden Construction at a contract price of Nu 0.600million.

5.3.22 Construction of Farm Road at ADTC Chimipang

The sector prepared designs, drawings and estimate for construction of first phase of farm road base course (0.807 km), road drain and cross-structures at ADTC Chimipang Farm, Lobesa. The work was awarded to M/s D-Builders, based in Punakha at contract price of Nu1.196 million.

Owing to late release of budget the work could be only awarded for implementation by the end of the fiscal year.

5.3.23 Construction of GI Chain-link at ADTC Chimipang

The sector prepared designs, drawings and estimate for construction of first phase of GI Chain-link fencing (0.817km), two numbers of RCC gates, and two cattle guards at ADTC Chimipang Farm, Lobesa. The work was awarded to M/s Dolzin Construction, based in Wangdue at contract price of Nu1.247 million. Owing to late release of budget the work is only awarded for implementation by the end of the fiscal year.

5.3.24 Consultation meeting with regional dzongkhags

The sector conducted consultation meeting with regional dzongkhags (Bumthang, Trongsa, Punakha, Wangdue, and Dagana). The objective of the meeting was to identify irrigation schemes that will be developed by the central programs during the 11 FYP. The Engineers based in RNR Engineering Division Thimphu, and RDCs will implement the work. The schemes were identified based on two criteria (a) command area more than 70 acres, and (b) irrigation channel having length of more than 10 km with major problem with irrigation water management. Other irrigation scheme not satisfying these criteria will be taken up either by Dzongkhag or Geog based on their priority. The intention of applying such criteria was to enable the sharing of the responsibilities between the central agencies and the dzongkhags, and to avoid the problems of budget ceiling for the Geog programs.

The meeting was conducted dzongkhag wise which was participated by the Gups and Extension Agents from the Geog, and DAO & DE from the respective dzongkhags. During the meeting individual geogs prepared list of irrigation schemes which fulfilled the said criteria and provided priority at geog level. At dzongkhag level, three highest prioritized irrigation schemes from all the geogs were selected and dzongkhag level priority rankings were provided based on the same criteria. Similarly all the highest prioritized irrigation schemes were selected and national level ranking was done. From these top highest 108 irrigation schemes were selected for implementation in the 11FYP, of which 33 schemes will be implemented by RDC Bajo within 11FYP period.

5.3.25 Preliminary water resource development feasibility study in Punakha

Following the command from Hon'ble Sanam Lyonpo, a team comprising of Dzongkhag Agriculture Officer (DAO), Punakha Dzongkhag, the Principal Research Officer (Irrigation Water Management), RDC Bajo and the Tsogpas and public representatives from the concerned communities visited proposed sites for establishing water pump irrigation and water reservoir under Guma and Chhubu Gewogs. The visit was made on 27 May 2014 with the objective to undertake pre-feasibility assessment of the four villages for the proposed projects. The findings are summarized below.

Changyul Chewog

The Changyul area consisting of more than 100 acres of Chhuzhing usually face acute water shortage during peak paddy transplantation period owing to small water source and delayed rainfall. The problem gets more severe during winter when there is prolonged dry spell. Considering its proximity to Mochhu riverbed, the area is highly feasible for setting up water pumps. Preliminary assessment shows that the estimated operation cost of the pump is Nu.353 per acre. This is derived based on transplanting gift of 200mm and electricity rate of Nu. 2.50 per unit (**Error! Reference ource not found.**50).

Docho-Ritsa Chewog

This chewog has more than 200 acres of Chhuzhing. This chewog shares the same water source with Changyul and has similar irrigation shortage problem. Although the height at which the water has to be pumped is much greater than Changyul (100-120m), the area is still found feasible for water pump irrigation. Assuming 50% of the paddy transplantation water requirement is pumped from Mochu River to the Docho-Ritsa main irrigation channel the estimated cost of pumping is Nu557 per acre. In fact, if a water pump is set up for this chiwog, their share of water could be used by Changyul and other communities upstream thereby reducing water problem.

Yebisa Chewog

In Yebisa setting up pump irrigation was done to supplement the existing source following the command from the Hon'ble Sanam Lyonpo. Tshogpa mentioned about 85 acres of paddy fields face acute water shortage during paddy transplantation. Although it appears possible to set up water pump

irrigation, the problem would be the distance and the height at which the water is to be pumped from the riverbed. The distance would be about 420 meters, which may not be recommendable economically. However, based on our preliminary assessment, the estimated cost of pumping is Nu538 per acre assuming 50% of the paddy transplantation water requirement is pumped from Mochu River to the main irrigation channel.

Nawakha Community

Nawakha community is currently facing irrigation water problem because of very small water source and large command area of about 600 acres. There are three existing channels fed by the same small water source and with occasional additional input from Jawakha irrigation channel (if there is surplus). The upper channel serves about 70 acres whereas the middle and the lower channels feed about 500 acres and 30 acres respectively. The direction from authorities were to (a) assess the site for water reservoir construction, (b) look at the possibility of setting up water pump irrigation as an alternative water source, and (c) discuss with the public about the possibility of constructing a new irrigation scheme from a different source.

Regarding the site for water reservoir construction, it was observed that the site identified by the community is too small for construction of a water reservoir to adequately store and supply water to 600 acres of paddy fields. An alternative off site water reservoir construction was also explored, but could not be found anywhere nearby the community. Therefore, it was decided that the construction of water reservoir is technically and economically not advisable considering the command area and the site condition.

The next option explored was setting up water pump irrigation. According to the local people, water has to be pumped up to the middle channel as it has the maximum command area (500 acres). But again the problem is the high static head of about 223m although the distance is only about 1240 m. Therefore, people were informed that the construction of water pump may not be advisable on economic ground. As per the preliminary estimates, pumping cost is estimated at Nu1,163 per acre considering only 50% transplanting water requirement is pumped from Phochu River to middle channel. Although, technically pumping is feasible but economic feasibility may be very low owing to high static head.

The final option was to explore further the construction of new irrigation scheme from a new water source called Chhuralum which is located at about 35km. People feel that this option would be more reliable than the earlier two options, although it might work out to be more expensive.

Table 50 : Profile of the proposed lift irrigation

Village/ Chewog	Geog	N-CA	Lift CA		Flow	Head	Length	Cost
		(ac)	(ac)	(%)	(litre/s)	(m)	(m)	(Nu/ac)
Changyul	Guma	100	100	100	41	32	358	352.26
Docho-Ritsa	Guma	200	100	50	41	113	700	556.99
Yebisa	Chhubu	85	43	50	18	100	408	537.69
Nawakha	Chhubu	500	250	50	104	223	1240	1,162.47

6 ANNEXES

6.1 Visitors to the centre

Date	Name of the visitor	Address	Purpose of Visitor
15-20/07/2013	Mr. Olan Pituck	Deputy Permanent Secretary, Thailand	Farm Planning of frontline Agriculture Demonstration Center, Chimipang, Punakha.
	Mr. Pradab Kladkem Petch	Director of Huai Hong Khrai Royal Dev Study Center, Thailand	
	Mr. Chatchai Pedugsorn	Head of Dam Safety, Thailand	
	Mr. Direk Kongpae	Soil Surveyor, Land Development Dept	
	Mr. Kiltipan Janthasri	Director of Extension	
10/02/2014	Mr. Chalit Damrongsak Mr. Lorsak Rewtarkulpaiboon Mr. Olan Pituck Mr. Derake Tonpayom Mrs. Sineenart Khovitoonkij Ms. Jitranont Suchart Mrs. D Somwatanasak Mr. Warapong Priraban Mr. Rasu Suepsahakarn	Royal Government of Thailand	Monitor the progress of Agriculture Development & Discuss fine tune the design of Irrigation ponds at ADTC, Chimipang.
11/04/2014	Group of graduate students	Charles Stuart University, Australia.	Field Visit
23/04/2014	Dr. Aran Joshi (Regional CIMMYT Coordinator)	CIMMYT & ICAR Wheat Scientists.	Field visit to Bajo Station trials.
	Dr. Indu Sharma (Director, Directorate of wheat Research)		
	Dr. CP Srivistavata (Professor from Banaras Hindu University)		
23/04/2014	Dr. Ashutosh Sarker, Coordinator	South Asia & China Regional Program (ICARDA)	Review ongoing ICARDA research activities and discuss future collaboration.
23/04/2014	12 Members Delegates.	Ministry of Agri Development, Nepal	Explore possibilities of trade in Livestock.
24/05/2014	Ambassador and delegation from Bangladesh	Bangladesh	Official Visit.
30/06/2014	Livestock officials from High Mountain Agri-Business, DoL	Nepal	Official Visit.

6.2 Training, meetings and workshops

Date	Name	Place	Purpose
01-12/07/2013	Ngawang Chhogyel	IRRI, Los Banos, Philippines	Training on Rice Breeding
12-13/07/2013	Tshering Wangchen	New Delhi, India	Workshop on "Regional initiation on Development of pulses and adaptive trials in SAARC Countries."
15/08/2013 - 4/09/2013	Jigme	Korea	Training on "Post harvest technology"
19-20/08/2013	Legjay	New Delhi, India	Workshop on "Borlaug Global Rust Initiatives (BGRI) 2013."
2-3/09/2013	Yeshey	Bangkok, Thailand	Expert consultation workshop on sustainable land management to respond to climate change
22/09/2013 - 2/10/2013	Legjay	Kenya Agricultural Research Institute (KARI), Kenya	Standardization of stem rust field notes and germplasm evaluation with discussion on stripe and leaf rust.
6-8/10/2013	Sangay Tshewang	Dhaka, Bangladesh	CSISA Wheat Breading Meeting
16-21/10/2013	M Ghimiray & Tshering Wangchen	Haryana, India	Meeting with Haryana State Development of Agriculture to explore commercial mustard varieties.
26-30/01/2014	Mahesh Ghimiray	Bangkok, Thailand	Consultative meeting on rice in Bangkok organized by EAO.
25-31/01/2014	Thinley Gyamtsho	Bangkok, Thailand	Agriculture working group meeting with MOAC-Thailand
16-25/02/2014	Mahesh Ghimiray	Philippines	Meeting on Agrobiodiversity.
22-28/03/2014	Sangay Tshewang	Ciudad Obregon, Mexico	Annual BGRI technical workshop.
27/04/2014 - 10/05/2014	Ngawang Chhogyel	Vietnam & Thailand	Meeting towards the Introduction of Low Cost Grain Dryers.
22-30/04/2014	Lhab Gem & Yeshey Dema	Kathmandu, Nepal	Training on Seed systems & community Based seed production.
19-22/05/2014	Dr.Yadunath Bajgai	DWR. Karnal, India	Regional workshop at DWR Karnal, India.
21/05/2014-9/07/2014	Puran Chhetri	Japan	Training on irrigation management system for paddies for Asian countries
28.05.2014 – 29/06/2014	Indra Bahadur Raika	Japan	Water management (Small Dam) for Asia training
01-12/06/2014	Cheku Dorji	Nepal	Study visit to Nepal.
10-13/06/2014	Ngawang Chhogyel	Daka, Bangladesh	Meeting on identification of rice varieties tolerant to a biotic stresses.

6.3 Financial progress

RGoB contribution for RDC,Bajo (current)

Code	Particulars	Approved Budget	Expenditure
1.01	Pay and Allowances	13603000	13163970
2.01	Other Personnal Emoluments	3768000	3270000
11.01	Travel-incountry	4391000	4393677
12.01	Utilities-Telephones,Telex,Fax,E-mail internet	192000	191116.85
12.02	Utilities-Telegram,Wireless Transmission postage	30000	30000
13.03	Utilities-Electricity,Water,Sewerage	120000	120000
14.01	S & M-Office Supplies,Printing, Publication	120000	119816
14.02	S & M- Medicines & Laboratory Comsumables	16000	15715
14.03	S & M-Fertilizers,Chemicals,Manures,innoculants	130000	129937
14.04	S & M-Seeds,Seedlings	177000	176626
14.06	S & M-Uniforms,Extension Kits,Linens	177000	177000
14.06	S & M-Text Books,Library Books,Stationeries & Sports item	10000	10000
15.01	Maintenace of Property-Buildings	78000	78000
15.02	Maintenance of Property-Vehiclels	980000	977457
15.05	Maintenance of Property-Equipment	85000	84992
15.06	Maintenance of Property-Plantations	65000	65000
15.09	Maintenance of Property-Water supply sewerage,playfield	25000	25000
17.01	Op. Exp- Advertising	140000	137003
17.02	Op. Exp-Taxes,Duties,Royalties,Handling Charges, Bank Charges	7000	7000
17.03	Op. Exp-Transportation	47000	47000
17.08	Op. Exp-Incountry Meeting and celebration	181000	175749
24.03	Contributions-Provident Fund	1067000	1067000
25.01	Retirement Benefits	240000	223,655
Total			**24685713.85**

RDC Bajo capital expenditure

Code	Particulars	Budget	Expenditure
52.05	Plant & Equipt-Agrucultureal Machineries	180000	171565
Total			**171565**

DRDP Contribution for RDC,Bajo(Current)

Code	Particulars	Budget	Expenditure
14.04	S & M-Seeds,Seedlings	100000	997144
15.06	Maintenance of Property-Plantations	500000	500000
17.09	Op. Exp-Survey/Census	500000	453363
Total			**1950507**

DRDP Contribution for RDC,Bajo(Captial)

Code	Particulars	Budget	Expenditure
45.01	Training-Human Resources Development	100000	893878
45.02	Training-Other	800000	645529
51.08	Exp.on Structure-Other	200000	
52.08	Plant & Equipt.-General Tools, Instrument	1500000	1499968
Total			**3039375**

6.4 Meteorological information

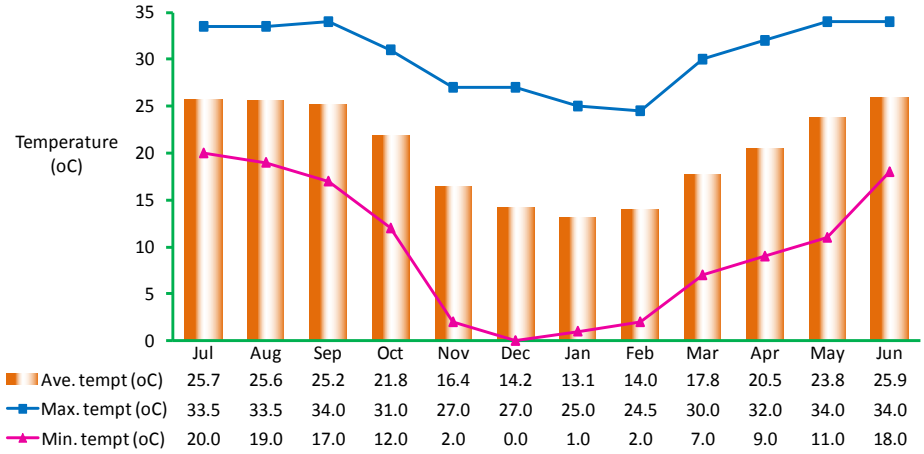


Figure 17: Monthly average, maximum and minimum temperature at RDC Bajo (July 2013-June 2014). Source: Bajo Meteorology Station

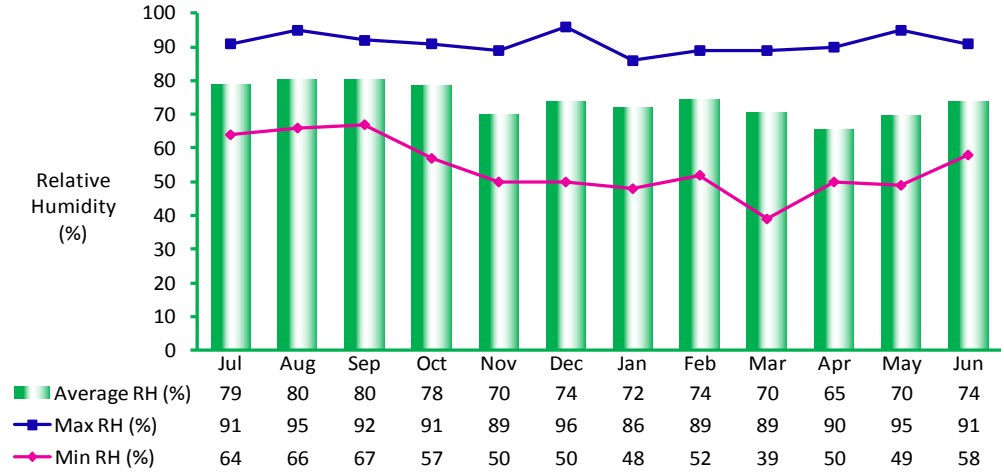


Figure 18: Average, maximum, and minimum relative humidity at RDC Bajo

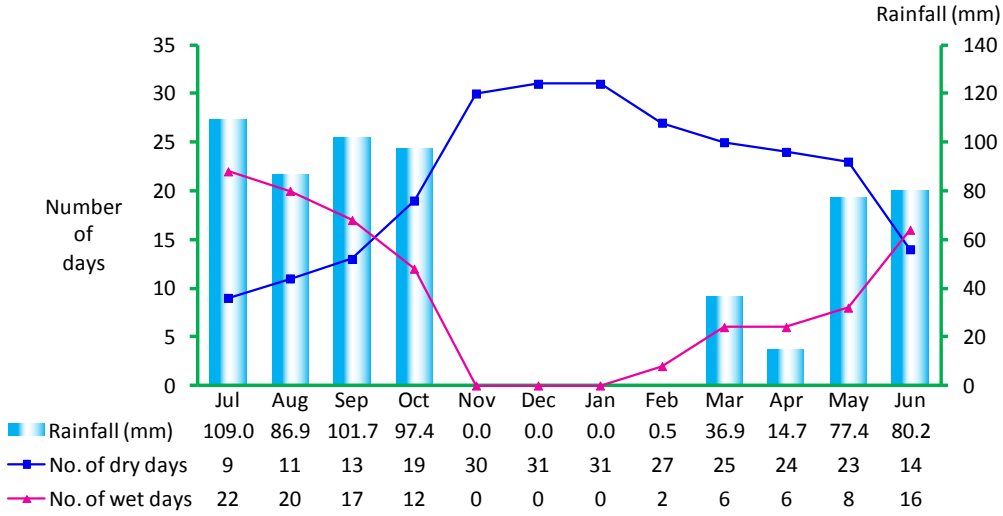


Figure 19: Monthly rainfall, number of wet and dry days at RDC Bajo

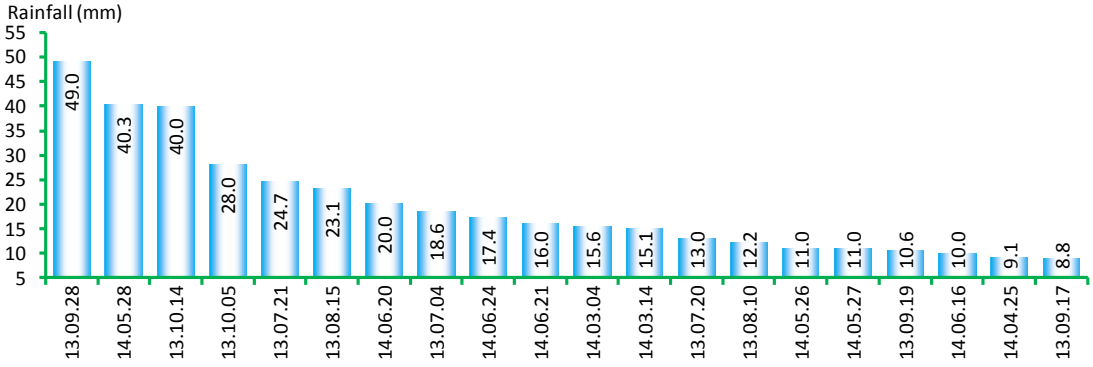


Figure 20: Highest 20 rainfall days at RDC Bajo

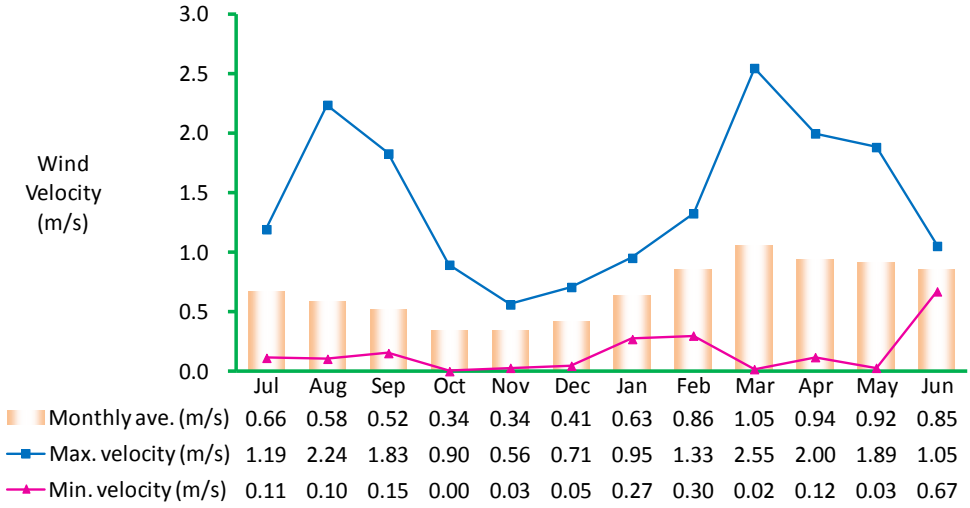


Figure 21: Monthly average, maximum and minimum wind speed at RDC Bajo

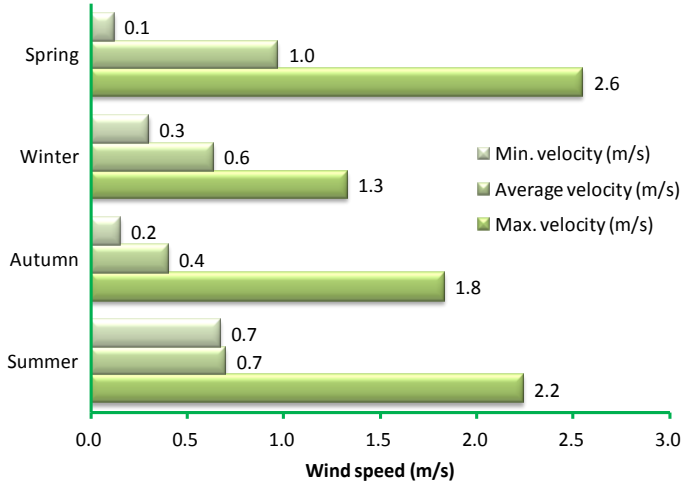


Figure 22: Seasonal wind speed pattern at RDC Bajo

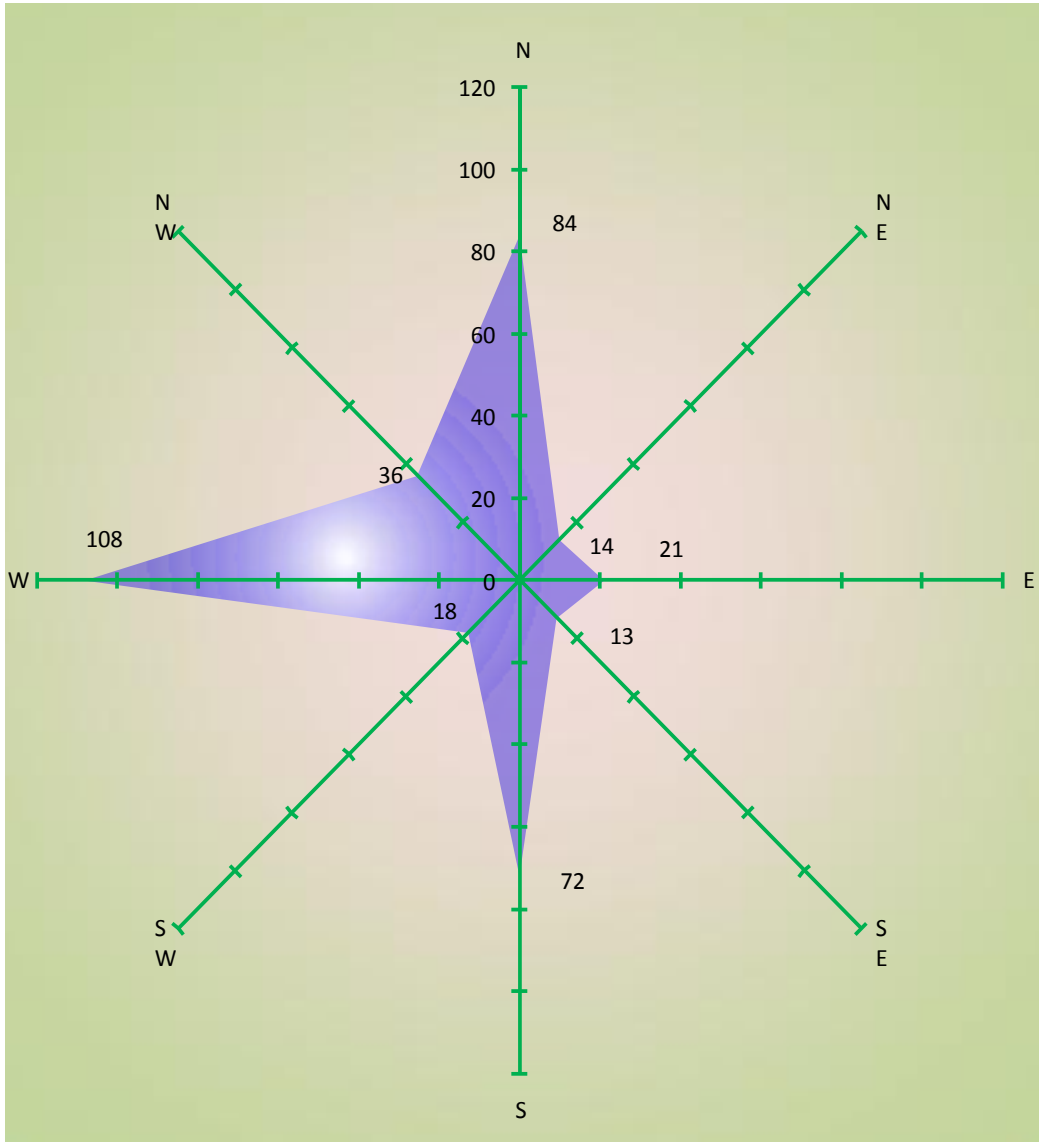


Figure 23: Annual direction pattern at RDC Bajo

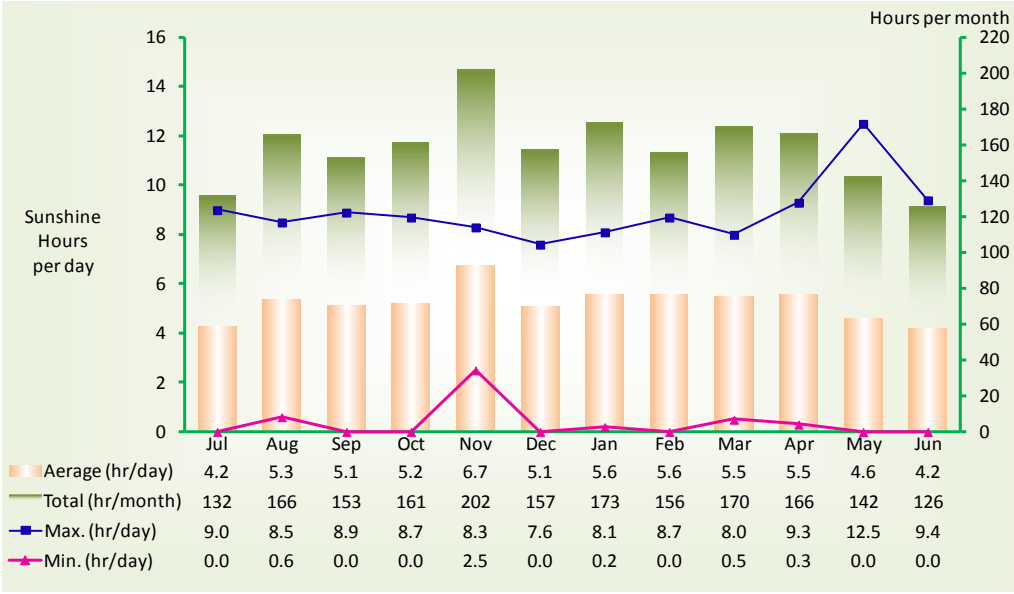


Figure 24: Monthly total, maximum, minimum and average sunshine hours at RDC Bajo

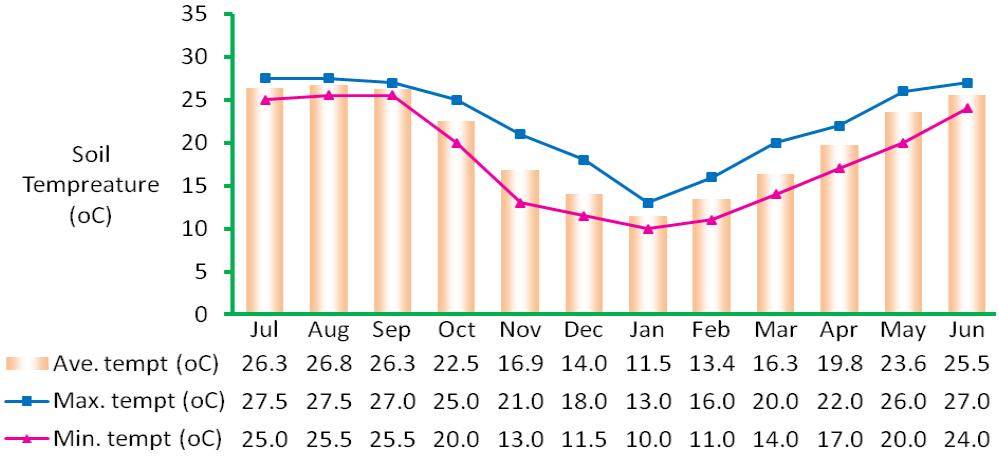


Figure 25: Monthly average, maximum and minimum soil temperature at 5cm depth

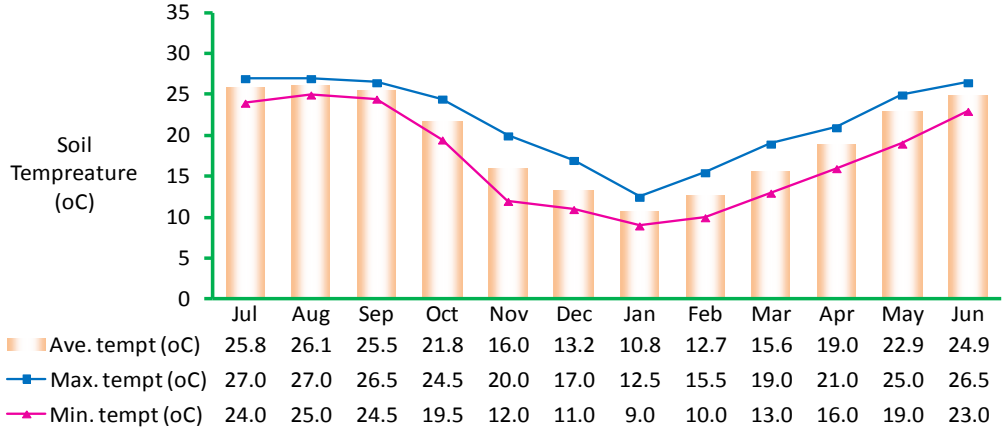


Figure 26: Monthly average, maximum and minimum soil temperature at 15cm depth

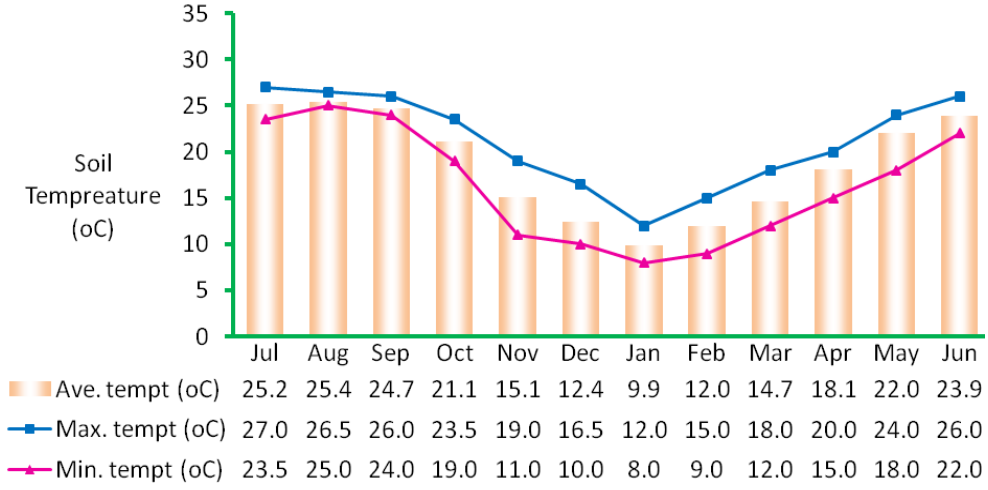


Figure 27: Monthly average, maximum and minimum soil temperature at 30cm depth

CENTRE AT A GLANCE

The centre was established in 1982 as the Centre for Agricultural Research and Development (CARD) to undertake research in rice and rice based crops. Research and farming systems was also started in the late 1980s. In 1995, the centre was renamed as RNR Research Centre to incorporate research in livestock and forest that are inseparable components of Bhutanese farming systems. The research centre is now renamed as RNR Research and Development Centre with the added development mandate and service delivery to farmers.

The centre is located at Bajo (1300m) in Wangdue Phodrang which is 70km west of the capital city Thimphu. At the national level RDC Bajo is mandated to coordinate field crops research, while at the regional level it undertakes relevant research and development for Gasa, Punakha, Dagana, Tsirang and Wangdue. The centre has about 64 acres of research farm, furnished office space, modest laboratory and library facilities. Sub-centre at Mithun, Tsirang was opened in 2006 to cater to the humid sub-tropical Dzongkhags of Tsirang and Dagana. It has about 36 acres of research area, office space and the National Citrus Repository is being developed.