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ROYAL GOVERNMENT OF BHUTAN

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FOREWORD

We are pleased to publish the 28th Annual Technical Report of RNR RDC Bajo for financial year 2012-13. The report format follows the agreed format for standardized reporting across RNRRDCs.

The report is a synthesis of 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 provides highlights of the activities implemented at Chimipang Royal Project/Frontline Agriculture Demonstration and Training Centre. In addition, the report presents the human resources, financial progress, visitors to the centre and the annual weather summary in addition to the technical findings.

In addition to 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. We believe that showcasing and promotion 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 stronger linkages and partnerships with regional and international agricultural research organizations, extension partners and farmers.

We hope this report will serve as a useful reference to everyone involved in agricultural research and rural development to attain Gross National Happiness.

Tashi Delek!

Dr Yadunath Bajgai
Offtg. Program Director
RNR-Research and Development Centre Bajo

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 mango fruit fly is reported. In weed management, the efficacy of new weedicides in controlling shochum is reported. The development section highlights activities mainly given in the form of support services. It 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 an useful information base and reference to our readers including academicians, development workers, students and field extension workers.

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Nidup	Certificate in driving	Driver-I
Tenzin Loday	Certificate in driving	Driver-II
Mon Bdr. Rai	Certificate in driving	Driver-II
Deo Raj Pradhan	Certificate in driving	Driver-II
Nedup		Tractor Driver-III
Bago		Office Messenger
Bikash Rai		
Lotey Jamtsho		
Farm attendants	-	33
Night guard	-	1

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 persuing 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. A separate study was carried out to find out the cost of cultivation for sunflower at the station. 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 2012-13, 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 AET, A total of 9 lines including a standard check (Bajo Kaap 2) were tested under Initial Evaluation Trial. The test entries in IET were the advanced introduction and the best performers of observation trials of 2011. The elite and promising lines were selected for some basic agronomic traits such as grain yield, optimum maturity, medium height and resistance to pest and diseases. The trial was laid out in a randomized complete block design with 3 replications. Seedlings were transplanted in 10 m^2 plot spacing of 20 cm x 20 cm was maintained. Chemical fertilizer was applied at the rate of 70:40:40 NPK kg/ha, with half the N applied after transplanting and half top dressed at panicle initiation. Butachlor 5G was applied at the rate of 1.5 kg a.i /ha to control weeds. Hand weeding and irrigation were carried out as required. Grain yield (adjusted to 14% moisture content) was obtained from a harvested area of 5.04 m^2 and data was analyzed using ANOVA for which SPSS software version 20.1was used. Performance of the entries is presented in Table 1.

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

Entries	50% flowering days	No of effective tillers hill	Plant height (cm)	Grain yield (t ha^{-1})
CT1 6658-4-1-1SR3-2-1-1-1-M	119	8	95	8.05
OMCS	75	10	89	6.74
IR71701-28-1-4	119	12	89	8.13
IR75288-144-1-3	119	11	88	6.15
IR72	120	11	81	7.93
GANZAOXIAN 49	120	10	88	7.53
IR80905-50-1-3-2	118	9	95	6.34
YN3109-23-1-2	121	8	94	6.94
Bajo Kaap 2	122	11	95	8.53

1.1.2 Rice Observation Nursery

In 2011 season, Bajo received 15 lines of rice varieties from Laoning Rice Research Institute in China. These lines were evaluated and multiplied for further testing. In 2012, a total of 19 lines were evaluated in which the

treatments were laid out in a single plot of 10 m^2 with the spacing of 20 cm x 20cm. The objectives of the observation nursery were to evaluate the performance of the test lines in terms of yield, maturity days, pest and disease resistance, plant height and adaptability. An inorganic fertilizer was applied at the rate of 70:40:40 NPK kg/ha. Butachlor was applied at the rate of 1.5 kg a.i /ha. Hand weeding and irrigation was done on need based. Grain yield was estimated from a harvest area of $10m^2$ (Table 2).

Table 2: Agronomic traits of Observation Rice nursery

Variety	Plant height	Tillers No	50% FWD	Grain yield (t ha^-)
3147728 (39B/Liaoxing 1)	95	8	99	8.7
3147729 (ILMIBYEO/Liaoxing 1)	90	9	99	7.6
3147730 (SHINUNBONGBYEO/ Liaoxing 1)	95	10	99	8.7
3147731 (SANJUBYEO/Liaoxing 1)	90	8	99	6.1
3147732 (ISTIQBOL/Liaoxing 1)	105	11	99	10.3
3147733 (sakha 101 SK-101/ Liaoxing 1)	85	8	98	10.0
3147734 (TAKANARI/Liaoxing 1)	97	10	98	8.7
3147735 (Liaoxing 1/Gi3a178)	110	11	99	7.6
3147736 (39B/Gi3a178)	75	11	109	10.0
3147737 (ILMIBYEO/Gi3a178)	70	13	109	10.3
3147738 (Gia177/Gi3a178)	90	11	110	10.0
3147739 (XAYAP/Gi3a178)	85	9	99	7.6
3147740 (KUSAHONNAMI/ TAKANARI)	90	11	110	11.7
3147741 (LUGEP/TAKANARI)	88	10	103	8.7
3147742 (XAYAP/TAKANARI)	95	13	160	8.7
Bhutan-1	120	6	108	10.0
Bhutan-2	160	7	104	10.2
Bhutan-3	135	10	111	5.6
Black rice	155	6	118	5.8

1.1.3 Green Super Rice – Irrigated Lowland Yield Trial

In 2012, a total of 32 entries were evaluated for optimum maturity, good yield and resistance to pest and diseases. The main purpose of this trial is for the evaluation of elite breeding lines received from the GSR project of IRRI under a wide range of irrigated lowland rice environments. The trial was laid out in a single plot of $10m^2$ with spacing of 20cm x 20cm. The fertilizer was applied at the rate of 70:40:40 NPK kg/ha. Butachlor was

applied at the rate of 1.5 kg a.i /ha. Hand weeding and irrigation was given as and when necessary. Though major pest and disease incidence was not observed, some entries were rejected during field selection based on their performance. The promising lines were selected for further evaluation (Table 3).

Table 3: Agronomic traits of Green Super Rice (GSR)

Designation	50% FWD	Plant Height (cm)	Tiller No	Grain yield (t ha^{-})
LOCAL CHECK	143	165	12	9.8
D4098	126	105	13	12.3
HHZ 5-SAL 10-DT 2- DT 1	118	93	11	10.3
HHZ 17-DT 6- SAL 3-DT 1	118	85	6	10.1
ZHONGHUA 1	112	87	10	9.8
WANXIZN 7777	112	99	9	8
IR64	117	95	11	10.1
HUA 565	119	90	10	99
LOCAL CHECK	120	96	10	12.1
P35	116	96	8	8.7
RC8	120	106	7	8.6
HUA 564	122	107	7	8.3
WEED TOLERANT RICE 1	118	96	7	10.1
SAGC-05	118	97	8	10.5
SAGC 4	118	105	10	10.1
PSBRC 18 (IR51672-62-2-1-1-2-3)	120	95	12	8
IR 84678-25-5-B	118	90	8	10.4
6527	118	95	7	8.6
ZGYI	113	105	9	10
LOCAL CHECK	119	95	12	10
PSBRC 18 (IR51672-62-2-1-1-2-3)	125	99	12	8.6
HUA 564	126	105	8	11.9
D4O98	123	107	9	12.2
HUA565	119	105	10	12
LOVAL CHECK	121	100	11	12.7
TME80518	119	95	11	12.1
WEED TOLERANT RICE 1	116	96	7	10.4
LOCAL CHECK	116	135	9	7.9
ZHONGHUA 1	122	85	7	7.9
P35	118	99	7	8.7
RC8	119	111	9	10
6527	118	98	6	8.7

LOCAL CHECK (SENSITIVE)	116	106	12	8.1
WANXIAN 7777	116	97	6	7.4
LOCAL CHECK	118	99	8	11
IR84678-25-5-B	118	89	11	8.4
HUANGUAZHAN	118	96	8	10
IR84678-25-5-B	124	100	10	13.9
LOCAL CHECK	112	117	12	8.5
6527	124	109	10	12.1
HHZ 5-SAL 10-DT 2-DT 1	118	105	10	12.2
HHZ 17-DT 6-SAL 3-DT 1	119	99	14	12.5
IR64	117	98	15	11.7
WEED TOLERANT RICE 1	116	157	9	7.8
HUA 565	119	105	9	8.4
LOCAL CHECK	118	107	12	10
P35	118	105	11	8.7
HUANGUAZHAN	118	95	14	10.4
HUA 564	125	109	8	10.6
D4098	126	114	12	8.5
WANXIAN 7777	116	105	10	8
TME80518	118	105	12	12.2
SAGC-05	119	113	10	10.1
RC8	120	112	11	10.1
PSBRC18 (IR51672-62-2-1-1-2-3)	125	104	11	8.1
HHZ 5-SAL 10-DT 1-DT 1	120	95	14	8.2
LOCAL CHECK	120	102	13	8

1.1.4 Effect of seedling age on rice yield under System of Rice Intensification

A field experiment with 3 different seedling ages as treatments was conducted at Bajo farm following SRI management techniques. The three different seedling ages were 10 d, 15 d and 20 d old seedlings and the design of the experiment was RCBD with 3 replications of 20 sqm plots. The seedlings were planted at 25 x 25 cm spacing. FYM was applied at 3 t/ ha and chemical fertilizer application rate followed NPK level of 70:40:40. For weed control, butachlor was applied @1.5 kg ai/ha and the most obnoxious weed of the rice paddies called Shochum was weeded manually. Intermittent Irrigation was given as and when required and care was taken to avoid complete flooding of the field.

The result of the experiment showed that the plants took between 76 to 96 days to flower and the number of productive tillers per plant averaged at

about 15 (Table 4). While the days to flowering and number of productive tillers per plant did not show any significant differences, root- shoot (r/s) ratios were significantly affected by different seedling ages. Highest r/s ratio was recorded with 15 d old seedlings (15 DAS) at 0.198 and 20 d old seedlings gave the lowest r/s ratios which were significantly low compared to those of 10 d and 15 d old seedlings. Higher r/s ratio indicated that transplanting of younger seedlings enables the plants to establish well with profuse rooting. Root-shoot ratio is an index of supply-demand relationship in crops' water economy and higher root shoot ratio denoted increased ability to absorb water and nutrients efficiently. Thus, use of younger seedlings had a potential to have better root system helping plants to cope well under stress conditions. Such plants could better mine nutrients than those plants planted at older ages.

Table 4: Agronomic traits as affected by seedling ages

Treatment	Days to flowering	No. of productive tillers hill^{-1}	mean R/S ratio*
10 DAS	96.00	14.67	0.174 a
15 DAS	87.00	15.33	0.198ab
20 DAS	76.00	14.67	0.128c
P < value	0.90	0.88	0.028

The grain yield for the three different seedling ages did not show significant difference. However, the grain yield was highest for 10 DAS (5.13 t/ha) and 20 DAS treatment showed the lowest yield (4.10 t/ha). The Figure 1 below shows the levels of grain yield among the three treatments and it is interesting to note that the there was a gradual decrease in grain yield with increasing seedling age. As the seedling age increased from 10 d to 20 d, there was corresponding decrease in grain yield from 5.13 t/ ha to 4.10 t/ha. Therefore, seedling age had tremendous affect on the crop performance.

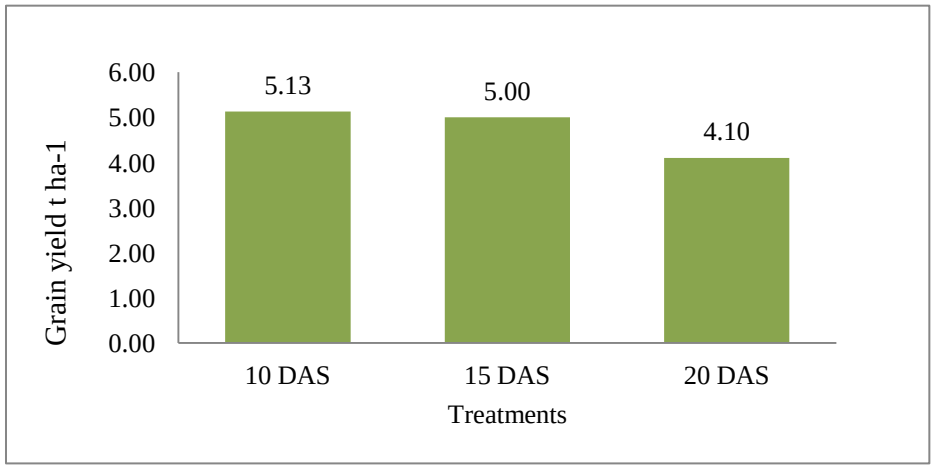

Figure 1: Grain yield as affected by seedling age under SRI

1.1.5 Demonstration of released varieties

The centre demonstrated the following varieties of rice as part of technology demonstration and educational program.

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
Kamja	<700	Main single
Karjat 3	<700	Main single
B2983B	600-1500	Pipeline
Guojing	600-1500	Pipeline

1.1.6 Seed maintenance and production of released/promising varieties

The following quantities of seed of different varieties (both released and promising varieties) were produced and maintained at the research farm. This is basically to meet the seed requirement for crop promotional programs and unforeseen circumstances such as emergencies during diseases and pest out breaks or natural disasters.

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

Variety	Status	Quantity (kg)
IR 64	Released variety	500
Bajo Kaap I	Released variety	500
Bajo Kaap II	Released variety	500
Bajo Maap I	Released variety	200
Bajo Maap II	Released variety	500
IR 20913	Released variety	500
Khangma Maap	Released variety	400
B2983B	Pipeline variety	400
Nabja	Popular local variety	350
Total		3850

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

Variety	Quantity (kg)
IR 64	1321
Bajo Kaap I	540
Bajo Kaap II	167
Bajo Maap I	650
Bajo Maap II	567
IR 20913	500
Khangma Maap	165
B2983B	10
Total	3920

1.1.7 On-farm evaluation of Mid-altitude rice varieties

In continuation to the previous year's production evaluation trial, three mid-altitude rice varieties namely IR28, BP176 and B2983B were further evaluated in 2012 to ascertain their adaptability and yield performance in the mid altitude rice growing areas of Punakha-wangdue valley. The evaluation was done at Kabesa (Punakha) and Kazhi (Wangdue). The trial was laid out in 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 agents 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 7.30 t/ha-1 and it is most preferred by the farmers. The other two varieties had also equally done 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.

1.1.8 PET of improved rice varieties in Tsirang and Dagana (Tsirang)

Rice is an important cereal crop in Tsirang and Dagana. However, the productivities in these two Dzongkhags (Dagana: 2.2 t ha^{-1}, Tsirang: 2.4 t ha^{-1}) are lower than the national average yield of 3.1 t ha^{-1}. With the aim to increase the productivity, widen the genetic diversity and provide varietal options to the farmers, a number of improved rice varieties were evaluated in a participatory mode in Tsirang and Dagana in 2012 cropping season. These included Bajo Maap 1, Bajo Maap 2 and Bajo Kaap 2 released by RNR RDC Bajo, and Bhur Rey Kaap 2 and Bhur Kambja 1 released by RNR RDC Bhur. The varieties introduced in different locations were as per their recommended agro-ecologies.

The crops were raised under farmers' management practices with timely monitoring from extension and research for any pests infestation or disease incidence. There were no major diseases or pests outbreak in any of the trial sites during the season. The recommended rate of inorganic

fertilizers was also suggested but none of farmers applied either owing to non availability or unaffordability.

A field day was organized during the harvest time where both the co-operating and non beneficiary farmers were present for the selection. The crop cut results demonstrated the yield advantage of improved cultivars as compared to their locals (Table 8). With the yield benefits that these improved varieties provide, farmers would like to continue cultivating in the ensuing seasons. The non-cooperative farmers after the field day chose their own preferred variety and requested for seed support in the 2013 cropping season. Thus, research and extension has supported 500 kgs of Bhur Rey Kaap 2 seed to Barshong, 300 kgs of Bajo Maap 1 seed to Drujeygang in 2013 season. The receptivity of improved varieties in Sergithang is low despite yield advantage because of the better eating quality of their local variety, Choti resulting to higher market price. However, support has been extended to interested farmers. Similar varietal evaluation programs are on-going in the neighboring villages or communities. These crops are closely monitored for their performance in 2013 season.

Table 8: Agronomic traits of improved and local rice cultivars at different locations in Tsirang and Dagana.

Site	Variety	Plant height (cm)	No of productive tillers hill^{-1}	Grain yield (t ha^{-1})
Drugeygang (Dagana)	Bajo Kaap 2	90	7	3.4
	Bajo Maap 1	78	7	2.9
	Attey (Local)	120	5	2.6
Sergithang (Tsirang)	Bajo Maap 1	88	7	2.6
	Bhur Rey Kaap 2	98	8	3.5
	Choti (Local)	119	6	1.5
Barshong (Tsirang)	Bhur Rey Kaap 2	110	8	3.8
	Bajo Maap 1	90	8	3.4
	Bajo Maap 2	92	9	3.5
	Bhur Kamja 2	93	9	2.0
	Attey (Local)	120	7	1.4
	Choti (Local)	124	6	1.0

1.2 Wheat Research

1.2.1 Advanced evaluation of Nepal wheat lines

The potential lines selected from 2011-2012 seasons were further tested in a replicated trial to ascertain their performance under our existing local conditions. Trial was set out in RCBD with three replications. A seed rate of 100 kg ha^{-1} was used, and a spacing of 20 cm was maintained between the rows. 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. Among the weeds, littleseed canarygrass (*Phalaris minor)* was the most dominant and problematic weed. At

maturity, different agronomic traits such as plant height, spike length, number of kernels per spike, 1000 kernel weight and grain yield were gathered. The crop management practices and data collection were same for all the following wheat trials unless specified otherwise. Crops in both the seasons were planted in mid November and harvested towards mid to end May, taking roughly about 180 days. In both years, the preceding crop in the trial site was rice.

The new lines produced comparable or higher than the check in all the measured agronomic traits though not significant statistically ($P \geq 0.05$) (Table 9). These lines are expected to undergo mass on-farm evaluation under different management conditions in the coming season which will help in determining their suitability and the true performance.

Table 9: Agronomic traits of Nepal Advanced Wheat Lines in 2012-2013 season

Line	Plant height (cm)	Spike length (cm)	Kernel spike^{-1} (no)	1000 kernel wt (gm)	Grain Yield (t ha^{-1})
Aditya	100 [a]	10 [a]	49 [a]	53 [a]	3.7 [a]
BL3235	102 [a]	9 [a]	45 [a]	52 [a]	3.9 [a]
BL3503	100 [a]	9 [a]	43 [a]	51 [a]	3.2 [a]
NL1050	92 [a]	9 [a]	49 [a]	53 [a]	3.8 [a]
NL1053	96 [a]	10 [a]	43 [a]	49 [a]	3.5 [a]
NL1054	86 [a]	10 [a]	50 [a]	45 [a]	3.8 [a]
Bajoka -1 (check)	90 [a]	9 [a]	43 [a]	40 [a]	2.7 [a]
P	0.18	0.84	0.83	0.28	0.41

Means indicated by a same letter within the columns are not significantly different at $P \leq 0.05$ by 95% confidence interval.

1.2.2 Initial Evaluation of ICARDA wheat

This trial was the continuation of the previous season where seven selected lines, introduced from International Center of Agriculture Research for Dryland Areas, was further evaluated. These lines were scrutinized for their consistency in yielding, adaptability and agronomic

traits of interest. The lines were further narrowed to three for further evaluation and seed multiplication for on-farm screening (Table 10).

Table 10: Agronomic traits of ICARDA Wheat Lines in 2012-2013 season

Line	Plant height (cm)	Spike length (cm)	Kernel spike^{-1} (no)	1000 Kernel wt (gm)	Grain yield (t ha^{-1})
V 401	107 a	8 a	37 a	29 a	4.2 a
V407	107 a	10 a	44 a	34 a	4.2 a
V419	102 a	10 a	44 a	29 a	4.4 a
Bajoka 2 (check)	89 b	9 a	45 a	39 a	3.0 a
P	0.02	0.07	0.33	0.08	0.99

Means indicated by a same letter within the columns are not significantly different at P ≤ 0.05 by 95% confidence interval.

1.2.3 Initial Evaluation of 32nd Elite Spring Wheat Yield Trial (ESWYT)

The nineteen lines that were selected from previous season were further screened for various desirable agronomic traits in the on-station. Six lines continue to demonstrate their adaptability and superior over the check (Table 11). These selected lines will be evaluated in the replicated plots in the ensuing season to ascertain their performance before commercial recommendation.

Table 11: Agronomic traits of 32nd Elite Spring Wheat Yield Lines in 2012-2013 season

Entry	50% DTH*	DTM¶	Plant height (cm)	Spike length (cm)	Kernel per spike (no)	TKW (gm)	Grain yield (t ha^{-1})
104	103	153	112	10.5	56	43.8	3.57
125	102	153	108	11.5	49	32.74	2.28
128	95	153	103	10.6	41	42.45	2.57
130	108	153	94	9.7	43	32.59	2.28
133	106	153	104	10.2	54	46.95	2.28
134	106	153	107	10.9	52	42.91	2.28
Sonalika	95	153	111	12.5	39	42.22	2.2

***** Days to heading ¶ Days to maturity

1.2.4 Initial Evaluation of 19th Semi-Arid Wheat Yield Trial

This trial is the continuation of the 2012 season where the fifteen selected lines were further evaluated for their adaptability and desired agronomic characters. Further selections were done where eight lines were found to possess desirable grain type (bold size), and yield comparable or better than the standard check (Table 12). The measured agronomic traits in these elite lines were also found to be acceptable. The selected entries will be further evaluated in a replicated trial to ascertain their performance.

Table 12: Agronomic traits of 19th Semi-Arid Wheat Yield Lines in 2012-13

Entry	50% DTH	DTM	Plant ht (cm)	Spike length (cm)	Kernel per spike (no)	TKW (gm)	Grain yield (t ha^{-1})
309	108	153	104	9.3	51	32.83	5
311	102	153	109	8.6	41	33.96	4.4
312	102	153	108	10	49	41.12	4.35
315	102	153	99	10.6	44	36.80	4.42
316	102	153	100	8.2	42	32.41	4.21
317	97	153	104	10.2	49	32.79	4.2
318	97	153	106	11.2	50	42.87	4.2
325	97	153	107	10	59	36.81	3.71
Bajoka 2	95	153	106	10.5	50	39.77	4.4

1.2.5 Observation of facultative wheat

Five lines possessing facultative/winter characteristics were introduced from Nepal high lands to determine their adaptability under our local conditions. Though the site may not be the true representative owing to milder cold temperatures, the initial observation at Bajo station showed promising in Bhutan too (Table 13). The seeds of these entries were already distributed to Bumthang and Haa for evaluation under true winter conditions in 2013-14 season.

Table 13: Agronomic traits of facultative wheat lines at Bajo on station

Entry	Plant height (cm)	Spike length (cm)	Kernel spike $^{-1}$ (no)	1000 Kernel wt (g)	Grain yield (t ha^{-1})
WK 936	93	10	70	51	4.1
WK 1776	112	11.6	45	31	1.7
WK 1792	151	9.2	60	43	3.7
WK 1803	108	11.3	43	33	3.1
WK 1975	124	13	74	51	3.3

1.2.6 Seed multiplication of potential and Ug99 resistant varieties

The availability of adequate seed after commercializing the variety is an issue, as the national seed system often takes few seasons to produce seeds in bulk quantity. This is disadvantageous as the varieties become obsolete by the time varieties reach farmers' fields. Therefore, seed production was taken in parallel with the varietal evaluation activity so that national seed system had adequate foundation seed to produce certified seed of appreciable quantities for mass coverage. The following quantities of seed of new varieties were produced in 2012-2013 season (Table 14).

Table 14: Quantity of wheat seed produced in 2012-2013 season

Varieties/lines	Seed produced in 2012-13 (kg)	Likely coverage in 2013-14 (acre)	Remarks
Aditya	58	1.45	Released in Nepal
Gaura	50	1.25	
Dhaulagiri	65	1.6	
NL 1050	32	0.8	Advanced lines from
NL 1053	70	1.75	Nepal
NL 1054	105	2.6	
Danphe	40	1.0	Ug99 resistant
Francolin	85	2.1	varieties and released in Bangladesh
Total	505	12.6	

1.3 Maize Research

On-station main activity implemented by the centre included seed production and maintenance of improved varieties. The main seed production was done with the main objective of maintaining genetic purity of seeds for supply to the Dzongkhags in the region. The bulk of the seeds will go as crop promotional program and the following are the two sub-activities implemented in 2012:

1. Seed production of Yangtsepa variety
2. Seed production of two extra early varieties

Table 15: Seed production of Yangtsepa variety

Sl. No.	Variety	Quantity Maintained (Kg)
1	Yangtsipa	120
2	Pop corn	3
3	Sweet corn	28
Total		151

1.3.1 Seed production of two extra early maturing varieties

RNR-RDC Bajo in collaboration with the maize coordinating center (RDC Wengkhar) has supported with farmers of Toeb geog with seeds of early maturing varieties. This was mainly to provide some extra push/support to the farmers doing business along the Thimphu-Punakha/Wangdue highway. In order to maintain and produce the seeds, early maturing varieties Arun 2 and Arun 4 were produced on station with the objective to support farmers in future and reap the benefit of its earliness.

Table 16: Seed production information of two extra early varieties

Sl. No.	Variety	Quantity Produced (Kg)
1	Arun 2	30
2	Arun 4	128
Total		158

The seeds produced will be promoted in a small scale to start with according to the demand and request from the Dzongkhag.

1.3.2 Participatory Production evaluation trial of two extra early varieties in Toeb geog

For the past few years the farmers of Thinlaygang have been making good income from the sale of roasted maize cobs. During the main cropping season, the farmers grow maize as cash crop (roasted form). With the roasted maize doing brisk business, the farmers even bring the cobs from as fas as India during the off season and it is imperative to provide the farmers with a choice in crop variety. For this two extra maturing varieties were evaluated at Toeb geog under Punakha Dzongkhjag for the past consecutive years.

The evaluation result of 2012 showed that both the varieties had performed extremely well under Toeb condition. In terms of plant height, Arun 2 variety was taller with height range of 1.67 m to 2.8 m. The mean plant height of Arun 4 ranged between 1.5-1.9 m and there wasn't any significant yield difference for the two varieties. In general, the grain yield varied from the low of 1.28 t/ha (Arun2) and high of 4.18 t/ha (Arun 4) (Table 17). While the farmers liked these two 90 d maturity duration varieties, Yangtsepa is still the most preferred vaiety with large cob size.

Table 17: Grain yield and plant heights Arun 2 and 4 tried at Toeb geog

Arun 2	Plant Ht	Yield (t/ha)
Sample 1	2.00	4.00
sample2	2.08	1.90
Sample3	1.79	2.36
Sample4	2.13	2.14
Sample5	2.50	1.28
Sample6	2.06	1.39
Sample7	2.80	3.00
Sample8	2.50	1.93
Sample9	1.67	1.28

Arun 4	Plant ht	Yield (t/ha)
Sample1	1.78	4.18
Sample2	1.97	1.93
Sample3	1.59	2.14
Sample4	1.87	1.90

Seeds of Arun 2 and Arun 4 were supplied to 22 farmers of Bumteykha, Mendrelgang, Chilikha and Silina as well.

1.3.3 Demonstration of provisionally released GLS and TLB tolerant maize varieties

Genotypes tolerant to Gray leaf spot (GLS) and Turcicum leaf blight (TLB) have been identified by RDC Wengkhar and since 2008 the genotypes were tested at various locations. Two entries (Entry No 35 and 38) were found promising and have been released as varieties. Demonstrations have

been done in Tsirang and Dagana Dzongkhags. The two entries (35 and 38) have been demonstrated and promotion works have been initiated through community based seed production and small scale promotion in selected sites. Seed replacement of GLS affected farmers of Drujaygang geog in Dagana was carried out mainly in collaboration with the extension agent. The new maize variety was found to be very good with better yield compared to their local variety. The disease incidence on the other hand was found to be minimal.

Community based seed production has been initiated with the farmers of Tsirang and Dagana. The communities of Gagaling in Tsirang and Tsangkha of Dagana have been growing the tolerant entries for seed production.

The trial result of the two promising varieties tested in Dagana showed that it could break the low maize yield ceiling and has potential to replace all the existing varieties. The two varieties performed well and exhibited high yield of 4.08 t/ha with lowest being 2.4 t/h (Table 18).

Table 18: Maize trial results from Dagana Dzongkhag

Entry No.	Pedigree	Husk Cover (1-5)	Rotten ears (No)	GLS	TLB	Yield (t/ha)
35	S03TLYQ AB05	1	2	1	1	2.7
38	ICA V 305	1	1	1	1	4.08
	Local variety	1	3	1	1	2.36

The new varieties are tolerant to diseases and are also higher yielding than the local varieties. Other activities concerning maize were the demonstration of roasting machines (bukari type). The maize roasting business along the Thimphu, Punakha highway has picked up tremendously and it has become a major source of income for the farmers. Currently the roasting is done traditionally on open fire using hard wood. In order to value-add and improve the quality of roasted cobs, RDC Wengkhar has modified a bhukhari that would roast the maize in a different way. The bhukhari is not efficient in roasting of maize cobs compared to the traditional method and therefore needs better modification.

1.3.4 Community-based maize varietal evaluation

A varietal evaluation using community based approach was undertaken during 2012 cropping season with a recently released variety (Chaskarpa), and a potential line (Entry no 33). These two new maize varieties are considered to be tolerant to the fungal disease namely grey leaf spot and turcicum leaf blight that had devastated the maize in most of the maize growing Dzongkhags. The purpose of this activity was to replace the existing disease susceptible cultivars, and to produce adequate qualitative seed though mass mobilization and involvement of whole community or farmers.

The 2012 cropping season was a dry one with prolonged dry spell in the sowing month (March). This has thus affected the crop germination, and final yield in most of the test sites. However, the crop cut data, conducted in the feasible locations, showed new entries producing higher grain yield than the local cultivars (Table 19). It was also noted that new entries were resistant to lodging (due to short statureness), and responsive to external inputs as observed through higher production from the fertile soils. On the other hand, these new entries were found to have poor husk cover leading to entry of rain water and cobs decaying. In Gagaling, short statureness is also a setback for the farmers as maize stalks are used as a support for beans cultivation. These issues particularly the poor husk cover has been looked into through proper seed selection by selecting cobs that had only full husk cover. The collected seed had been promoted to the newer areas for 2013 season, and is expected to make an impact in disease management and overall maize production.

Table 19: Grain yield and quantities of seed collected in 2012 cropping season

Site	Variety/line	Grain yield (t ha^{-1})	Quantity of seed collected (kgs)	Remarks
Gagaling (Tsirang)	Chaskarpa	3	400	Released variety
	Local	2.3	-	
Tsangkha (Dagana)	Entry no. 33	3.8	700	Promising line
	Local	2.7	-	
Shamdoley (Dagana)	Entry no. 33	3.4	300	Promising line
	Chaskarpa	3.7	100	Released variety

1.4 Grain Legumes Research

1.4.1 On-Station Germplasm Evaluation

Through the initiation of the pulses shuttle breeding program in 2008 which mainly involved the sharing of germplasm and evaluation between India, Bangladesh, Nepal and Bhutan testing of the elite lines were done. The crops identified and implemented in the program were varieties of mungbean, urd bean and lentil.

Following a series of on station testing, seed production was carried out for better performing varieties. The small quantity of seeds that we maintained was also promoted on a small scale. The details of the seed production of the elite lines are mentioned below.

1.4.2 Seed production

As part of seed multiplication and maintenance, 3 varieties of mung bean were grown producing 9 kgs of seeds in total. For Urd bean, the total seed production was 8.2 kg while it was 15.1 kg for French beans. Three varieties of lentils were also grown and produced 11.8 kg seeds. The following Tables show details of grain legume seeds.

Table 20: Different varieties of mung bean and quantity of seeds

Sl No	Variety	Quantity (kg)
1	KPS 2	3
2	Bari Mungbean 2	3.4
3	Hum 16	2.6

Table 21: Seed production of Urdbean

Sl No	Variety	Quantity (kg)
1	BLG 0067-1	2.6
2	IPU 2002-1	3.2
3	IPU 2002-2	2.4

Table 22: Seed production of French bean

Sl No	Variety	Quantity (kg)
1	HUR 15	2.4
2	VL 125	2.3
3	PDR 14	3
4	UTKARSH	3.2
5	Rajma Local	4.2

Table 23: Seed production of Lentil

Sl No	Variety	Quantity (kg)
1	Shital	3
2	Simal	4.6
3	Mahesh Bharati	4.2

1.4.3 Participatory Production Evaluation Trial of Lentil varieties in Tsirang Dzongkhag

Lentil is a very important crop in terms of its place in modern Bhutanese cuisines. After its introduction, RDC Bajo is trying to promote legumes in order to fit in our cropping system. Given the nitrogen fixing ability of the crop and the increasing demand by the consumers it is a potential crop that could be promoted at a larger scale in future. The demand of lentil currently is fulfilled from the imports mainly from India.

The varieties tested through the pulse shuttle breeding had the qualities to fit in the Bhutanese cropping system. Among the varieties, the Nepalese lentils were promoted in Salari village as a part of participatory production evaluation trial. Seeds were given to them and cultivation was done as per the farmers practice. Regular monitoring was done by the staff of RDSC Tsirang. In the process of monitoring it was felt that early sowing would be beneficial for better yield of the crop. The sowing at Salari was done during midweek of December and it was little late as per the recommendation. It was also found out that the fertility status of the soil was low and it could be augmented with fertilizers. Of the three varieties tested at Salari village, Simal variety recorded highest grain yield of 313 kg and the other two varieties gave 175 kg and 150 kg for M.Bharati and Shital respectively.

Table 24: Lentil varietal trial results

Sl. No	Variety	Sowing date	Harvesting date	Irrigation	Yield (t/ha)
1	Maheshwor Bharati	22/12/2012	5/5/2013	2 times	.175
2	Shital	15/12/2012	8/4/2013	2 times	.150
3	Simal	15/12/2012	4/5/2013	2 times	.313

1.4.4 Participatory Production Evaluation Trial of Mungbean varieties in Dagana

Mung bean is one of the most important grain legumes in the country in terms of acreage and production. It is referred to as green gram, golden gram and choe suey bean. Mungbeans are grown widely for use as human food (as dry beans or fresh sprouts), but can be also be used as a green manure crop and as a forage for livestock.

Dagana dzongkhag has the maximum acreage in the country with more than 150 acres utilized for mungbean. The varieties cultivated in the region are indigenous ones that have been cultivated from long time. High yielding varieties could improve the production of the crop. The released varieties have not been promoted in the potential dzongkhag.

Small quantities of seeds were requested from Wengkhar for promotion in Drujaygang geog where mungbean is commonly grown. The sowing time is generally done in the month of July-August and that could be one reason for poor yields of the supplied seeds. The details of the crop performance are given in the table below.

Table 25: Agronomic traits of mung bean varieties and their yields

Sl No	Variety	50% flowering	75 % Maturity	Plant height	Yield (t/ha)
1	Bari Mung 2	36	58	35	0.300
2	KPS 2	35	55	39	0.400
3	Local	38	63	49	0.500

The three varieties tested at Drujaygang in Dagana showed that the two introduced varieties, Bari Mung 2 and KPS 2 did not perform better than the local check. The two gave yield of 300 and 400 kg per ha while the local variety recorded 500 kg per ha. For other traits such as plant height, days to flowering and maturity duration, the improved varieties seemed to be quite favorable being shorter in height, lesser days to flowering and days to maturity. Few more years of evaluations might be required to ascertain their yield potential and suitability.

1.4.5 ICARDA Trials (Legume International Testing Program)

ICARDA trials mainly involved the evaluation of their breeding lines. The trials included sets of chickpea and lentil. In the first year of introduction 35 breeding lines of chick pea and 24 lines of lentil were evaluated on station. The yields of these breeding lines were very low in the first year of evaluation. With the limited quantity of seeds from the previous harvest the trial was laid as per the protocol but the crop was damaged extensively by gram pod borers that affected the stages of evaluation.

It was therefore decided that ICARDA trials will be discontinued. The varieties that were sent for testing were breeding lines and not released

varieties and with severe infestation of gram pod borer it is not helping our cause to identify suitable and high yielding varieties. When it came to lentil, the pod size was big and is not the preference of our consumers. So for the promotion of lentil we will continue with the three varieties that we received through the pulses shuttle breeding. Also in future there are plans to receive mega varieties from SAARC countries as a part of exchange of germplasm to improve the productivity of pulses in the region.

1.5 Oilseeds Research

1.5.1 Seed Production of released varieties

Oilseeds research and development has been a challenge. The limited seeds we have is maintained every year and supplied to few gewogs/Dzongkhags for demonstration in the region. In the year 2012 the following quantities of seeds were maintained.

Table 26: Details of oil seed produced in 2012

Sl No	Variety	Quantity maintained
1	BSA (Bajo Peka 1)	8 kg
2	PT 30 (Bajo Peka 2)	6 kg

1.5.2 Advanced evaluation trail of Indian Mustard lines

The selections from the initial evaluation trial were tested in the form of advanced evaluation trial with an objective to find high yielding varieties. It was also implemented with a hope to find varieties wish superior agronomic characters that would adapt to Bhutanese conditions. The trial was carried on station.

The trial was laid in a RCB design with three replications. Each variety was sown in a plot size of 24 m^2 as against the previous plot size of 6m^2 with a row to row spacing of 20 cm. The nutrient was managed with the application of FYM and inorganic fertilizers. Inorganic fertilizers was applied at the rate of 60-30-20 kg NPK per ha. The weeds were controlled by mechanical means. Two crucial irrigations were given at flowering stage and pod filling stage.

According to the trial result, there was a significant difference in yield, plant height, days to flowering and maturity duration (Table 27). The local check (Bajo Peka) used in the experiment outyielded all the four Indian lines. While Bajo Peka produced 700 kg /ha, the yield of introduced lines ranged between 320 to 400 kg/ha. In terms of plant height, RGN 13 was the shortest with just 99 cm while other varieties have recorded plant height of over 100 cm with the tallest being Bajo Peka.

Similar trial will have to be conducted for few more seasons to arrive at a conclusion as all the introduced lines might prove potential with proper management ststem.

Table 27: Performance of Indian mustard lines

Variety	50% flowering	75% Maturity	Plant Height (cm)	Yield (unit)
RGN 13	34b	127.3b	99a	0.40a
PBR 201	37c	127.3b	104a	0.33a
GM2	32.3a	127b	103.3a	0.32a
Shivani	32.3a	129c	105.6a	0.35a
Bajo Peka 1	34.3 b	126a	119.6b	0.70b
P Value	0.00	0.00	0.02	0.00

Means indicated by different letters in columns are statistically significant (95% confidence level)

1.5.3 Economics of Sunflower production

Although sunflower is known to be an important oil seed crop worldwide, it is rarely grown in Bhutan as an oilcrop, rather it is grown in small scale for its ornamental value and for seeds that are eaten as snack. Sunflower as an oilseed crop is a completely new intervention in Bhutan and efforts will go a long way in making this crop popular in the country. Since it has 45-50 percent good quality oil and high quality protein, it has good scope in Bhutanese agriculture. Sunflower holds great promise because of its short duration, photo-insensitivity, wide adaptability and drought tolerance. It can be grown at any time of the year and can serve as an ideal catch crop during the periods when lands are left fallow.

Following the proposal of Jigme Trading, a private firm based in Thimphu, the DoA has taken initiatives to make sunflower a commercial oil seed crop in the country. In accordance with the proposal of Jigme trading,

some hybrid seeds were procured from India and distributed across the country to see its potential. RNRRDC Bajo also received some seeds of sunflower and it was grown on station. The objective was to determine the cost of production of this new crop. According to the trial results of Bajo farm, the cost of producing for a kg of sun flower worked out to Nu. 40 (Table 28). The seed yield was 125 kg/ac which was quite reasonable when compared to the yields elsewhere. Since this was the first time, some more trials will be required to provide better assessment and yield performance of this crop.

Table 28: Sunflower cost of production

Outputs	Unit	Quantity	Opportunity Costs (Nu)	Total Cost benefit
Benefits				
Gross returns				
Value of Production	Sunflower seeds (kg)	125	40	5000
Costs				
Capital materials				
seeds	Kg	1.5	40	60
FYM	Kg	0	0.5	0
Fertilizers (Suphala)	kg	15	6.8	102
Machinery (ploughing)	hours	3	350	1050
	Power tiller hour	3	300	900
Tools	Depreciation per yr	Total Nu 1000 used during 5 yrs = Nu 200 per year		200
Total capital				2312
Total labour (Hh labor)				
land preparation	Person-days	1	300	300
Ploughing	Person-days	1	300	300
seed sowing	Person-days	1	300	300
weeding 1	Person-days	1	300	300
weeding 2	Person-days	1	300	300
weeding 3	Person-days	1	300	300
Harvesting	Person-days	1	300	300
threshing	Person-days	1	300	300
cleaning	Person-days	1	300	300
land preparation	Person-days	1	300	300
Ploughing	Person-days	1	300	300
seed sowing	Person-days	1	300	300
Total labor	Person-days	9	2700	2700
Land Opportunity	acre	1	20000	2240

costs		
Total costs excluding land		5012
Cost of production		
Total costs	Nu	5012
Divided by total prodn		125
Cost of production	Nu per kg	40.10

HORTI-CULTURE RESEARCH

2 HORTICULTURE

2.1 Fruits and nuts

2.1.1 Passion fruit variety evaluation trial

The pecan nut variety trial was established in 2002. The objective of the trial was to assess and select the suitable cultivars for mid altitude region. Five pecan nut cultivars were introduced from Australia (Desirable, Cheyenne, Wichita, Kiowa and Western Shelley) and two plants each were planted with spacing of 3m x 3m plant to plant and row to row. The trees were trained into modified centre leader system. The weeding, basin preparation and mulching were done during the proper season. Manure and fertilizer application was carried out as recommended. Irrigation was carried out during the dry period of the year i.e. during the winter months.

Table 29: 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

The growth of all the cultivars is very good. The performance parameters recorded are on vegetative growth, precocity, yield, nut and kernel qualities, shell thickness nut size and weight, and pest and diseases incidences. Till 2009, no major pest and disease was observed except trunk borer. Severe incidence of twig borer and the scab was observed in 2009 and insecticides had to be used. The injection of cypermethrin (contact insecticide) for the twig borer management was found to give positive results. The yield also dropped in 2009 due to this severe incidence of trunk borer and scab. Since then we have been using insecticides to prevent such incidence in proper season every year. The morphological characteristic, yield and nut quality aspects are presented in Table 30.

Table 30: Nut characteristics, yield and quality of pecan nut cultivars

Cultivars	Shape	Weight	Dia	Length	Yield (kg tree-1)						
		(gm)	(cm)	(cm)	2006	2007	2008	2009	2010	2011	2012
Wichita	Oblong	6.2	1.8	3.3	2.2	1.27	0.75	0.3	0.9	1.4	9
Western Shelley	Oblong	7.6	2.2	3.7	3.5	1.3	2	1.2	1.2	1.2	1
Kiowa	Oblong	8.9	2.6	4.9	0.35	0.8	--	--	--	--	--
Desirable	Oblong	6.4	2.1	3.1	0.4	0.4	0.63	0.65	0.6	1.2	--
Cheyenne	Oblong	6.2	2	3.5	--	--	--	--	--	--	--

The Cheyenne variety was lost as the trees succumbed to disease and could not be replaced. The Kiowa varieties were also nearly lost due to disease but now they are recovering.Wichita and Desirable started to bear fruits on the third year while the rest started to bear fruits from the fourth year after planting. Kiowa has the largest and Wichita the smallest fruit nut size. Western Shelley recorded the highest yield and has medium nut size. It is too early to draw any conclusion at this stage and will have to be continued for another 3 years or till the trees attain full production potential.

Figure 2: Different pecan nut varieties

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 practised. The removal of dead wood and thinning of overcrowded and misshapen branches were done as and when required. Supplementary irrigation was provided in the dry season particularly in the spring or at the time of flowering. Weeding was carried out when required and basin preparation was done twice i.e. once in spring and another in autumn after crop harvest. Fertilizer application and mulching was carried out right after harvest. FYM was applied in winter and 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. Performance parameters like vegetative growth, precocity, cropping habit, fruit quality, yield, and pests and diseases incidences were also studied (Tables 31 and 32).

Table 31: Morphological characteristics of five persimmon cultivars

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

Table 32: Fruit characteristics and quality of persimmon cultivars

Variety	Shape	Fruit wt. (gm)	Dia (cm)	Length (cm)	Yield (kg tree -1) 2008	2009	2010	2011	2012
Z-Fuyu	Flat	150	7.01	4.5	1.4	4	2.8	8.5	11.66
P-Jiro	Flat	125	6.9	4.6	0.5	0.65	4.6	8	9
G-Fuyu	--	--	--	--	--	--	--	--	--
Z-Maru	--	--	--	--	--	--	--	--	--
P-Hg	Flat	250	5	3.75	0	0	2.6	4	11
G-Jiro	--	--	--	--	--	--	--	--	--
Sorrento	Oval	--	--	--	--	--	--	--	--

Slow and stunted growth was observed which might be attributed to the climatic factors and soil condition. Z-fuyu and P-jiro started bearing since 2007 and P-Hg from the year 2009 while the rest of the varieties are yet to bear fruits. All the varieties have smooth pericarp texture which is favoured by the buyers. The tree has to be covered with nets as the fruits start to mature or otherwise the entire crop will be lost to fruits fly and birds. The trial is scheduled to be continued for another year for clear identification of the suitable variety before being released.

2.1.3 Walnut varietal evaluation trial

Walnut has huge potential in Bhutan due to climatic suitability and good domestic market. It is perfect cash crop for places located in remote regions which are located far from market as it has long shelf life and can be transported without any physical damage. Both soft shelled (which was introduced) and hard shelled wild walnut are found in Bhutan within an altitude range of 1500 to 2700 masl. The walnut varietal trial was

established in the year 2003 in the centre with an objective to evaluate suitable varieties for lower altitudes like Bajo which is located at about 1200 masl. 19 varieties were chosen which includes 5 introduced varieties and 14 local selections. 8 varieties started to bear fruit from the year 2010 and their yield and fruit quality were assessed Tables 33 and 34).

Table 33: Morphological characteristics of different walnut varieties

Variety	Tree Appearance	Bloom time	Leafing	Harvest time
B3	Vigorous	April	April	September
B6	Vigorous	April	April	August
B5	Vigorous	March	March	August
B9	Vigorous	April	April	September
B14	Vigorous	April	April	September
Chandler	Vigorous	April	April	October
Vina	Vigorous	April	April	September
Payne	Stunted	April	April	September

Table 34: Nut characteristics and yield of different walnut varieties

Variety	Shape	Weight (gm)	Length (cm)	Diameter (cm)	Yield (Kg/tree) 2010	2011	2012
B3	Oblong	200	4.00	3.60	0.20	0.10	0.08
B6	Oblong	50	3.30	3.00	0.05	0.06	0.09
B5	Round	75	4.40	3.93	0.18	0.12	0.20
B9	Oblong	25	3.46	3.03	0.06	0.10	0.10
B14	Round	25	2.90	2.70	0.03	0.10	0.10
Chandler	Oblong	10	2.40	2.60	0.01	1.30	2.50
Vina	Oblong	100	3.50	3.20	--	0.01	0.09
Payne	Round	5	2.00	2.00	0.05	0.20	0.10

Though the trees have started to fruit, the yield is found to be very low compared to an average yield of 40 kg/tree. It might be due to low elevation inhibiting full expression of potential characteristics. The kernel qualities of the improved varieties were found to be of better quality than the local varieties. The shell thicknesses of improved varieties were also found to be thinner, which can be easily crushed, while it was thick and

hard in case of the local varieties. As the yield is found to be continuously very low, the trial is not found feasible. However, the trial will be continued for another year and if the yield does not increase, it will be terminated.

2.1.4 On-going fruits and nuts variety evaluation

1. Citrus rootstocks-scion compatibility trial
2. Nationally co-ordinated chestnut variety trial
3. Litchi variety evaluation
4. Loquat production evaluation
5. Japanese pear variety evaluation
6. Mango variety evaluation
7. Strawberry production evaluation
8. Banana varietal evaluation

2.2 Vegetable Research

2.2.1 Evaluation of high beta-carotene tomato lines

With more people looking for safer and more nutritive food, it has become important for the farmers to grow crop as per the demand of the consumers. Six tomato lines having high beta-carotene content were provided in 2010 to the centre by Asian Vegetable Research and Development Center (AVDRC) in Taiwan for evaluating their yield performance in the local condition and subsequent promotion of the promising lines. Beta carotene is associated with many health benefits including antioxidant functions and cardio-vascular health.

Table 35: Characteristics evaluated for high beta-carotene tomato lines

Variety	Fruit yield (t/ha)	Fruit weight (gm)
CLN1314G	17.56a	85b
CLN2070A	24.93a	15a
CLN2071C	23.33a	19a
CLN2366A	18.66a	30a
CLN2366B	23.26a	44ab
CLN2366C	22.36a	78b
Roma	23.80a	29a
P	0.92	<0.01

The yield evaluation of these tomato lines was carried out from the year 2010. All the six lines were evaluated in 2012 also. The released variety Roma was used as the check variety. The RCB design was adopted for this trial.

Statistically, the yields of all the lines were found to be in the same level with that of check variety. However, the highest yield among the evaluated lines was obtained from CLN2070A (24.93 t/ha) followed by CLN2071 (23.33t/ha) and CLN2366B (23.26 t/ha). The check variety gave the second highest yield of 23.80 t/ha. CLN2070A was found to also have good shelf life. The fruit weight differed significantly among some lines. The highest fruit weight was obtained from CLN1314G with mean fruit weight of 85g while lowest fruit weight was obtained from CLN2070A with mean fruit weight of 15g. The fruit weight indicates the size of the fruit which is one of the major factors in the market. Further yield assessment of the lines will be continued in the coming season.

2.2.2 Evaluation of Late Blight Resistant (LBR) tomato lines

In continuation to the trial conducted in year 2010 and 2011, all seven Late Blight Resistant (LBR) tomato lines (LBR-6, LBR-7, LBR-9, LBR-10, LBR-11, LBR-16 and LBR-17) 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. The same management practices were followed for all the trials on tomato carried out in the centre.

The data was collected for yield and the fruit weight. The fruit weight data was collected because big size fruits are not preferred by consumers and most of the above varieties are of big size. The variation in yield and the fruit size of different varieties are as indicated in Table 36.

Figure 3: Different tomato varieties evaluated

Table 36: Characteristics evaluated for Late Blight Resistant lines

Variety	Fruit yield (t/ha)	Fruit weight (gm)
LBR-10	35.00a	116a
LBR-11	14.60ab	115a
LBR-16	28.10 ab	115a
LBR-17	5.20 b	95 a
LBR-6	23.00 ab	98 a
LBR-7	5.90 b	102 a
LBR-9	26.50 ab	121 a
Ratan	14.90 ab	68 a
P value	0.01	0.78

All varieties exhibited some degree of resistance to the late blight in Bajo condition which was similarly noted in previous year's reports. However, the yield was found to be inconsistent with last year's result and had increased drastically. It has increased by more than 3-4 times in some lines. The yield of all the varieties were found to be in the same significant level with the check variety Ratan (P>0.01). However, the yield was found to be statistically significant among some LBR lines as depicted in the Table 36. The highest yield was obtained from LBR-10 with a yield of 35 t/ha followed by LBR-16 (28.1t/ha), LBR-9 (26.5 t/ha) and LBR-6 (23 t/ha). The lines LBR-11 (14.6 t/ha), LBR-7(5.9 t/ha) and LBR-17 (5.2 t/ ha) had lower yield than the check variety Ratan (14.9t/ha). The fruit weights of all the varieties were found to be statistically similar (P>0.78). The biggest fruit was obtained from LBR-9 variety with mean fruit weight of 121g. The check Ratan had the lowest fruit weight with mean fruit weight of 68g. Further assessment of the high yielding lines will be continued in the coming season.

2.2.3 On-going evaluation trial

1. Adzuki bean production trial (NCT).
2. Heat tolerant hot pepper evaluation trial (NCT).

2.2.4 Vegetable breeder seed maintenance

The centre is mandated to maintain the stock of breeder seeds of released cultivars. Horticulture sector maintains stock of various vegetable crop cultivars released from RNRRDC-Bajo. However, maintaining stock of all released cultivars is not possible because of specific climate requirement for seed production of some cultivars. There are currently 22 different types of vegetables seeds being produced and maintained in the centre.

2.3 Medicinal and Aromatic plants

2.3.1 Asparagus provenance trial

The wild asparagus provenance 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. The accessions were collected from 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. No major pest and disease problem has been observed and the plants have rooted well. No data was collected in the past year as the crop was subjected to accidental flooding which lead to wilting of some plants. The plants have been replaced and data collection will start from the coming season.

2.3.2 *Zanthoxylum* provenance trial

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

There are nine *xanthoxylum* 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. The suckers are removed every winter and irrigation is provided as and when required. Weeding was carried out twice in last season. The seedlings are still in vegetative stage at present. Yield data will be collected as soon as the tree starts yielding.

FORESTRY RESEARCH

3 FORESTRY

3.1 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 for different propagation techniques. Species selected for developing propagation techniques are purely based on the farmer's preference and some are based on their important multiple uses. Priorities are also given to develop propagation techniques for native tree species which have multiple uses and can be promoted in agro-forestry, private and community forestry programs.

We developed two types of propagation methods i.e. through seed and by vegetative cuttings (root/shoot/branch/stem/nodes) or rhizomes. The former is used for seed bearing important agro-forest species, while the latter is used for important species with long seeding cycle especially bamboos and also for woody perennial species. Sometimes both the methods are also tried for species which have high economic importance. Besides production of propagation techniques, the nursery also produce sufficient amount of planting material of MPTS as well as some ornamental species for planting within the RDC campus. We supply surplus seedling to the schools and institutions in Wangdue and Punakha when demanded.

3.2 Evaluation Assessment of In-Situ Resource Sustainability – Documentation of Peoples' Perceptions about Jala Yangka in Jala, Ruebi Geog, Wangduephodrang

Yangka is a bamboo species under genus Yushania, (Family Poaceae), that grows above Jala village at an altitude of about 2800 meters above sea level (m asl). Owing to the important use that Yangka had (a chief material for making traditional arrows); Yangka was collected annually for the purpose either legally or illegally. Thus, there were concerns that Yangka resource was threatened as Yangka was found in a very small area that is virtually inaccessible. The price of traditional arrows, especially the arrows made from Yangka was increasing over the years.

The study therefore analyzes and presents resource status and factors affecting sustainability of Jala Yangka in its growing area. This was done by analyzing the data collected from Yangka growing area in Jala. Empirical survey was conducted to analyze whether or not Yangka was a different species of bamboo from the archers' and artisan's point of view and whether they had more likings for Yangka over other bamboo for making arrows.

The fact that more number of Yangka clumps and culms were found only in the areas with steep slope in itself acted as explanation for Yangka being threatened primarily by free cattle grazing. The sustainability of Yangka resource in the natural growing area was highly threatened and only few Yangka clumps were taking refuge in areas that were not readily accessible to cattle (60% - 70% in the study site). Sadly however, the steep slopes could not provide a safe refuge for Yangka from the collectors. This exacerbated the vulnerability of Yangka. The rapid species vulnerability scored 27, indicating high vulnerability according to the scale developed by Watt, (1998) & Wild and Mutebi, (1996).

Knowing Yangka was found to be the precursor for archers' preference for Yangka. Age of archers played a significant role in knowing Yangka and its differences from other bamboos while archers' preference for Yangka was found to be the best predictor of knowing whether Yangka was a different bamboo. It was found that the availability of resources have remained steady over the years. However, there was a decreasing trend in the number of buyers. There was significant increase in the price of Yangka arrows during the past decade (2002 to 2012), but time was not a good predictor of the trend in price of Yangka although it had significant contribution.

FARMING SYSTEMS RESEARCH

4 FARMING SYSTEMS

4.1 Soils Research

4.1.1 Rice yield response to different rates of NPK fertilizers

This trial was started in 2012 and one season's results were analyzed and published in the preceding annual report. The main objectives of this trial are to assess the yield response of rice variety IR 64 to different rates of fertilizer under Bajo climatic conditions and to develop an economical fertilizer recommendation rate for the centre. The trial was laid out in a randomized complete block design (RCBD) with three replications. Rice variety IR 64 was used and rice seedlings were transplanted in 40 sqm plots at a spacing of 20 x 20 cm. Chemical fertilizers was applied as per the treatment design. FYM was applied at the rate of 7.5 t/ha. To control the weed, Butachlor 5G was applied at the rate of 1.5 kg active ingredient per hectare. Proper crop management, including pest control was applied as and when required. Similarly hand weeding was done at the tillering stage and irrigation was applied as and when required. The economic yield target for the trial is 9-10 t/ha. The treatments used for the trial are as follows:

T1 Control, no fertilizer input
T2 70:40:20 NPK kg/ha (Low NP)
T3 90:60:20 NPK kg/ha (Mid NP)
T4 110:80:20 NPK kg/ha (High NP)
T5 70:40:20 NPK kg/ha (Low NK)
T6 90:40:40 NPK kg/ha (Medium NK)
T7 110:40:60 NPK kg/ha (High NK)
T8 70:40:20 NPK kg/ha (Low PK)
T9 70:60:40 NPK kg/ha (Medium PK)
T10 70:80:60 NPK kg/ha (High PK)

Crop cut was taken from an area of 6 sqm during the harvest time to measure the yield. Grain moisture content was standardized at 14%. Before harvest, number of effective tillers and plant height were measured and grain yield was measured after the harvest. ANOVA was used to analyze the data and the results showed that there was a statistically significant difference between the treatments as determined by one-way ANOVA (p = 0.00). Aside from the ANOVA test, a Tukey post-hoc test was carried out to find out which treatment is significantly different from

which treatment and the results revealed that the difference in rice grain yields were statistically significant between most of the treatments.

Table 37: Mean of the agronomic traits under different rates of fertilization

Treatments	Mean grain yield (t/ha)	Plant height (cm)	Number of tillers
T1	8.7	65.00	17.00
T2	9.6	76.5	18.33
T3	11.3	78.9	19.25
T4	11.2	90.66	20.67
T5	11.4	78.33	20.33
T6	11.2	72.33	19.33
T7	11.6	80.00	19.00
T8	10.8	85.00	20.50
T9	10.6	84.67	21.45
T10	9.2	87.33	18.00
P	< 0.00	< 0.00	< 0.00

Among the treatments, T7 (110:40:60 NPK kg/ha) yielded the highest while the control followed by T2 (70:40:20 NPK kg/ha) and T10 (70:80:60 NPK kg/ha) yielded almost at par. This indicates that under higher doses of P nutrient, if N nutrient rate is low, rice crop will not achieve its full yielding capacity and/or the soil cannot supply the amount of nutrient N requirement by the rice crop. Looking at the mean rice yield data, it seems that nutrient nitrogen is the key to the realization of the yield potential of modern rice varieties. The mean grain yield of the control plot is 8.7 t/ha. This yield is the indicator of the potential soil supply of N, P and K in a cropping season. Most of the treatments yielded higher than the targeted economic rice yield for the centre. However, to further validate the results, this trial will be continued for one more seasons to rule out the effect of climatic factors.

A correlation was computed to assess the relationships between the treatments and rice grain yield, plant height and number of effective tillers. There was no significant correlation between grain yield and the treatments (r=0.232, n=30 and p=0.108). However, there was significant correlation between treatment and plant height (r=0.553, n=30 and p=0.001) and effective tiller numbers (r=0.845, n=30 and p=0.00). This indicates that the increase in grain yield with increasing rates of fertilizers is not significant; however the increase in fertilizer rates have significant effect on plant height and number of effective tillers.

Pre-trial soil fertility status

The soil fertility status at the start of the trial before fertilizer application is shown in Table 38.

Table 38: Soil nutrient status before the trial

pH	C%	C:N Ratio	Av. K (mg/kg)	Av. P (mg/kg)	Ca (me/100g)	Mg (me/100g)
5.55	1.70	12:52	41.20	24.69	4.18	0.52

The soil pH of 5.6 was slightly on the lower side but suitable for growing rice. Rice is known to grow well under a pH range from 5.0 to 6.5. Total carbon percentage of 1.7% was within the medium range indicating moderate soil organic matter content. Available K of 41 mg kg-1 and the available P of 24.7 mg kg-1 were both within the moderate ranges. Calcium and Mg were both low and the response to fertilizers supplying these elements could be expected.

Post trial soil fertility status

There was no significant treatment effect on any of the soil variables measured after the crop harvest. The soil fertility status was determined based on the mean values of the soil variables after the trial. About 90% of the samples had pH within the medium range; all the samples had moderate soil organic matter content and low total nitrogen percentage. Available P of the samples ranged between medium (40%) to high (60%) while the available K was within the very low (30%) to low (70%) range. About 70% of the samples had low calcium and about 50% had very low Mg. The overall soil nutrient status is quite low and in the absence of other production constraints, rice would show good response to higher rates of fertilizers.

4.1.2 Wheat yield response to different rates of Nitrogen fertilizer

Wheat is an important crop next to rice and maize as staple food grains. Wheat is grown in the wetland after paddy in wetland system and in the dry-land as spring crop. The area under wheat has decreased from 21,907 acres in 2005 to 5,802 acres in 2011. Similarly wheat production has reduced from 11,306 MT in 2005 to 6,266 MT in 2011. The national

average yield of the wheat crop is 1080 kg/ac as per 2012 RNR Statistics. Wheat has so far received very little research attention and focus, therefore there is a general lack of improved technologies including soil nutrient management. As with other crops, nitrogen is the most important element for wheat production, however, farmers hardly use any chemical fertilizer in wheat. Few farmers apply FYM. Furthermore, crop need for nitrogen is also immense with wheat. However, wheat is grown under very poor nutrient conditions and yields are very low. Because of low yield and high labor cost, it is always cheaper to import wheat from India than to produce wheat domestically. Nevertheless, opportunities to increase yield exist if fertility management is improved. NSSC recommends 50 and 80 kg nitrogen per hectare for low and high resource farmers respectively for Punakha and Wangdue Dzongkhags. While these recommended rates are generalized, data on yield response to different N rates is lacking. This trial was thus executed to assess the yield response of wheat variety Sonalika to different rates of nitrogen and to determine an economical nitrogen rate for wheat production under Bajo's climatic conditions.

The trial was conducted on-station and was laid out in a randomized complete block design (RCBD) with three replications. Good quality seeds of wheat variety Sonalika were used and seeding was done through broadcasting in 60 sqm plot area (5x12m). Chemical fertilizers were applied as per the treatment design. FYM was applied at the rate of 2.5 tons per acre. Proper crop management, including irrigation water and pest control was applied as and when required. Nitrogen fertilizer was divided into two applications; one as basal dressing and the other half as top dressing during middle to end of shooting stage. The treatments used for the trial were as follows:

T1 00:00:00 NPK kg/ha
T2 50:30:20 NPK kg/ha
T3 80:30:20 NPK kg/ha
T5 100:30:20 NPK kg/ha

At harvest wheat grain yield and straw was measured from each treatment plot ($60m^2$) area. Data was analyzed using ANOVA. The results showed significant differences between the treatments ($p=0.002$) for grain yield and ($p=0.003$) for straw yield. Similarly the correlation test showed significant relationship between the rates of nitrogen and the yield ($r=0.906$, $n=12$, $p=0.00$). This shows that the wheat yield increases with every increase in the rate of nitrogen fertilizer. This means that wheat

growers can substantially increase wheat productivity simply through improving the nitrogen fertilizer application rate. As expected among the treatments, T4 (100:30:20 NPK kg/ha) out yielded (1.8t/ha) over other treatments both in terms of grain and straw yield.

Pre and post trial soil nutrient status

Soil samples had low pH, between 5 and 5.5, very low to low available K (< 40 and > 40 and < 99 respectively), very low to low available P (< 5 and > 5 and < 14.9) with very low CEC and C percentage. After trial soil sample analysis results showed that, there have been slight changes in the soil nutrient status, samples had medium pH ranging between 5.5 and 6.5, both available K and P had decreased while the CEC and the carbon percentage had improved slightly, although still low. Therefore, the overall soil fertility was low before and after the trial. The treatments did not have any significant effect on the soil nutrient status.

4.1.3 Mustard yield response to different rates of Nitrogen and Phosphorus fertilizers

Mustard and rapeseed are the predominant oilseed crops grown from 200 m to 3000 m elevation. According to RNR Statistic 2010, an estimated 3,106 acres of land falls under one season cultivation of oilseeds with national average yield of 429 kg/acre. However, the acreage is gradually diminishing because it is not economically viable due to limited choice of cultivars and high cost of production with low productivity. The total mustard production in the country decreased from 4,423 MT in 2005 to 2,344 MT in 2011. The average yield of mustard in Punakha and Wangdue Dzongkhags are 364 kg/ac and 379 kg/ac respectively. Low production of the crop is mainly due to poor crop management, particularly low soil nutrient input, practiced by farmers. Mustard yield improvement is also constrained by the lack of suitable improved varieties for different agro-ecological zones. In addition, there has been little or no research done to improve the production of mustard through soil nutrient management. As in other crops, mustard is a high nitrogen, phosphorus and sulphur demanding crop. This trial was carried out with the aim to assess the yield response of Bajo Peka 2 to different rates of Nitrogen and Phosphorus fertilizers and to determine an economical nitrogen and phosphorus rate for mustard production under Bajo climatic condition.

The trial was conducted on-station and was laid out in a randomized complete block design (RCBD) with three replications. Good quality seeds of Bajo Peka 2 were used and seeding was done through broadcasting in 45 sqm plot area (9x5m). Chemical fertilizers were applied as per the treatment design. FYM was applied at the rate of 2.5 tons per acre. Proper crop management, including irrigation water and pest control was applied as and when required. While all the phosphorus and potassium fertilizers was applied as basal dressing, nitrogen was divided into two applications; one as basal dressing and the other half as top dressing at 35 days after sowing. The treatments used were as follows:

T1 00:00:00 NPK kg/ha
T2 60:30:20 NPK kg/ha
T3 80:50:20 NPK kg/ha
T4 100:70:20 NPK kg/ha

Mustard yield was measured from each treatment plot ($45m^2$) area. Analysis of variance did not show significant difference ($p>0.05$) between treatments (Table 39).

Table 39: Mean of mustard yield under different rates of nitrogen and phosphorus

Treatments	Mean yield (t/ha)
T1	0.12
T2	0.30
T3	0.21
T4	0.30
p	>0.05

The overall low yield of the trial is mainly because of severe mustard aphid (*Lipaphis erysimi*) infestation during pod formation. There was poor pod maturation and those matured were mostly empty. Aphids sucked the sap from the plant and also from the young pods thereby greatly reducing healthy seed formation. The crop thus could not show the yield differences as affected by the different rates of nitrogen and phosphorus fertilizers. The matured pods also have very tiny seeds and contributed to the overall low yield. This trial will thus be continued for another season to validate the data.

Pre trial soil nutrient status

Pre trial sample had medium pH (5.6 to 5.9) with very low-to-low available P (< 5 and > 5 and < 14.9) and low available K (> 40 and < 99). Percent nitrogen was very low-to-low (< 0.1 and > 0.1 and < 0.19) with medium percent organic matter content (>0.2 and < 0.49).

Post trial soil nutrient status

After harvest, soil sample results showed slight changes in soil nutrient status. Samples had pH of (>5.6 and < 6.5), available P very low to low (< 5 and > 5 and < 14.9); available K (<40 and >40 and < 90); and percent of nitrogen (< 0.1 and > 0.1 and < 0.19). The percent of organic matter did not show any changes.

4.1.4 Rice yield response to Dhaincha (*S.aculeata*) as pre rice green manure

This trial was planned in response to farmers using very limited or no farmyard manure application in rice production. The trial was conducted in Lobesa as part of the rice commercialization program and in Tashiding and Goshi geogs of Danaga Dzongkhag. Dhaincha seeds were supplied to the farmers with technical services from the centre. In Lobesa seeds were supplied to 9 farmers and in Dagana 4 farmers, two farmers from each geog. In Lobesa seeds were sown in the last week of April while few farmers did the sowing in the first week of May. Similarly in Dagana, sowing was done in the first week of May.

In Lobesa, none of the farmers could manage to grow Dhaincha to the required height and biomass before incorporation. In some fields the germination was very late and in other fields there was very poor growth. All the nine farmers observed lack of irrigation water as the main cause of poor performance of Dhaincha. The sowing season coincided with dry months (no rainfall) and the irrigation channel was under renovation and they could not irrigate their field before sowing the seeds. This was reported as the main reason for poor germination and performance later. Therefore, during rice harvest, crop cuts were not done for yield assessment as there was hardly any Dhaincha crop incorporated during transplanting. Unlike in Lobesa, in Dagana there was good percent germination, growth and also nodulation of dhaincha. Incorporation was done between 40 to 45 days after sowing. However, during rice harvest,

rice crop cut results did not show statistically significant yield difference between the treatments (with dhaincha and without dhaincha). This was expected because the pre trial soil sample analysis results showed very poor soil fertility status for all the four sites. While the rice grain yield did not show any difference between the treatments, the post trial soil sample analysis results showed improvement in most soil variables.

Except soil pH, other variable slightly improved after growing dhaincha. This means dhaincha could be used as one option to improve the soil fertility. Soil pH was little bit lower than what is required (5-6.5) for rice crop. This could be because of high rainfall which Dagana normally receives. Soil acidity develops with sufficient rainfall, as much of the bases leach out leaving the colloidal complex dominated by H and Al ions. Percent nitrogen and organic matter improved slightly after dhaincha cultivation while available K was still very low. This could be because of the complete removal of the rice straw from the field, insufficient application of K fertilizer, and low soil capacity to supply K. Deficiency of K also occurs in coarse-textured soils with low CEC. Unlike K, available P increased fairly. It can be concluded from one season's trial result that Dagana rice farmer could use dhaincha crop to improve their field soil fertility. Similar long-term station trials showed improvement in overall soil fertility and rice production as a result of pre-rice dhaincha cultivation.

4.1.5 Demonstration of recommended inorganic fertilization in rice

Inorganic fertilizers are inevitable in rice production particularly for improved varieties. The varieties in Punakha and Wangdue Dzongkhags are predominantly improved ones with most farmers growing IR 64. NSSC recommends chemical fertilizer rates of 70:40:40 N: P_2O_5: K_2O kg/ha for rice in these Dzongkhags. However, a study to assess the adoption rate of the recommended fertilizer rates showed very few to none adopter of the rates recommended. Therefore, there is a need to sensitize the rice farmers on correct dose of fertilization, and simultaneously assess the yield difference between recommended and farmers' fertilization. The demonstration was carried out in Lobesa area as part of the rice commercialization program. There are a total of nine collaborating farmers. Together with the farmers, demonstrations sites were selected and measured for area calculation. Pre trial soil sampling was done from all the nine sites and was analyzed for fertility status. Trials were implemented in single large plots without replication on the same farm.

There were only two treatments; farmer's practice and the recommended practice of fertilization.

Based on the area calculated, the required fertilizers were provided from the centre. Except fertilization difference, other management practices were same for both the treatments. Rice variety IR 64 was used for all the sites. While all of the fertilizers P and K were applied as basal dressing half of the N was applied as top dressing after weeding. During harvest, crop cuts were taken from all the sites and the results are presented in Figure 4. Irrespective of sites, the recommended practice out yielded the farmer practice by 310.3 kg at Yuwakha, 384 kg at Tshokona and 681 kg at Yusakha. All the collaborating farmers were happy with the yield differences and were planning to apply the recommended practice from the coming season. Of the nine farmers, only two were concerned about affordability in adopting the recommendation practice. Rest of the farmers mentioned that they did not apply the recommended practice as they were not aware about the practice.

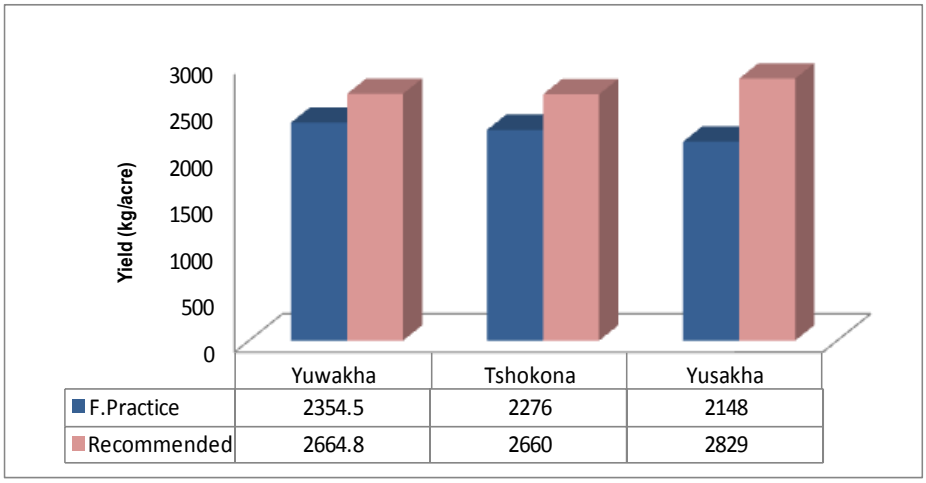

Figure 4: Rice yield difference between farmer practice and recommended

While there is some uncertainty with regard to the application of required amount of fertilizers per unit area, however it is likely that farmers will start using balance fertilization instead of single nutrient (only urea). This change will not only help farmers to increase their rice yield, but also help in sustaining the rice productivity of their farms. This activity is being continued with the aim to sensitize more farmers about the recommended fertilization and its effects both on the yield and also on the soil in the long run.

4.1.6 Rice yield response to sequential direct seeding under Bajo's climatic condition

In Bhutan, rice is commonly grown by transplanting seedlings into puddled soil. Repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in sub-surface layers, and forming hard-pans at shallow depths. Moreover, puddling and transplanting require large amount of water and labor, both of which are becoming increasingly scarce and expensive in the country. Therefore, agronomic management and technological innovations are needed to address these issues in Bhutan. In view of this need, a trial was executed with the aim to assess rice yield to sequential direct seeding. The trial was implemented on-station. A big terrace was divided into three equal parts and the first direct seeding was done on 25th April, second on 5th May and third on 15th May, 2012 with an interval of 10 days. Besides the sowing dates, the other management practices were similar across all the plots. Chemical fertilizers were applied at the rate of 80:40:40 NPK kg/ha. FYM was applied at the rate of 7.5 t/ha. To control the weed, Butachlor 5G was applied at the rate of 1.5 kg active ingredient per hectare. Proper crop management was applied as and when required.

At maturity the grain yield was estimated from a crop cut of 6 m^2 from each plot and the moisture was adjusted to the standard. The results did not show significant difference between the yields. The plot sown on 25th April yielded 2015 kg/ac, the plot sown on 5th May produced 1830 kg/ac and last sowing on 15th May yielded 1725 kg/ac. With one season's data and with minimal difference in yield, it is difficult to draw any conclusive recommendation from this trial at this stage. Direct seeding can be a good alternative to transplanting and yield potential of direct seeded rice is equivalent to transplanted rice under good water management and weed control conditions. One important observation made from this trial was that weeds pose a serious threat to the direct seeded rice by competing for nutrients, light, space and moisture throughout the growing season. In addition to the application of Butachlor, three hand weeding were done. Considering the yield which is almost at par with the transplanted method, it could be possible to improve the overall yield performance with effective weed control measures. Therefore effective and economical weed management strategy needs to be explored and implemented if direct seeding method needs to be promoted.

4.2 IPM Research

4.2.1 Effect of different herbicide on Shochum control

Potamogeton distinctus belonging to the family Potamogetonaceae (local name *shochum)* is considered to be the most serious rice weed in Bhutan. It is a perennial, floating-leaved aquatic plant with rhizomes down to 20 cm in the soil below, which form dormant resting organs (rhizome tips or turions) at the end of the season and emerge as soon as flooding recur the following season. Punakha-Wangdue valley is one of the major rice growing areas in Bhutan and *Shochum* is the major weed in this valley. This trial thus was executed to come up with appropriate strategy to mitigate the problem. The main objective of the trial was to evaluate the efficacy of different pre and post emergence herbicide in controlling *Shochum* and other weeds (sedges and grasses) in rice.

The trial was conducted on-station at RDC Bajo for three consecutive years (2010-12). The trial was laid out in an RCBD with four treatments and three replications. Good quality seed of rice variety IR 64 was used and rice seedlings were transplanted in 25 sqm plots at a spacing of 20 x 20 cm. Weed sampling was done two times at 20 and 40 days after transplanting. The weed samples were collected from each treatment using quadrat of 0.25 m^2. Two random samples were taken from each treatment from each replication. Therefore, altogether 6 samples were collected for each treatment annually. The collected weed samples were washed thoroughly with clean water, identified and fresh weights were recorded. The weeds were then categorized into *Shochum* and other weeds, air dried and weighed. The other weeds comprised of sedges and grasses such as *Scirpus juncoides*, *Cynodon dactylon* and *Cyprus spp.* Chemical fertilizer was applied as per the recommended rate of 70:40:40 NPK kg/ha. FYM was applied at the rate of 7.5 t/ha. Proper crop management, including pest control and irrigation was applied as and when required. Data generated was analyzed using ANOVA.

Statistical analysis showed that the mean fresh biomass of *Shochum* was significantly different between treatments ($F = 10.043$, $df = 3$, $P = .004$). The plots treated with Sunrice for three consecutive years gave the lowest mean biomass of fresh *Shochum* (404 kg/ha ± 204.56) while the control plot had the highest mean biomass of 5019.4 kg/ha ± 1496.40 (Figure 5 &

6). The results indicated that Sunrice is effective in controlling *Shochum* as compared to other treatments.

Table 40: Mean Shochum biomass of 3 consecutive years (in kg ha^{-1})

Treatment	N	Minimum	Maximum	Mean	Std. Deviation
Topstar	3	1300.67	2025.32	1718.20	374.73
Sunrice	3	189.32	596.67	404.00	204.56
Butachlor	3	2196.00	5022.00	3278.80	1524.33
Control	3	3366.25	6281.32	5019.40	1496.40

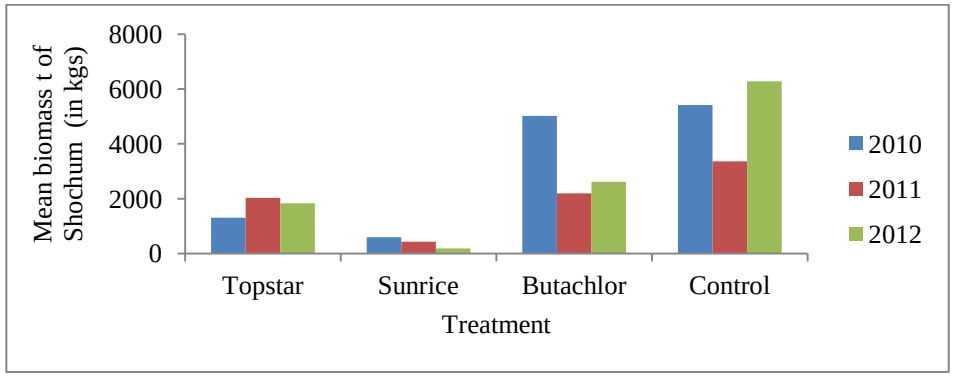

Figure 5: Mean biomass of Shochum between treatments in different years (in kg ha^{-1})

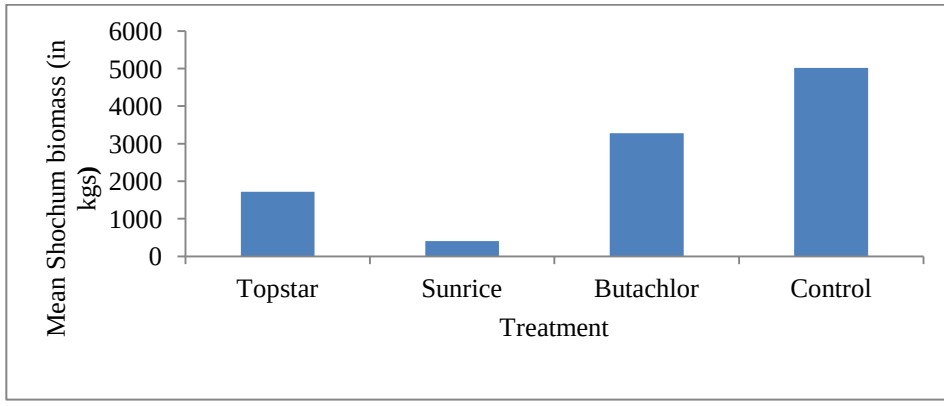

Figure 6: Mean Shochum biomass of 3 consecutive years (in kg ha^{-1})

The plots treated with Butachlor had the lowest mean biomass of other weeds (222 kg/ha ± 123) while the highest mean biomass (4160 kg/ha ± 3124) was found from the Control plot (Figures 7 and 8, Table 41). Statistical analysis showed that there was no significant difference in mean biomass of other rice weed between treatments. This may be due to low pressure of other rice weeds as compared to *Shochum*. The fresh weight of other rice weed was recorded lowest from the plots treated with Butachlor followed by Topstar. While application of Butachlor in transplanted rice is said to eliminate almost all grasses and sedges, Topstar seems to have effect both on *Shochum* and on other weeds, though not as effective as Sunrice against *Shochum* control and Butachlor for other weeds control.

Table 41: Mean biomass of other weeds of 3 consecutive years (in kg ha^{-1})

Treatment	N	Minimum	Maximum	Mean	Std. Deviation
Topstar	3	116.67	876.00	451.33	387.58
Sunrice	3	345.32	2966.67	1536.00	1327.05
Butachlor	3	107.72	353.32	222.57	123.56
Control	3	2055.60	7750.67	4160.50	3124.55

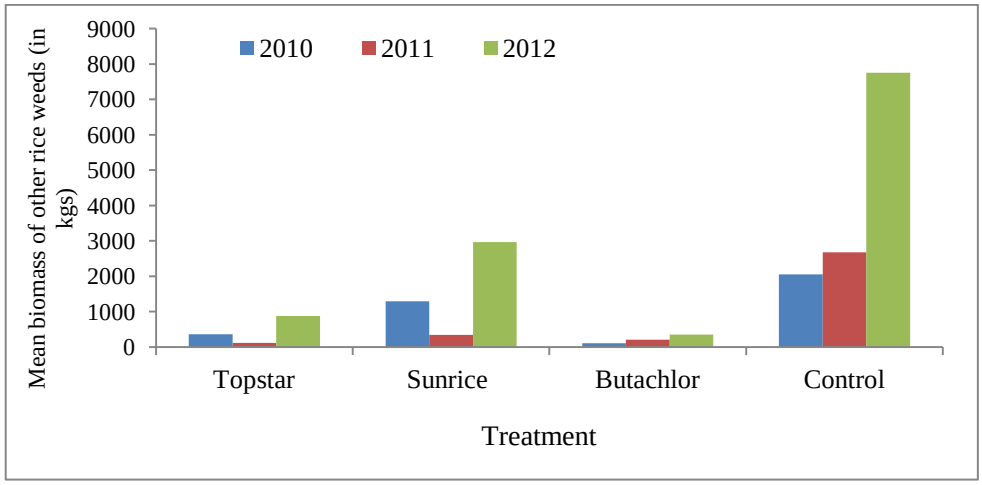

Figure 7: Mean biomass of other weed between treatments in different years (in kg ha^{-1})

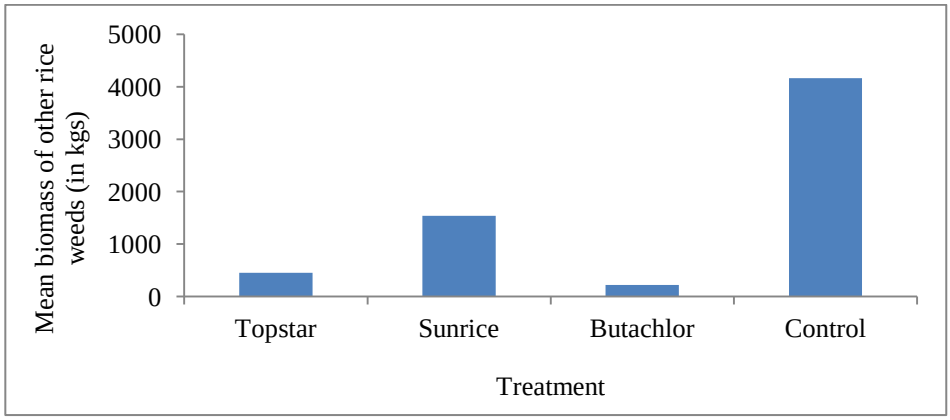

Figure 8: Mean biomass of other weeds of 3 consecutive years between treatments (in kg ha^{-1})

Rice grain yield was estimated from an area of 25 sqm plot and grain moisture content was standardized at 14%. Statistical analysis showed that mean weight of grain yield was significantly different between treatments ($F = 11.039$, $df = 3$, $P = .003$). The mean grain yield was highest from the plots treated with Sunrice and the lowest was found from the Control plot (Figure 9 & 10). The highest mean grain yield was 6.02 t/ha and the lowest was 3.42 t/ha (Table 42). The plots treated with Sunrice and Topstar yielded significantly higher than Butachlor treated ones indicating the ineffectiveness of Butachlor in controlling *shochum*. The result indicated that Sunrice is most effective in controlling *shochum*.

Table 42: Mean weight of grain yield of 3 consecutive years between treatments (in t ha^{-1})

Treatment	N	Minimum	Maximum	Mean	Std. Deviation
Topstar	3	4.90	5.73	5.29	.41
Sunrice	3	5.79	6.50	6.02	.40
Butachlor	3	3.76	5.40	4.33	.92
Control	3	2.96	3.86	3.42	.45

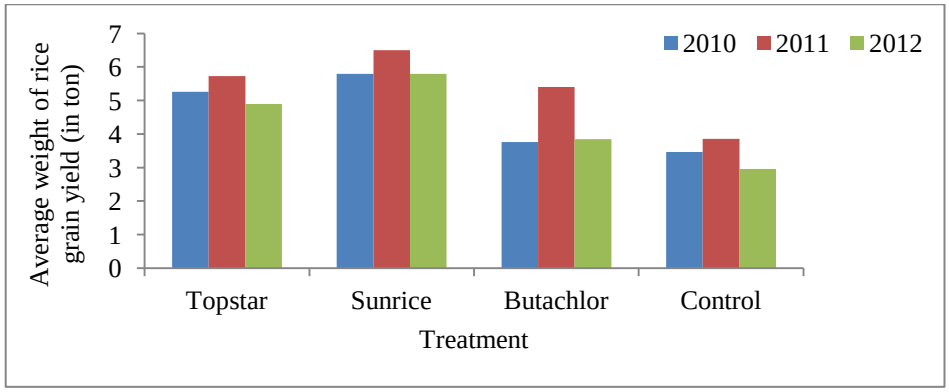

Figure 9: Mean weight of grain yield between treatments in different years (in t ha^{-1})

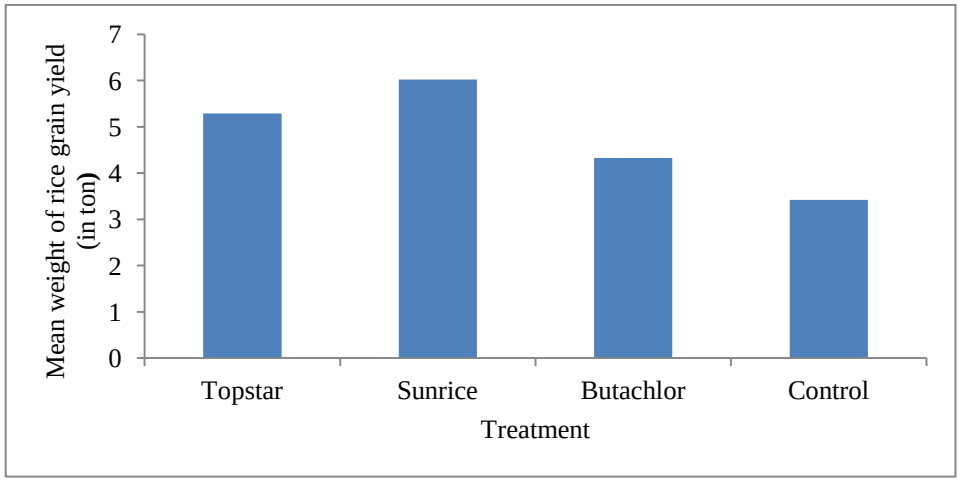

Figure 10: Mean weight of grain yield of 3 consecutive years (in t ha^{-1})

The study conducted over a period of three years clearly indicated and showed that the herbicide Sunrice is effective in controlling the *Shochum* and increasing the grain yield. On the other hand, Butachlor is found to be effective in controlling the other weeds (sedges and grasses). However, Topstar is found to control both Shochum and other weeds but not as effective as Sunrice and Butachlor. Therefore, the further research on combined efficacy of Sunrice and Butachlor is recommended in future.

4.2.2 On-farm weedicide trial

The on-farm weedicide trial was conducted at three locations i.e. in the field of 3 farmers at Gangkha and Euwakha village under Baap geog, Punakha during 2012. The main objective of the trial was to evaluate the efficacy of the weedicide Sunrice and Topstar in controlling *Shocum* in rice. The weedicide trial will be conducted for three consecutive years during 2012-14. Terraces will be changed every year to minimize the experimental error but in the field of same farmer at same location. Data generated during three years will be analyzed using ANOVA. The trial results of the first year are as follows.

The terraces with severe *Shochum* problem were identified and selected. In order to avoid mixing of the herbicide due to the flow of water from one terrace to another, the terraces which were far apart were selected. The farmers were also advised on maintaining proper water level in the trial field to avoid over flooding and drying up of the field. The weedicides were applied as per the recommended rate. Topstar was applied at the rate of 35-45 gm per acre of rice field. Before application, a paste was made by adding little water to the weighed quantity of chemical. After making the paste, solution of the chemical is made by adding 1 litre of water. This solution is mixed with sand @ 20-25 kg of sand per care for broadcasting or adequate water for spraying. Sunrice was applied at the rate of 33-40 gm per acre. The chemical solution is sprayed @ 200 litres water per acre on moist soil after draining the excess water. Each location of the trial site was considered as replication so altogether there were three replications.

Two random samples were collected from an area of 1 sqm, using a quadrat from each treatment from each farmer. The collected *Shochum* weed samples were washed, air dried and weighed fresh for each treatment separately. The weed samples were collected 2 times i.e. once in 20 days after transplanting and secondly in 40 days after transplanting. The fresh weights of the weed sample were taken. In order to have the uniformity in assessing the grain yield, the famers growing the same variety of rice crop were selected as an important parameter. In this case, all the 3 farmers growing the rice variety IR 64 were selected. One crop cut sample of $6m^2$ was taken from each treatment from each farmer. The fresh field weights of the samples were taken and the moisture content standardized at 14%.

The results revealed that the lowest Shochum weed biomass of 192 kg/ha was found in Sunrice treated plot and the highest in Farmers Practice plot

with 1534.7 kg/ha in 20 days after transplanting (20 DAT). Similarly, in 40 DAT also the lowest Shochum weed biomass with 1217.10 kgs per hectare was recorded from Sunrice treated plot and the highest was 5812.30 kg/ha from Farmers Practice plot. In both 20DAT and 40DAT, the fresh weight of Shochum weed sample was recorded to be the least in Sunrice treated plot followed by Topstar and the highest weight of Shochum weed was found in Farmers Practice plot (Figure 11). The result indicated that the herbicide Sunrice is effective in controlling the weed Shochum as compared to Topstar.

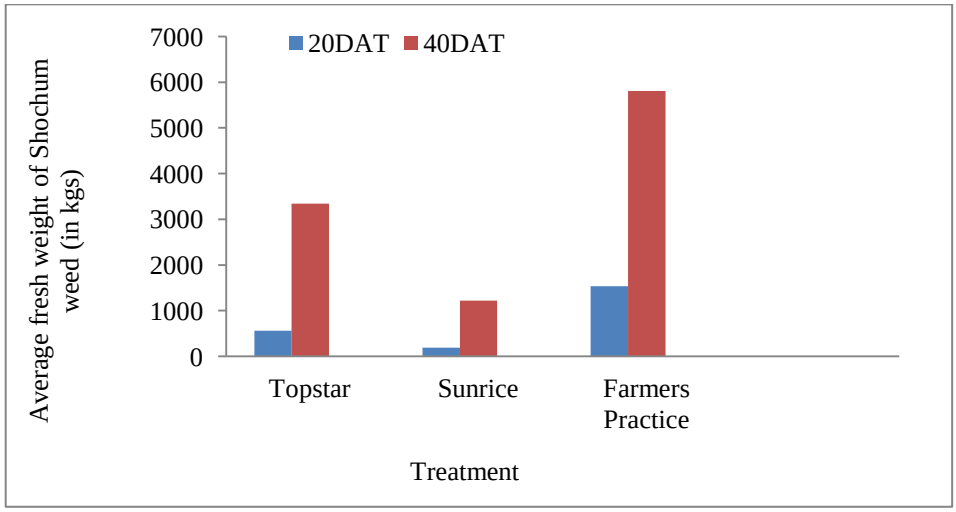

Figure 11: Mean biomass of Shochum in 20 DAT & 40 DAT (in kg ha^{-1})

The highest grain yield (6.48 t ha^{-1}) from Sunrice treated plot followed by Topstar (6.40 t ha^{-1}) and the lowest yield was obtained from the Farmers Practice (6.38 t ha^{-1}) plot (Figure 12). This also indicated that Sunrice is effective not only in controlling Shochum but also in increasing the grain yield. Therefore, the on-farm trial result further supported the findings of on-station trial result and indicated that Sunrice is effective both in terms of controlling the Shochum and increasing the rice grain yield.

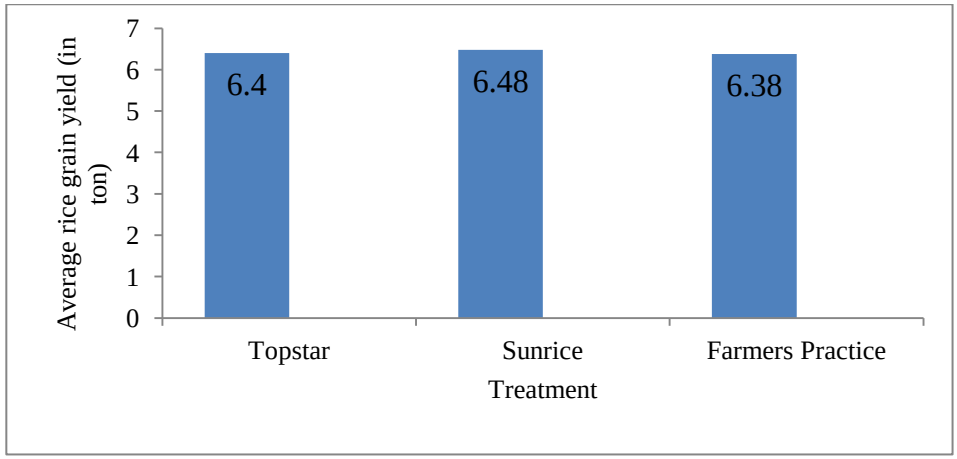

Figure 12: Mean weight of grain yield between treatments (in t ha^{-1})

4.2.3 Monitoring of fruit fly emergence and population trend in mango

The study on monitoring the mango fruit fly (*Bactrocera dorsalis*) population was carried out at Kamichu and Baychu Royal orchards on mango. The altitude of Kamichu and Baychu is 625 masl and 670 masl respectively. The area of the mango orchard at Kamichu is about 2 acres and at Baychu it is about 1 acre. The trees in both the orchards are in full fruit bearing stage. Baychu is bit higher than Kamichu and the environment at Baychu is highly dusty due to Punatsangchu project vehicle plying on the road. The infestation and fruit drop caused by the fruit fly was the major problem in the orchard thereby leading to reduction in mango production every year. The main objective of the trial was to study the fruit fly population trend and determine the peak emergence period in the orchard and initiate further research on developing control strategies of the pest.

The study was carried out for four consecutive years during 2009 – 2012 at Kamichu and Baychu orchard. The pheromone traps were set up to attract the male fruit fly @ 5 traps per acre during the last week of every February. Therefore, depending upon the size of the orchard, 10 traps were set up at Kamichu and 5 traps were set up at Baychu. The data for 8 months were collected in a year i.e. starting from the first week of March till the last week of October. The pheromone traps were hung in the orchard to a height of 2 metres. The data on fruit fly was recorded every week starting from the 1st week of March till the last week of October. The

trapped fruit flies were removed every week after counting and recording the data. The methyl eugenol blocks were used to attract the fruit fly in the pheromone trap. Methyl eugenol acts as a sex attractant for males of fruit flies. The pheromone blocks were changed once in every two months to maintain the efficacy of the pheromone trap. The set of pheromone traps were purchased from S. B. Agency, Siliguri, India. ANOVA was used for analyzing the data.

The results showed that the highest mango fruit fly population occurred during the month of July (Figure 13 & 14). The lowest population was found during the month of October. A slight increase in fruit fly population from April to May was recorded, almost reaching the peak in June. This may be due to ripening season of fruit as fruit ripening season coincided during the month of July under Kamichu and Baychu condition. The result indicated that the spray schedule for the control of fruit fly needs to be implemented from the month of April till September with the highest priority during the month of June and July which are the peak months for the occurrence of fruit fly. The decrease in population from August might be due to harvesting of fruits. Statistical analysis showed that the number of fruit fly caught in pheromone trap between the months was significantly different ($F = 2.743$, $df = 7$, $P = .030$). This indicated the high fruit fly population fluctuation during the months of the year. This may be due to changes in weather pattern over the years with regard to rainfall, humidity and temperature. Further, the change of pheromone block during the period might have also contributed to some population fluctuation as usually high fruit fly population were recorded in the succeeding week after the change of the new pheromone block in the orchard. Table 43 showed the highest mean fruit fly population during the year 2012 (3454.10 ± 3915.81) followed by 2011 (3174.00 ± 4521.58), 2009 (1492.00 ± 2255.93) and the lowest mean population was recorded during the year 2010 (754.62 ± 701.83). However, statistical analysis showed that there is no significant difference in fruit fly population between the years ($F = 1.341$, $df = 3$, $P = .281$) This indicated that there was not much difference in fruit fly population fluctuation between the years.

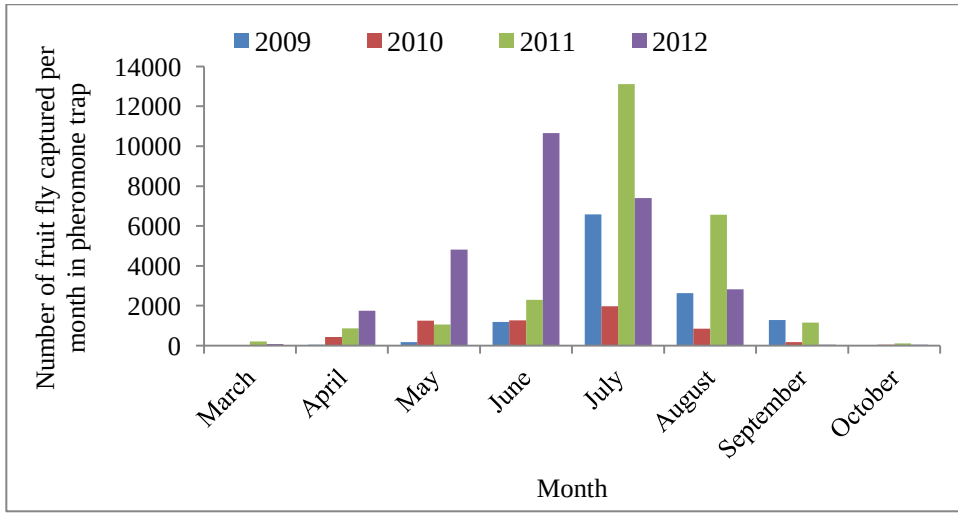

Figure 13: Mango fruit fly population trend at Kamichu orchard during 4 consecutive years

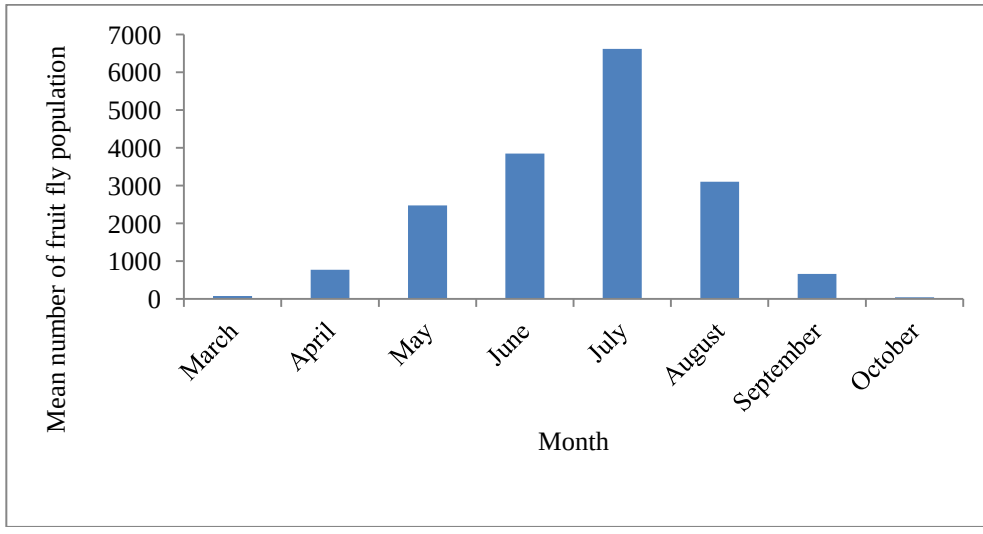

Figure 14: Mean fruit fly population of four consecutive years at Kamichu orchard in different months.

Table 43: Mean fruit fly population at Kamichu orchard in different years

Year	N	Minimum	Maximum	Mean	Std. Deviation
2009	8	6.00	6589.00	1492.0	2255.93
2010	8	31.00	1972.00	754.62	701.83
2011	8	121.00	13120.00	3174.00	4521.58
2012	8	45.00	10664.00	3454.10	3915.81

The result of Baychu orchard also showed the similar trend of fruit fly population reaching its zenith during the month of July (Figure 15 & 16). Statistical analysis showed that there is no significant difference in fruit fly population caught between the months of the years ($F = 1.799$, $df = 7$, $P = .134$). This indicated that there is not much difference in population fluctuation between months of the years under Baychu condition. However, statistical analysis showed that the number of fruit fly caught in pheromone trap between the years was significantly different ($F = 4.185$, $df = 3$, $P = .014$). Table 44 also showed the highest mean fruit fly population during the year 2011 (1741.60 ± 1687.64) followed by 2012 (665.00 ± 700.62), 2010 (388.62 ± 286.90) and the lowest mean population was recorded during the year 2009 (232.88 ± 341.92). This indicated that there is a greater difference in fruit fly population between the years under Baychu condition. This may be due to drastically high population recorded in the year 2011 as compared to other years. Besides, this may also be due to the difference in dusty environment created by the project vehicle over the years.

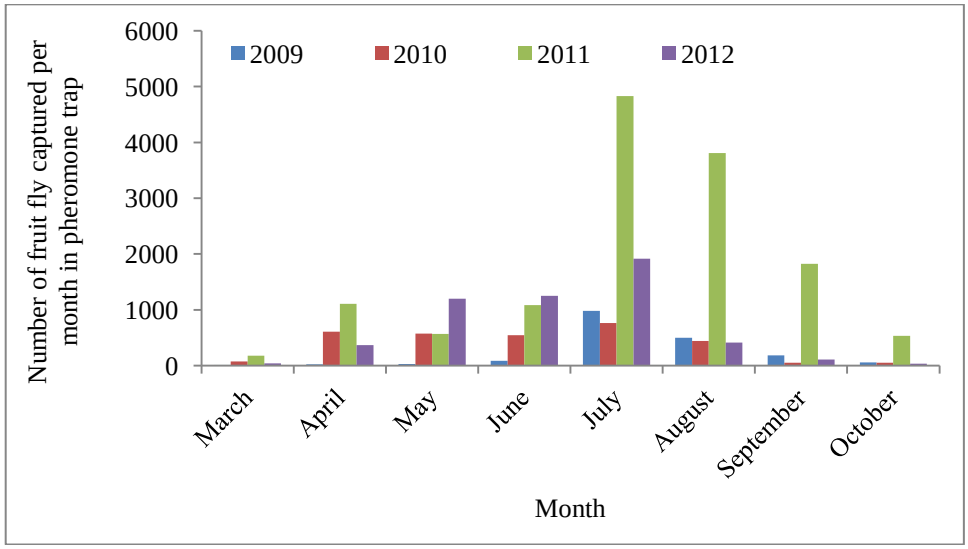

Figure 15: Mango fruit fly population trend at Baychu orchard during 4 consecutive years

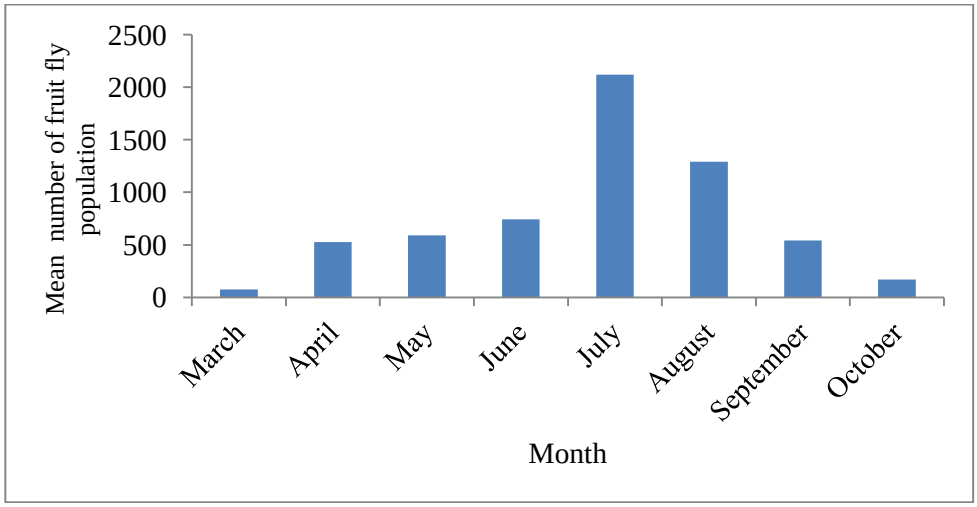

Figure 16: Mean fruit fly population of 4consecutive years at Baychu orchard in different months

Table 44: Mean fruit fly population at Baychu orchard in different years

Year	N	Minimum	Maximum	Mean	Std. Deviation
2009	8	11.00	979.00	232.88	341.92
2010	8	52.00	765.00	388.62	286.90
2011	8	179.00	4829.00	1741.60	1687.64
2012	8	36.00	1913.00	665.00	700.62

The month of July was found to be the peak season for the occurrence of mango fruit fly under both Kamichu and Baychu condition hence more attention is required during the aforementioned period for effective control measures. The peak occurrence of the fruit fly coincided with the ripening of mango fruit.

DEVELOP-MENT ACTIVITIES

5 DEVELOPMENT ACTIVITIES

5.1 National Rice Development Program

The national rice program started on a high note with increased budgetary outlay and made tangible progress in terms of crop variety promotion, capacity building and mechanization services. An area of 2364 ha has been brought under various forms of interventions bringing total area under intervention to 6893 ha (up by 52% from the previous year). Activities such as farm mechanization, supply and promotion of improved seeds, demonstration of integrated nutrient and pest management, including capacity building of farmers and EAs were vigorously carried out in collaboration with central programs and Dzongkhags. As in the previous year, the rice potential Dzongkhags of Sarpang, Samtse, S/Jongkhar, and Wangdue-Punakha have received maximum budgetary support for implementing various rice commercialization activities. With additional funding from DRDP, 3.5 tonnes of Khangma Maap rice seed was supplied to Trongsa, Zhemgang, Tsirang and Dagana to promote improved varieties. Following the rice commercialization strategy, the potential dzongkhags will continue to get maximum support and plans are in place to intensify interventions in the years to come. Some notable progress made under the national rice program which was coordinated from RDC Bajo are briefly described below.

5.1.1 Rice production and sale

The Chuzargang Agricultural Farmers Cooperative (CAFCO) under Chuzargang geog in Sarpang Dzongkhag continued with the operation of rice mill generating gross revenue of Nu. 533,180 from the sale of 13.5 MT head rice including 125 kg brown rice, 1,635 rice bran and 356 broken rice. The paddy collection for the current year was just 21.5 MT (Table 45) which is down by 60% from the previous year. This reduction was owing to CAFCO's choice for low yielding local varieties such as Champa, Khamtey, Choti Masino, and Kalibog which fetch higher price in the market. However, the DoA is concerned about such dismal performance of CAFCO thereby leading to development of a different strategy for the future. The net income of CAFCO in the year ending 2012-2013 is a meager Nu. 92,535.

Table 45: CAFCO's revenue generation for the year 2012-2013

Variety	*Head Rice*	*Broken*	*Bran*	*Brown rice*	*Total*
Champa	289218	1800	7650	0	298668
Khamtey	41648	585	1080	0	43313
Kalobog (Jeera)	97660	63	2205	5000	104928
Chotimasino	60300	405	2250	0	62955
Kalobog (bold)	12420	81	810	0	13311
Kamja	7440	270	720	0	8430
Mix Rice	1575	0	0	0	1575
Gross Income	510,261.00	3,204.00	14,715.00	5,000.00	533,180.00

5.1.2 Promotion and supply of HYV seeds

For improving rice productivity, the national rice program continued with vigorous promotion and supply of higher yielding variety seeds in the potential dzongkhags including the DRDP beneficiary Dzongkhags of Trongsa, Zhengang, Tsirang and Dagana. As part of rice commercialization program, improved seeds to the tune of 63.1 MT were supplied to the five cluster Dzongkhags, viz. Samtse, Sarpang, S/Jongkhar and Wangdue-Punakha as shown below (Table 46). For the DRDP supported Dzongkhags, about 6 MT of Khangma Maap was supplied.

Table 46: Supply of rice seeds under rice commercialization program

Sl. No	Variety	Quantity (MT)				Total
		Wangdue - Punakha	Sarpang	Samtse	S/Jongkhar	
1	Khangma Maap	10200	100	0	0	10300
2	IR-64	5060	310	400	0	5770
3	Bhur RayKaap1	0	3290	11800	2700	17790
4	Bhur RayKaap2	0	1000	8420	2200	11620
5	Bhur Kambja 1	0	4690	1690	2100	8480
6	Bhur Kambja 2	0	2010	3300	2000	7310
7	Bajo Maap 2	270	0	0	0	270
8	Bajo Kaap 1	800	0	0	0	800
9	No.11	1320	0	0	0	1320
		17650	11400	25610	9000	63660

Additionally, 3.9 tons rice seeds comprising of 9 improved varieties produced at the research station were supplied for crop varietal improvement program (Figure 17).

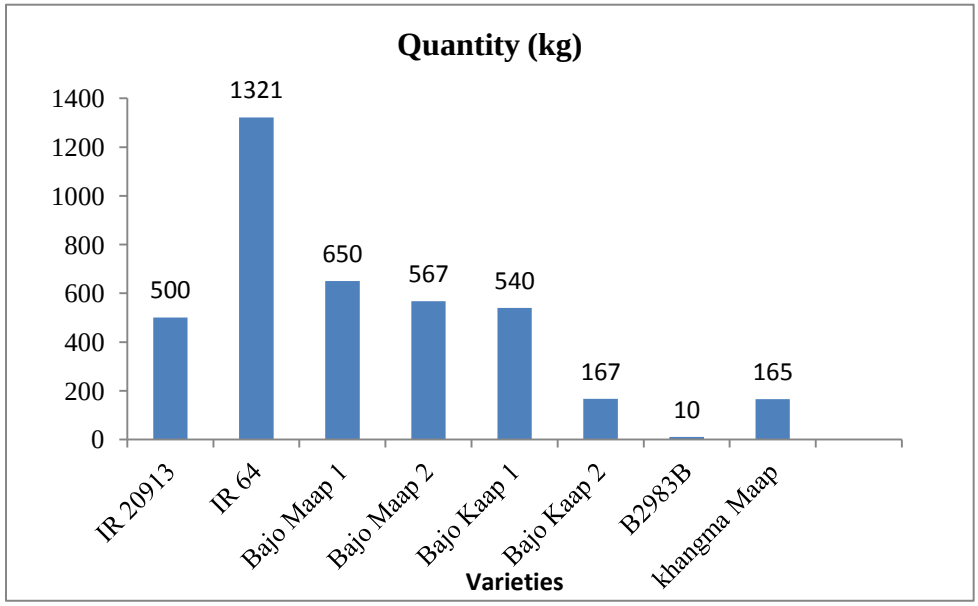

Figure 17: Seeds supplied to the dzongkhags from the Centre.

5.1.3 Integrated soil fertility management

To improve yield potential of the improved varieties, the national rice program has advocated on plant nutrient management through demonstration of balanced fertilizer application and integrated nutrient management technologies in the farmers field. A total of 10 balanced fertilizer demonstrations are under way covering Samtse, Sarpang, Wangdue, Punakha Dzongkhags. Further, 11 demonstrations on pre-rice dhainacha green manuring are being initiated. In the current season, a total of 2100 kg dhaincah seed was procured and supplied to the farmers as part of technology promotion. To create awareness and inculcate farmers' sense of plant nutrient application for enhancement of yield, demonstrations on urea top dress were also initiated in the Dongkhag starting this year.

5.1.4 Farm mechanization

Farm mechanization is seen to be rapidly picking up especially in Sarpang and Wangdue-Punakha valley. This is attributed to introduction of machinery hiring services and vigorous promotion of farm mechanization through demonstrations and training of both farmers and extension staff. In the current rice season, about 3123 acre has been brought under partial and full mechanization (Table 46). While farm mechanization is reported to be gaining popularity in Sarpang Dzongkhag there is an increase in area under mechanization in Wangdue-Punakha valley. This season, Wangdue-Punakha valley alone recorded 1553 acre under mechanization (Table 46), an eight fold jump from the previous year.

Table 47: Dzongkhag wise area coverage by various forms of interventions

Dzongkhag	Mechanization (ac)	Seeds	Green manuring	INM.IPM	Total
Sarpang	660	456	20	65.98	1201.98
Samtse	275	1024.4	40	30.06	1369.46
S/Jongkhar	635	360	4	0	999
Wangdue-Punakha	1553	706.6	20	60	2339.6
Total	3123	2547	84	156.04	5910.04
		Area (ha)			2364.016

5.1.5 Rice double cropping

After a span of over a decade, RDC re-introduced spring rice cultivation at Rinchengang village, Thetsho geog in Wangdue Dongkhag. The objective of such initiative was to enhance rice production and revive rice double cropping at Rinchengang which is said to have high poverty in the Dongkhag. This initiative is also to demonstrate that rice double cropping is feasible in Wangdue-Pnnakha valley and attach importance on its cultivation through mechanization. An area of about 20 acre belonging to 46 HHs was grown to No.11 rice variety. As per the sample crop cut results, the yield was recorded at 2450 kg /ac which gave about 48, 980 MT production from 20 acre land. RDC Bajo provided 720 kg No. 11 seeds and collaborated with RAMC Bajo on farm mechanization aspects such as farmers training on tray nursery development, demonstration of mechanized transplanting and other machinery services.

5.1.6 Capacity building

For enhancing crop production, capacity building was accorded one of the highest priorities under the national rice commodity program. Focused trainings were provided for both farmers and extension agents on various aspects of crop production and farm mechanization. The following are the brief information on staff and farmers training implemented in 2012-2013 financial year.

I. Farmers training on improved cultivation practices: 108 farmers from Chubu and Baap geogs of Punakha and Thetsho geogs were trained on improved cultivation practices including IPM and INM practices.

II. Farmers training on tray nursery preparation: 160 farmers from Wangdue and Punakha were trained on tray nursery production. This is to help them in rice mechanization.

III. Farmers training on farm machinery operation and maintenance: With the DoA's target to mechanize rice farming in all the potential dzongkhags, the following 3 levels of trainings were provided by AMC.
   - Intensive training on machinery operation and maintenance for the key farmers: trained 14 key farmers to promote farm mechanization
   - Basic machinery operation and maintenance (power tillers and tractors): Trained 102 farmers
   - Basic operation and maintenance training (power tillers and tractors) for the extension staff: trained 12 EAs from Wangdue and Punkha

IV. Refresher course for EAs on improved rice production: EAs and the researchers were provided with a weeklong refresher course on rice production at CNR which has benefited 42 participants. The participants were from RDC Bajo and Dzongkhags of Trongsa, Bumthang, Tsirang, Dagana, Wangdue and Punakha.

5.1.7 Rice processing facility

Four modern rice mills with complete processing facilities are all set to be up and running after the current season's crop harvest. These facilities will benefit the rice potential clusters of Samdrup Jongkhar, Samtse, Wangdue-Punakha valley and Tsirang-Dagana. The rice mill for Samtse is being contracted out to Charru Tshongdrel, a pvt firm based in Paro under multi-partite module of contract farming and the ones for S/Jongkhar, Wangdue-Punakha and Tsirang-Dagana are being taken up by the Department of Agriculture. Works have already been awarded to the contractors for

construction of mill house and installation. It is hoped that these mills and processing facilities will bring surplus rice into the market encouraging rice farmers.

5.2 HORTICULTURE

5.2.1 Mushroom Program

As per the decision in the 5th PCCM meeting, the National Mushroom Centre (NMC), Semtokha delegated mushroom cultivation activities in the districts to the respective RNR RDCs. This was done to provide better services to the farmers as NMC was not able to meet the service demand of farmers from all over the country owing to distance and also lack of adequate staff. Moreover, Oyster mushroom spawn has to be replenished almost every month and it was difficult to produce enough spawn from one centre to meet the demand of the whole nation.

Consequently, RNRRDC-Bajo was mandated to take up mushroom program for the western central region. One staff was nominated as the mushroom focal person and trained for duration of one month in NMC. RC started providing support to farmers for shiitake mushroom cultivation about a year back.

Table 48: Total number of billets inoculated

Sl.no	Dzongkhag	House hold	No. of billets
1.	Wangdue	5	2310
2.	Dagana	13	2356
3.	Tsirang	2	610
	Total		5276

However, shiitake mushroom requires high level of technical expertise like on spot identification of problems which is above the technical capacity of the focal person. Therefore, as an interim measure, RDC has decided to focus only on oyster mushroom program (both spawn production and cultivation) till centre develops the technical capacity and structures required for shiitake mushroom.

Figure 18: Mushroom billets inoculated

5.2.2 Shiitake mushroom billets in Tsirang

Owing to budget constraint in last financial year, we could not set up oyster mushroom incubation laboratory. However, the necessary equipments have now been arranged and the spawns for oyster mushroom is underway. We will be able to provide both the spawn and technical support for production of oyster mushroom in the coming season.

5.2.3 Temperate fruits top working campaign

The horticulture sector coordinated the top working of local temperate fruit crops and farmers training on grafting and top working techniques with the respective district/ geog counterparts in Wangdiphodrang, Punakha, Tsirang and Dagana districts. The program was carried out in February and March, 2013 with the fund support from the Fruits and Nuts sector, Horticulture Division, Department of Agriculture, Thimphu. The following were the objectives of the program.

1. To replace the local cultivars with the improved ones.
2. To create awareness to the farmers on the availability of improved released varieties.
3. To equip the farmers with grafting and top working skills.

The temperate fruit crop cultivars grown in these districts are mostly of low yielding and inferior qualities. The released varieties of Peach (Bajo kham-1, Bajo kham-2), Pear (Bajo Lee-1), Apricot (Bajo Khamchu-1), Persimmon (Fuyu, Jiro) and Walnut (Yusipang-2, Kanthal selection and Kazi) were top worked on the local varieties. A total of 285 peach, 352 pear 173 apricot 149 persimmon and 749 walnut trees were top worked in these district. The monitoring is being carried out by both the dzongkhag and research staff but success percentage has not been calculated due to

Figure 19: Successful graft union in Persimmon

lack of complete data. However, success percentage of at least 85% is expected from our observation during the follow up visits.

Ideally, it would be best to plan the orchard and start by planting the improved varieties after proper site identification and layout. However, top working also has many advantages. It is a method to improve the already existing stock which saves time as top worked trees can bear fruit after one year though it is recommended that it be lead to fruit only after two years to allow the scion to develop and establish. In Wangdiphodrang and Punakha, it is very difficult to establish big orchards as almost all the land are wetland and dry land are small with no irrigation facilities. So, improving on the already existing stock is one of the best options.

Top working not only helps in reaching the released cultivars to the fields but also boost local production of improved fruits which has higher market value. This will not only generate income to the farmers but will also supply essential vitamins and minerals necessary for a healthy body to our rural community.

Figure 20: Private walnut nurseries

We have also established three walnut private nurseries in the West Central Region: Nobugang (Punakha), Palukha (Wangdiphodrang) and Patshaling (Tsirang). About 7000 walnut seedlings are generated in total from these nurseries which are sold to National Seed Centre (NSC). The income generated from sale of seedlings ranges from Nu. 80,000.00 to 3 00,000.00 annually. In future, we have plans to establish more nurseries and demo orchards.

5.2.4 Commercial potato production in Taksha, Silli and Tsara

The three villages under Daga gewog in Wangdiphodrang districts namely Taksha, Silli, and Tsara are among the remotest villages in the country. It has been connected with farm road in 2011 but it still remains remote as these villages are relatively distant from urban centres and markets. The farmers there are comparatively poor and grow crops solely for self consumption. RDC Bajo initiated commercial potato production in these villages in order to improve the livelihood and to inculcate the culture of cash crops cultivation.

Three farmers groups comprising of one group from each village were formed. By-laws and working modalities (including appointment of office bearers and work plan) were drawn and the group's registration is currently under process. In total, there are 60 households from these villages and all are members of their respective village's group. RDC supplied about 8 MT of seed potato to these villages through the support of National Potato Program (NPP) based in Paro. It was to be cultivated in

the rice based system, wherein the potato has to be harvested before rice transplanting, as the villages have very less dry land. Though farmers were not new to potato cultivation, one day training and field demonstration was provided and the fields were monitored from time to time by the by the staffs from the centre.

Figure 21: Taksha Silli potato farmers group formation meeting

Figure 22: Potato fields in Taksha Silli

The centre provided training/demonstration on harvesting, grading, packing and storing of potato *during* the harvesting time. The packing materials were also provided and farmers were shown how to pack and stitch the bag. Though the initial plan was to auction the harvest in the Phuntsholing auction yard, it was not possible as the farm road got blocked. In total, about 50 MT of potato was harvested. Some quantity

was sold. The farmers are now showing interest in cash crops and in last season we have already grafted about 300 walnut rootstocks based on their request. The farmers have also have made demands for improved temperate fruits crops and asparagus in the coming season. We are also planning to construct one marketing shed in Wangdi-Tsirang Highway through the support of National Post Harvest Centre based in Paro.

5.2.5 Commercial vegetable production in Sha Ngawang and Bjaphu villages

Consequent to the Rupee crunch faced by the country, a number of initiatives were undertaken by the Government to minimize the Rupee shortage in the country. The Ministry of Agriculture was mandated to increase the domestic vegetable production in order to reduce the import of vegetables from India. In line to this, RDC-Bajo initiated commercial vegetable production program in Sha Ngawang and Bajphu villages in collaboration with the District Agriculture Sector in Wangdiphodrang. The other objective was to produce summer vegetables to be sold to Punatsangchu Hydroelectric Project (PHEP) which could absorb huge amount of local vegetable and MoU had already been signed between the PHEP authorities and the farmers group of Wangdiphodrang, Tsirang and Punakha districts. In Bjaphu village, all the 28 households were involved while in Sha Ngawang, one progressive farmer was chosen.

Figure 23: Vegetable fields in Bjaphu village

The program started from October, 2012. The seeds of vegetables like onion, potato, pea, cauliflowers, broccoli, brinjal, chilli, corriander, tomato, carrot and beans were provided to the farmers. The fields were monitored throughout the growing period jointly by the geog extension and the RDC. All the necessary technical support was provided as and when required. As farmers were cultivating onion for the first time, its cultivation practices starting from nursery raising till harvesting and curing was demonstrated to them.

Table 49: The details of the vegetable production from Sha Ngawang demo farm.

Sl. No.	Crop	Total yield (Kg)	Market price (Nu.)	Total income (Nu.)
1	Chilli	20	45	900
2	Tomato	260	37	9620
3	Brinjal	80	32	2560
4	Pea	50	40	2000
5	Bean	260	34	8840
6	Radish	300	27	8100
7	Dolo chilli	100	200	20000
Total		1070		52020

The produces were sold to PHEP, local markets and in Thimphu Centenary market. The farmers are now encouraged to grow vegetables in commercial scale. They could earn some cash income from undertaking commercial vegetable cultivation and also have gained good experience in growing and marketing the produce. The farmers are planning to increase their area of cultivation in the coming season and RDC will continue to provide technical support to the farmers.

Table 50: Total vegetable produced from Bjaphu village

Sl.No	Type of vegetables	Total Production (ton)	Rate (Nu/kg)
1.	Potato	6.5	8
2.	Green sag	20.6	10/bundle
3.	Onion	1.5	40
4.	Radish	7.00	15
5.	Beans	5.6	30
6.	Coriander	0.8	10/bundle
7.	Peas	0.50	60

5.2.6 Strengthening rural livelihood and resilience to climate change

Samtengang is one of the Chiwogs under Gesarling geog of Dagana Dzongkhag and it is located on the right bank of Daga Chu river. The altitude of the chewog ranges from 1200 – 1800 m asl. According to the finding of the consultative meeting with the farmers, there are 66 households with a population of 196 people living in this Chiwog. Of the

total households, 14 households are new resettlements. While the original inhabitants are living almost in hand to mouth condition, the new settlers are starting their lives from the scratches. This Chiwog is one of the most remote and far flung Chiwogs under Dagana Dzongkhag where not much development has taken place compared to other places.

Although agriculture is the main livelihood source of the farmers, due to remoteness of the Chiwog, the improved technologies have not been adopted by the farmers as the farmers have limited awareness of the available technologies. Also, there has been limited intervention in terms of disseminating farming technologies. The Chiwog has a total of 140 acres of wetland, 160 acres of dry land, 3 acres of kitchen garden and 2.80 acres of orchard. Main crops cultivated are paddy, maize, millet and buckwheat. Similarly major fruit crops grown are orange, banana, guava and sugarcane. Crop yields of both cereals and fruits are very low. This has left the farmers with never ending problems with regard to farming for sustaining their livelihoods. Farmers are facing food deficit period ranging from 4-6 months. The food insufficiency stems from low crop yields, less landholding and low income to buy food grains, less irrigation water and declining soil fertility. The low yields and income are due to subsistence nature of farming and the traditional practice of farming. Selling of few livestock products and off-farm activities are the only sources of cash income for the farmers.

Mamethang Chiwog under Dorona Geog in Dagana Dzongkhag comprise of three villages (Mamethang, Chukam and Lalidhapper). With the total population of 167 and 30 households, the people in Mamethang Chiwog are re-settlers from various Dzongkhags. These villages are located towards north of the Nimtola Geog centre and on the right side of Nimtola Chu. It falls within altitude range of 1480 to 1680 meters above mean sea level. It is one of the remotest Chiwogs under Dagana Dzongkhag. The community has total landholdings of 150 acres and great majority are on gentle slope fringed by the natural forest. This Chiwog is one of the remotest villages under Dagana Dzongkhag whereby many development activities are sidelined from reaching this community.

The farming practices are still subsistence and natural although the community is bestowed with ideal agro-climatic condition with fertile soil. At present, the only cash crop that the community grows is *Dorley Khorsaney* (round chilly). The cardamom cultivation was discontinued for almost a decade back due to viral disease outbreak nevertheless it is now

grown in backyard farm. Cereal crops such as paddy, maize, wheat, buckwheat, barley and millet are grown in minute quantities for self consumption while few fruits exist at backyard farm.

A large number of people are stricken with poverty with the per capita income below Nu 1100 per month as per the survey conducted by a technical team from RDC Bajo. All the farmers are re-settlers from different Dzongkhags with different ethnicity and culture. Of late, the community is connected with a farm-road. The prevailing conducive agro-climatic condition in the *Chiwog* for crop production and the remote location offer high potential for natural or organic farming. The objectives of the program are as follows:

- Conservation of Cardamom land races
- Strengthen rural livelihood and resilience to climate change
- Reduce human wild life conflict

Activities implemented

Farmers Capacity Development

- Group formation and development of bylaws

Enhancing Community resilience to Climate Change

- Plantation of 2000 high value timber trees and 700 fruits and nuts (native to the location)
- Plantation of cardamom on fallow land (land left fallow due to less water and erratic rainfall)

Project Management and Publicity

- Project review and planning
- Project Management
- Installation of signage

Supply of seeds and seedlings to the community

- Supplied 1400kg of seed potatoes, 705 kg of maize seed and 7 assorted vegetable seeds (30packets each/variety) were distributed to three communities in project site.
- Land preparation, layout and pit digging for plantation of Cardamom, assorted fruits plants and high value timber species were carried out

Rain water harvesting and rehabilitation of irrigation channel

- Supplied 230 bags of cement(50kg) to three local based community organization for rain water harvesting and rehabilitation of irrigation channel
- Supplied 67 numbers HDPE pipes(160mm x 4PN) to three local based community organization for rain water harvesting and rehabilitation of irrigation channel
- Supplied 57 numbers HDPE pipes socket (160mm x 4PN) to three local based community organization for rain water harvesting and rehabilitation of irrigation channel
- Supplied 1 number of GI pipes(160mm x 6PN) to three local based community organization for rain water harvesting and rehabilitation of irrigation channel
- Supplied 3 rolls of HDPE pipes(63mm x 4PN) to two local based community organization for rain water harvesting and rehabilitation of irrigation channel.

5.3 FARMING SYSTEM

5.3.1 Soil

An assessment of inputs use in potato production in Phobjikha and Gangtey

In Wangduephodrang, Phobjikha and Gangtey are major potato producing areas. Because of the crop's high productivity, wide adaptation, and commercial value, it has provided tremendous income for the farmers. However, potato production in these areas did not come without a cost. Farmers are believed to apply higher rates of inputs on potato while yields are reported to be on the decline. This study was therefore an attempt to make an assessment of input use in potato production. A household survey was conducted with 153 households. Descriptive statistics were applied to analyze the data. The application dosage of metribuzin range between 2 – 3gm/litre water,glyphosate between 3.2 – 3.8 ml/litre water and mancozeb between 4 – 6gm/litre water. According to NPPC, the recommended application dosage of metribuzin is 1 gm/litre water, glyphosate is 2.5 ml/litre water and mancozeb is 2 gm/litre water. Similarly commonly use inorganic fertilizers include Suphala, Urea and SSP. Of the total respondents,15% practiced balanced fertilization, 30% applied Suphala and SSP, and 24% applied Suphala only. The average application rate

practiced by majority is 95:70:45 NPK kg/Ac while the recommended rate is 40:32:32 NPK kg/Ac. Irrespective of inputs, application rates exceeded the recommended rates. It is not known whether it is the awareness aspects and related factors, especially the knowledge regarding inputs and their associated benefits and risk, or lack of awareness about the recommended rates that led farmers to using higher rates.

Sustainable land management at Loduma

The on-going sustainable land management program at Loduma was further supported with fruit plant seedlings, vegetable seeds, other material support such as plastic for winter vegetable cultivation. By the end of the financial year 2012, of the total dry land 65.15 acres, 54.15 acres were brought under various land management measures. Fruit seedlings include 600 mangos, 220 Litchi, 135 Guava, and 270 Banana. In addition, 200 kgs of maize seeds and Nu.10000 worth vegetable seeds were also provided to the farmers. About 90% of the fruit plants planted last year have survived. While few households have excess vegetable production to sell, most of them produce enough for their home consumption.

Soil erosion measuring plot

Land degradation through soil erosion is one of the major environmental issues in the country, however, the nation as a whole lack reliable hardcore data to support the visual observations. To respond to this concern, a soil erosion measuring plot was established at sub-centre Tsirang with the financial support from SLM project. The objective of activity is to establish soil erosion database for the region and ultimately contribute for the national soil loss database. The plots will be further modified through incorporation of different treatments. Soil loss data collection will start from the coming rainy season.

Support to Co-Sectors at the research out-reach program sites

In addition to execution of the planned activities, the sector has supported horticulture sector in farmer group formation for potato production and marketing at Taksha Silli and in drafting of the group by-laws. As part of the citrus ordinance program at Drujeygang geog, the sector has started implementation of sustainable land management measures in the citrus orchards through improving basin making and balance soil nutrient application.

Green manure seed production and maintenance

Production and maintenance of the seeds of Dhaincha *(S. aculeata*) is an on-going activity. The main objective of this activity is to maintain the seeds of dhaincha and produce seeds for on-farm use. In 2012-13, the sector has produced a total of 1300 kilograms of Dhaincha seeds and supplied to Dagana, Tsirang, Tsirang Sub-Centre and in the Royal Project Chimipang. The activity will be continued to meet the seed requirements of the client Dzongkhags for trial purpose.

Capacity Development

The sector has trained about 150 farmers in Chubu and Barp geog on soil fertility management for rice production, around 120 farmers in Drujeygang geog on soil fertility management in citrus orchard and about 60 farmers in Khotakha on soil fertility management for potato production.

Adjunct Lecturer in CNR

Research officer also served as adjunct lecturer in College of Natural Resources, Lobesa. Sustainable Land Management with six credit course was taught to degree students which required 5 lecturing hours per week. In addition to theoretical concepts through lecturing on sustainable land management, the lecturer had the opportunity to share practical experience on the implementation of some of the land management technologies.

Publications

During the year, the sector has been able to come up with four publications. The findings of the study done for assessment of the adoption of inorganic fertilizer recommended rate in rice: a case study from Punakha and Wangdue Dzongkhag was published as the center's technical series. The other article on the economics of mechanizing traditional method of rice cultivation was published in the RNR Journal Volume 8, Number 1, 2012. In addition, the sector has submitted two articles, one on the inputs assessment of potato production in Phobjikha and Gangtey and the other on the effect of different herbicides on

Shochum (*Potamogeton distinctus*) in paddy to the RNR Journal for the next publication.

5.3.2 IPM

Farmers training

In order to enhance their capacity, farmers training on IPM were conducted at Chubu and Baap geog under Punakha dzongkhag through the fund support from the ABSD project during the month of September and October, 2012. The training on IPM was imparted on major pests/diseases of major crops like rice, wheat and mustard to the selected farmers. Besides, the training on IPM was also conducted to Drujegang Citrus Group as a support to citrus ordinance program during the last week of May, 2013. The training was imparted to the selected farmers of Drujegang, Thangna, Pangna and Pangserpo village under Drujegang geog, Dagana dzongkhag. The training emphasized and highlighted on the control measures of major citrus pests/diseases like citrus trunk borer, citrus fruit fly, citrus shield bug, psyllid vector, citrus Huang Long Bing (HLB) and citrus powdery mildew.

Wheat rust survey

The wheat rust survey was conducted during the month of April and May, 2013 along with the NPPC team and CIMMYT scientists. The main objective of the survey was to identify the probable alternate host plant of the wheat rust fungus. The survey was conducted two times with two different groups of team in April and May, 2013. The survey with the first group was conducted during the last week of April and the places visited included Toewang, Guma and Omtekha area under Punakha dzongkhag and Kazhi and Bae Langdra area under Wangdue dzongkhag. The first group of the team was headed by Dr. Thinley of the NPPC. The team visited the various wheat and barley field and observed for the presence of the rust diseases in the field. Besides, the team also observed for the presence of rust acial spore in *Berberies spp.* in the nearby or surrounding area of the wheat field which is said to be the most probable alternate host plant of the wheat rust diseases. The samples of the rust acial spore found in *Berberis spp.* were collected and taken by the team for further research purposes. The survey with the second group was conducted during the 2nd week of May, 2013 and the places visited included Thangu, Omtekha, Toewang and Zomi under Punakha dzongkhag and Bae Langdra and

Kazhi area under Wangdue dzongkhag. The similar type of survey was carried out during the second time also as conducted by the earlier group. The most of the places visited during the second time also included the same place as visited earlier except few places like Thangu and Guma which was not a repeat. As in the earlier survey, the team visited the various wheat fields and observed for the presence of wheat rust diseases and acial spore in *Berberies spp.* plant in the field. The samples from both the wheat field and *Berberies* plant were collected and taken by the team for further studies. The *Berberies* plant from where the samples were collected were tagged and labeled during the second survey.

Technical training/meeting/workshops

As part of the capacity building program, several training or workshops were attended: one day training on wheat rust surveillance in Thimphu in October, 2012; 7 days training on e-governance at Bajo Higher Secondary School in November 2012; workshop on contingency planning for management of wheat rust diseases for 2 days at Kathmandu in Nepal in mid December 2012. The rust workshop venue was attended by participants from Turkey, Pakistan, Bhutan, Nepal, Bangladesh and India. There were 3 participants from Bhutan and country wise presentations on wheat were made on the first day and action plan for combating the disease was presented during the second day of the workshop.

Field visit on pests/diseases problem

Field visits were made to attend the pests/diseases problem at various geogs based on the request from the dzongkhags and co-sector. Since there was an outbreak of armyworm during the month of May, 2013, field visit to various places were made to identify the problem and advise the farmers on the control measures. Field visit to Taksha, Shilly and Sara village on potato tuber moth was made along with staff of the horticulture sector in April 2013. Similar field visits were also made to Dangchu geog along with the EA on drying up of paddy nursery and armyworm outbreak problem in rice nursery in May 2013. A field visit was also made on rice seedling damping off, potato blight and armyworm problem in rice nursery at Japhu village under Rupeisa geog, Wangduephodrang. Farmers were advised on both short term and long term recommended control measures of the pests/diseases. Insecticides were also supplied to control armyworm in rice nursery in the area. Field visit was made to determine drastic citrus yield decline in Khebisa geog in Dagana which is said to be

affected by the Dagachu Hydro Power Corporation (DHPC) construction activities. The citrus orchard was visited along with the staff of the horticulture sector, staff from the DHPC, EA and Geog Administration Officer (GAO) during the end of May 2013. The possible causes of pests/diseases were ruled out in the orchard at the time of field visit and the overall tree health was found to be in very good condition like any other orchard in the region. However, the orchard owner was advised on the recommended control measures of major citrus pest/diseases.

Weedicide demonstration at Chimipang

As a development and support program to Chimipang, the herbicide Sunrice was applied in an area of 2 acres in transplanted rice to control the noxious weed Shochum during the 1st week of June, 2013. The early post emergence herbicide was applied 10 days after transplanting. In order to have a better evaluation on weedicide efficacy, rice with same variety (IR 64) was selected for the weedicide demonstration purpose.

5.3.3 Agriculture Economics and Organic Outreach Program

Gasa Organic Outreach Program

Bhutanese agriculture is often referred to as traditional which is experiencing a gradual transition to semi-commercial operations. With 69% of the population engaged in farming, the Royal Government of Bhutan (RGoB) has accorded high priority for the development of agriculture sector. In the past, emphasis has been laid on the provision of modern varieties and requisite inputs for higher production in line with green revolution elsewhere. However, with the current global movement for clean environment and natural products, Bhutan with a very low usage of chemical inputs could easily become a pioneer in organic farming.

In realization to the aspiration of Bhutan as a country with environmentally clean food production systems and products as inscribed in Bhutan 2020, Gasa was the first dzongkhag to be declared as organic in 2004. Although Gasa was considered as remote in the past, with the access road now it has potential and opportunity in marketing organic produces. The National Organic Program (NOP) under MoAF has provided substantial support for both extension staff and farmers in terms of inputs, capacity building and infrastructures related to organic program. However, the adoption rate of technology is still low.

Therefore, deliberation was made regarding Gasa organic program during the Agriculture Review and Planning meeting at RNR-RDC Bajo in January, 2012. The meeting adopted Gasa dzongkhag as a 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. Relevant stakeholders and partners were identified as NOP, DoA, NPHC, DAMC and Dzongkhag Agriculture extension with the mission to enhance income and livelihood of farmers. The following activities were initiated during the fiscal year 2012-2013.

Commercial vegetable production and marketing program

Based on the farmers' feedback, there has been crop diversification and it has solved problem of winter vegetable scarcity after the inception of organic program. Farmers reported that although they have difficulties in finding market for vegetables, there is an increase in vegetable production and self-sufficiency at household level. Gasa has advantage of growing summer vegetables when it is off season for Indian vegetables and there is a good market price. Being near to the capital city, the outreach program can focus on production of commercial organic vegetables which will fetch good price. The vegetable program was initiated with the objective to enhance income of the rural people through adoption of cash crop and commercial vegetable production.

RDC Bajo in collaboration with NOP and Dzongkhag Agriculture sector of Gasa initiated semi-commercial vegetable production program at Khatoe and Khamae geogs in May 2012. In the beginning a consultation meeting was held to plan joint activities among the stakeholders. More than 20 acres of land of 53 households was proposed for commercial vegetable production for summer and winter. Potential markets include local market in the area, Centenary Farmers Market in Thimphu, weekend market in Punakha and Wangdue and the Punatshangchu Hydropower project.

To start with, farmers were trained on the basics of vegetable production in both the geogs by the dzongkhag extension. 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 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 to improve the 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 of having crop damage by pests, the major pest being cutworm. Hand picking was practiced in addition to using cow urine solution at the ratio of 1:10. Other pests like hopper and caterpillar also damaged nurseries. Bio-pesticides like neem oil, last straw and Jeevatu were provided by NOP. Liquid manure and Jeevatu solution are made available at farms for pest/disease control.

Figure 24: Vegetable production in Gasa

With the flash flood at Gasa in 2013 which was triggered by a week-long incessant rainfall washed away two bridges between Punakha and Damji and damaged the road at several places isolating Gasa from other dzongkhags for about five months. The flood damaged the road badly and it remained blocked for eight months which affected farmers in marketing of their produce. However, farmers produced cole crops, radish, beans, chili, leafy greens, garlic and potato abundantly and were able to meet the local vegetable demand of 1.62 MT per week for more than 900 people at Gasa and Damji, comprising of government servants, shopkeepers, labourers, armed force personnel, monk and students. Farmers sell their vegetables at doorsteps of residences, school mess, dratshang and shops.

Few farmers even request the shopkeepers to keep their produce for sale in the shop. Although large portion of the vegetable can be absorbed in school mess and dratshang, farmers are hesitant to sell due to low rate quoted by these institutes. Farmers expect a higher price for their produce being organic but only few vegetables like cauliflower, chili, cucumber, carrot, leafy greens and broccoli fetch a good price. In contrary, cabbage, radish and beans fetch less.

Mustard Production Program

Mustard is a major winter oilseed crop of Bhutan. The area and production of mustard in the country has been declining over the years and oil demand in the country is met through import from India. Bhutan has the potential of achieving self sufficiency in oil crops without displacing other crops. The present high prices in Bhutan and favourable climatic condition makes Gasa suitable for oilseed production. As mustard releases biotoxic compounds or metabolic byproducts that exhibit broad activity against bacteria, fungi, insects, nematodes and weeds, it is least preferred by pests and it can be grown organically. Therefore, mustard production program was initiated to evaluate if mustard production is feasible at Khamae geog of Gasa.

The mustard production program was implemented at Yemina, Paniko, Khailo and Damji. In total 65 households were involved in mustard production, covering 30 acres of wetland during the first year. A total of 132 kg of mustard seed was sourced locally from Khailo village and distributed to farmers. These farmers were advised to keep their own seed further. Seeds were sown in the first and second week of November, 2013. Constant monitoring for pest and disease attack was carried out.

The crop performed well at Yemina, Khailo and Paniko whereas there was no harvest from Damji area since the crop was damaged by heavy frost as it lies at higher altitude compared to other sites. The crop matured after three months time and crop cuts were taken from three villages from 6 m^2 area. Table 50 presents the result of cropcut of mustard conducted in three different sites.

Table 51: Mustard crop-cut result

Sl.No	Village	Crop-cut area	Crop-cut yield (kg)			Average yield per plot	Yield (kg/ac)
			Sample I	Sample II	Sample III		
1	Khailo	6 m^2	1.50	1.70	1.40	1.53	1034.23
2	Yemina	6 m^2	1.40	1.20	1.30	1.30	876.85
3	Paniko	6 m^2	1.50	1.30	1.40	1.40	944.30
				Average		1.41	951.79

The average yield from 6 m^2 is computed at 1.41 kg (±0.12). The average yield computed for an acre is 951.79/kg (±78.96) per acre which is higher than the national average yield. The national average yield of mustard recorded is 756 kg per acre (MoAF, 2013).

Although the yield is good, farmers reported that the crop did not perform that well as it used to due to drought period at the time of vegetative growth. Pest and disease attack were not observed much while monitoring although there was negligible aphid damage. RDC, Bajo will continue the

Figure 25: Mustard at Farmers' field

program and there is a plan tom set up one oil expeller machine with the financial support from NOP. By-laws will be developed for the oil expeller user group by RDC Bajo. In the coming season the area of mustard production will be increased as per the planned program. RDC Bajo will also facilitate marketing of organic mustard oil.

Organic Pear Production Program

Pear Production and Marketing has been taken as one of the major activities of Organic Outreach Program with the objective to enhance income through fruit production. Interested farmers for pear plantation were listed during the consultative meeting held in February 2012. Technical staff from RDC Bajo carried out orchard layout during October 2012 for 32 households with the help of extension staff. Mostly square and diagonal design was used in layout depending on land topography. Pit digging and pit filling were demonstrated to the farmers.

Pear saplings were sourced and funded by Horticulture Division, Thimphu. The saplings were collected from NSC Paro during February end and distributed to the farmers who had done pit digging and filling. Demonstrations on planting (keeping the grafted portion above the soil and planting the sapling a little raised from the surface) were carried out. Farmers were advised to water the plants for at least for two weeks if there was no rainfall. There are 32 farmers with pear plantation covering 5 acres of land with 500 saplings.

Regular orchard visit and monitoring is carried out by the extension and research staff. Farmers were asked to protect the orchard from stray animal and wild animal attack and to report if any problem arises with the orchard. The plants came up well at Khamae geog compared to Khatoe geog. It would be because of higher altitude for Asian pear. The survival rate is 85% as of June, 2013.

There will be continuous technical support from RDC, Bajo. The centre will seek financial assistance from other agencies and will facilitate in procurement of pear sapling in future till the communities have good orchard developed.

Asparagus production program

During the financial year 2012-13, about 2 acres of land has been planted with 20000 asparagus seedlings provided by NOP and with technical guidance from RDC Bajo. The main objective of this program is to generate rural household income through low volume high value crop production. Timely field monitoring, data recording and crop cuts will be carried out in collaboration with dzongkhag extension.

Potato production and marketing

As the farmers have adopted potato cultivation at larger scale, the centre facilitated potato production and marketing to enhance farmers income. Field monitoring were carried out for pest and diseases attack. Pest attack was observed but not to the economical threshold level. Potato blight attack was very negligible. The centre facilitated in marketing 14 MT of seed potato which was supplied within the region as seed potato.

Garlic Production and Marketing

Garlic production and marketing program has been taken with the objective of crop diversification and to enhance rural income. To start the program seed was purchased locally from Khailo and Damji and distributed to 22 farmers of Khamae and Khatoe geog during September 2012. Farmers having their own seeds were encouraged to cultivate for marketing. In total about 2.5 acres of land was planted with garlic seeds.

Raised beds were prepared by the farmers for garlic plantation. Timely

Figure 26: Organic garlic production at Gasa

monitoring and data collection was carried out by the extension and research team. In few cases cutworm problem was observed in some of the field. The crop performed well with average yield computed at 1754.76 kg/acre. RDC, Bajo in colabaration with Horticulture Division facilitated in marketing 1150 kg of garlic as seed to Tsirang and Dagana dzongkhags. Farmers were able to sell about 700 kg locally and at Punakha weekend market the balance quantity was kept for home consumption and as seed for next season.

5.4 ENGINEERING SECTOR

5.4.1 Construction of Range Office at Punakha

The Engineering Sector (ES) of RDC Bajo provided site supervision services for the construction of Forest Management Unit Range Office at Guma Geog, Punakha. The work was awarded to M/s Rada Construction at cost of Nu.3.00 million. The work was started (07 March 2012) and completed (06 November 2012) as per the schedule. The construction of approach road which was not initially included in the tender document was awarded to the same contractor as additional work.

5.4.2 Construction of Nobding Range Office

The unit provided site supervision services for the construction of Range Office at Nobding for Forest Management Unit under Dangchu Geog, Wangdue. The work was implemented by M/s Dorji Wangmo Construction at cost of Nu 3.00 million. The work was started (06 March 2012) and completed (05 November 2012) as per the schedule. The construction of approach road which was not initially included in the tender document was awarded to the same contractor as an additional work. The final value of the work done was Nu.3.00 million.

5.4.3 Construction of Zero Energy Cold Storage

The unit provided site supervision for the construction of Zero Energy Cold Storage at Dagapela under Dagana Dzongkhag. The work was awarded to M/s Lhanam Construction for implementation by the National Post Harvest Center at Paro at a cost of Nu 2.877 million. The implementation was started on 10 February 2012 and was completed by 10 March 2013 at a cost of Nu 2.887 million. Although the work was completed, rectification work is currently under progress. The cold store has a net storage capacity of 22 tons.

5.4.4 Construction of storm water drainage system at RDC Bajo

The sector implemented the second phase of the storm water drainage system construction work on the lower part of RDC Bajo research farm. The first phase was completed in the previous year. The phasing of the work was done as the budget was limited. Further to minimize the cost,

this work was executed departmentally at a cost of Nu.0.15 million. The work was started on 13 Jan 2013 and was completed by 30 May 2013. The work included preparation of drawings and estimate, mobilization of materials and labour, site supervision, and verification of the payments.

5.4.5 Construction of vegetable shed in RSC Bajo

The construction of vegetable shed at Regional Seed Centre at Bajo was an adhoc activity. This activity was part of the ministry's initiative to enhance vegetable production in the valley. This activity was implemented departmentally as quantity of work was small and required to be completed in a short span of time. The engineering service included preparation of drawings and estimate, mobilization of labour and materials, site supervision, passing of bills and payments. The work completed on 30 May 2013 at a cost of Nu.0.17 million.

5.4.6 Construction of GI Chain-link fencing at RSC Bajo

The engineering services were provided to RSC Bajo for the construction of GI Chain-link fencing work. The work was part of the planned activity of the sector. The work was awarded to M/s Delma Construction by RNR Engineering Division, Thimphu at cost of Nu 1.622 million. The services provided by the RDC Bajo Engineering Sector included preparation of drawings, estimate and Bill of Quantity (BoQ), site supervision, verification and passing of bills. The final value of work done was Nu.2.4 million. The work started on 19 March 2013 and completed on 30 May 2013 on schedule.

5.4.7 Construction of GI Chain-link fencing at RAMC Bajo

The engineering services were provided to Regional Agricultural Machinery Centre (RAMC) Bajo for the construction of GI Chain-link fencing work. The work was part of the planned activity of the sector. The services provided by RDC Bajo Engineering Sector included surveying, preparation of drawings, estimate and Bill of Quantity (BoQ), tendering, site supervision, verification and passing of bills. The work was awarded to M/s Rigsen Construction through open tendering process at contract price of Nu.0.300 million. The final value of work done was Nu.0.300 million. The work was started (13 April 2013) and completed (30 May 2013) on schedule.

5.4.8 Construction of ESP Residence at Chimmipang Farm

The Engineering Sector was entrusted in the design, preparation of drawings and estimate for the construction of ESP Residences at Chimmipang Farm. The process of design, preparation of drawings and estimate went through several cyclic stages which consumed substantial amount of time for the sector before it was finally accepted. This was merely due to the lack of clear statement of design parameters at the early stages. The design parameters finally applied were (a) cheap- limited budget, (b) temporary as master plan for infrastructure is not ready, (c) aesthetically blending with the environment- culturally sensitive area as the site is near to Chimmi Lhakhang, and (d) comfortable, and (e) spacious enough of small family. The outcome of the design was single story double unit block, with PCC floor, bamboo mat wall with half ply linings inside on wooden frames, CIG roofing overlaid by bamboo mat on timber frames, standard electrical fittings without any plumbing works. Each unit has plinth area of 33.075 sqm comprising of single bed room, a sitting room, and a kitchen. The cost of each block was estimated at Nu.436,846 per block (218,423 per unit). To maximize the utility of the budget allocated (Nu 2.6m), the work was implemented departmentally which enabled to construct about 6 blocks (12 Units).

5.4.9 Construction of Park Head Office at Chokhortoe

The engineering services were provided for construction of Park Head Office at Chokhortoe under Bumthang Dzongkhag. Except for the design and drawing which was done by the consultant, all other services like preparation of estimate, BoQ, tender document, tendering, site supervision, measurement and passing of the bills were done by Engineering Sector. The work was awarded to M/s National Builder, Bumthang by Wangchuk Centennial Park Office, Dekiling at a contract price of Nu.7.74025 million. The work was started on 22 April 2011 and due to be completed by 22 April 2012. Currently the work is under liquidity period and about 90% of the work is completed at the time of preparing this report.

5.4.10 Construction of Park Manager Residence at Chokhortoe

The engineering services for the construction of Park Manager Residence at Chokhortoe for Wangchuk Centennial Park were provided by RDC Bajo. The services included preparation of estimate, BoQ, tendering, and site supervision, verification and passing of bills. The work was awarded

to M/s Dorji Construction, Bumthang by at a contract price of Nu.2.736 million. The work was started on 05 July 2012 and was completed only on 21 April 2013 against scheduled completion date of 21 January 2013. The final value of the work done was Nu.2.736 million.

5.4.11 Construction of External Water Supply at Park Head Office at Chokhortoe

Engineering services for the construction of external water supply at park head office at Chokhortoe was also provided by RDC Bajo Enginneing Sector. The entire process starting from surveying till passing of the bill were done by the Sector. The work was awarded to M/s Banga Construction, Bumthang by at a contract price of Nu.1.831 million. The work was started on 28 August 2012 and complete on 28 February 2013 as per the scheduled. The final value of the work done is Nu.1.831 million.

5.4.12 Infrastructure development for Eco-tourism Camp at Tang

Engineering services for the construction of external water supply at park head office at Chokhortoe was also provided by RDC Bajo Engineering Sector. The work was awarded to M/s Banga Construction, Bumthang by at a contract price of Nu.1.514 million. The work started on 29 August 2013 and was completed on scheduled completion date on 01 March 2013. The final value of the work done is Nu.1.514 million. The complete process starting from surveying till the passing of the bills were done by the Sector.

5.4.13 Construction of Double-Unit Staff Quarter at Sephu

The engineering services for the construction of double-unit staff quarter at Sephu for Wangchuk Centennial Park was being provided by RDC Bajo. The service includes site survey, preparation of drawings, estimate and BoQ, tendering, supervision, verification and passing of bills. The work was awarded to M/s Wandicholing Construction, Bumthang by at a contract price of Nu.2.755 million. The work was started on 28 August 2012 and was scheduled to be completed by 28 March 2013. The completion date was extended till 30 June 2013 as only 50% of the work was completed by the end scheduled completion period. By the end of the extended period only 60% of the work was completed, hence the work currently under liquidity period.

5.4.14 Construction of Shower House at Busa Community School, Sephu

RDC Bajo Engineering Sector was involved in the construction of shower house for Busa Community School at Sephu. The sector was engaged in the construction starting from surveying till the passing of the final bills. The work was implemented through a ***Community Contract model*** at a contract price of Nu.0.391 million. The work was started on 01 August 2012 and completed on 01 December 2013 as per the schedule. The final value of the work done is Nu.0.391 million.

5.4.15 Construction of Garbage house at Sephu and Dhur

RDC Bajo Engineering Sector also constructed Garbage House at Sephu and Dhur which was as part of the Wangchuk Centennial Park activities. The sector was provided the engineering services starting from surveying till the passing of the final bill. The work was implemented through a ***Community Contract model*** at a contract price of Nu.0.296 million. The work was started on 01 August 2012 and completed on 01 December 2013 as per the schedule. The final value of the work done is Nu.0.296 million.

5.4.16 Maintenance of approach road at WPRO, Sephu

The entire engineering services were provided by RDC Bajo Engineering Sector for the maintenance of approach road at WRPO, Sephu. The work was implemented through the community contract model at a contract price of Nu.0.206 million. The work was started on 01 March 2013 and was completed on schedule date of 20 June 2013. The final value of the work done was Nu.0.206 million.

5.4.17 Construction of Beat Office, Check Post and 3 Unit Staff Quarter at Kurkubithang

The site supervision for the construction of Beat Office, Check Post, and 3-Unit Staff Quarter at Kurkubithang was provided by the sector. The Division Forest Office at Dekiling in Bumthang awarded the work to M/s Legsho Construction at a contract price of Nu.2.752 million. The contract period which spanned from 01 March 2013 till 01 December 2013 had to be extended till 25 July 2013 as the work could not be completed on time. The final value of the work done was Nu.4.971 million.

5.4.18 Construction of BAFRA Office cum Residence at Bumthang

The sector also provided site supervision services for the construction of BAFRA Office cum Residence at Bumthang. The BAFRA agency at Bumthang awarded the work to M/s UP Construction at a contract price of Nu.5.738 million. The contract period for this construction started from 13 March 2013 and scheduled to be completed by 13 December 2013. At present 30% of the work is completed.

5.4.19 Construction of Program Director Residence at Khangma

The engineering sector at RDC Bajo had provided the entire engineering services for the construction of Program Director Residence at Regional Livestock Development Centre at Khangma in Trashigang. The RLDC Khangma had awarded the work to M/s Namsel Construction at a contract price of Nu.6.793 million. The scheduled contract period spanned from 27 July 2012 till 27 May 2013 had to be extended till 30 September 2013 as the work remains incomplete. About 60% of the work was completed at the time of this reporting.

5.4.20 Major Renovation of RLDC Office at Khangma

The engineering sector also provided the entire engineering services for major renovation of RLDC Office at Khangma. This work was awarded to M/s Yu-druk Construction at a contract price of Nu.1.101 million. The work was completed within the scheduled contract period which spanned between 25 July 2012 and 25 February 2013 at a cost of Nu.1.386 million.

5.4.21 Major Renovation and Extension of Staff Quarter for RLDC at Khangma

The engineering sector is providing the entire engineering services for major renovation and extension of staff quarter for RLDC Khangma. This work was awarded to M/s Tshongdrup Construction at a contract price of Nu.2.332 million. The scheduled project duration which started from 25 July 2012 and ended on 31 December 2012 was extended till 30 June 2013. At the time of reporting 80% of the work was completed. The work has entered into liquidity damage period.

5.4.22 Site Development Work for Citrus Repository Block at RDSC Tsirang

The engineering sector provided the entire engineering services for site development work for Citrus Repository Block at RDSC Tsirang. This work was awarded to M/s TY Construction at a contract price of Nu.1.881 million. The construction was started on 19 November 2012 as scheduled, however the completion was extended till 10 March 2013 against scheduled date on 27 January 2013. The final value of the work done was Nu.1.881 million.

5.4.23 Citrus Repository Block Maintenance Work

The engineering sector provided the entire engineering services maintenance of Citrus Repository Block at RDSC Tsirang. The works included painting of screen houses and construction of tank stand amounting to Nu.0.151 million. The work was implemented departmentally and was completed by 30 June 2013.

5.4.24 Supply of steel rack for the Citrus Repository Block at RDSC Tsirang

The engineering sector provided the entire engineering services for supply of steel rack for Citrus Repository Block at RDSC Tsirang. The fabrication of steel rack was awarded to M/s Bhutan Hardware, Phuntsholing at a cost of Nu.0.300 million through open quotation. The supply was completed by 30 June 2013.

5.4.25 Renovation of Irrigation channel at Dorona

The engineering sector provided the entire engineering services for renovation of irrigation channel at Dorana village under Geserling Geog in Dagan Dzongkhag. The work was implemented departmentally based on the National Irrigation Policy-1992 model. The materials which are not available locally and transportation up the nearest road head point amounting to Nu.0.90 million was provided the project while the local material and labour for the renovation work was provided by the beneficiary farmers.

5.4.26 Vegetable farm development in Kumchi, Phangyul Geog

The engineering sector supported for vegetable farm development in Kumchi village in Phangyul Geog, Wangdue Dzongkhag. RDC Bajo provided materials and machine for land development and construction of water management structures amounting to Nu.0.24 million. The beneficiary farmers provided the labour and local materials.

5.4.27 Construction of Irrigation Water Storage Lake at Gyemsa

The sector was engaged in the construction of irrigation water storage pond in Gyemsa Village, under Toep Geog in Punakha. The topographical survey of the lake site was done with the help of expertise from the RNR Engineering Division. The design, drawings, estimates and BoQ was prepared by the Engineering Sector of RDC Bajo. The tendering of the work was done by the RNR Engineering Division, while site supervision and passing of the bills were done by the engineering sector at Bajo. The work was awarded to M/s Kinley Chimmi Construction at a contract price of Nu.4.464 million. The work was completed on scheduled time frame. The final value of the work done was Nu.5.049 million. The increase in the final amount was attributed to the additional work with respect to change in the location of pipe inlet structure for irrigation channel by-pass pipeline, earth embankment on the lower ridge of the lake, and minor variations in other items.

5.4.28 Lift Irrigation Proposal for Lobesa Rice Commercialization and Chimmipang Farm

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.

5.4.29 Construction of Soil Erosion Plot at RDSC Tsirang

The engineering sector supported the construction of soil erosion plot at RDSC Tsirang. The support was in the form of producing drawings, preparation of estimate and providing site supervision. The work was implemented departmentally. The cost was estimated at Nu.0.174 million however the work was completed at an additional cost of Nu.12,000. This escalation in the cost was owing to high cost of sand and boulder in Tsirang.

5.4.30 Farm infrastructure improvement at RSC Farm in Phobjikha

The engineering sector prepared proposal for major farm infrastructure improvement proposal for RSC Farm in Phobjika. 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 the decision, drawings and estimates were prepared for various types of activities 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.

5.4.31 Proposal for GI Chain-link fencing for Nangsiphel Farm at Bumthang

The engineering sector also prepared drawing and estimate for GI chain-link fencing for Nangsiphel Farm at Bumthang. The cost for implementing this activity is estimated Nu.2.175 million.

6 Annexes

6.1 Visitors to the centre

Date	Name of the visitor	Address	Purpose of Visitor
30 Aug 2012	13 member ICIMOD Delegates	Kathmandu, Nepal	Field Visit
28 Aug 2012	Director General & Officials of MoAF	Thimphu	Demonstration & Hands on training program on vegetable production.
06 Sep 2013	Team of ACIAR Staff	Australian Centre for International Agriculture Research.	A team of ACIAR staff Australia in relation to citrus project visited RDC-Bajo.
	LES BAXTER (Principal Regional coordinator, PNG & Pacific Islands Research program Manager, Horticulture.)		
	Graeme Sanderson (Research Horticulturist Agriculture Research & Advisory Station)	Slver city Highway Dareton NSW 2717 Australia.	
	Sandra Hardy (Industry Leader citrus Industry Development Agriculture & Forestry)	Gosford Primary Industries Institute Locked Bag 26	
07 Sep 2012	Hasegawa Masayuki (Volunteer Coordinator)	Japan International Cooperation Agency (JICA) Bhutan Office, Thimphu.	Site visit to the centre from JICA.
	Tshering Palden, Program Officer (Volunteer & Training Program)		
20 Sep 2012	Six member delegates from DoA Thailand.	DoA, Ministry of Agriculture Cooperatives, Royal Government of Thailand	To discuss on Agriculture Cooperation between the two Agriculture Organizations
4 Oct 2012	Three member delegates from Nepal.	Building Cooperation for Promoting Practical Technologies in Climate Sensitive Farming Practices. (Nepal)	To observe water related issues.
8 Oct 2012	Seven member team from Sikkim	Sikkim (Citrus Group)	To see the cut come of exchange programme towards improving Citrus

			production in Bhutan & Sikkim.
7 Nov 2012	IFAD Mission Team & Project Coordinator (MAGIP)	MAGIP (Project)	Field Visit.
27 Mar 2013	20 students from America	America	Site visit to the Centre.
17 Apr 2013	Six member delegates led by Ms. Panpimon Chunyanuwa	Director General, DoEA, MoAC, Thailand.	To discuss the Joint Agricultural working Group work plan & exchange visit of Agricultural extension workers.

6.2 Training, meetings and workshops

Date	Name	Place	Purpose
16-27 Jul 2012	Kinley Dorji, Ngawang Chhogyel & Yeshey	UWICE, Lamai Genpa, Bumthang	Training on R-Stats
20-24 Aug 2012	Gyambo Tshering	New Delhi, India	Workshop on "Scaling up of climate Smart Agriculture Practices."
6-7 Sep 2012	Tenzin & Pema Yuden	Thimphu. IMS	Training on "PLAMS, MYRB & PEMS"
9-19 Sep 2012	Yeshey Dema	UWICE, Bumthang	
1-4 Sep 2012	Sangay Tshewang	China	Training on Basic Social Research method.
1-11 Oct 2012	Mahesh Ghimiray & Lhab Gem	Thailand	Study Tour to Thailand on rice research and development
25 Sep – 5 Oct 2012	Ngawang Chogyal	Kenya AgAgricultural Research Institute, Njaro	Training Course in standardization of Stem Rust and evaluation of Germplasm.
8-19 Oct 2012	Thinley Gyeltshen	Faridabad, New Delhi, India	Training on Procurement of Goods Works and Consultancy Service.
4-12 Nov 2012	Yeshey & Cheku Dorji	(IRRI), Philippines	IRRI Rice Conference.
11-24 Nov 2012	Dawa Dakpa	Nasik, India	Training on onion cultivation & post harvest management practices.
11-27 Nov 2012	Kinley Dorji	Vetencia, Spain	International conference on Citrus.
	Thinley Gyamtsho	Kabul, Pakistan	Climate change & water resources management for Drought Prone Areas South-East Asia.
20 Nov – 02 Dec 2012	Gyambo Tshering & Ngawang Chhoyel	Thailand & IRRI, Philippines	Institutional visit to the Department of Agriculture in Thailand.
22 Nov- 02 Dec 2012	D.B.Rana	Nepal	Study visit on "Post Production Supervisor on community based seeds production."

27 Nov-06 Dec 2012	Tanka M.Pulami	Banglore, India	International Organic Seminar & Institutional visit.
18- 19 Dec 2012	Sangay Tshewang & Om Prakash Ghalley	Kathmandu, Nepal	Workshop on contingency planning for management of wheat rust disease for South Asian Countries.
15-28 Dec 2012	Mahesh Ghimiray	Sri Lanka & Bangladesh	Study tour to Sri Lanka & Bangladesh under Rice commercial programme.
10-17 Feb 2013	Doley	Nepal	Study Tour to Nepal.
01-28 Feb 2013	Tirth Man Rai, Tenzin Dorji, Pema, Phuntsho Wangdi & Lok Bdr. Tamang	AMC, Paro	Training on basic repair & maintenance of tractors, power tiller.
26 Feb-02 Mar 2013	Cheku Dorji, Legjay & Yeshey Dema	CNR, Lobesa	Training on basic rice production.
07 Feb- 06 Mar 2013	Indra Bdr. Raika	CMI, Phuntsholing	Hardware and Networking
07 Feb- 06 Mar 2013	Lhamo	CMI, Phuntsholing	Training on Office Management & IT
17-23 Jun 2013	Cheku Dorji	Bangkok, Thailand	Study visit on Rice Production
17-20 Jun 2013	Neten Drukpa	Sikkim, India	Cardamom propagation & Nursery management workshop.
24-27 Jun 2013	Yeshey	New Delhi, India	Workshop on climate resilient agriculture for small holder farming system.

6.3 Financial progress

RGoB contribution for RDC, Bajo (Current)

Code	Particulars	Approved Budget	Expenditure
01.01	Pay and Allowance	12,786,000.00	12,670,976.00
02.01	Other Personnel Emoluments	2,090,000.00	2,090,000.00
11.01	Travel-In-country	3,797,000.00	3,796,719.00
12.01	Utilities-Telephones, Fax, E-mail, Internet	300,000.00	299,134.00
12.02	Utilities-Telegram, Postage	29,000.00	28,510.00
12.03	Utilities-Electricity, Water, Sewerage	83,000.00	83,000.00
14.01	S & M-Office Supplies, Printing, Publ.	115,000.00	115,000.00
14.02	S & M- Medicines, Lab Consumables	19,000.00	18,720.00
14.03	S & M-Fertilizers, Chemicals, Manures	108,000.00	107,410.00
14.04	S & M-Seeds, Seedling	154,000.00	153,256.00
14.06	S & M-Uniforms, Extension Kits, Linens	177,000.00	177,000.00
14.07	S & M- Text Books, Library Books	50,000.00	43,748.75
15.02	Maintenance of Property- Vehicles	1,130,000.00	1,122,712.03
15.05	Maintenance of Property-Equipment	73,000.00	73,000.00
15.06	Maintenance of Property-Plantations	29,000.00	28,480.00
15.09	Maintenance of Property-Water supply	52,000.00	51,208.00
17.01	Op. Exp- Advertising	214,000.00	213,993.00
17.02	Op. Exp- Taxes, Duties, Royalties, Handling Charges, Bank Charges	1,000.00	50.00
17.03	Op. Exp- Transportation	40,000.00	40,000.00
17.04	Op. Exp- Engry/Propulsion Charges	1,000.00	560.00
17.08	Op. Exp- In-country Meetings and Celebrations	106,000.00	105,937.00
24.03	Contributions- provident Fund	1,135,000.00 502,000.00	1,133,467.00 502,000.00
25.01	Retirement Benefits		**22,854,880.78**

RDC, Bajo capital expenditure

Code	Particulars	Budget	Expenditure
45.02	Training- Others	307,000.00	285,279.00
51.05	Exp. On Structure-Drainage Systems	168,000.00	168,000.00
52.05	Plant & Equipt- Agriculture Machineries	175,000.00	171,580.00
	Total:		**624,859.00**

RGoB contribution for RDSC, Tsirang

Code	Particulars	Budget	Expenditure
11.01	Travel-In-country	681,000.00	978,905.00
12.01	Utilities-Telephones, Telex, Fax, E-mail, Internet	56,000.00	55,771.00
12.02	Utilities-Telegram, Wireless, Transmission, Postage	1,000.00	350.00
12.03	Utilities-Electricity, Water, Sewerage	22,000.00	21,358.51
14.01	S & M-Office Supplies, Printing, Publication	100,000.00	100,000.00
14.03	S & M-Fertilizers, Chemicals, Manures, Inoculants	18,000.00	17,640.00
14.04	S & M-Seeds, Seedling	48,000.00	47,774.00
14.06	S & M-Uniforms, Extension Kits, Linens	91,000.00	90,026.00
15.02	Maintenance of Property- Vehicles	375,000.00	375,000.00
15.05	Maintenance of Property-Equipment	3,000.00	2,765.00
15.06	Maintenance of Property-Plantations	20,000.00	19,868.00
	Total:		**1,409,456.51**

Capital expenditure for RDSC, Tsirang

Code	Particulars	Budget	Expenditure
45.02	Training- Others	150,000.00	150,000.00
	Total:		**150,000.00**

6.4 Meterological information

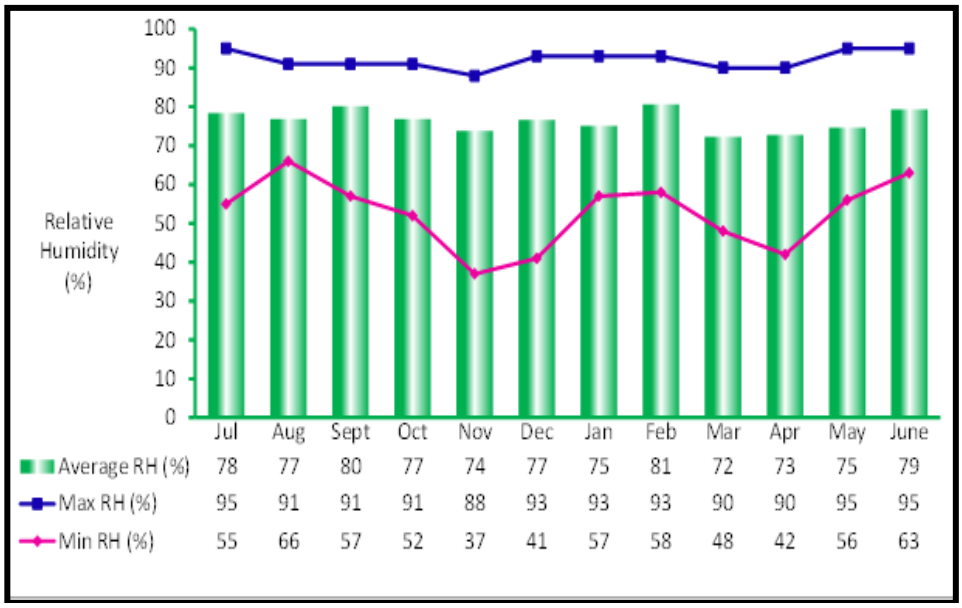

Figure 27: Average, maximum, and minimum relative humidity at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

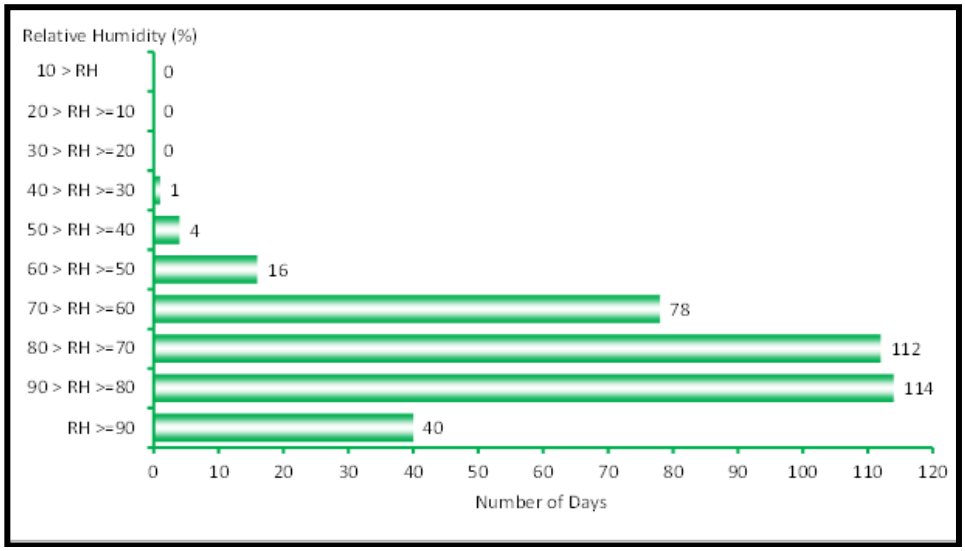

Figure 28: Distribution pattern of relative humidity at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

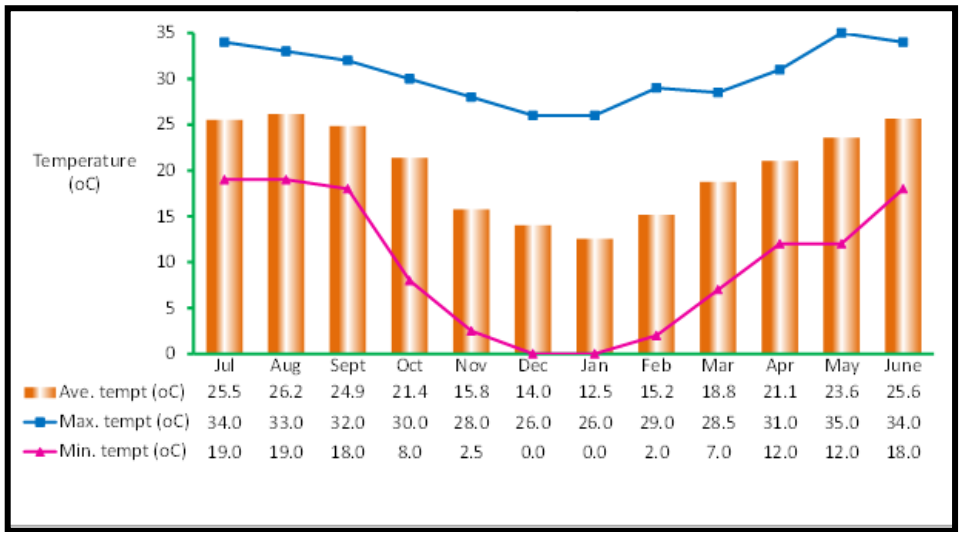

Figure 29: Monthly average, maximum and minimum temperature at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

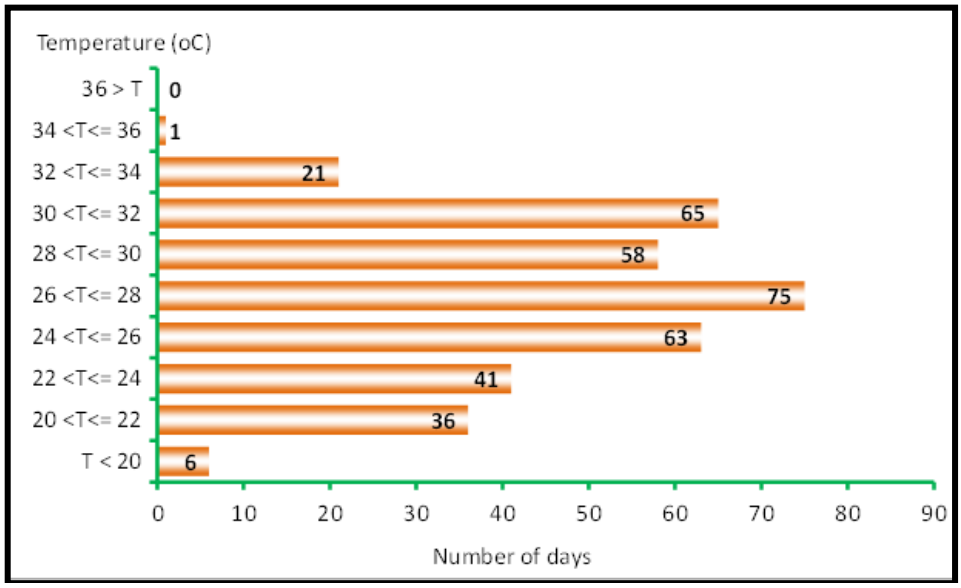

Figure 30: Maximum temperature distribution pattern at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

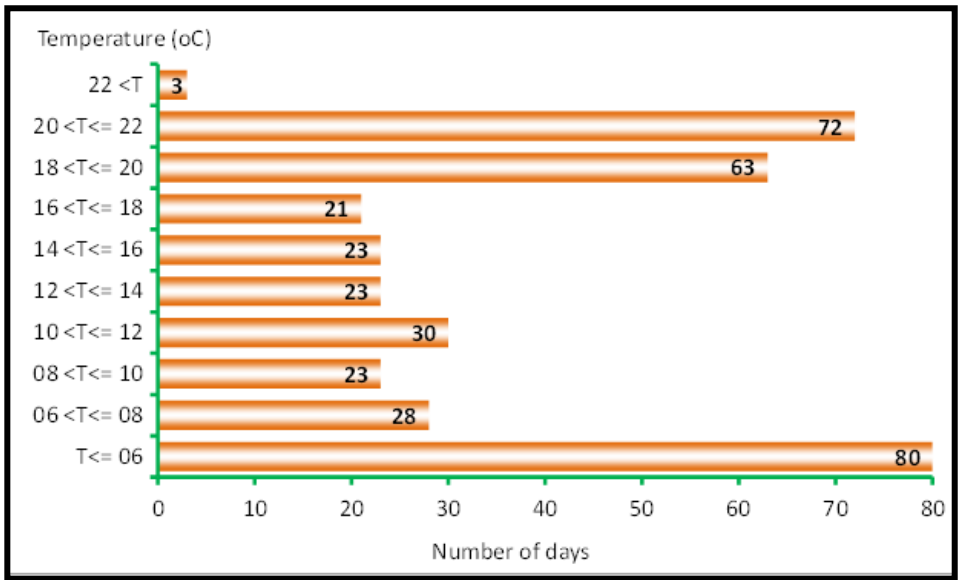

Figure 31: Minimum temperature distribution pattern at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

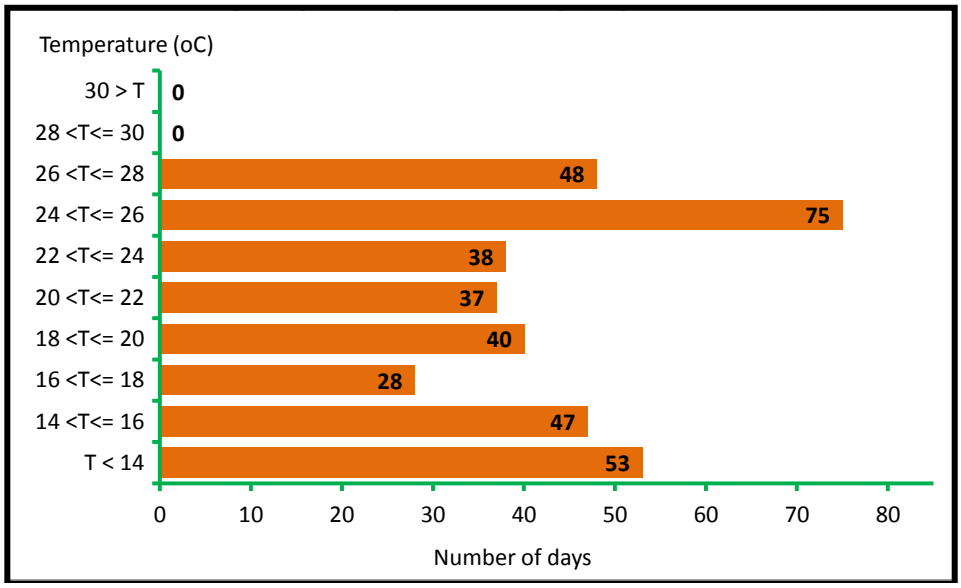

Figure 32: Average temperature distribution pattern at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

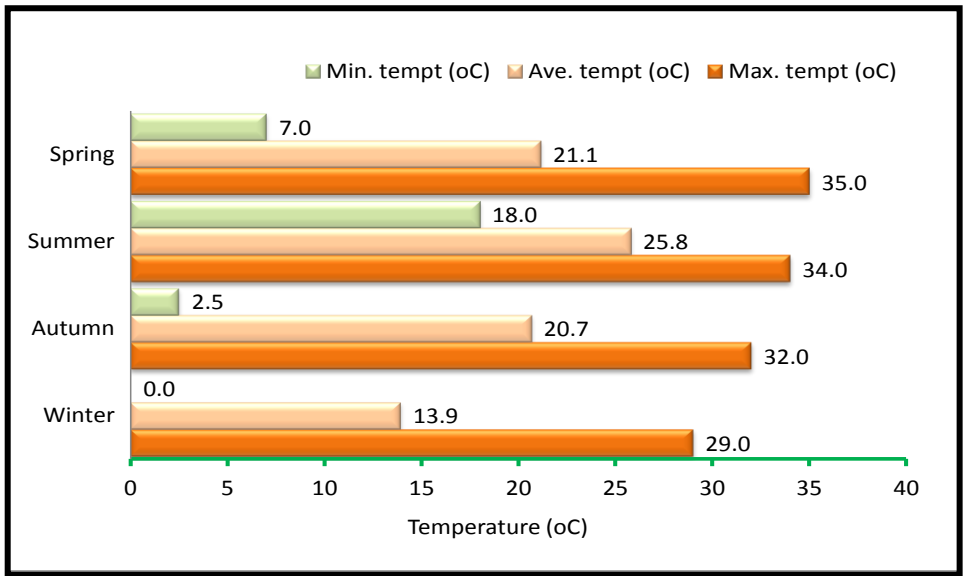

Figure 33: Seasonal temperature pattern at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

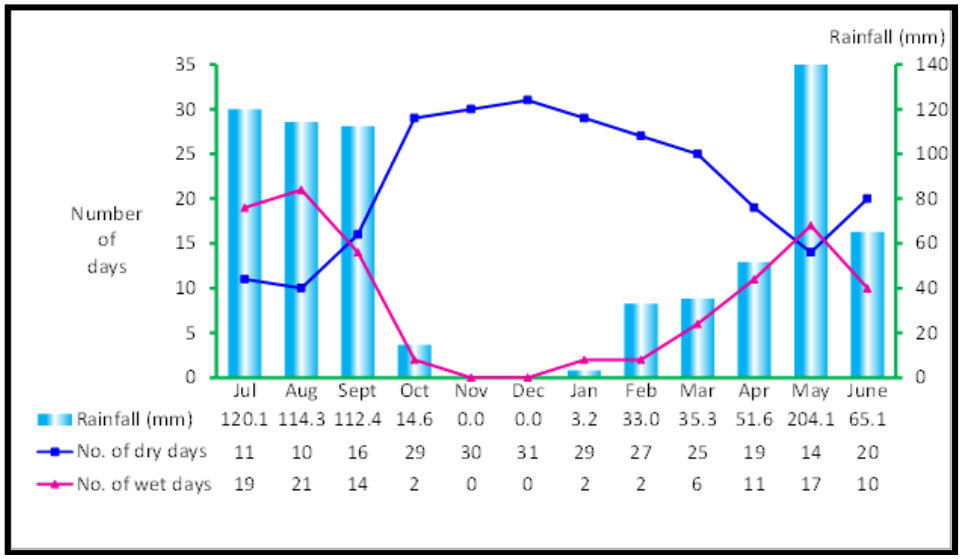

Figure 34: Monthly rainfall, number of wet and dry days at RDC Bajo (July 2012-June 2013). Source: Bajo Meteorology Station

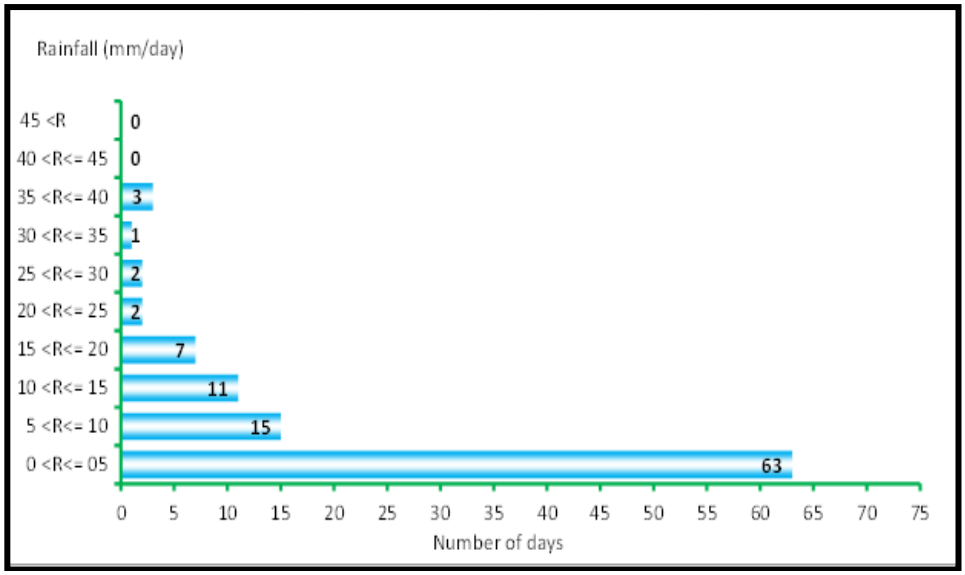

Figure 35: Rainfall intensity distribution at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

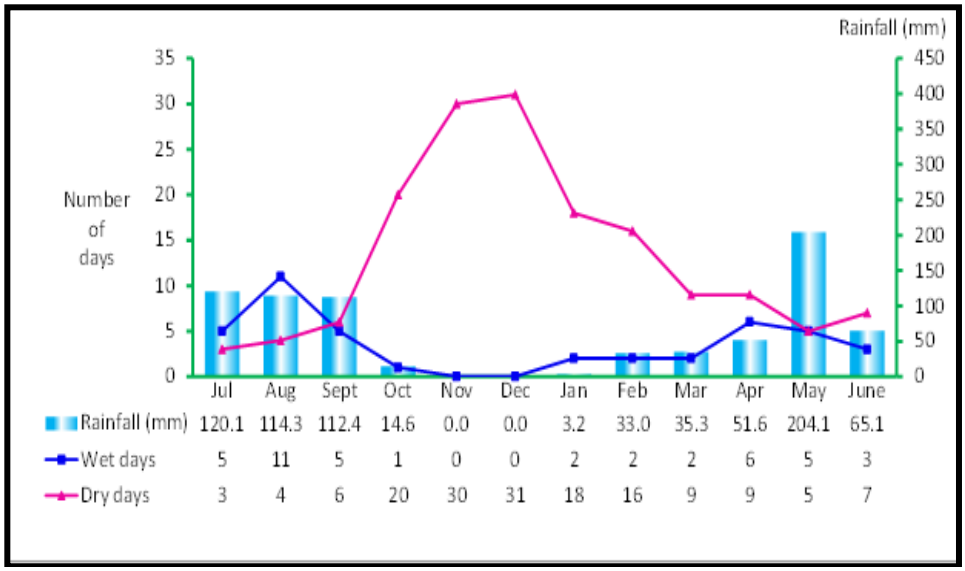

Figure 36: Monthly maximum number of continuous wet and dry days at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

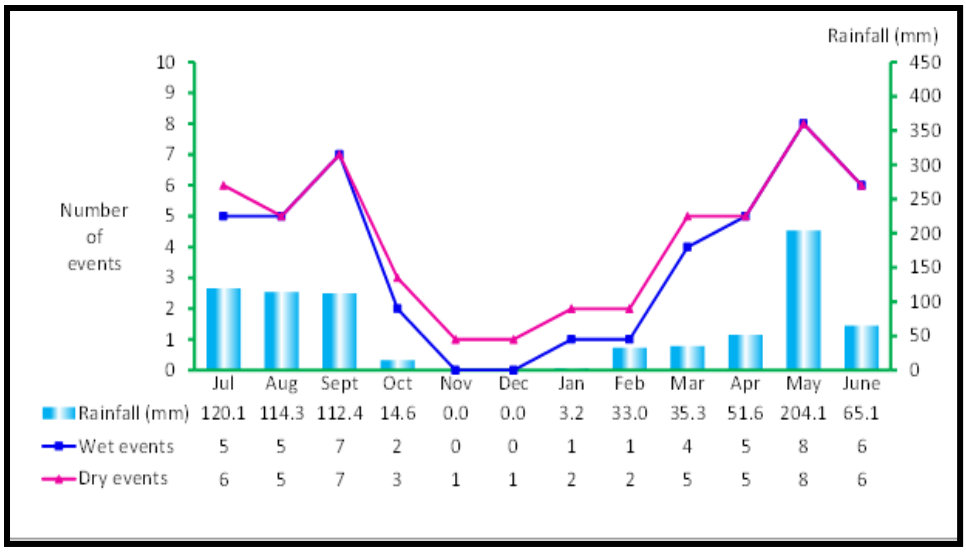

Figure 37: Monthly maximum wet and dry events at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

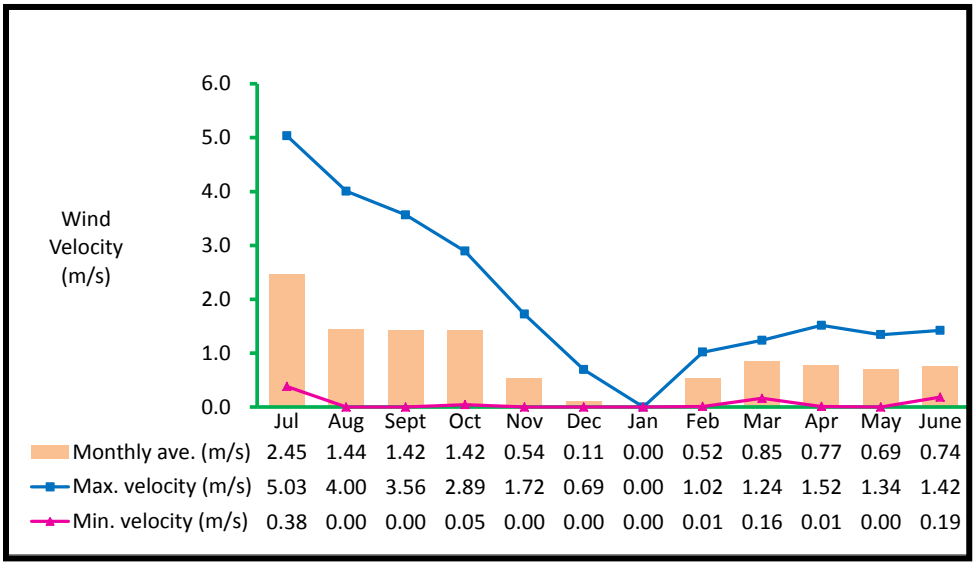

Figure 38: Monthly average, maximum and minimum wind speed at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

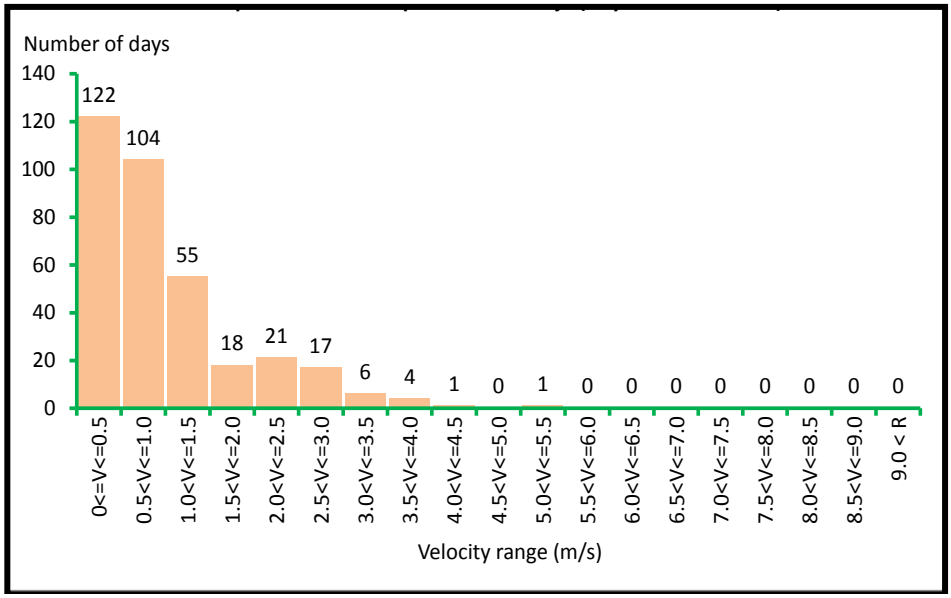

Figure 39: Wind speed pattern at RDC Bajo (July 2012-June 2013).
Source: Bajo Meteorology Station

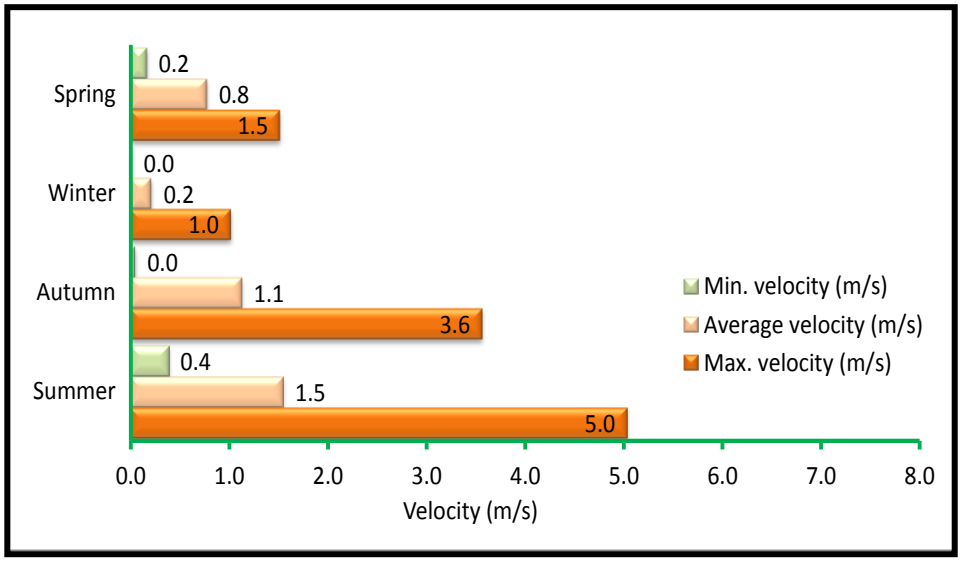

Figure 40: Seasonal wind speed pattern at RDC Bajo (July 2012-June 2013).
Source: Bajo Meteorology Station

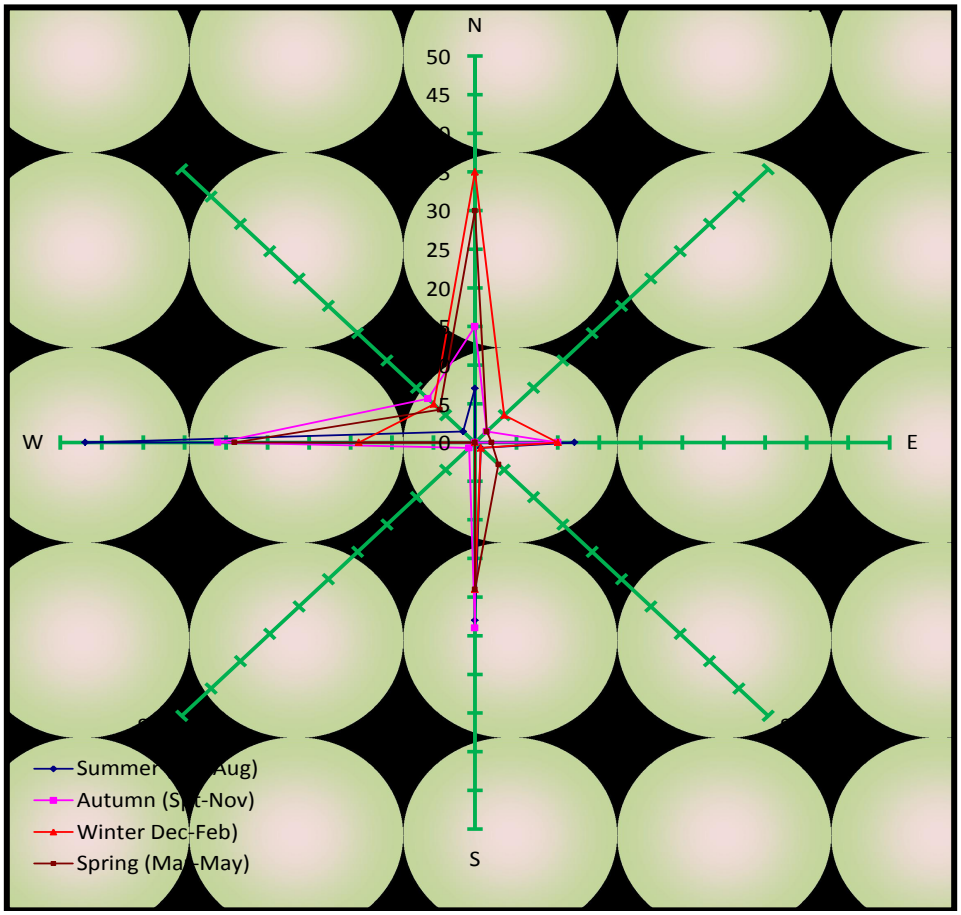

Figure 41: Seasonal wind direction pattern at RDC Bajo (July 2012-June 2013).
Source: Bajo Meteorology Station

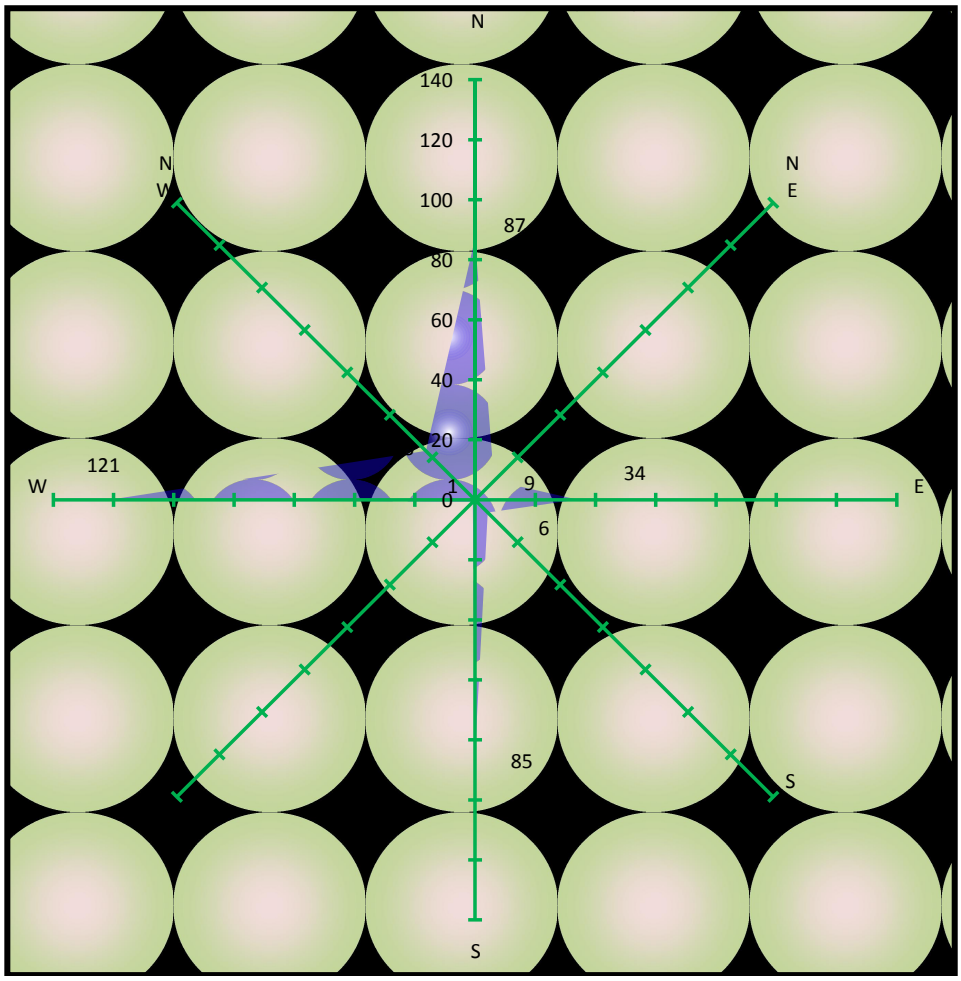

Figure 42: Annual direction pattern at RDC Bajo (July 2012-June 2013). *Source: Bajo Meteorology Station*

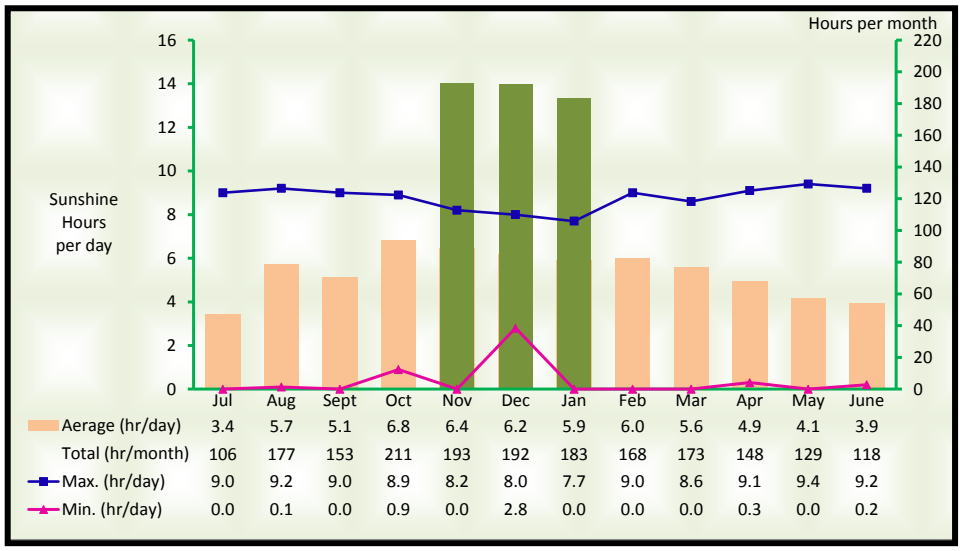

Figure 43: Monthly total, maximum, minimum and average sunshine hours at RDC Bajo (July 2012 - June 2013). *Source: Bajo Meteorology Station*

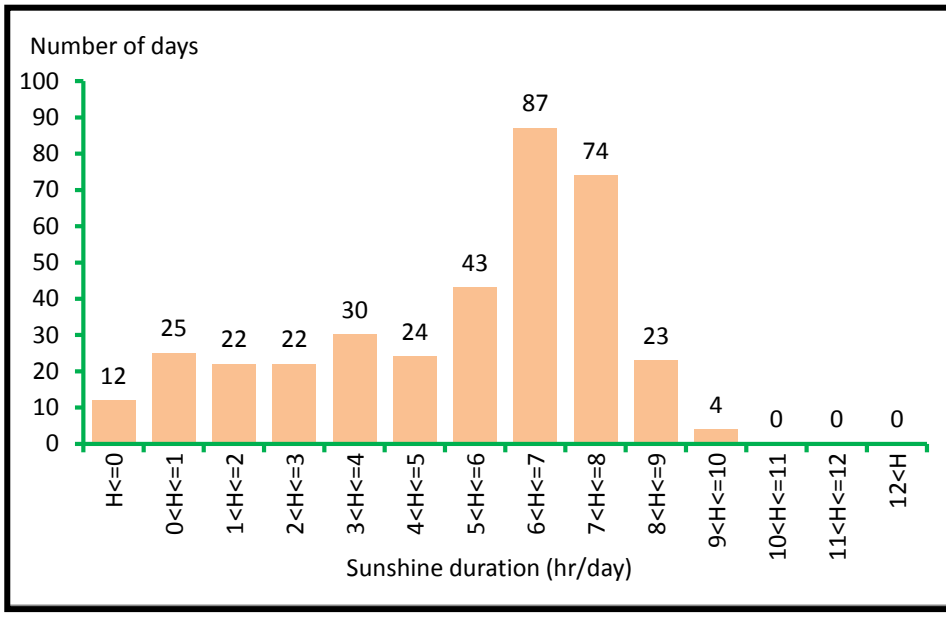

Figure 44: Pattern of sunshine hours at RDC Bajo (July 2012 - June 2013). *Source: Bajo Meteorology Station*

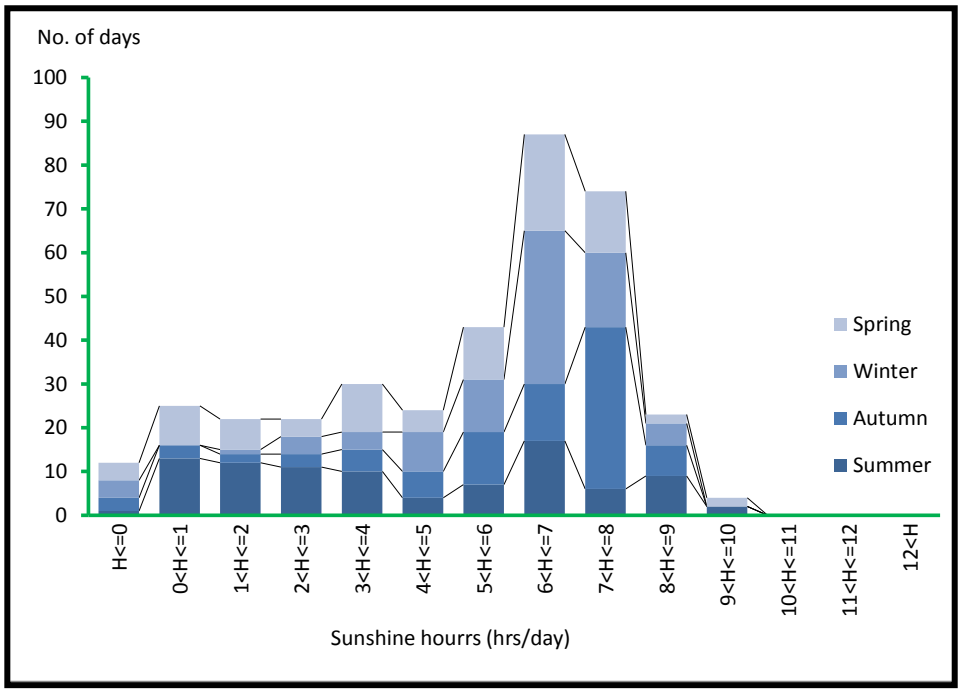

Figure 45: Pattern of sunshine hours by season at RDC Bajo (July 2012 - June 2013). *Source: Bajo Meteorology Station*

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.