ANNUAL REPORT
2011-12

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

ROYAL GOVERNMENT OF BHUTAN

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

Editors:
Mahesh Ghimiray, Kinley Dorji, Sangay Tshewang, Thinlay Gyamtsho, Yeshey, Tshering Wangchen and Sigay Phub

Suggested Citation:
RNR-RDC Bajo. 2011. **Annual Report 2011-2012**, Department of Agriculture, Ministry of Agriculture and Forests, Wangdue Phodrang

Layout and design:
Kinley Dorji

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

FOREWORD

We are pleased to publish the 27th Annual Technical Report of RNR RDC Bajo. 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 research communication. The report also highlights 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.

Tashi Delek!

Gyambo Tshering
Program Director
RNRRDC 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 the 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. Ever since 'development' was emphasized as a continuum of the Research Centers, equal importance is given in the promotion and dissemination of proven technologies. Starting this 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. Work on soil fertility management and farm mechanization are fine tuned every year in order to make it farmer friendly and easily adopted by them in the end. The development section on the other hand will highlight 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 the latest information on farming.

We hope this publication will provide useful information to our readers including academicians, development workers, students and field extension workers.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

REASEARCH AND SUPPORT STAFF

Name	Qualification	Designation
Gyambo Tshering	M. Phil. Horti Science	Program Director
Mahesh Ghimiray	M. Phil. Plant Biodiversity	Rice Specialist III
Singye Phub	MSc. Agriculture Extension	Principal Research Officer
Thinley Gyamtsho	MSc. Natural Resources Mgt.	Dy. Chief Research Officer
Thinlay Gyaltshen	Diploma in Civil Engineering	Dy. Chief Research Officer
Kinley Dorji	M.Sc in Tropical Agriculture(Citrus)	Sr Research Officer
Ngawang Chogyal	M.Sc in Agronomy	Sr Research Officer
Sangay Tshewang	Master in Rural Science	Sr Research Officer
Yeshey	M.Sc in Natural Resources Mgt	Research Officer
Tshering Wangchen	BSc in Agriculture	Research Officer
Dawa Zangpo	Diploma in VSc & AH	Administrative officer
Dawa Delma	Diploma in Agriculture	Sr. Research Assistant
Purna B Gurung	Diploma in Forestry	Sr. Research Assistant
Cheku Dorji	Diploma in Agriculture	Sr. Research Assistant
Legjay	Diploma in Agriculture	Sr. Research Assistant
Neten Drukpa	B.ScAgriculture	Sr. Research Assistant
Sonam Chophel	B.ScAgriculture	Sr. Research Assistant
Aita Kr. Bhujel	Diploma in VSc. & AH	Sr. Research Assistant
Tanka M Pulami	B.Sc Agriculture	Sr. Research Assistant
Rinzin Dorji	Diploma in Forestry	Sr. Research Assistant
Yograj Chettri	Diploma in Forestry	Sr. Research Assistant
Kinzang Dorji	Diploma in Forestry	Sr. Research Assistant
Dawa Drakpa	Certificate in Agriculture	Research Assistant-I
Lhab Gem	Diploma in Agriculture	Research Assistant-I
Sangay Tshering	Certificate in Feed & Fodder	Research Assistant-II
Lungki	Diploma in Agriculture	Research Assistant-II
Yeshi Zangpo	Diploma in Agriculture	Research Assistant-II
Karma Yoezer	Diploma in Laboratory	LA II

Kinga Lhamo	Diploma in Agriculture	Research Assistant-II
Pasang Dorji	Diploma in Agriculture	Research Assistant-II
Yeshey Dema	Diploma in Agriculture	Research Assistant-II
Indra Bdr. Raika	Diploma	Technician II
Tenzin	Diploma in Finance Mgt.	Acctt. Assistant-II
Tshering Yangden	Certificate in Laboratory	Research Assistant-II
Om Prakash Ghalley	B.Sc Agriculture	Sr Research Assistant
Dhan Bdr. Rana	Certificate in livestock	Research Assistant-II
Sangay Gyeltshen	Certificate in store Mgt	Sr. Store Keeper
Pema Yuden	DIMS	ICT II
Gyem Lham	Certificate	Library Assistant
Lhamo	Certificate	Adm. Assistant-II
Pema Lhamo	Class X Pass	PABX Operator-III
Ugyen Trashi	Certificate in driving	Driver-I
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
Farm attendants	-	33
Night guard	-	1

EXECUTIVE SUMMARY

Field Crops

The field crops research was implemented with the objective to increase the productivity of different cereals, oilcrops and grain legumes. Research and Development work were carried both on station and on farm. Selection of elite lines and commercial varieties from collaborating regional and international research centres continued to be a major activity of the centre. The development activities on rice gained momentum under the aegis of Accelerating Bhutan's Socio Economic Development (ABSD) and the centre played a crucial role in coordination and implementation. The onfarm research on rice conducted in Tsirang and Dagana yielded good results. Maize research was given more importance than in the past and important trials were implemented. In a bid to find new varieties to replace old wheat varieties such as Sonalika, 134 varieties from ICARDA, CIMMYT regional office based in Nepal and CIMMYT Mexico were assessed and promising selections were made. Farmers were also involved in the selection process as part of the participatory varietal selection in at least two trials at the station. Newer materials of grain legumes from ICARDA were obtained and tested as SAARC pulse shuttle breeding project ended. In oilcrops, six Indian mustard varieties were evaluated in a replicated trial which will be further tested in the ensuing season. The elite and potential lines will be tested in the farmers' fields, including the outreach sites, after their initial testing at the research station.

Horticulture

Horticulture research of RDC Bajo focuses on improvement of rural livelihood and achievement of vegetable and fruit self sufficiency within the region and at the national level through exploration opportunities and solving of field constraints. Further, in line with the national coordinating center (RNR RDC Wengkhar), the sector programs are also aimed at realizing the significant potential of diverse agro-ecological zones that address the emerging challenges of climate change. Some of the approaches being adopted are broadening of genetic resource base for prioritized horticultural crops either through introduction or selection from local diversity. Crop management technology, post-harvest practices, improved seeds, plant propagation techniques and maintenance of mother plants and breeder seeds of released crop varieties are also some of the research activities carried out at the center. Research component comprises of research on fruits and nuts, vegetables, medicinal and

aromatic while developmental section includes promotion of promising technology at farmers' field level in research outreach sites. On-station research programs are carried out at Bajo and at sub-station Tsirang for sub-tropical conditions. Participatory research approach is adopted to popularize the technology wherein the crops and management practices are demonstrated at farmers' fields in collaboration with extension officials. In addition, the sector in collaboration with other central agencies also carries out the capacity development of farmers by providing hands-on training beside technical support.

Livestock

During the fiscal year 2011-2012, Livestock Research Program executed a total of seven activities mainly on apiculture and fodder production. The activities mainly emphasized on the effect of improved management on honey production in local bee species, study of bee flora to understand the honey flow and floral dearth during various season. Maintenance of live herbarium of different fodder species both at RDC Bajo and RSC Tsirang was continued. Propagation, multiplication and promotion of promising fodder species was also given importance as part of land management programs.

Forestry

The forest staff are currently undergoing their undergraduate courses at the College of Natural Resources in Lobesa. Therefore the number of activities is much less compared to the previous years. The RDC Bajo continued to play a crucial role in the Community Based Capture Fisheries Management in Hara Chhu, Adhang geog. Establishment of bamboo arboretum was done at RNR RSC Tsirang. On station activities included multipurpose tree species (MPTS) domestication, evaluation and seedling distribution to institutions and campuses for planting on social forestry day.

Farming System

Farming System Sector consists of four research programs such as soils, IPM, agriculture economics and water management. Soil research and development focus is to bring together the research, the extension and the farmers to improve land productivity through the application of 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, IPM sector mostly provides need-based technical plant protection services to the client Dzongkhags through field visits, surveillance and monitoring. IPM research and development for 2011-2012 was concentrated on wheat rust disease study and fruit fly population monitoring in mango. Under the agriculture economics research program, research and development focus has been on organic farming through research out-reach program site at Gasa. Commercial vegetable production and pest disease monitoring and management through application of different bio-pesticides were the main activities implemented. Irrigation channel construction feasibility studies, renovation and new construction of channels were the main activities under water management program.

FIELD CROPS RESEARCH

1 FIELD CROPS

1.1 Rice

1.1.1 Advance evaluation trial

In AET, 9 entries were evaluated including local check during the 2011 cropping season. The test lines were basically the best performers from IET of 2010 season. The main objective of the AET was to evaluate lines for yield, pest and disease resistance for mid- altitude rice growing areas. The trial was laid out in a randomized complete block design with three replications. Seedlings were transplanted on $10m^2$ plot and spacing of 20 x 20 cm was maintained. Chemical fertilizer was applied at the rate of 70:40:40 NPK kg/ha with half N as top dress at panicle initiation. Butachlor 5G was applied at the rate of 1.5 kg a.i/ha after two to three days of transplanting to control weeds. At the later stage, hand weeding was done depending on the weed pressure especially to control shochum *(Potammogeton distinctus).* Irrigation was given as and when required with timely monitoring for pest and disease incidences. Grain yield was estimated from a harvest area of 5.04 m^2 and grain moisture content standardized at 14%.

The data were analyzed using IMB SPSS statistical software version 20, and comparisons among the means were done using LSD at 5% level of significance. Basic agronomic traits such as plant height, days to 50% flowering, number of productive tillers per hill and grain yield were assessed. The result showed significant difference in plant height, days to 50% flowering, no of productive tillers and grain yield (Table 1). Among the varieties, IR-80486 P-7, IR 80484 P-11, IR-80496 P-15 and IR-80484 P-14 were the tallest with mean plant heights of 167 cm, 159 cm, 152 cm and 148 cm, while the mean plant heights of IR-28, BP-176 and PSB RC 60 were medium tall with 106 cm, 113 cm and 114 cm respectively (Table 1). In all the cases, the standard check (BK2) was the shortest.

The average days to 50% flowering ranged between 113 days to 140 days, and varieties such as PSB RC 60, IR-43, BP-176 and IR-28 had comparable values to the standard check. As regards the number of productive tillers, almost all the varieties gave exceptionally higher values which even peaked at 80 for IR-28 and IR-80486 P-7 (Table 1). In terms of grain yield (t ha^{-1}) three varieties viz. BP-176, IR-28 and IR-43 gave yield of over 3 t ha^{-1} which was comparable to the standard check. Based

on the grain yield and other agronomic parameters 3 varieties (BP-176, IR-28 and IR-43) could be selected for multi-location trials in the next season.

Table 1 : Agronomic traits of different rice varieties evaluated in AET

Varieties	P. height (cm)	Days to 50% flowering	No of productive tillers hill^{-1}	Yield (t/ha)
IR80484 p-11	159.26 ef	137.33 g	57.00 ab	2.30 a
IR80484 P-14	148.00 de	128.00 e	49.67 a	2.20 a
IR80496 P-15	152.00 ef	136.00 f	49.03 a	2.56 a
IR-80486 P-7	166.67 fg	140.00 h	79.67 cde	2.28 a
IR-28	106.00 b	112.67 a	79.67 cde	3.90 bc
BP-176	112.67 bc	114.67 cd	57.67 abc	4.33 cd
IR-43	121.33 cd	114.33 cd	54.30 ab	3.58 b
PSBRC 60	114.33 c	114.00 bc	78.00 cd	3.54 b
BK2	95.33 a	113.00 ab	65.67 bc	3.91 bc

Means within a column indicated by same letter (s) are not significant at 5% level.

1.1.2 Rice observation nursery

A total of 9 lines were evaluated for various agronomic traits such as yield, maturity days, pest and disease resistance and plant height. The test lines were selected from INGER module 1. The objectives of the observation nursery was to screen and advance promising lines for further testing based on selection criteria. The design was a single observation plot of 20m^2 with the spacing of 20 cm x 20 cm. Fertilizers were applied at the rate of 70:40:40 NPK kg/ha. To control the weeds, Butachlor was applied at the of 1.5 kg a.i/ha. Irrigation was given on need based and shochum was weeded manually. The highest yield of 13.37 t/ha was observed from CT 16658-4-1-1SR-3-2-1-1-1M (Table 2). The promising entries were selected for further evaluation and the rest were rejected.

Table 2: Agronomic traits of Observation Rice nursery

Variety	Plant height (cm)	Tiller No	Grain yield (t/ha)
CT16658-4-1-1SR-3-2-1-1-1M	101	12	13.37
OMCS 2009	99	16	6.85
IR 71701-28-1-4	93	11	11.64
IR 75288-144-1-3	93	17	10.96
IR 72	93	17	11.52
GANZAOXIAN 49	76	16	10.51
IR 80905-50-1-3-2	92	9	9.52
YN 3109-23-1-2	99	12	7.97
Bajo Kaap 2	94	12	12.93

1.1.3 Selection from rice breeding populations

In 2011 RNRRDC, Bajo received 15 lines of rice varieties from Laoning Rice Research Institute in China. Those lines were from breeding population and were evaluated during 2011 season. Such breeding populations were very vital in order to save time and effort in varietal developmental process. However assessments were necessary to identify their suitability in our local conditions. The main objectives were to select the populations with desirable characteristics such as yield, pest/disease resistance and optimum maturity etc. Single plot design was used with a row spacing of 20 cm x 20 cm between each variety. Fertilizers were applied at the rate of 70:40:40 NPK kg/ha. To control the weeds, Butachlor was applied at the of 1.5 kg a.i/ha. The most promising lines were selected and will be evaluated in observation nursery in the coming season (Table 3).

Table 3: Agronomic traits of rice breeding populations

Variety	50% flw (days)	Grain yield (gm/row)
3147728 (39B/Liaoxing 1)	115	310
3147729 (ILMIBYEO/Liaoxing 1)	115	290
3147730 (SHINUNBONGBYEO/Liaoxing 1)	116	290
3147731 (SANJUBYEO/Liaoxing 1)	116	210
3147732 (ISTIQBOL/ Liaoxing 1)	115	340
3147733 (sakha 101 SK-101/ Liaoxing 1)	115	140
3147734 (TAKANARI/Liaoxing 1)	115	390
3147735 (Liaoxing 1/Gi3a178)	118	130
3147736 (39B/Gi3a178)	118	90
3147737 (ILMIBYEO/Gi3a178)	118	60
3147738 (Gia177/Gi3a178)	119	590
3147739 (XAYAP/Gi3a178)	116	170
3147740 (KUSAHONAMI/TAKANARI)	118	310
3147741 (LUGEP/TAKANARI)	119	140
3144742 (XAYAP/TAKANARI)	116	70

1.1.4 Effect of seedlings age on rice yield under SRI

Numerous reports, both success and failure, had been reported on System of Rice Intensification (SRI) Methodology both within and abroad. While this particular method of rice cultivation is still under verification under Bhutanese context, one of the main issues with our farmers was the age of seedling. SRI recommends 10-14 days old seedling in the mid rice growing areas. The main objective of the study therefore was to assess the effect of seedling age on rice yield and its components under SRI cultivation practice.

The trial was laid out in a single observation plot. There were three treatments, 14 days old, 21 days aged and the control, 30 days old seedling. A single seedling of required age was transplanted at 25 cm x 25 cm. Individual treatment was assigned to a single adjacent terrace, and was assumed that all the terraces are identical in soil fertility. All the treatments received same dose of butachlor herbicide, 1.5 kg a.i ha-1 and the inorganic fertilizer of 70:40:20 NPK kg ha-1, a rate recommended by National Soil Service Centre. Half of N, and whole P and K was applied as basal dose while other half N was top-dressed at panicle initiation. Different agronomic traits were measured at harvest time, and five crop

cuts were taken randomly from each treatment. Individual crop cuts were taken as a replicate to facilitate analysis.

Except in effective tillers per hill (P<0.05), there was no significant difference (P>0.05) in other traits (Table 4). While there was an indication of advantaging in transplanting 14 days old seedling through production of higher effective tillers and 1000 grain weight, no grain yield benefit was noted. The higher yield production in fact was from 21 days aged seedling. This one season result suggests that 21 days old seedling which is handier during transplanting can yield equally or more than that of recommended age, 14 days under SRI method. Further studies are required to confirm the findings.

Table 4: Grain yield and its components of different rice seedling age under SRI

Treatment	P. height (cm)	Panicle length (cm)	Tiller No. hill-1	Productive tillers m2 (no)	1000 grain weight (g)	Yield (t/ ha)
14 days	89.4 ab	22.5 a	24 b	282 b	29.5 a	6.9 a
21 days	90 b	23.3 a	22 b	267 b	29 a	7.5 a
30 days	85.2 a	22.3 a	17 a	217 a	29.3 a	6.5 a
P	0.05	0.29	<0.001	0.01	0.16	0.10

Means followed by different letters within a column are significantly different at P ≤ 0.05 by 95% confidence interval

1.1.5 Demonstration of released varieties

The centre received visitors who came on educational visit. In order to showcase and disseminate technology to farmers, students and extension staff, a demonstration plot consisting of 9 released rice varieties was established at the research station. The following rice varieties (Table 5) were demonstrated.

Table 5: List of released rice varieties for demonstration

Recommended agro ecology			
Variety	**Altitude (m)**	**Crop**	**Yield potential (t/ha)**
Bajo Kaap 1	600-1500	Main single	2.0-3.4
Bajo Kaap 2	600-1500	Main single	2.0-3.4
Bajo Maap 1	600-1500	Main single	2.0-3.2
Bajo Maap 2	600-1500	Main single	2.0-3.0
IR 64	600-1500	Main single	2.0-3.2
IR 20913	600-1500	Second double	1.6-2.4
Karjet	<700	Main single	1.0-2.0
Kamja	<700	Main single	1.0-1.5
Khangma Maap	Above 1500	Main single	1.6-2.4

1.1.6 Seed Production and maintenance of varieties

The following quantities of seed of different varieties that include both released and promising varieties were produced and maintained. The seed production (Table 6) is basically to maintain the seed at research to meet the unforeseen circumstances and support to the Dzongkhags during times of need. The seed stock also serve as ad hoc request (Table 6) from extension centres.

Table 6: Seed production in 2011

Variety	**Quantity**	**Status**
Bajo Kaap 1	500	Released variety
Bajo Kaap 2	500	Released variety
Bajo Maap 1	200	Released variety
Bajo Maap 2	500	Released variety
IR 64	500	Released variety
IR 20913	500	Released variety
B2983B	500	Pipeline variety
Khangma Maap	500	Released variety
Total	**3700**	

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

Variety	Quantity (kg)
IR 64	400
IR 20913	20
Bajo Maap 1	387
Bajo Maap 2	39
Bajo Kaap 1	100
Bajo Kaap 2	250
B3983B	60
Khangma Maap	350
Total	**1605**

1.1.7 Production Evaluation Trial of improved rice varieties in Tsirang and Dagana

Rice is one of the main crops in Tsirang and Dagana Dzongkhags. Tsirang shares about 8% and 5% of national area and production respectively while Dagana's contribution in area and production are 8% and 6% respectively (DoA 2011). The two Dzongkhags have one of the lowest rice productivities at 2.3 - 2.4 t ha^{-1} (DoA 2011) despite having considerable rice areas. It is often suggested that productivity could be increased through introduction of high yielding varieties, improved crop husbandry, and adequate inputs such as inorganic fertilizers particularly for the improved varieties. The main objective of this study therefore was to determine whether improved rice varieties could adapt to local environmental conditions of these two districts, and how would farmers perceive the new varieties. The increase of rice productivity through identification of suitable high yielding varieties in attaining the food security was the ultimate aim.

The trial was conducted during 2011 rice season in Drujeygang and Goshi in Dagana, and Sunkosh in Tsirang. The trial fields were located within an elevation of 1200-1300 m except Sunkosh which was 650 m. The general characteristics of soil in the test sites were sandy loam to loam. Chemical fertilizers of 70 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1}, a rate recommended by National Soil Service Centre (2009), was suggested. Additional recommendation was to apply 50% of N, and whole P and K during final day of land preparation, and remaining 30% and 20% N at mid tillering (30 days after transplanting) and panicle initiation (60 days

after transplanting) respectively. However, none of the farmers applied the recommended dose and most common rate of application was 100-125 kgs of Suphala (16:16:16) ha^{-1} as basal dose. All farmers reported of top dressing 20 kg N ha^{-1} after 40-45 days of transplanting in the form of urea to improved varieties.

Average productive tillers $hill^{-1}$ and plant height were determined from ten hills and plants respectively through random sampling. For productive tillers, a panicle bearing more than 5 filled spikelets was considered as effective while plant height was measured from base of plant till tip of panicle or flag leaf whichever the highest. The grain yield was estimated from the crop cut using a quadrant of 3 m x 2 m with grain moisture content adjusted to 14%. Each crop cut was considered as a replicate, and every precaution was taken to avoid the border rows and be the representative of the general field. At harvest, both the cooperative and non-participating farmers (neighbours) were engaged in the field exercise and the yield measurements to assess the improved varieties participatory. There was a significant difference ($P \leq 0.05$) in grain yield and the productive tillers between the treatments in all the locations (Table 8). Plant height also differed significantly except at Drujeygang. The introduced improved varieties yielded more than 50% of their local counterparts. Similar trends could be observed in the productive tillers per hill. These trials suggest that higher rice yield can be achieved through adoption of improved mid and low altitude rice varieties. Farmers' preference for the varieties varied depending on the location. There is a need to demonstrate the Integrated Nutrient Management practices to maintain or improve the soil fertility for long term sustainability. Future research is needed to evaluate these cultivars in wider non-tested or remote rice growing areas in Tsirang and Dagana from food security perspective.

Table 8: Agronomic traits of different rice cultivars at various locations

Site	Variety	Height (cm)	Productive tillers/hill	Yield (t/ha)
Drugeygang	Bajo Kaap 2	78 a	8 a	4.4 a
	Attey (traditional)	80 a	5 b	2.6 b
P value		0.88	< 0.05	0.05
Goshi	Wengkhar Rey Kaap 2	105 ab	6 ab	4.7 a
	Wengkhar Rey Kaap 6	98 b	7 b	4.1 a
	Attey (traditional)	114 a	4 a	2.3 b
P value		< 0.05	< 0.05	< 0.05
Sunkosh	Bhur Rey Kaap 2	114 a	13 a	5.5 a
	Bhur Kambja 1	119 a	11 a	4.0 c
	IR 64*	78 b	6 b	2.4 b
P value		< 0.05	< 0.05	< 0.05

Means followed by the same lowercase letter within the columns do not differ significantly by 95% confidence interval at $p \leq 0.05$.
*Though improved, it is considered as local in the current study as farmers were cultivating since last 10 years.

1.1.8 Upland rice demonstration

The upland rice demonstration was done at Katekha, Phangyul at an altitude of 1800 msl which is favourable for Khangma Maap rice variety. The objectives of the training /field day were:

- To create awareness on the upland rice technology
- To offer a rice production choice to the farmers wherever irrigation is a problem
- To popularize improved upland rice variety in the potential chewogs or the geog

The demonstration was conducted on an area of about one 'langdo'(one fourth of acre). RDC-Bajo provided Khangma Maap rice seed and the technical inputs. Seed sowing was done in May first week and the seeds were sown in lines which were 25cm apart. The seed rate was 25 kg/ha. The crop was grown totally under rain fed

condition without any supplementary irrigation. Weeding was done twice and the crop reached maturity in about 110 days after sowing. The crop stand was excellent and farmers were really happy with the performance of crop at the demonstration site.

During the field day, three sample crop cuts were conducted at random from an area of 6 m^2 (3m x 2m) each which gave an average grain yield of 3.2 t ha^{-1}. This high grain yield coupled with good crop stand at the field enthralled the participating farmers who came forward proposing for seed support. Accordingly, several farmers enlisted for seed support in the next year's cropping season. The demonstration of upland rice at Katekha under Phangyul geog was a success with grain yield of 3.2 t ha^{-1} which is almost at par with the yield from irrigated system. As the farmers have shown interest to take up upland rice variety (Khangma Maap), the centre has planned to provide seeds to 19 farmers a follow up on this activity.

1.1.9 Research outreach program

During the annual Regional Agriculture Review and Planning workshop held at RNR-RDC, Bajo from 26th-28th January 2012, after three days of intensive discussion with the ten Dzongkhag Agriculture Officers of west and west central regions and other regional heads of central programs, concerns were raised by the different Dzongkhags and other agencies. There were lot of problems and needs pertaining to agriculture that needs to be solved jointly with research centres, dzongkhags and other central programs. Subsequently under Dagana dzongkhag two geogs (Dorona and Gesarling) have been selected as outreach research program by the RDC, Bajo considering the needs and issues faced by the geog where research intervention is needed immediately.

RNRRDC has adopted Samtengang chewog as one of the research outreach sites under Gesarling geog of Dagana Dzongkhag. The altitude of the chewog ranges from 1200 – 1800 masl. According to the finding of the consultative meeting with the farmers, there are 66 households with a population of 196 people living in this chewog. 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 chewog is one of the most remote and far flung chewogs 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 chewog, 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 chewog 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.

Objectives of the outreach research

- To improve the livelihoods of local communities in Samtengang chewog through promoting appropriate agriculture-based and improved technologies
- To increase the participation of local communities in rural poverty reduction and development of rural adaptation capacity
- To build capacity of the rural poor in sustaining their livelihoods through effective utilization of natural resources.

Constraints

- **Low crop yields** – This is mainly because of lack of adequate irrigation water, declining soil fertility, lack of improve technologies, and wild animal damage to crops.

- **Inadequate irrigation water** – This is because of poor condition of the channel, lots of seepage, parts of the channels are washed by landslides and most of the channels are earthen, prone to high water lose through seepage and washed down by soil erosion.

- **Declining soil fertility** – This is due to less or no soil nutrient input in terms of both organic and inorganic. Farmers cannot afford to buy chemical fertilizers and their livestock population is not big enough

to produce enough farmyard manure. Farmers are not aware of other soil fertility management practices such as composting and green manure. So, the continuous crop harvest without applying soil nutrient input in any form has led to declining of soil fertility.

- **Farm labour shortage** – Crop yield are very low. There is no other cash income source from the farm to buy food. This has made many farmers to go for off-farm activities such as working at construction sites such as buildings, roads and bridges. This rural urban migration not only affects the rural agriculture development but it adds onto the urban poverty.

1.1.10 Research outreach activities

Supply of cereal seeds

During the consultative meeting, it was learnt that there was not even a single improved rice varieties grown in those villages. Some of the released varieties seems to have great potential in these area and hence, to promote the improved released cereals crops and as alternative planting sources, RDC, Bajo has supplied the following rice, maize (Table 9) and vegetable seeds (Table 10) to Samtengang and Tanju farmers. The centre also supported the upland rice Khangma Maap to those farmers where there is no irrigation water.

Table 9: Seed supplied to outreach sites

Variety	Quantity (kg)	Village
IR 64	50	Samtengang/Tanju
Bajo Maap 2	50	Samtengang/Tanju
Khangma Maap	10	Samtengang
Total	**110**	
Maize (Yangtsipa)	30	Samtengang/Tanju
Maize (Yangtsipa)	151	Kapasay
Total	**181**	

Table 10: Vegetable seed supplied

Variety	Quantity (Pkts)	Village	No. farmers
Cabbage	36	Samtengang/Tanju	36
Cauliflower	36	Samtengang/Tanju	36
Carrot	36	Samtengang/Tanju	36
Beans	72	Samtengang/Tanju	36
Mustard green	36	Samtengang/Tanju	36
Tomato	36	Samtengang/Tanju	36
Pea	72	Samtengang/Tanju	36
Onion	36	Samtengang/Tanju	36
Radish	36	Samtengang/Tanju	36
Cucumber	36	Samtengang/Tanju	36
Brocolli	36	Samtengang/Tanju	36
Total	**468**		

1.2 Wheat

1.2.1 Initial Evaluation Trial of Nepal Advanced Lines

In collaboration with the Regional CIMMYT Office in Nepal and Nepal Agriculture Research Council, 10 lines of wheat were introduced in 2011 season. These lines were promoted through various rigorous on-stations testing in Nepal, and were identified as the promising or lines in pipeline for release by the national wheat program. Given the urgent need of improved varieties for our wheat growers, the objective of the introduction was to assess the performance of these advanced materials under similar Bhutanese agro-ecosystem.

Trial was laid out in a RCB design with 2 replications. Spacing of 20 cm x 20 cm was maintained to facilitate weeding and other intercultural operations. An inorganic fertilizer of 60-40-30 N: P_2O_5: K_2O kg ha^{-1} was applied with half of N and full dose of P and K as basal during final land preparation. The remaining N was applied at tillering stage, a month and half after planting. The crop received four irrigations during its entire crop period, and weeding was done when required. Among the weeds, *Philaris minor* was the most dominant and problematic weed. At maturity, data on different agronomic traits were gathered, and grain yield was estimated from 6 m^2 crop cut area.

There was a significant difference ($P < 0.05$) on plant height and 1000 kernel weight, but not on spike length, spikelet spike^{-1}, productive tillers plant^{-1} and grain yield ($P > 0.05$) (Table 11). Though not statistically significant, all the introduced lines produced higher productivity than the standard checks. In addition to yield benefit, it was also noted that the introduced lines were resistant to rusts diseases, a major concern for wheat growers worldwide. On the other hand, the currently available improved varieties were susceptible to disease, yellow rust in particular. A field day was organized at maturity where the wheat farmers of Punakha and Wangdue selected 6 best lines based on the morphology and other agronomic characteristics. These selected lines will be further evaluated in a replicated trial at on-station, and if possible at multi-location trial in the farmers' fields to ascertain their performance.

Table 11: Agronomic traits of Nepal lines

Variety	Plant height (cm)	Spike length (cm)	1000 kernel weight (g)	Spikelet spike^{-1} (no)	Productive tillers/hill	Yield (t/ ha)
Aditya*	103 bde	8 a	61 d	50 a	5 a	3.85 a
BL3235*	115 d	9 a	58 ad	40 a	6 a	4.50 a
BL3503*	106 cd	8 a	58 ad	41 a	6 a	3.15 a
NL1050*	99 abc	8 a	57 bd	46 a	5 a	5.30 a
NL1053*	100 bce	8 a	53 abc	45 a	5 a	3.40 a
NL1054*	92 ab	9 a	56 cd	41a	5 a	3.35 a
NL1055	91 ae	8 a	50 bc	40 a	6 a	4.65 a
NL1064	106 cd	8 a	52 abc	44 a	5 a	4.40 a
NL1073	97 abc	9 a	50 bc	45 a	5 a	4.90 a
NL971	102 bce	8 a	55 cd	44 a	5 a	4.00 a
Bajoka1	96 abc	7 a	53 abc	44 a	4 a	2.70 a
Sonalika	104 bd	8 a	49 c	39 a	4 a	2.80 a
P	<0.05	0.08	<0.05	0.12	0.054	0.06

Means indicated by different letters within a column are statistically significant ($P < 0.05$) by 95% confidence interval. *Varieties most preferred by farmers during the field day.

1.2.2 Observation of ICARDA wheat lines

A total of 24 lines were introduced from International Centre for Agricultural Research in the Dry Areas (ICARDA). The main objective of the study was to assess the performance of advanced lines of ICARDA breeding program under local conditions. Being an observatory study, the trial was laid out in a single plot of 4 m x 2 m. Chemical fertilizers, and other crop inputs were provided as in Nepal lines. At maturity, different agronomic traits were measured, and grain yield was estimated from a crop cut of 4 m2.

Of the 24 entries, 7 lines were found to be potential in agronomic traits and grain yield (Table 12). Some lines were highly susceptible to diseases such as powdery mildew and brown rusts, and thus were rejected from the field itself. Few entries were also not uniform in maturity, and hence rejected from the field itself. The selected lines will be tested in the ensuing season in a replicated plot to validate their suitability and performance.

Table 12: Agronomic traits of ICARDA wheat lines

Entry	Plant height (cm)	Spike length (cm)	Productive tillers plant^{-1} (no)	1000 kernel weight (g)	Grain yield (t/ ha)	Remarks
Anapurna	115	9	4	-	-	Rejected*
V401	114	8	5	52	4.75	
V402	96	10	5	-	-	Rejected
V403	96	9	5	-	-	Rejected
V404	106	7	5	47	4.5	
V405	109	10	6	-	-	Rejected
V406	112	11	4	-	-	Rejected
V407	108	9	5	52	4.7	
V408	83	7	3	-	-	Rejected
V409	102	9	3	-	-	Rejected
V410	106	10	4	55	4.2	
V411	105	9	5	54	5.2	
V412	92	7	3	-	-	Rejected
V413	94	6	4	-	-	Rejected
V414	86	7	3	-	-	Rejected
V415	92	8	5	-	-	Rejected
V416	102	9	4	-	-	Rejected
V417	106	9	5	-	-	Rejected

V418	109	9	4	-	-	Rejected
V419	110	10	6	54	5.4	
V420	89	9	4	-	-	Rejected
V421	116	8	4	-	-	Rejected
V422	100	9	4	-	-	Rejected
V423	113	10	4	54	5.4	
Sonalika (check)	102	8	4	40	2.7	Standard check

*The lines rejected were either due to late maturity, disease susceptibility or non uniformity.

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

A total of 50 wheat lines were introduced from CIMMYT, Mexico through its regional office Nepal. The prime objective of this introduction was to determine the yield potential followed by disease reaction and other desirable agronomic traits. The trial was laid out in a single observation plot of 2.4 m^2, and chemical fertilizers and other inputs were provided as in other trials.

Of the 50 lines, 17 were found to be potentially acceptable or promising considering all the measured traits. However, these selected lines (Table 13) need further scrutiny in replicated trials to ascertain their performance before promoting for on-farm evaluation. The positive point with these materials is their resistance to rusts diseases, one of the major concerns for wheat growers.

Table 13: Agronomic traits of 32nd Elite Spring Wheat Yield Lines

Entry	**50% heading days**	**Height (cm)**	**Grain yield (t/ha)**	**1000 kernel (g)**	**Agronomic score (5=best)**	**Disease incidence**
Sonalika (check)	107	88	3.8	50	2	Stripe rust
PBW343	107	95	3.8	52	2	None
PRL/2*PASTOR	107	85	4.7	56	2	None
ROEFLFS F2007	109	92	3.6	49	2	None
MUNAL 1	109	98	3.8	51	4	None
WHEAR//2*PRL-1	109	96	4	52	4	None
WHEAR//2*PRL-2	121	92	4.7	55	5	None

MARCHOUCH*4	122	96	5.7	56	4	None
WAXWING/6/PVN	107	100	4.7	55	4	None
INQALAB 91*2	121	100	3.6	52	3	None
ATTILA*2	121	86	4.2	58	4	None
WBLL1/KUKUNA	102	100	4.6	58	2	None
WBLL1/UP2338	102	100	3.3	53	2	None
TACUPETO F2001	105	100	3.8	58	5	None
FRET2*2/4/SNI	102	85	4.7	58	2	None
KAUZ//ALTAR	107	96	4.7	53	2	None
KACHU/SAUAL	113	103	3.8	54	3	None
SAUAL/3/KAUZ	114	93	2.8	51	2	None
WBLL1*2/VIVITSI	114	86	3.1	53	3	None
ATTILA/3*BCN	114	90	3.3	54	3	None
ROLFO7/YANAC - 1	121	105	2.8	60	5	None
ROLFO7/YANAC - 2	121	121	4.2	59	5	None
ROLFO7*2/KIRITATI	121	102	4.7	56	2	None
FRET2*2/4/SNI - 1	123	95	5.2	59	3	None
FRET2*2/4/SNI - 2	123	86	4.7	59	2	None
FRET2/4/SNI -3	123	94	4.5	60	1	None
FRET2/4/SNI -4	121	95	4.5	62	2	None
FRET2/KUKUNA/PARUS	121	87	4.2	57	1	None
FRET2/KUKUNA-YANAC	107	87	4.1	55	1	None
FRETS/KUKUNA/FRET 2	109	92	5.2	58	1	None
WBLL1*2/KUKUNA*2	109	102	6	62	2	None
TRCH/SRTU	107	92	5.2	55	3	None
TRCH*2/7/TNMU	107	116	4.2	62	2	None
SERI.1B/KAUZ	121	102	4.7	57	2	None
WAXWING/WHEAR	119	97	4.7	59	1	None
PBW343*2/KUKUNA-1	117	97	4.5	57	1	None
PBW343*2/KUKUNA-2	117	94	3.6	51	1	None
PBW343*2/YANAC - 1	121	107	4.1	54	1	None
PBW343*2/YANAC - 2	121	89	3.8	51	1	None
PBW343*2/YANAC - 3	118	87	2.8	56	1	None
PBW343*2/KHVAKI-1	121	87	3.8	59	1	None
PBW343*2/KHVAKI-2	107	92	3.6	52	1	None

PBW343*2/PASTOR	109	90	4.1	54	1	None
ATTILA*2/PBW65 -1	121	103	2.9	55	2	None
ATTILA*2/PBW65 -2	124	98	2.9	57	1	None
BAV92/IRENA	117	100	4.7	56	2	None
TRCH/PRINIA	117	114	3.8	55	1	None
WAXWING*2	118	100	3.6	54	1	None
ATTILA*2	119	104	3.3	51	2	None
PBW343*2/KUKUNA-3	118	86	3.8	56	1	None

1.2.4 Observation of 19th Semi-Arid Wheat Yield Trial

A total of 50 wheat lines were introduced from CIMMYT, Mexico through its regional office Nepal. The main objective of this trial was to determine the yield potential under semi-arid conditions. Additional aim was to observe the disease incidence and other desirable agronomic traits. The trial was laid out in a single observation plot of 2.4 m^2, and chemical fertilizers and other inputs were provided as in other trials.

Of the 50 lines, 14 were found to be potentially acceptable or promising (Table 14) considering all the measured traits. However, these selected lines need further scrutiny in replicated trials to ascertain their performance before promoting for on-farm evaluation. As in ESWYT, these materials were resistant to rusts diseases, one of the major concerns for wheat growers.

Table 14: Agronomic traits of 19th Semi-Arid Wheat Yield Lines

Entry	**50% heading days**	**Height (cm)**	**Grain yield (t/ha)**	**1000 kernel (g)**	**Agronomic score (5=best)**	**Disease incidence**
Sonalika (check)	105	84	3.5	54	2	Stripe rust
Dharwar Dry	121	97	5.7	54	5	None
Vorobey	105	90	4.2	50	3	None
W15.92/4	102	95	5.7	60	3	None
POTCH 93	105	94	3.8	52	5	None
ACHTAR*3	107	92	3.8	54	4	None
QG4.37A/4	109	102	4.7	54	5	None
NSM*4/14-2	109	100	5.7	50	3	None

BABX/LR42-1	109	90	5.7	52	3	None
BABX/LR42-2	105	97	6.6	58	4	None
FRET2*2/4-1	102	106	5.2	50	5	None
FRET2*2/4-2	102	93	4.7	62	4	None
ONIX/ROLF07-1	103	100	3.8	52	4	None
ONIX/ROLF07-2	105	84	4.1	58	3	None
ONIX/4/MILAN	102	85	6	58	3	None
ACHTAR/4	107	95	4.7	58	4	None
CNO79-1	110	97	5.2	60	5	None
CNO79-2	113	102	4.7	56	5	None
CNO79-3	114	93	4.1	54	2	None
CNO79-4	114	107	3.3	58	2	None
MILAN/KAUZ	121	109	3.8	56	3	None
SOKOLL*2 -1	121	106	3.8	54	2	None
SOKOLL*2 -2	121	104	4.2	52	2	None
SOKOLL/PBW343	124	93	4.7	54	2	None
SOKOLL*2/ROLF	124	100	3.8	56	2	None
GK ARON - 1	124	84	3.8	58	3	None
GK ARON - 2	121	96	3.8	54	2	None
GK ARON - 3	121	110	4.7	56	4	None
SW89-5124*2	107	93	4.7	46	2	None
SOKOLL/ROLF07	109	104	4.2	56	2	None
SOKOLL/FRTL-1	109	104	4.7	54	4	None
SOKOLL/FRTL-2	109	94	5.7	56	2	None
BAV92/SERI	107	97	5.2	50	2	None
ROLF07/3 -1	107	96	5.7	54	2	None
ROLF07/3 -2	121	107	4.7	68	2	None
MILAN/KAUZ/	119	92	5.7	60	2	None
ATTILA/BAV92	117	102	2.8	46	2	None
CUNNINGHAM	117	106	3.8	48	2	None
ESDA/KKTS	117	100	2.8	56	2	None
GOUBARA-1/2	121	102	4.7	28	2	None
SOKOLL*2/PASTOR1	111	104	2.8	50	2	None
SOKOLL*2/PASTOR2	111	100	3.3	48	2	None
SOKOLL*2/4 CHEN-1	113	86	3.8	50	2	None
SOKOLL*2/4 CHEN-2	114	100	3.3	56	2	None
BOW/VEE-1	122	105	4.7	50	2	None

BOW/VEE-2	124	105	4.7	52	2	None
BOW/VEE-3	122	118	3.8	52	2	None
GONDO/WBLL1*	111	106	3.8	54	2	None
PASTOR*2/BAV92-1	113	89	4.2	54	2	None
PASTOR*2/BAV92-2	114	87	4.7	54	2	None

1.2.5 Effect of Nitrogen on yield and its components

Nitrogen is one of the most important inputs for crop production. Wheat, as with other crops such as rice, is also a nitrogen demanding cereal. The reports elsewhere suggest that wheat yield is drastically reduced when it is not nourished with chemical fertilizer, nitrogen in particular. The objective of this study therefore was to determine the effect of different rates of nitrogen on grain yield and other components. An improved variety, Sonalika was used for the study.

The trial was laid out in RCB design with four replications. The plot size was 9 m x 3 m and spacing of 20 cm x 20 cm was maintained to facilitate weeding and other intercultural operations. The treatment consisted of 0-0-0 (control), 50-40-30, 80-40-30, 100-40-30 and 120-40-30 N: P2O5: K2O kg ha-1. Half 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 sowing. The crop received four irrigations during its entire crop period, and weeding was done when required. Among the weeds, *Philaris minor* was the most dominant and problematic weed. At maturity, data on different agronomic traits were gathered, and grain yield was estimated from 6 m2 crop cut area.

Statistics showed significant difference ($P<0.05$) in all the measured parameters except 1000 kernel weight (Table 15). Application of nitrogen had an influence and there was a linear increase with increasing nitrogen rate in most of the agronomic traits including grain yield. The agronomic traits, however, plateaued at 100 kg N ha-1 indicating that this rate would be economical to realize the maximum benefits.

Table 15: Agronomic traits of Sonalika under varying nitrogen rates

Treatment	P.height (cm)	Spike length (cm)	1000 kernel weight (g)	Spikelet spike^{-1} (no)	Productive tillers plant^{-1} (no)	Yield (t/ha)
00-00-00 NPK kg ha^{-1}	73 c	6 a	56 a	31 a	2 a	1.36 a
50-40-30 NPK kg ha^{-1}	84 a	8 ab	59 a	39 ab	4 a	2.08 a
80-40-30 NPK kg ha^{-1}	96 b	10 b	57 a	44 ab	7 b	3.24 b
100-40-30 NPK kg ha^{-1}	96 b	10 b	55 a	50 b	7 b	3.87 b
120-40-30 NPK kg ha^{-1}	96 b	10 b	53 a	48 b	8 b	3.66 b
P	<0.05	<0.05	0.23	<0.05	<0.05	<0.05

1.2.6 Rusts survey

The wheat and plant protection researchers participated in the wheat rust survey which was undertaken in collaboration with National Plant Protection Centre and Durable Rust Resistance in Wheat (DRRW) project. Surveys were undertaken in the wheat/barley/oat growing areas of five Dzongkhag's in western Bhutan (Haa, Paro, Punakha, Gasa, Wangdi Phodrang) with elevations of surveyed sites ranging from 1200m to 2700m. A total of 26 individual sites were visited, using standard Borlaug Global Rust Initiative survey methodology. The main crop stage during survey was flowering-milk growth stage, with tillering at higher elevations areas. The main objective of the surveys was to assess the status of cereal rusts in Bhutan and to monitor the potential spread of new virulent races of stem rust (Ug99 race lineage) into the South Asian region. The role of Berberis sp. as a potential alternate host for cereal rusts (stem and stripe rust) was also investigated. Berberis sp. bushes in close proximity to cereal crops and along the roadside were checked for aecial infections along the survey route.

Stripe or yellow rust (*Puccinia striiformis*) was the most widespread cereal rust, being observed at 13 out of the 26 sites visited. Highest incidence and severity of stripe rust was observed in Punakha Dzongkhag. Four of the sites visited in Punakha exhibited moderate to high severity of disease.

The commonly grown cultivar "Sonalika" was susceptible to stripe rust. Both bread wheat and barley were also infected with stripe rust.

Leaf rust (*Puccinia triticina*) was observed at 11 out of the 26 sites visited with low to high incidence. However, increases in both incidence and severity of disease may occur as temperatures rise.

No stem rust (*Puccinia graminis*) was observed at any of the survey sites visited. Subsequent visit at ripening stage also confirm its non occurrence. Individual pustules with unusual morphology indicative of possible stem rust infections were collected at several sites, but subsequent microscopy at the NPPC laboratory indicated that all such pustules were actually leaf rust.

The current surveys provided a valuable update on the situation regarding wheat rusts in Bhutan. Though considered as secondary cereals, wheat, barley and oats are planted in sufficient area that could permit a significant build up of rust inoculums and to play a potentially important role in disease epidemiology for the wider South Asian region. Under increased and intensified wheat production, consideration for control of a range of cereal diseases (including rusts) should be undertaken as a high priority. The usage of durably resistant cultivars will not only have good control of cereal rusts in Bhutan but also would have significant benefits for the wheat farmers in the region.

1.3 Maize Research

One of the commodity approaches to maize program is to strengthen maize research in other Research and Development Centre's as it is logistically difficult to cater from RDC Wengkhar alone, the national coordinating centre for Maize. In the year 2011, two important on farm trials were carried out with technical assistance from RDC Wengkhar.

- Evaluation of two extra early varieties of Maize in Toeb geog
- Demonstration of two provisionally released GLS and TLB tolerant maize varieties in Talo geog.

1.3.1 Evaluation of two extra early varieties of Maize in Toeb geog

The farmers along the Thimphu Wangdue highway mainly Toeb geog started to sell roasted maize because of the good demand from the commuters. Besides they also get good income from the consistent sale of maize cobs.

The farmers would be further benefiting if there are early varieties. In order to obtain early crop of maize, seeds of two extra early varieties were supplied to selected farmers of Toeb geog. The evaluation of the extra early varieties was carried out as per the farmer's management practice. Eleven farmers from Chilikha, Goemkha and Mendrelgang under Toeb geog were involved in the evaluation of the two extra early varieties. The varieties supplied were Arun 2 and Arun 4.

Photo: Arun 2 and Arun 4

The crop was frequently monitored and a crop cut was done in the end to compare its yield with the popular Yangtsipa.

The yield was higher in Yangtsipa (3.35 t/ha) than those new varieties (Arun 2 with 3.17 t/ha and Arun 4 with 3.15 t/ha) that were evaluated as evident from the crop cut. Yangtsipa has been grown from a very long time and their general preference is towards Yangtsipa. There was more number of plants from the crop cut area of the extra early varieties than Yangtsipa but in terms of yield Yangtsipa surpassed the two varieties. One of the concerns from the farmers was that Arun 2 and Arun 4 are earlier in maturity than Yangtsipa but notably the cob size of these extra earlier

varieties were smaller than Yangtsipa. Since bigger cobs fetch good price, their preference for the choice of variety is Yangtsipa although they have kept seeds of Arun 2 and Arun 4 to take advantage of the early market next year.

1.3.2 Demonstration of GLS and TLB tolerant varieties in Talo

The two diseases of maize GLS and TLB is a major threat in most of the maize growing environments. Selections were made in the diseases hotspot sites by RDC Wengkhar and two promising lines were indentified while implementing the National coordinated trials. The promising lines were Entry No 35 (S03TLYQ AB05) and Entry No 38 (ICA V 305).

The extension agent of Talo geog realizing the severity of GLS and TLB in his geog requested RDC Wengkhar for the demonstration of two provisionally released GLS tolerant maize varieties. The seeds were supplied with support from RDC Wengkhar.

A total of 10 households were selected for the implementation of the demonstration trial. Five farmers were given the seeds of Entry No 35 and similarly the other half were supplied with Entry No 38 seeds. All the farmers had Yangtsipa as the standard check.

Table 16: Crop cut data of new maize varieties in Talo

Farmer's Name	Variety	Plant Height (m)	1000 kernel weight (gm)	Shelling %	Plant Density (acre)	Grain yield (t ha^{-1})
Talo Tenzin	Entry No35	1.8	51	70	16207	1.11
Hollam	Entry No38	2.3	88	69	13492	1.83
Hodo	Entry No38	2.6	68	50	8231	8.0
Tsetsim	Yangtsipa	2.6	73	68	12414	1.53
Tashi Dem	Entry No35	2.5	102	70	11740	3.45
Sonam Pem	Yangtsipa	3.4	92	69	10120	1.60
Ngangse	Entry No35	2.3	128	68	9985	3.03
Wangchuk	Entry No38	2.5	81	75	11604	2.23
Dorji Wangmo	Entry No35	1.8	105	65	15247	1.94
Choden	Entry No38	2.3	101	62	10390	1.15

Thinley	Yangtsipa	2.1	139	73	11942	1.72
Tshering Duba	Yangtsipa	1.9	99	64	12009	1.55
Tashi Pelki	Yangtsipa	1.8	123	75	9985	1.92
Karma	Yangtsipa	2.1	92	64	10252	1.41
Am Chimmi	Yangtsipa	2.2	144	72	10795	1.00
Ap Gomchen	Yangtsipa	3.3	419	61	12144	2.48
Kinley Penjor	Yangtsipa	2.5	80	73	12818	3.06

Table 17: Score and other traits of GLS tolerant maize lines

Pedigree	Date: 5/6/2011		Date: 25/7/2011		Date: 8/8/2011		Root	Stalk	Husk	Rotten
	GLS	TLB	GLS	TLB	GLS	TLB	Lodging	Lodging	Cover	Ears
Entry 35	1	1	1	1	1	1	1	1	1	1
Yangtsipa	1	1	1	1	1	1	1	1	1	1
Entry 38	2	1	2	1	2	1	1	1	2	3
Yangtsipa	1	1	1	1	1	1	1	1	1	2
Entry 38	1	1	1	1	1	1	1	1	2	1
Yangtsipa	1	1	1	1	1	1	1	1	2	1
Entry 38	2	2	3	3	3	3	1	1	2	2
Yangtsipa	1	1	2	2	2	2	1	1	2	2
Entry 38	1	1	2	1	1	1	1	1	1	2
Yangtsipa	2	2	3	2	3	2	1	1	1	1
Entry 38	1	1	2	2	2	2	1	1	1	1
Yangtsipa	2	2	3	3	3	3	1	1	1	1
Entry 35	1	1	1	1	1	1	1	1	1	1
Yangtsipa	2	2	2	2	2	2	1	1	1	1
Entry 35	1	1	1	1	2	2	1	1	1	2
Yangtsipa	1	1	2	2	2	2	1	1	1	3
Entry 38	1	1	2	2	2	2	1	1	1	1
Yangtsipa	2	2	2	2	2	2	1	1	1	1
Entry 35	1	1	1	1	1	1	1	1	1	1
Yangtsipa	1	1	1	1	1	1	1	1	1	1

GLS and TLB incidences were regularly monitored and the diseases were scored based on a scale of 1-5 (1-No lesions are visible; 2-Few lesion seen on two lower leaves; 3-lesions visible on most leaves below the ear; 4-

Many lesions visible on leaves above the ear and 5- all leaves dead). The husk cover is an important trait which was scored on a scale of 1-5. A score of 1 indicates good husk cover and 5 indicates open husk or poor husk cover. The new demonstration entries showed good tolerance to both GLS and TLB (Table 16) with a score of less than 3 in all the entries (Table 17). The farmers are interested to cultivate the new varieties in the coming years.

1.3.3 On-station seed production

We continued to maintain few quantities of seeds to support needy areas for maize varietal evaluation or promotion. A total of 941 kgs was produced during 2011 season. The seeds of sweet corn and pop corn are also maintained at the centre.

1.4 Grain Legumes Research

The three-year SAARC project on shuttle breeding of pulses which was started in July 2009 ended. The project was coordinated by the Indian Institute of Pulses Research (IIPR) in Kanpur under the aegis of ICAR. The project collaborators included India, Nepal and Bhutan. The overall goal of this project is to improve and sustain the rural livelihood and nutritional security through enhanced pulse production using conventional breeding techniques. The legumes that were evaluated under the SARRC project were lentil, mungbean, urdbean and French bean.

1.4.1 Lentil (Advanced Evaluation)

We continued to evaluate three improved varieties of lentil from Nepal (*Shital*, *Simal* and *Maheshwar Bharati*) in a RCBD with three replications in 12 m^2 plots. A seed rate of 50 kg per ha was used. Inorganic fertilizers of 18:46:20 kg NPK per ha was applied as a basal dose during the final day of land preparation. Weeds were controlled through mechanical means and timely irrigation was provided according to the crop demand.

Table 18: Agronomic traits of different lentil varieties in AET

Variety	50% flowering	75% Maturity	Plant Height (cm)	Yield (t/ha)
Shital	75a	119b	42a	0.66a
Simal	76a	110a	43a	0.57a
Mahesh Bharati	77b	119b	40a	0.40a
P Value	0.004	0.00	0.68	0.37

Means indicated by different letter(s) within a column are statistically significant at $P \leq 0.05$ by 95% confidence interval

There was a significant difference ($P<0.05$) in days to 50% flowering and 75% maturity but not ($P>0.05$) in plant height and grain yield. However, these varieties need to be tested in the farmer's field to assess their performance, get feedback of the farmers and reassess these varieties.

1.4.2 Advanced Evaluation of Mung Bean

Of the 12 entries of mungbean evaluated in the previous year, seven varieties were selected for advanced screening. The experimental design used was RCB, with three replications having a plot size of 12 $m^{2.}$ Inorganic fertilizer of 15:23:20 kg NPK per ha was applied as a basal dose before sowing. Hand weeding was done for the control of weeds and irrigation was not given much because of ample rainfall.

Table 19: Agronomic traits of different Mungbean varieties in AET

Variety	50% flowering	75% Maturity	Plant Height (cm)	Yield (t/ ha)
KPS 2	34a	52a	37ab	0.41ab
Bari Mungbean2	33a	50a	32a	0.40ab
HUM 12	33a	52a	35ab	0.44ab
Saptari Local	34a	52a	35ab	0.50b
Limithang Mung 2	39bc	63b	49c	0.41ab
IPM 16	37ab	66b	44bc	0.51b
HUM 16	42c	71b	34ab	0.31a
P Value	0.004	0.00	0.04	0.06

There was a significant difference in (P<0.05) in almost all the measured agronomic traits except the grain yield (Table 19) KPS 2, Bari Mung 2 and HUM 16 will be tested on farm. The yield of the improved varieties will be compared with some of the local varieties popularly grown in one mungbean growing area of the country. Since Drujaygang under Dagana geog is a major grower of mungbean, the selected varieties will be tested in the ensuing season.

1.4.3 Advanced Evaluation of Urd bean

A total of 6 entries were selected from the previous year trial and were subjected to further evaluation for yield potential, maturity and other agronomic characters using RCBD as the experimental design. Each variety was replicated 3 times in a plot size of $12m^{2.}$ Inorganic fertilizer of 15:23:20 kg NPK per ha was applied as a basal dose before sowing. Hand weeding was done for the control of weeds and irrigation was not given much because of ample rainfall. There was a significant difference (P< 0.05) in days to 50% flowering and 75% maturity but not (P>0.05) in plant height and grain yield (Table 20). The crop is relatively new to our cropping system, seed multiplication of promising lines such as IPU-2002-1, IPU-2002-2, BLG-0067-1 will be carried out in the following season.

Table 20: Agronomic traits of different Urdbean varieties in AET

Variety	50% flowering	75% Maturity	Plant Height (cm)	Yield (t/ ha)
Uttara	45d	77c	43a	0.41ab
NDU 1	44d	80d	33a	0.45ab
IPU-2002-1	32b	61a	32a	0.43ab
IPU-2002-2	39c	61a	32a	0.51b
BLG-0067-1	31b	61a	42a	0.39ab
BLG-0067-2	26a	64b	34a	0.33a
P Value	0.00	0.00	0.86	0.29

Means indicated by different letter(s) within a column are statistically significant at P ≤ 0.05 by 95% confidence interval

1.4.4 Rajma Bean

The improved varieties were tested in a RCBD with three replications. The same varieties tested in the previous season were tested this year also to see the difference of the yield. The trial was carried out in a plot size of 12 m^2. Inorganic fertilizer of 120:46:40 kg NPK per ha was applied as a basal dose before sowing. For the control of weeds, hand weeding was done.

Table 21: Agronomic traits of different Rajma varieties in AET

Variety	50% flowering	75% Maturity	Plant Height (cm)	Yield (t/ ha)
HUR 15	38d	65c	52bc	0.58ab
Arun	33ab	54b	42a	0.87ab
PDL 14	36c	67d	58c	0.48a
Utkarsh	36c	53ab	42ab	0.99b
VL-125	34b	68d	44ab	0.61ab
Local rajma	32a	52a	45ab	0.42a
P Value	0.00	0.00	0.009	0.125

Means indicated by different letter(s) within a column are statistically significant at $P \leq 0.05$ by 95% confidence interval

There was significant difference ($P<0.05$) on 50% days to flowering, 75% maturity and plant height but not ($P>0.05$) on grain yield (Table 21). Although there was no significant difference on the yield, the yields of improved varieties were better than the local variety unlike the previous year. The seeds of promising lines will be multiplied for on farm testing.

1.4.5 Legume International Nurseries and Trials

The center received two trial sets from the International legume testing program ICARDA and is mentioned below.

1. Lentil International Elite Nursery
2. Chickpea International Elite Nursery

Lentil International Elite Nursery-Yellow

The breeding lines were introduced from ICARDA. The nursery was managed in accordance with the local recommendation as the data collection manual stated. There were a total of 24 entries. Each entry was

grown in a plot size of 1 m^2. A row to row spacing of 25 cm was maintained. Weeds were controlled by normal hand weeding and two irrigations were given during the cropping period. The performance of the selected lines is given in Table **22** .

Table 22: Agronomic traits of different lentil lines from ICARDA

Name	50% flowering	Maturity days	Plant ht (cm)	Yield (t/ ha)
FLIP 2010-1L	117	176	32	0.39
FLIP 2010-7L	118	176	32	0.60
FLIP 2010-10L	119	176	40	0.40
FLIP 2010-16L	118	176	28	0.30
FLIP 2010-18L	116	176	26	0.24
FLIP 2011-2L	117	176	29	0.27
FLIP 2011-3L	122	176	29	0.27
FLIP 2011-6L	118	176	26	0.26
FLIP 2011-7L	125	176	36	0.42
FLIP 2011-9L	122	176	31	0.50
FLIP 2011-12L	126	176	28	0.51
Improved check 1	122	176	30	0.73
Improved check 2	121	176	31	0.35

Chickpea International Elite Nursery

The nursery was managed keeping in mind the local recommendations for farmers. Weeds were controlled by hand weeding and the test entries were grown in an area of 4 m^2. Four improved checks were supplied with one provision for a local check but due to the non availability of a local check, one plot was left empty. The crop however was heavily infested with pod borer. The performance of the selected lines during the first year of evaluation is listed in Table 23.

Table 23: Agronomic traits of different chickpea from ICARDA

Name	50% flowering	Maturity days	Plant ht (cm)	Yield (t/ ha)
FLIP03-26C	104	184	26	0.37
FLIP05-109C	118	182	53	0.37
FLIP05-110C	105	184	60	0.37
FLIP06-33C	111	182	54	0.34
FLIP06-39C	116	184	32	0.43
FLIP06-47	117	184	55	0.39
FLIP06-55C	116	180	42	0.36
FLIP06-59C	116	180	48	0.38
FLIP06-104C	106	182	39	0.36
FLIP06-105C	115	186	56	0.34
FLIP06-111C	120	183	56	0.33
ILC482	114	184	38	0.41
FLIP82-150C	117	184	38	0.42
FLIP88-85C	120	186	38	0.34

1.5 Oilseeds

1.5.1 Initial Evaluation trial of Mustard

We continued to evaluate six commercial varieties obtained through Indian Council of Agricultural Research (ICAR), India. The varieties were tested on station with an objective to find high yielding varieties and other superior agronomic characters that would suit our condition.

The trial was laid in a RCB design with three replications. Each variety was sown in a 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 fertilizer was supplied at the rate of 60-30-20 kg NPK per ha. The weeds were controlled via mechanical means. Two crucial irrigations were given at flowering stage and pod filling stage.

Statistics showed significant difference ($P<0.05$) in 50 % days to flowering, 75% days in maturity and plant height. However when it comes to productivity it is not significant ($P>0.05$). The yields of mustard

varieties were found out to be low during the initial years of evaluation but some higher yielding varieties like RGN 13, PBR-201, GM-2 and Shivani (Table 24) will be further evaluated in the ensuing season to see its potential.

Table 24: Agronomic traits of different mustard varieties

Variety	50% flowering	75% Maturity	Plant Height (cm)	Yield (t/ha)
Pusa Jaganath	38d	100c	129d	0.51a
RGN-13	33b	94a	122bc	0.62ab
GM-2	30b	103d	106a	0.55a
Basanti	38d	100b	126bc	0.55a
PBR-201	38d	99b	118bc	0.68b
Shivani	28a	93a	116ab	0.58ab
P Value	0.00	0.00	0.007	0.070

Means indicated by different letter(s) within a column are statistically significant at P ≤ 0.05 by 95% confidence interval

1.5.2 Evaluation of New Mustard Varieties from India

In a bid to find high yielding mustard varieties, three varieties were procured from National Seed Corporation, Siliguri India. The varieties procured were

i. Goldie Nam (yellow seeded)
ii. V 9 (yellow seeded)
iii. Sakata 555 (black seeded)

The mustard varieties were tested on farm. Sowing was done in single

large plots at Thango under Thedtsho geog in Wangdue Phodrang in collaboration with the extension staff. Crop management was done as per the farmers practice. The seeds of these mustard varieties are yellowish in colour which are mostly used for religious purposes and not so common for oil extraction. In the ensuing season, only the germplasm will be conserved and other commercial varieties will be explored for the farmers.

Table 25: Agronomic traits of the commercial mustard varieties

Variety	50% flw days	75% Maturity	Seed Color	P. Height (cm)	Yield (t/ ha)
Sakata 555	40	139	Black	130	1.60
Goldie Nam	39	125	Yellow	57	1.10
V-9	39	125	Light Yellow	55	0.64

1.5.3 Seed Production of released varieties

A total of 35 kg seeds of released varieties were maintained for future research and development uses.

HORTI-CULTURE RESEARCH

2 HORTICULTURE

2.1 Fruits and nuts

2.1.1 Passion fruit variety evaluation trial

Passion fruit is a hardy crop which yields within a year after planting. Now with the increasing unreliability of weather parameters especially the rainfall pattern, pest and disease incidence, this crop would be of farmers' choice. Both research and extension emphasize on promotion of passion fruit (*Passiflora edulis* Sims) as an alternative cash crop. Dagana and Trongsa Dzonghags have identified passion fruit as one of the products for One Geog Three Products (OGTP) approach of commercialization farming by Ministry of Agriculture and Forest. S far, Dzongkhag agriculture in the region has been promoting local passion fruit production as there is no improved passion variety identified by the research system. Therefore, the objectives of this trial were to select the superior passion fruit variety suitable for commercial farming in our conditions and to generate information for crop management practices.

The trial consisted of one improved variety introduced from Nagaland and local varieties collected from Tsirang, Wangdue and Punakha. A total of 20 plants per variety were planted at a spacing of 4m x 4m. The plants were trained in trellis system of training. The weeding, irrigation and fertilizer applications were done as appropriate for the crop. The trial was set up in 2007 at the station and is on-going.

The vine growth was very vigorous and crop showed high degree of precocity. Passion fruit started production after a year of planting. Both local and Nagaland varieties fruited in 2008, a year after planting. Both varieties have same fruit shape, purple skin and flesh color. It was observed that crop water requirement was high under Bajo conditions. Fruit shriveling and premature drop occurred under water stress condition.

Passion fruit showed very short juvenile period. Both Local and Nagaland varieties fruited in the following year (2008). The yield was found high thereby providing faster return to the investor. The characteristics such as time of flowering, fruit maturity, fruit shape and color, pulp color, yield and yield parameters such as average fruit weight, fruit length and breadth and fruit size are shown in Tables 26 and 27.

Table 26 Morphological characteristics and yield of passion fruit

Cultivar	Date of			Yield (kg/plant)		
	Flowering	First harvest	Second harvest	2010	2011	2012
Local	March	Mid June	Mid July	0.90	2.00	0.80
Nagaland	March	Mid June	Mid July	1.30	1.16	0.70

Table 27 Fruit characteristics and quality of the passion fruit cultivars

Cultivars	Shape	fruit wt (kg)	Dia (cm)	Length (cm)	Fruit colour	Pulp colour	Juice content (ml/fruit	TSS (%)
Local	Round	0.033	4.5	5.0	Purple	Yellow	2.1	15
Nagaland	Round	0.032	4.3	4.8	Purple	Light yellow	1.9	14

There was no difference observed for fruits size, shape, color and average fruit weight between the two varieties. However, Nagaland variety is a prolific bearer and juice content is higher than the local check. The taste also did not vary much between the varieties except the slight difference in aroma. As of now, no major pests or diseases incidences were observed. Initially, jackal had been a major constraint to the crop attacking fruits and destroying the vines. Regular watering was observed to induce flower and fruit almost continuously. Water requirement was found critical at the fruit set, fruit development and fruit maturity stage. This study will continue for another one year to generate adequate information and appropriate production package.

2.1.2 Pecan variety evaluation trial

The pecan nut variety trial was established in 2002. The objective of the trial was to assess and select the suitable cultivar for mid altitude region. Four pecan nut cultivars were introduced from Australia (Desirable, Wichita, Kiowa and Western Shelley), and two plants each were planted in 3m x 3m spacing. The trees were trained into modified centre leader system. The weeding, basin preparation and mulching were done as appropriate. Irrigation was done only during the dry period (winter months) of the year.

The plant started fruiting after 3 years from date of planting. However, it may take another 3-4 years to attend their full production potential. The performance parameters recorded are: precocity, yield, nut and kernel qualities, shell thickness nut size and weight, and pest and diseases incidences.

Till last year no major pests and diseases were observed except for the small incidence of trunk borer. The growth of all the cultivars was very good. Minor incidence of twig borer and scab disease was observed. An insecticide, cypermethrin was injected for the twig borer management which gave a positive result. The morphological characteristics are presented in Table 28, while the yield and nut quality aspects are presented in Table 29.

Table 28 Morphological characteristics of five pecan nut cultivars

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

Table 29 Nut characteristics and quality aspect of the pecan cultivars

Cultivars	Shape	Weight (gm)	Dia. (cm)	Length (cm)	Yield (kg/tree)					
					2006	2007	2008	2009	2010	2011
Wichita	Oblong	6.2	1.8	3.3	2.20	1.27	0.75	0.30	0.90	1.40
Western Shelley	Oblong	7.6	2.2	3.7	3.50	1.30	2.0	1.20	1.20	1.20
Kiowa	Oblong	8.9	2.6	4.9	0.35	0.80	--	--	--	--
Desirable	Oblong	6.4	2.1	3.1	0.40	0.40	0.63	0.65	0.60	1.20
Cheyenne	Oblong	6.2	2.0	3.5	--	--	--	--	--	--

Early fruiting was observed for Wichita and Desirable while Western Shelley, Kiowa and Cheyenne fruited a year later. All the varieties attained fruiting in three to four years after planting. Kiowa has the largest fruit nut size and Wichita the smallest. Western Shelley recorded the highest yield with medium size nut. However, it is too early to draw any

conclusion for this trial as plants are yet to attain their full production potential.

2.1.3 Avocado variety evaluation trial

The avocado variety trial consisting of eight introduced varieties was established in 1999. The five varieties of avocado are: Hass, Zutano, Bacon, Fuertte and Pinkerton. Later in 2004, additional 3 varieties: Shepherd, Sherwill and Reed were introduced from Australia and planted in the trial site. The main objective of this trial was to select suitable variety for homestead fruit farming in the low and mid altitude areas, and to add diversity to the fruit basket. Three trees per plants were planted at spacing of 5x5m plant to plant and row to row. The trees are trained into centre leader system. No systemic pruning is done except thinning of crowed branches and removal of dead and diseased twigs. The supplementary irrigation was done at flowering, fruit setting and during the dry period. Weeding and basin preparation were done as and when needed. The organic manures and fertiliser application was done as recommended for general production.

Table 30 Morphological characteristics and yield of different avocado cultivars

Cultivars	Tree growth	Bloom time	Harvest time	Yield (kg/tree)				
				2006	2007	2008	2009	2010
Hass	Semi-vigorous	Mid March	March	19.2	14.2	15.0	12.5	53.0
Zutano	--	--	December	58.0	30.5	40.0	47.0	62.0
Bacon	Vigorous	Mid March	December	35.0	46.5	--	65.0	125.0
Shephard	Semi-vigorous	Mid March	First fruiting	--	--	--	--	--
Reed	Semi-vigorous	Mid March	Not fruited	--	--	--	--	--

Table 31 Fruit characteristics of different avocado cultivars

Cultivars	Shape	Fruit weight (gm)	Dia. (cm)	Length (cm)	Fruit colour	Skin texture	Flesh colour
Hass	Pear shape	190	6.20	9.30	green	rough	Creamy
Zutano	Oval	480	8.65	12.96	Light green	smooth	white
Bacon	Oval	475	8.36	13.90	Dark green	smooth	white

Fuertte, Pinkerton and Sharwill did not survive under our conditions. Vigorous plant growth was observed for Bacon and Zutana but Hass was less vigorous under Bajo condition. Fruiting commenced 4 years after planting for Bacon and Zutana while Hass fruited a year later (Figure). Shepherd started flowering and fruiting in 2011 but Reed variety has not yet fruited.


Zutano


Bacon


Hass

Hass, Zutano and Bacon started flowering from mid March and ripen in the month of December except for Hass which matured in March. There was no difference in fruit size, skin colour and texture, season of ripening and productivity for Zutano and Bacon varieties. No major diseases were observed in all the varieties except die back in Bacon variety. Hass and Zutana seemed promising varieties for release thereby adding to the fruit diversity of our country. However, Zutano exhibited alternate bearing habit.

Bacon and Zutana had similar fruit characteristics and fruit ripened at the same time in December. But Zutano showed alternate bearing characteristics. Hass is late maturing variety (March of the following year) and can persist on tree for longer duration (approximately 4 months) after

maturity. Technology Release Committee (TRC) approved for the release of Bacon and Hass for general cultivation. The trial will be terminated on station although on-farm assessment will be continued in different agro-ecological zones.

2.1.4 Persimmon variety evaluation trial

The persimmon variety evaluation trial was established in 2003. The persimmon varieties were introduced from Nepal through JICA project, RNRRDC-Wengkhar and they are: G-Fuyu, P-HG, Z-Maru, Z-Fuyu P-Jiro and G-Jiro. The objective of the trial was to identify the appropriate varieties and provide alternative variety options for the persimmon growers as the existing persimmon varieties are processing or astringent type. The single plot design was followed for the trial layout with three plants for each treatment and plants density was maintained at 4m x 4m. No systematic pruning was done. The removal of dead wood and the thinning of over-crowded and misshaped branches were done as and when needed. Supplementary irrigation was provided in the dry season particularly in spring or at the time of flowering. Weeding was done as and when needed. Basin preparation was done twice, once in spring and another in the autumn after the crop was harvested and fertilizer application and mulching followed immediately. FYM was applied in winter and varying dose of chemical fertilizer appropriate to the size or age of the tree was applied in the spring prior to flowering. Performance parameters such as vegetative growth, precocity, cropping habit, fruit quality, yield and pests and diseases incidences were studied and are presented in Table 32 and Table 33.

Table 32 Morphological characteristics of five persimmon cultivars

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

Table 33 Fruit characteristics and quality of persimmon cultivars

Var	Shape	Fruit weight (gm)	Dia. (cm)	Length (cm)	Yield (kg/tree)				
					2007	2008	2009	2010	2011
Z-Fuyu	Flat	150	7.01	4.5	1.2	1.4	4	2.8	8.5
P-Jiro	Flat	125	6.9	4.6	0.5	0.65	3.6	4.6	8.0
G-Fuyu	--	--	--	--	--	--	--	--	--
Z-Maru	--	--	--	--	--	--	--	--	--
P-Hg	Flat	250	5	3.75	0	0	3	2.6	4.0
G-Jiro	--	--	--	--	--	--	--	--	--
Sorrento	oval	--	--	--	--	--	--	--	--

Under Bajo climatic condition the plant growth was slow and stunted. The climatic factors and the soil condition may be reason for slow growth of the plants. Two persimmon cultivars, Z-fuyu and P-jiro had started bearing fruit by 2007 and P-Hg fruited from 2009 while remaining varieties have not yet fruited. The three varieties- Z-fuyu, P-jiro and P-Hg have orange flesh color, non-astringent or table type varieties with smooth pericarp texture. We have not observed major pest and diseases as of now, except the birds' damages at maturity. The trial will be continued for another 2 years to enable vigorous identification of most suitable variety.

2.1.5 Walnut varietal evaluation

Walnut is one horticultural crop with huge potential in Bhutan due its good keeping quality and high quality poly unsaturated fatty acids. Soft shell walnut has been cultivated from very early days in Bhutan and the wild hard shell walnut is found within the altitude range of 1500 to 2700m. Similarly the soft shell walnut is also commonly found within this altitude range. With the change in climatic parameters such as rainfall and winter temperature, it is imperative to have some variety suitable for cultivation in lower elevations as well. Therefore, 19 walnut varieties are evaluated at the center. The trial includes both introduced (5 varieties) and local selection (14). The trial was established in the year 2007. Out of 19 varieties under evaluation, 6 varieties fruited since 2010. The varieties fruited at Bajo condition as shown in Table 34.

Table 34: Walnut varieties with their observed characters

Catagory	Varieties	Kernel quality	Shell Thickness
Introduced	Payne (indicator)	Good	Thin
	Chandler	Very good	Thin
	Vena	Good	Thin
Local	B3	Ok	Thin
	B5	Good	Thick
	B15	Good	Thick

All the introduced varieties were superior in quality than local cultivars. Chandler was observed with very good quality whole kernel. The fruits of B5 were mostly with three sides. The different walnut fruit evaluated are as shown below in Figure 1.

Figure 1 Different walnut cultivars fruited at Bajo condition

The kernel quality keeping quality and kernel color of 3 diffferent cultivars are as shown in the figure above.

On-going variety evaluation trials

The fruits and nuts variety evaluation trial not in reporting stage are:
Citrus rootstocks-scion compatibility trial
Citrus varietal evaluation
Kiwifruit variety evaluation
Loquat production evaluation
Japanese pear variety evaluation
Mango variety evaluation
Litchi varietal evaluation
Banana varietal evaluation
Strawberry production evaluation

2.2 Vegetables

2.2.1 Evaluation of Late Blight Resistant (LBR) tomato lines

The evaluation of different yield parameters for different tomato resistant lines in terms of marketable yield depicted that LBR-17, LBR-11, LBR-9 and LBR-7 would be of potential for further studies against late blight during initial evaluation in 2010. Therefore, LBR tomato lines were assessed for yield performance in 2011. The seeds of different lines were sown in nursery by may end and transplanted by last week of June, 2011, at vegetable research plot of RDC-Bajo. Popular local varieties Roma and Ratan were used as check. A total of 20 plants were planted in each bed. RCB design was followed with three replications. Recommended management practices were followed. The resistant lines from AVRDC are: LBR-6, LBR-7, LBR-9, LBR-10, LBR-11, LBR-16 and LBR-17. The data was collected for yield (ton/ha), fruit length (cm) and fruit diameter (cm). The variations in yield parameters are as shown in figure below.

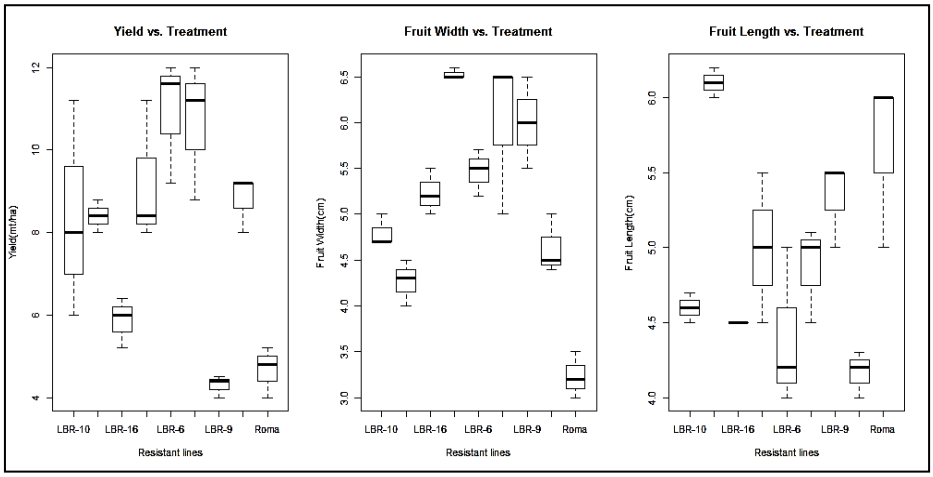


Figure 2 The variation in yield (t/ha), fruit width (cm) and fruit length (cm)

Table 35: Performance of late blight resistant tomato lines

Resistant lines	Yield(t/ha)	Fruit Width(cm)	Fruit Length(cm)
Roma	4.7 a	3.2 a	5.7 de
LBR-9	4.3 a	6.0 ef	5.3 cd
LBR-11	8.4 b	4.3 b	6.1 e
LBR-16	5.9 a	5.2 cd	4.5 ab
LBR-17	9.2 b	6.5 e	5.0 bc
LBR-10	8.4 b	4.8 bcd	4.6 ab
LBR-7	10.7 b	6.0 ef	4.9 bc
LBR-6	10.9 b	5.5 de	4.4 ab
Ratan	8.8 b	4.6 cd	4.1 a
F-values	9.729**	20.166**	1.222**

Statistically a significant difference was observed among all lines for yield, fruit width and fruit length. All the seven resistant lines showed some degree of resistance to late blight under Bajo condition. LBR-6 gave the highest yield (10.9 t/ha) followed by LBR-7 (10.7 t/ha). LBR-17 and LBR-7 consistently gave higher yield among others for two years (2010 and 2011).

2.2.2 Effect of different organic sprays on the aphids on broccoli

Organic farming is quite recent in Bhutanese agriculture system with inadequate information for crop husbandry especially in controlling the pests and diseases. There are several commercial bio-pesticides that claim to control pests and diseases on a wide range of crops. Thus, this particular experiment investigated the efficacy of locally prepared biocides (wood vinegar and liquid manures) and a commercial organic certified biocide against aphid on broccoli.

Following formulations were used: (i) Wood vinegar produced from Quercus griffithii (hard-wood) through a pyrolytic process in a locally constructed kiln (ii) Commercial bio-pesticide (LASTRAW) (iii) Jeevatu bio-agent sourced from NFI through ZECS project and (iv) Neem oil as shown in Table 36.

Table 36: Different organic srays and their formulation

Treatment	Rate of application	Source
Wood vinegar	1:200 ratio dilution in water	Prepared locally at RDC-Yusipang
Lastraw	5ml/Ltr water	Provided by Pest Control India Pvt Ltd (India)
Jeevatu	1:4 (JLM : Water)	Provided by Nepalese Farming Institute (Nepal)
Neem oil	1.5ml/1 ltr of water	Prepared locally at RDC-Yusipang from local plants
Control	without use of any pest control measure	

The study was laid out in RCB design with four replications in the year 2011 at the center. All the other practices were followed as appropriate for each treatment. Data was recorded for the number of nymph, eggs and the severity and means were compared using one way ANOVA as shown in Table 37.

Table 37: Effect of different organic formulations on broccoli aphid

Treatment	No. of nymph	Severity
Wood vinegar	1.4 b	1.4 b
Lastraw	0.4 a	1.5 ab
Jeevtu	0.8 a	1.1 ab
Neem oil	0.3 a	0.8 a
Control	0.5 a	1.4 b
p-value	0.04	0.03

Means with the same letter within a column do not differ significantly at 0.05 level.

There was statistically a significant difference for number of nymph ($p< 0.05$) and the severity ($p< 0.05$) of the chili assessed. Neem oil was found effective in controlling aphids both in terms of severity and the number of nymph followed by Lastraw. On the other hand, no effect was observed with for wood vinegar and jeevatu. No difference in effect was observed for number of egg.

2.2.3 Advance evaluation of high β-carotene tomato lines

The characteristics strong red-orange coloration of tomato is because of β-carotene. AVRDC has developed new lines of tomato with high β-carotene content. They provide rich source of vitamin A (3-4 times) higher than normal tomato on average. Therefore, six high β-carotene lines were introduced and evaluated for yield performance at mid altitude region of Bajo. Initial assessment on these lines (2010) has shown that CLN2070A, CLN2366A and CLN2366C were promising in terms of yield performance. However, the experiment was repeated in 2011 with high B-carotene lines to observe the consistency in yield performance. Ratan, the popular variety was used as a check.

Statistically, significant difference was observed for all the variables. CLN2366C and CLN1214G had the highest yield of 16.3 t/ha (Table 38) and followed by CLN2366A(11.2 t/ha) and CLN2366B (11.1 t/ha).

Table 38: Characteristics evaluated for high Beta-carotene tomato lines

Entries	Yield (t/ha)	Fruit width(cm)	Fruit length(cm)
Ratan	7.9 b	5.0 c	3.7 b
CLN2070A	4.4 a	3.1 a	2.5 a
CLN2071C	5.9 a	2.9 a	2.8 a
CLN2366A	11.2 c	3.9 b	4.2 bc
CLN2366B	11.1 c	4.0 b	4.7 c
CLN2366C	16.3 d	4.3 b	4.6 c
CLN1214G	16.3 d	4.4 b	5.4 d
F-value	65.556**	22.698**	22.209**

Means with same letters within column do not differ significantly.

In summary, among high β-carotene tomato lines, unlike last year's result, CLN2366C and CLN2141G gave higher yield. Further assessment of high yielding lines will be continued in the coming season.

On-going variety evaluation trials

The vegetable variety evaluation trials that are on-going during the reporting time are:
Sweet pepper variety evaluation trial
Egg plant variety evaluation trial
Cucumber variety evaluation trial

Outreach Program

2.2.4 On-farm asparagus production

Asparagus production was initiated in Tshokothang, Taksha, Silli and Tsara in 2006. It was a collaborated activity with Wangdue Dzongkhag, Agriculture sector. The objective of activity was to study feasibility of asparagus production as a cash crop and to demonstrate asparagus cultivation practices to the farming communities. Asparagus cultivation practices were demonstrated by selecting one farmer from each village and by giving hands-on training to communities as per the crop stage. Crop in Taksha and Tsara could not be harvested due to heavy damage caused by cut worm. Also there was major red ant problem in Tsara. In Tshokothang crop was harvested since 2008. Data on total yield and the price (Table 39) of asparagus in the market were collected.

Table 39: Total yield and price of asparagus in the market of year wise

Year	Total yield (bundle)	Price in the market (Nu)	Total income (Nu)
2008	280	30	8400
2009	364	35	12775
2010	300	35	10500
2011	450	50	22500

2.3 Medicinal aromatic plants

2.3.1 Asparagus provenance trial

Wild *Asparagus racemosus* is found growing right from 200-2150m. In Bhutan there are three prominent wild *Asparagus* species found growing naturally ranging from tropical to subtropical forest in the north (Noltie, HJ Flora of Bhutan volume III, part 1). This plant can grow well in various soil conditions without much change in the morphological appearance even though it prefers sandy well drained soil.

It is one of the highest value vegetable crops in local market fetching higher price than cultivated species. However, current system of harvesting wild asparagus from its natural habitat is not only seen as unscientific but also unsustainable. Therefore, exploratory survey was carried out to collect and evaluate the wild asparagus from different locations within a region. Besides, the study is focused on domestication of these wild species and to generate appropriate technology for cultivation and maintaining of wild asparagus germplasm in the center.

The passport information about the accessions was gathered through the reconnaissance survey and informal oral interview with local people. The area was selected based on preliminary survey: availability of wild species in that particular location. The accessions were collected from Sunkosh, Tshokana, Yusowom, Yusogom Toebe Rongchu, Gasatshowom, Tsakaap and Kabesa. The seeds were sown in the nursery at RC, Bajo. The soil conditions and natural habitat was replicated to near natural condition (wild habitat). About 90% of the plantings have survived and they are still to establish. No major problem of pest and

disease was observed as of now. Data collection will begin from the coming season.

2.3.2 Zanthoxylum provenannce trial

Zanthoxylum is a deciduous shrub growing up to 4m. The flowers are dioecious (individual flowers are either male or female, but only one sex is to be found on any one plant so both male and female plants must be grown if seed is required). The plant not is self-fertile.

There are nine *Zanthoxylum* species found growing naturally in Bhutan (Flora of Bhutan Volume II part I). Among those species, *Zanthoxylum armatum* (locally called Zhung-thing, Dzongkha, Song-gee in Sharchupkha and Heerpo-Chawa in Kheng kha) are predominantly used as spices and condiments in the Bhutanese home. Another *Zanthoxylum* species *acanthopodium* and *bungeanum* which are being used as spices and condiments to flavour Thups and noodles in Bhutanese home (called Menche-thigngey in Dzongkha, Khai-gee in Sharchup kha and Nam-Chawa in Kheng kha). It is found growing in the forest of an altitude range 250 to 3500 meter above sea level in the Himalayas.

The seeds and the bark are used as an aromatic tonic in the treatment of fevers, dyspepsia and cholera. The fruits, branches and thorns are considered to be carminative and stomachic. They are used as a remedy for toothache. No study as of now has been initiated on the wild and cultivated Zanthoxylum species or land races in the country, although it has been an important spice used for most of the Bhutanese delicacies. This study aimed to document wild and cultivated Zanthoxylum species and land races, identification of potential land races suitable for commercial cultivation as a cash crop. The findings can also be used for strategic planning for biodiversity conservation and sustainable utilization.

The seeds were stratified and sown in green house in early months of the year and germinated in late spring. The seedlings were transferred into individual pots. The seedlings were transplanted in early summer. The plant survival percent is very high. The suckers were removed in late winter. Currently, seedlings are in vegetative growth stage. Yield data will be collected as soon as it starts giving economic yield.

2.4 RDSC-Tsirang for horticulture sector

2.4.1 Citrus rootstock-scion compatibility trials

The citrus root stock compatibility trial was established in July 2008. The planting was done in single plot design with the 4mx4m spacing plant to plant. The trial was planted coinciding with raining season and did field grafting after plantation of rootstocks. The local mandarin scion wood was collected from identified selected trees in Tsirang Dzongkhag. The local mandarin was grafted on 6 varieties of citrus escorted root stock and the trial consists of 30 plants in total. The objectives of this experiment is to identify suitable root stock compatible to local mandarin and evaluate fruit quality of different combination of scion- root stock varieties (Table 40).

Table 40 Detail of rootstocks and number of plants

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

No major insect pests and diseases are observed but animal damage specially deer is the main problem in winter. The growth of plants is quite poor although appropriate management was followed. The slow growth may be due to cold as the centre falls slightly higher than the citrus growing zone.

2.4.2 Citrus variety evaluation trial

The citrus variety trial was established in June 2008. The single plot design was used for lay out of the trials. There are 5 plants per variety with the spacing of 4m x 4m from plant to plant. The performance parameters of citrus varieties such as plant growth, phenological stages, fruits quality and yield aspects, market acceptance and pest and diseases incidences will be assessed. Standard citrus management husbandry and supplementary irrigation in late autumn and spring season is adopted for all varieties. As of now, the plant growth is good and no major pests and

diseases were observed except deer damage during the winter. The objective of the trial is to identify the appropriate citrus cultivar for the dry and wet subtropical ecological zone of west-central region.

Table 41 Citrus type and varieties

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

2.4.3 Citrus rootstock production block

The citrus root stock block was established in July 2008 in Tsirang Research Sub-Centre. It was laid out in single plot design with the spacing of 3x3m plants to plant 3x3m row to row. The block consists of 30 plants. 5 plants each in 6 varieties of rootstocks was used namely Cleopatra, Volkamariania, Troyer, Carrizo, Ranpur lime and local rootstock were planted. The objective of this study is to generate citrus root stock from greening free area and produce root stock in sufficient quantity for our region.

The growth of plants seems good compared to grafted saplings. No Major pests and diseases observed except powdery mildew in local rootstocks. From this year Rangpur lime started fruiting on 2 plants.

2.4.4 Pear variety evaluation trial

Most farmers in Tsirang grow 2 to 3 plants of pear near their house. It is also one of the cash crops in high altitude where the growing of mandarin is not suitable. The farmers usually grow local pears that are not very delicious as improved pears. Therefore, to enhance the crop quality, the pear variety evaluation trial was established in 2007 in the centre to evaluate and study varieties suitable for the location.

The grafted saplings were brought from RDC Bajo. Single plot design was followed for layout with 4 plants in each of Nitake and Chojuro varieties and 8 plants of Flemish beauty. The trial consists of 16 plants in total planted with a spacing of 4x4m. The plants were pruned to modified centre leader system. Supplementary irrigation was done in dry season. Weeding and basin preparation was done as and when needed. For all the varieties, equal amount of FYM and recommended doses of chemical fertilizer appropriate to the age of the trees prior to flushing of the leaves and top dressing with urea during autumn were done.

Until now no major diseases observed but white grub is causing most damages in all varieties near the collar region, fiber roots and as while as tap roots which lead the plants to death. The damages are more during the months of September and October. Two plants each of Chojuro and Flemish beauty started to fruit from this year.

2.4.5 Persimmon varietal evaluation trial

Persimmon is actually a new fruit in Tsirang farmers. Therefore RDSC Tsirang established the persimmon trial with the objective to study the feasibility and evaluate the quality of the fruits in Tsirang. The trial was established in 2007 with the local persimmon rootstock (astringent type). In 2009 improved non- astringent variety, Fuyu variety was grafted on local rootstocks. The trial consists of 15 plants. The trial was laid out maintaining 4x4m spacing. The plants were pruned and trained to centre leader system. Supplementary irrigation was provided in the dry season particularly during flushing and flowering period. Weeding was done as and when needed to control the weeds. Basin preparation is done as and when needed with mulching in dry season. The amount of recommended FYM was applied in winter and varying dose of chemical fertilizers

appropriate to the age of the tree were applied in the spring prior to flowering and top-dressing of nitrogen fertilizer was done in autumn.

The growth of the plants seems to be quite slow; it may be due to cold. No major pests and diseases were observed except for minor incidence of beetles. Adults feed on the upper surface of foliage, chewing out tissue between the veins. This gives the leaf a lacelike appearance if timely spray was not done.

2.4.6 Kiwi variety evaluation trial

The kiwi variety trial was established in 2007 in RDSC, Tsirang. The trial consists of 15 plants with 3 plants in each variety. Three varieties namely Thimphu 1, Thimphu 2 and Thimphu 3 were planted with the spacing of 5x5m. Kiwi plants are trained to permanent framework adopting pergola system.

The growth of the kiwi plant seems quite poor although with 4 years of growing period. The plant started fruiting only from last year in Thimphu 1 variety. Since it is the first year of fruiting with limited fruit, data could not be collected. The kiwi fruit in Tsirang condition matures in last week of October. Until now no major pests were observed except for white grub damaging tap roots, fibrous roots and collar regions.

2.4.7 Maintenance of released fruit and nut cultivars

The released fruit and nuts cultivars block was established in 2006 with the spacing of 3x3m. The block consists of 8 varieties of released fruit and nuts cultivars with 5 plants each. The varieties are avacado, promogranate, peach (July Elberta & Shani Punjab), Pear (Flemish beauty), Apple (Anna), Walnut (kanthal selection and B15). In total the block consist of 40 plants.

The released fruit and nuts cultivars block was established with the objective to collect scion for nursery grafting and for top working in the region. Both the varieties of peach (July Elberta and Shani Pubjab) have started fruiting from 2008. For top working peach and pear for interested farmers, scion wood was collected from the centre. The growth of pomegranate is very poor and seems to be not suitable for Tsirang condition. The growth of other varieties is also affected because of wild

animal damage. Now we have initiated individual fencing of plants. The walnuts have been grafted this year with 2 varieties and growth is good.

2.4.8 Top working of improved fruit on local varieties

Although mandarin is the main cash crop for Tsirang in general but in some villages mandarin cannot be cultivated. Therefore to support those farmers to earn some cash income, the RDSC Mithun has top worked their local pear, peach, apricot and walnut rootstock with improved scion wood. The scion wood for top working had been collected from fruit and nuts block of the centre and from RDC Bajo. The local ones are sour in taste, small in size, poor eating quality and therefore there is no demand. In case of walnut farmers usually cultivate only hard shell walnut and we did top working of soft shell in 2009. The top working was carried out in the last week of January 2009 in 8 villages under Shemjong, Rangthangling, Tsolingkhar and Dunglagang geogs. The total nos of pear top worked was 93 trees, 83 peach, 36 apricots, 12 sub-tropical apple and 2 walnut. After the top work regular monitoring is done. So far no major pests and diseases were observed. The growth of top worked tree is good in all villages and started fruiting from this year.

2.4.9 Powdery mildew spray trial in Gosiling geog

The powdery mildew spray trial in citrus orchard was conducted in Gosiling geog in collaboration with NPPC and horticulture division in 2010. The protocol was developed by Horticulture division. The trial was conducted in one of the commercial orchards. The objective of the trial is to compare the effectiveness to control powdery mildew in citrus using Sulphur dust, Oil and water in different time intervals. The trial was laid out with single block design with 5 treatments and 4 replications/trees (Table 42). For assessment, 10 branches from each replication were selected and tagged. The assessment was done for 6 weeks.

Table 42 Spray materials at different rate and time

Treatment	Product	Rate (%)	Timing between sprays	Total no. of sprays
T1	Sulphur	0.3	Weekly	6
T2	Sulphur	0.3	Fortnightly	4
T3	Oil	0.5	Once a week for 3 weeks	3
T4	Oil	0.5	Every 2 weeks for 6 weeks	3
T5-Control	Water		weekly	6

The spray trial was done when 20% of trees reached shoot emergence. To achieve consistent coverage of top and bottom of leaves, pointing spray nozzle towards tree and applying from top of tree in a downwards motion and repeating the process was done.

Table 43 Assessment criteria

Assessment categories	Category	% Infection
	1	Nil
	2	1-25% (0.1-2.5 shoots)
Leaf infection	3	26-50% (2.6-5 shoots)
	4	51-75% (5.1 – 7.5 shoots)
	5	>76% (> 7.5 shoots)
Twig dieback	Yes/No	--
Defoliation	Yes/No	--

2.4.10 Breeder Seed Maintenance

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

Table 44 Breeders seeds maintained

Crop	Variety	Quantity produces(kg)
Radish	Bajo Laphu(45 days)	1.100
Radish	tokanish	1.000
Broccoli	disico	1.200
Beans	RNRRC dwarf	2.000
Beans	Top crop	12.000

2.4.11 Nursery management and plant propagation

The RDSC Tsirang maintains and propagates citrus saplings in the nursery. Following different citrus rootstocks and grafted saplings are maintained in the centre.

Table 45 Rootstocks and number of seedlings produced

Variety	Nos. of seedlings produced	Nos. of grafted saplings	Supplied to
Troyer rootstocks	4500	--	The grafted planting materials are used for establishing on-farm demonstration and on-station research trials.
Carrizo rootstocks	50	--	
Trifoliate rootstocks	800	--	
Local mandarin rootstocks	1000	--	
USDA rootstocks	350	--	
Teishu ponkan grafted		200	
Otha ponkan grafted		150	
Local mandarin grafted		650	

LIVESTOCK RESEARCH

3 LIVESTOCK

3.1 Effect of improved management on honey production

This is a collaborative activity with RDC Jakar with trial sites at Thakorling and Pashaling in Tsirang, and Goshi and Tshendengang geog in Dagana Dzongkhag. The trial was established in 2009 with the objectives to:

- Compare honey production of indigenous honey bees managed in traditional and improved hives
- Study absconding habits and measures to curtail it.
- Understand cost benefit ratio of keeping bees in traditional and improved hives and
- Select queen/colonies with higher yield and are not frequent migratory for further research.

In Tsirang, a total of 110 bee hives were made and set for trials at different sites. It was observed that only 55 hives were occupied by a bee which is only 55% occupancy. A similar number of log hives were found to have been inhabited by bees at these sites indicating that bee's preferences for log and improved hives are not very different. However, only 21 hives were available for harvest in 2011-2012 which shows an absconding percentage of about 62. Observations reported by farmers in the site indicate that rate of absconding is higher from the improved hives than from local log hives. This could be because the improved hives have more open space to which the bees are not used to, and thus facilitating their escape. The average honey production per improved hive/colony was on average 2.82 kg.

Similarly, 114 improved bee hives were made and set for trial at different sites in Dagana. Of these only 23 hives were inhabited with occupancy percent of about 20. However, there were only 9 harvestable hives. The absconding rate was 61%. The average honey production per hive at the site was about 2 kg. Overall, these observations indicate that occupancy rate in improved hives differs with site while absconding rate and honey production was similar at both sites. With the training farmers availed on queen grafting and colonies multiplication, it is expected that number of colonies would be increased in the coming years.

3.2 Study of bee floras in Bhutan

The value of the beekeeping has been observed in many parts of the world. While adequate knowledge on bee keeping is a prerequisite to make bee keeping a successful venture, there are other factors that will decide the success in beekeeping. Of these, the accessibility of bees to the flora is a primary factor. Bees obtain nectar and pollen from the flowers. However, plant types and their flowering duration differ from one place to other due to variation in topography, climate and farming practices. The extensive information on type, density and quality of the bee flora in region are requisites for successful bee keeping. This study was conducted as a nationally coordinated activity with following objectives:

- To prepare an inventory of bee flora and develop floral calendar
- Understand the honey flow and floral dearth period (s) of short or long duration
- To enable beekeepers to utilize them at the maximum level, so that, they can harvest a good yield of the honey and other bee produces

The study sites were Goshi and Tsendengang geogs in Dagapela under Dagana Dzongkhag and Pashaling, Kikhorthang and Dunglagang Geogs under Tsirang. This study was carried out through household interview and monthly field visits/inventory.

A survey questionarie was prepared comprising mainly of common and local names of the different flowering plants of the selected geogs, their flowering season and duration, habit, nectar or pollen yielding ability and their abundance in the area. Information was collected mainly through farmer interviews. Field visits were made to identify and confirm the bee foraging plants. Bee foraging plants were marked and monthly observations were made during the flowering season. The observations on nectar and pollen source were recorded based on activities performed by honeybees on different flowers. In addition, a bee flora calendar was developed based on the following steps.

1. We made a general survey of the area to draw up a list of flowering plants found in the area with special attention being paid to plants with high floral population density/unit area/ tree.

2. Then we placed some honeybee colonies in the area and monitored the hives for food stores in surveys areas and in the vicinity of the apiary and within the flight ranges of the bees (approx 1 km radius), This was done to record species of the plants that bees visit.
3. Then we recorded all the changes in the blossoming plants and the weather.
4. Then we took note of when bee colonies migrate, swarm and abscond the hives.

Table 46: Bee Floral Calendar of Pashaling geog of Tsirang

Plant species[a]	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Mustard	0	0	1 n	2 n	3 n	3 n	3 n	2 n	2 n	0	0	0
Sag	0	0	0	0	1 n	1 n	3 n	2 n	0	0	0	0
Pear	0	0	0	0	0	0	0	2 n	3 n	0	0	0
Plam	0	0	0	0	0	2 n	3 n	2 n	0	0	0	0
Peach	0	0	0	0	0	2 n	3 n	1 n	0	0	0	0
Panyu Katush (big)	0	0	0	0	0	0	0	0	0	1np	3 np	1np
Kharaney	0	0	0	0	0	0	0	0	0	2 n	3 n	1 n
Musharey Katush	0	0	0	0	0	0	0	0	0	3np	2 np	0
Wild Avocado	0	0	0	0	0	2 p	2 p	0	0	0	0	0
Tree Tomato	3 n	1 n	1 n	0	0	0			1 n	1 n	2 n	2 n
Passion fruit	3 np	2np	2np	1np	0	0	0	0	0	1 n	2 n	2 n
Sisi fall	1 n	0	0	0	0	0	0	0	0	0	0	2 n
Thotray	2 p	0	0	0	0	0	0	0	0	0	0	1 p
Maize	3 p	0	0	0	0	0	0	0	0	0	1 p	2 p
Dadura	3 np	1np	0	0	0	0	0	0	0	2np	2 np	3 n

[a] Bee foraging plant species

Legend: Low = 1, Medium = 2, High = 3, n = Nectar, p = Pollen, np = Nectar + Pollen

Table 47 : Bee Floral Calendar of Kikhorthang geog of Tsirang

Plant species[a]	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Mustard	0	0	0	0	0	0	0	2 n	2 n	2 n	0	0
Sag	0	0	0	0	1 n	1n	3 n	2 n	2 n	0	0	0
Pear	0	0	0	0	0	0	0	2 n	3 n	0	0	0
Plam	0	0	0	0	0	2 n	3 n	2 n	0	0	0	0
Peach	0	0	0	0	0	2n	3n	1 n	0	0	0	0
Panyu Katush (big)	0	0	0	0	0	0	0	0	0	1 np	3np	1np
Kharaney	0	0	0	0	0	0	0	0	0	2 n	3 n	1 n
Musharey Katush	0	0	0	0	0	0	0	0	0	3 np	2 np	0
Wild Avocado	0	0	0	0	0	0	0	0	0	0	0	0
Kalo seriws	0	0	0	0	0	0	0	0	0	2 p	3 p	1p
Tree Tomato	1n	1n	0	0	0	0	0	0	0	0	2 n	2 n

Passion fruit	2 n	2 n	0	0	0	0	0	0	0	0	1 n	2 n
Sisi fall	0	0	0	0	0	0	0	0	0	0	0	0
Thotray	0	0	0	0	0	0	0	0	0	0	0	0
Maize	3 p	2 p	0	0	0	0	0	0	0	0	0	2 p
Dadura	3np	2np	0	0	0	0	0	0	0	1 np	2 np	3np
Bottle brush	1np	0	0	0	0	0	0	0	1np	3n+	3n+	3n+
Orange	0	0	0	0	0	0	0	1np	2np	2np	0	0
Ornamentental florwers	2np	2np	2np	1np	0np	0np	0np	1np	1np	2np	2np	2np
Jakaranda	2np	0	0	0	0	0	0	0	0	0	1np	3np
Pumkin	2p	2p	2p	0	0	0	0	0	0	0	1p	2p
Cucumber	2p	2p	0	0	0	0	0	0	0	0	1p	2p
Arachis pintoi	1np	0	0	0	0	0	0	0	0	1np	3np	3np

[a] Bee foraging plant species

Legend: Low = 1, Medium = 2, High = 3, n = Nectar, p = Pollen, np = Nectar + Pollen

Table 48 : Bee Floral Calendar of Dunglagang geog of Tsirang

Plant species[a]	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Mustard	0	0	1 n	2 n	3n	3n	3n	0	0	0	0	0
Sag	0	0	0	0	1n	1n	3n	2n	0	0	0	0
Pear	0	0	0	0	0	0	0	2n	3n	0	0	0
Plam	0	0	0	0	0	2n	3n	2n	0	0	0	0
Peach	0	0	0	0	0	2n	3n	1n	0	0	0	0
Panyu Katush -big	0	0	0	0	0	0	0	0	0	1np	3np	1np
Kharaney	0	0	0	0	0	0	0	0	0	2n	3n	1n
Musharey Katush	0	0	0	0	0	0	0	0	0	3np	2np	0
Wild Avocado	0	0	0	0	0	0	0	0	0	0	0	0
Tree Tomato	1n	1n	0	0	0	0	0	0	0	0	2n	2n
Passion fruit	2n	2 n	0	0	0	0	0	0	0	0	1n	2 n
Banana1	1n	1n	1n	1n	1n	0n	0n	1n	1n	1n	1n	1n
Mango	0	0	0	0	0	0	0	0	2 p	3p	0	0
Maize	3p	2p	0	0	0	0	0	0	0	0	0	2p
Sweet buck wheart	0	0	0	1p	3p	3p	0	0	0	0	0	0
Dadura	3np	2np	0	0	0	0	0	0	0	1np	2 np	3np
Gogan					1n	1n	0	0	0	0	0	0

[a] Bee foraging plant species

Legend: Low = 1, Medium = 2, High = 3, n = Nectar, p = Pollen, np = Nectar + Pollen

3.3 Maintenance of live herbarium

Live herbarium is to showcase the different improved fodder species to all visitors to the centre. In addition it also caters to the demand for seeds and seedling or fodder planting materials. The live fodder herbarium was established in 2007 at RDSC Tsirang. Currently, RDSC Tsirang maintains about nine grasses species which are suitable for intermediate or upper

sub-tropical zone. RDC Bajo maintains about 18 legumes and 26 grass species and six most promising hedge legumes species.

At RDSC Tsirang, there are 10 most promising grasses. These are *Andropogan gayanus, Paspalum atratum, Paspalum dilatatum, Setaria sphaceleta, Panicum maximum, Brachiria brizantha, Brachiria decumbent, Brachiria ruzizensis, Milinis minutiflora* and *Chloris gayanus* maintained in the herbarium blocks. This activity will also be continued.

3.4 Propagation and maintenance of promising fodder species

The main objectives of propagating and maintaining promising fodder species are to produce basic planting materials either in the form of root slips, cutting and seeds for fodder production, and rehabilitation of degraded farm land. The propagated planting materials are supported to different Dzongkhags on demand for the extension purpose (Table 49). In addition, 225 kg of oat seed was also maintained for further promotional or demonstration related activities.

Table 49 : Different species of planting materials supplied

Species	**Quantity (**slips)	**Beneficiaries**
Pennisetum purpureum	14,500	Punakha, Wangdue & Tsirang
Tripsacum laxum	3,800	Tsirang & Wangdue
Chrysopogon zizanioides	2,500	Tsirang & Punakha
Paspalum atratum	2,500	Tsirang & Punakha
Bracheria brizantha	1,200	Tsirang
Ficus Oruculatus (seedlings)	631	Tsirang & Wangdue
Panicum maximum	300	Tsirang
Andropogan gayanus	200	Tsirang
Brachiria brizantha	1,200	Tsirang
Saccharum officinarum	230	Tsirang
Setaria sphacelata	200	Tsirang

3.5 Promotion of promising fodder species for soil conservation and fodder production

One of the households at Sunkosh village is located in a sloppy area which is highly prone to erosion. Due to lack of manpower, the farmer carries minimal land management activities. Given the practical impact of land

management on livelihood, and the threat to his occupancy, a need was felt to develop the land. Contour lines were made with A frame, and different grasses (Napier, Vetiver, *Paspalum atratum*), shrubs (*Flemingia macrophylla*) and fodder tree legumes (*Leucaena diversifolia*, *Leucaena leucocephala* and *Desmodium cenarea*) were planted along the contour lines in form of seeds or slips. The distance between the contour lines was made based on the slope gradient. Apart from conserving the soil from erosion, these planting materials will also be the source of fodder for his livestock. The performance of these species will be periodically monitored.

Taking the advantage of the land management, it is also planned that the spaces between contours be used for vegetable and cereals production. The crop cultivation will supplement the farmer in vegetable and food production for daily consumption.

FORESTRY RESEARCH

4 FORESTRY

4.1 Community Based Capture Fisheries Management in Hara Chhu

RNR-RDC Bajo in collaboration with Department of Livestock (DoL), RNR sector of Wangdue Dzongkhag and JSWNP formed the Hara Chhu Captures Fisheries Management Group in 2010. A management plan was accordingly developed and the management was handed over to the Adhang geog communities.

Adhang *Geog* comprises of seven *Chiwogs*, amongst which, Rukha, Samthang, Lawa, Lamgang and Metena are traditionally dependent on fishing from Hara Chhu. These chiwogs were considered while forming the Harachhu Capture Fisheries Management Group (HCFMG) mainly for their livelihood and household nutrition. There are 72 beneficiaries (households) from Hara Chhu. In the year 2010 – 2011 the communities harvested around 1157 kg fish as per the prescribed management plan.

The community is best known for *Nya-Doesem* (smoked fish). In the past the well-being of the community mainly depended on the success of seasonal fish harvest from Hara Chhu. The main product of Harachhu community is *Nya-Doesem*, prepared from snow trout using traditional smoking procedure. Fishes are caught/trapped using traditional methods and equipment such as *Drow* and *Dang*. The system of fishing and dependence on each other during fishing within the community have evolved into a unique culture through generations.

Therefore, it is of high importance that fishing in Harachhu should continue in view of preserving the identity of the community, specifically the traditional way of living as a fishing community. This will also hold importance in view of preserving the original taste of *Nya-Doesem,*

traditionally prepared from snow trout. Elderly member of the community still recall the payment of taxes in the form of *Nya-Doesem.*

Management Objectives

The formation of Harachhu Capture Fisheries Management Group (HCFMG) is meant to ensure sustainable harvest and management of fishery resources while improving household nutrition and cash income. Specific emphasis will be given to manage the fish resources by putting sustainable community based conservation and management practices in place. Therefore, the specific objectives have been defined as follows:

Short term

- Improve household level nutrition
- Improve household income
- Improve post-harvest processing and marketing of fish products
- Empowering communities with rights, responsibilities and ownership to manage natural resources
- Capacitate the communities in joint (cooperative) marketing

Long term

- Poverty reduction
- Promotion of eco-tourism
- To promote flexible, resilient and sustainable management of capture fish resources

Activities

The history of bringing development intervention to those communities of Harachhu catchments started back in 2005 with a diagnostic survey to see the potential opportunities to uplift the livelihood of the communities (RNRRC, Bajo, 2005). This was followed by a feasibility study by Department of Livestock in 2007. A community consultation meeting was held in November 2009 with an idea to reaffirm the community's interest to manage the Capture Fishery in Harachhu. This was followed by another meeting with the communities to elect the Committee members and also to discuss on the equitable distribution of fishing sites to all the subgroups (Gyamtsho & Dorji, 2010). After this, the resource management plan and the group by-laws were developed. The draft plan was later presented to all the village representatives in January 2010 to get final feedback and suggestion, accordingly the plan was finalized in March 2010 and

submitted to Department of Livestock for seeking further approval from Department of Forest and the Ministry of Agriculture and Forest.

Until now there was no blue print document regarding the management regime of fresh water fish resources. Thus, the "Harachhu Capture Fisheries Management Plan" was developed to ensure legal fishing rights and sustainability of fish resources in Harachhu. The document spells comprehensive fish resources management strategies and group functioning mechanism. The plan was prepared for a period of five years and will be revised accordingly. The activities were conducted with financial support from EU-SLS Project based at Department of Livestock Thimphu.

4.2 Establishment of Bamboo arboretum at Mithun, Tsirang

Bamboo is a group of plants in the grass family *Poaceae*. Some of its members are giants, and form the largest members of the family. Its stems, or 'culms', can range in height from a few centimetres to 30 meters or more, and from a diameter of a few mm to over 15 cm. It is found in diverse climates, from cold mountains to hot tropical regions. It spreads mainly through its roots or *rhizomes*, which can spread widely underground and send off new culms to break through the surface.

There are 34 identified bamboo species from 15 genera found in the different vegetation types in Bhutan. Bamboos have multiple uses to the rural communities. Some of the bamboos may get extinct *ex situ* conservation activities (growing bamboos having high local and commercial demand outside their traditional habitat) are not implemented. Therefore, the sub-centre initiated the establishment of *Bambusetum* at Tsirang initially with seven different species of bamboo which are of high commercial value.

This would firstly preserve the bamboo species from extinction and also will act as a showcase for different bamboo species. The *Bambusetum* would serve as living bank for the bamboo species and will also provide information on bamboo, can become a useful facility for training and extension, research site for scientists, instructors and students of the country. Some exotic species that were introduced will also be planted in the *Bambusetum* to maintain species diversity.

4.3 Evaluation of multipurpose tree species

The evaluation of Multi-purpose tree species (MPTS) is one of the on-going activities carried out on station. The evaluation parameters are considered on the propagation techniques and its husbandry. Species are selected for evaluation taking in consideration the farmer's preference and its important uses. The main focus is on the native tree species which has multiple use and can be promoted in agro-forestry, private and community forestry programs. The main research focus in the nursery is to critically look at propagation techniques either through seeds or other vegetative means. Basically two different types of propagation methods are used 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 later 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 has economic importance.

FARMING SYSTEMS RESEARCH

5 FARMING SYSTEMS

5.1 Soils Research

5.1.1 Rice yield response to different rates of NPK fertilizers

Fertilizer management in rice requires both preventive and corrective nutrient management strategies. Crop response to fertilizer application is not always easy to predict due to the effects of seasonal and year-to-year variation in climate (particularly solar radiation), and spatial and temporal variation of indigenous soil nutrient supplies. Both factors lead to large differences among sites, seasons, and years in optimal rates for fertilizer inputs. In addition, the existing fertilizer rates are based on the results of the FAO Fertilizer Project trials that were conducted between 1986 and 1989. Though the current fertilizer recommendation in practice may be the best available estimate, however, research is required in refining the current rates and to develop site specific nutrient management recommendations. The main objectives of this trial are to estimate soil nutrient supplies and to develop economical fertilizer recommendation rate for the centre.

The trial was laid out in a randomized complete block design (RCBD) with three replications. Good quality seed of 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)

Two weeks after the establishment of the crop, different agronomic traits such as plant height and tiller numbers were measured on weekly basis. This was done to assess how tiller and plant height development respond to different rates of nutrient application (N, P and K).

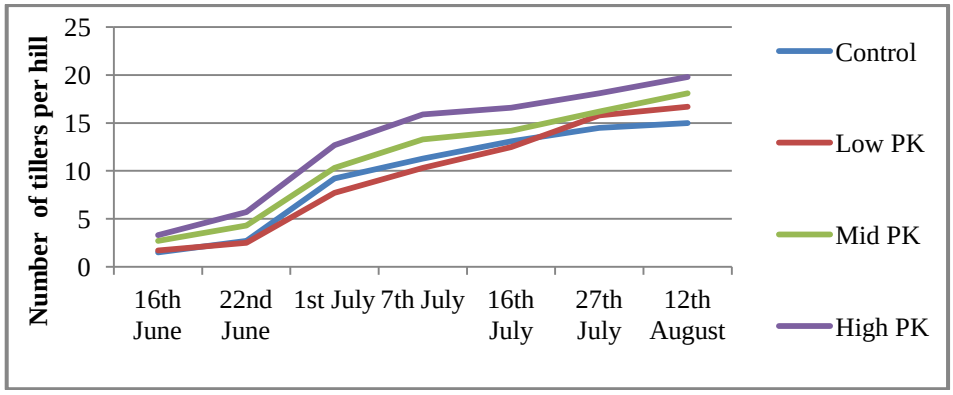


Figure 3: Effect of different rates of P and K nutrients on rice tiller development

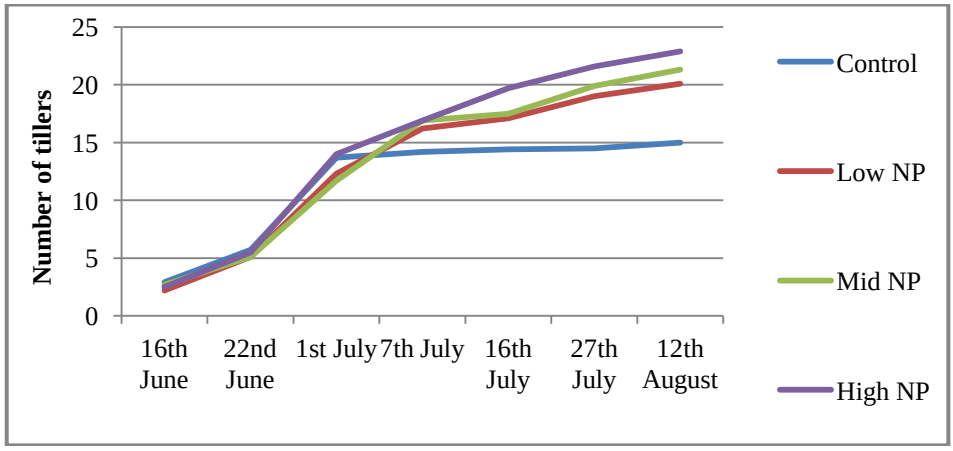


Figure 4: Effect of different rates of N and P nutrients on rice tiller development

Application of N fertilizer greatly affects tiller development in rice crop (Figure **4** and Figure 5). This could be because of Nitrogen being the promoter of rapid growth in rice plant through increasing in plant height, tiller number, and size of leaves. In addition, rice plants require large

amount of N nutrient at early and mid-tillering stages to achieve maximum panicles.

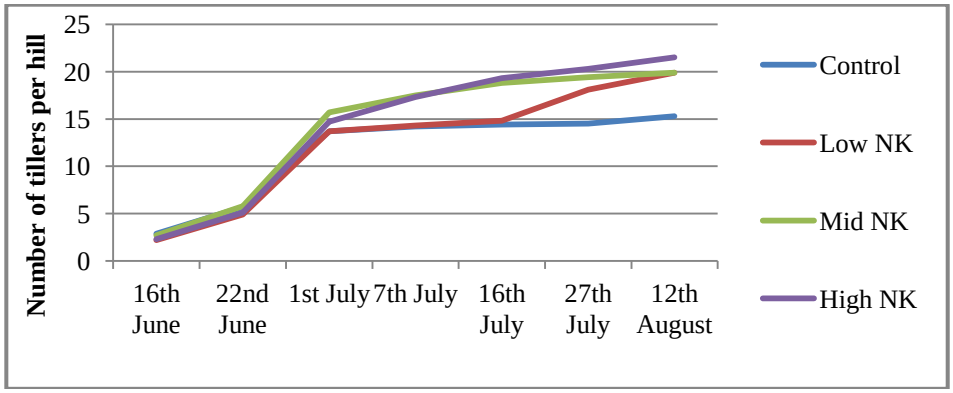


Figure 5: Effect of different rates of N and K nutrients on rice tiller development

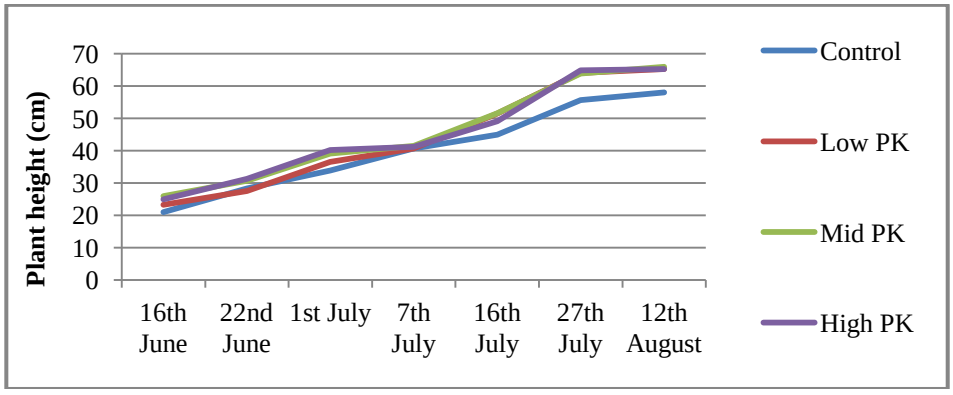


Figure 6: Effect of different rates of P and K nutrient on rice plant height development

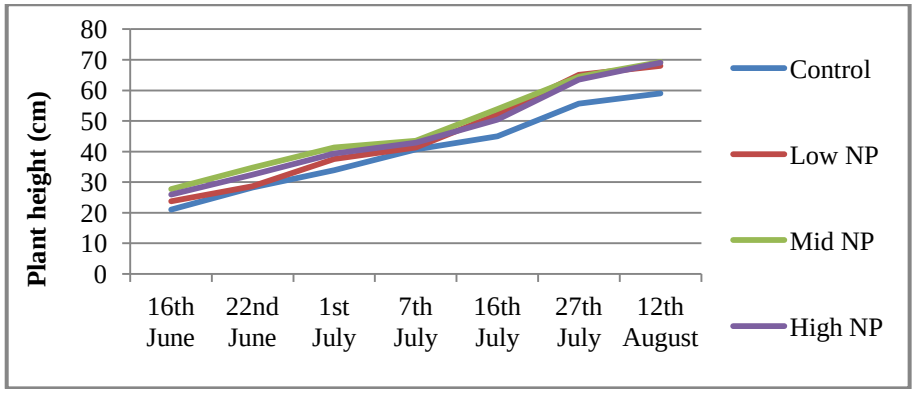


Figure 7: Effect of different rates of N and P nutrients on rice plant height development

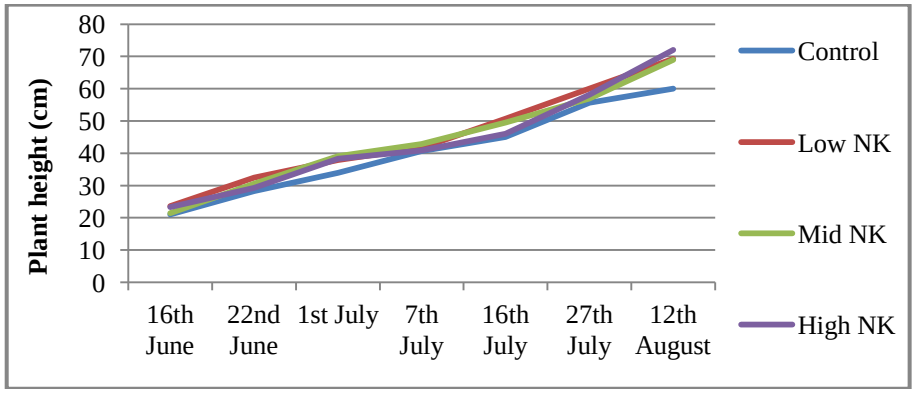


Figure 8: Effect of different rates of N and K nutrients on rice plant height development

The effect of nutrients N and K on the rice plant height development is similar to that on the tiller development (Figure 6, Figure 7 and Figure 8). While high application of nutrients N and P gave the maximum tillers per rice hill the tallest rice plant height was observed in the treatment with high N and K nutrient application.

At maturity, grain yield was estimated from a harvest area of 6 sqm and grain moisture content was standardized at 14%. Before harvest, the 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 a significant difference ($P < 0.05$) on grain yield, plant height and effective tillers (Table 46). Statistically significant difference

was observed between the means of the treatments at $P \leq 0.05$ by 95% confidence interval.

Table 46: Mean of agronomic traits under different rates of fertilization

Treatments	Mean grain yield (t/ha)	Plant height (cm)	Number of tillers
T1	7.7	64.00	15.00
T2	8.4	75.33	17.33
T3	8.9	79.67	17.25
T4	9.4	92.00	19.67
T5	9.9	76.67	19.33
T6	9.8	70.33	18.33
T7	10.1	81.00	18.00
T8	9.2	82.00	18.50
T9	9.7	87.67	20.45
T10	7.8	85.33	16.00
P	**< 0.05**	**< 0.05**	**< 0.05**

Among the treatments, T7 (110:40:60 NPK kg/ha) yielded the highest while T10 (70:80:60 NPK kg/ha) yielded just as much as the control. 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 N requirement by the rice crop. While all the three nutrients (N, P and K) are the macronutrients which are needed by rice plant in large quantities, the treatments (T5-T7) with different rates of N and K nutrients yielded higher. This indicated that rice yield can be substantially increased with increasing the rates of nutrients such as N and K. The mean grain yield of the control plot is 7.7 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 few more seasons to rule out the effect of climatic factors.

5.1.2 Tomato yield response to different soil nutrient sources

The detailed report of this trial was already published in the 2010-11 annual report. However, the trial was continued for one more year to further confirm the results. Same set of treatments were used and same parameters were measured.

Treatments

T1 = Vermi compost at the rate of 1ton/acre
T2 = Bio fertilizers at the rate of 1ton/acre
T3 = Inorganic fertilizers at the rate of 20:12:15 NPK kg/acre
T4 = Farm yard manure at the rate of 4ton/ac
T5 = No inputs (Control)

Parameters

- Yield
- Plant height
- No. of fruits/plant

ANOVA was used to analyze the data and the results showed a significant difference ($P < 0.05$) on yield, but not on plant height and number of fruits per plant Table 47. Statistically significant difference was observed between the means of the treatments at $P \leq 0.05$ by 95% confidence interval.

Table 47: Results of different soil nutrient trial on tomato

Treatments	Yield (t/ha)	No. of fruits per plant	Plant height (mts)
1	22.8	18.67	1.05
2	21.8	16.46	1.05
3	24.5	17.67	1.10
4	19.9	16.33	0.92
5	18.1	13.68	0.93
P	**<0.05**	**>0.05**	**>0.05**

As presented in the table above, T5 (Recommended chemical fertilizer) yielded the highest followed by T1 (Vermi-compost). T2 (Bio-fertilizer) and T4 farmyard manure yielded almost the same. The results indicate that application of chemical fertilizer gives the highest yield, however, considering the government's effort towards going organic, application of vermi-compost could be the best alternative followed by bio-fertilizer and farmyard manure.

Pre and post trial soil nutrient analysis results

Soil analysis results did not show any difference between the treatments. This could be because of the poor inherent soil fertility. Both pre and post trial soil analysis results had medium soil pH ranging between 6.2 and 6.3. Similarly, available P is in medium range (19.35-26.21) while available K and the percent N are in very low range. Percent carbon and the CEC are in low range. The CEC gives an indication of the soil's potential to hold plant nutrients as CEC refers to the total amount of positively charged elements (basic cations) that a soil can hold. Thus a low CEC indicate poor fertility of the soil.

5.1.3 Maize yield response to Dhaincha intercropping

Maize is the staple crop of Salamjee farmers. Other crops include mustard, millet, buckwheat, beans and vegetables. Area cultivated under these crops is relatively small compared to maize cultivation. Few farmers practice maize double cropping. They use maize mainly as kharang, for making alcohol, and as animal feed. Small quantity is consumed and sold as green maize. The commonly grown maize variety is local and yield is very low (485 kg/ac) compared to the national average yield of 983 kg/ac (RNR Statistics, 2010). The low maize yield stems from limited application of soil nutrient inputs coupled with cultivation of low yielding local maize varieties. Application of chemical fertilizer is not practiced by the farmers and use of FYM is very minimal, mainly done through animal tethering. Farmers tether animals mainly in the fields with gentle slope usually located nearer to their homestead for easy management and comfort of the animals. This means that most of the fields do not get nutrient input even from tethering.

Without any soil nutrient input in any form, the current practice of farming in Salamjee is causing soil nutrient mining mainly due to removal of soil nutrients through plant uptake. This could lead to reduced crop growth and yield because of rapid decline of soil fertility status. The past land management project lacked a holistic approach for balanced management of soil fertility. The project has addressed the issue of minimizing the top soil losses through surface erosion by implementing soil conservation measures. However, the project has not placed much focus on soil nutrient depletion through nutrient uptake by crops. As a result, there are chances that the benefit of being able to conserve soil through implementing soil

conservation measures could be soon offset by declining soil fertility. This in turn could make the farmers live in vicious circle of poverty.

Intercropping of grain legumes is practiced by majority of the farmers. However, grain legumes are sown when the maize crop reaches almost at harvesting stage. Until harvesting time, maize crop remains as sole crop during the early growing stage. Thus this activity was planned to intercrop dhaincha with maize as green manure to suppress weed growth during the early stage, use dhaincha biomass as mulch while weeding to add organic matter to the soil and improve soil fertility. The main objectives are to assess maize yield response to Dhaincha intercropped and to demonstrate to the farmers the benefits of legume crops intercropped with maize. The trial cum demonstration was implemented with two interested farmers. Single large plots covering about 0.25 ac was used for the trial with two treatments.

T1 – Maize sole crop as control

T2 – Maize intercropped with dhaincha

Pre and post trial soil samples were collected and analyzed for nutrient content. Local maize variety was sown in both treatments. Except dhaincha intercropped, other management practices were same as that of the farmers for both treatments. Timely monitoring was done to record percent germination and nodulation of dhaincha crop. Dhaincha biomass data was collected from an area of 6 sqm before uprooting during weeding to use as mulch. Similarly, maize crop cut was taken from an area of 7 sqm at harvest.

Good germination and nodulation of dhaincha was observed at both sites. Out of 20 plants uprooted, 18 plants have good nodulation with effective nodules. Dry matter biomass production is recorded about 4500 kg/ac. Similarly maize grain yield from the dhaincha intercropped plot was 562 kg/ac while plot with maize sole crop yielded only 475 kg/ac at 15% moisture content.

Pre and post trial soil sample analysis results showed some difference in percent Nitrogen and Organic Matter content. Percent N and OM was increased in the plots with dhaincha intercropped while other soil variables remained the same. Results indicated that intercropping dhaincha with maize as green manure can effectively increase maize grain yield through

improving soil fertility, especially nitrogen and organic matter content. In addition farmers have reported less weed intensity in the plots with dhiancha intercropped.

5.1.4 Economics of Mechanizing Rice Cultivation

Rice production is the livelihood of 69% of Bhutanese farmers. Currently rice is cultivated in 56375 acres with a national productivity of 3.2 t/ha (RNR Statistics, 2010). The quantity produced (7,637MT) is not adequate to meet the requirements of the people and therefore a substantial amount (58000 MT) is imported from India. Bhutanese rice production therefore still needs to be increase to feed the expanding population. However, rice cultivation being labour intensive, increasing rice production with labour shortage as nationwide problem is challenging. The scarcity of manual labour and the drudgery require alternative sources of power to carry out rice production and to make rice cultivation an attractive job to the educated youth in general. In addition since rice is an important crop in Bhutan, it is important to study how best the rice production could be made more economical and profitable to the rice farmers. This study was therefore, conducted on-station at RDC Bajo in 2011 with the objectives to quantify inputs such as labour, machineries and other material inputs in mechanization of rice cultivation and to determine the cost of rice production.

The results showed that the total production costs (Nu/acre) of rice through mechanization is Nu. 45944. Similarly labour use (man-days/acre) of rice production is 121 man-day/acre with the cost of production of rice at Nu.14/kg. Since similar study for traditional/manual method of rice production was not done parallelly, it is difficult to draw any conclusive recommendations at this stage. Given the fact that rice is facing competition from cheaper imports, this study will be continued with a parallel study on traditional/manual rice production method to devise an appropriate strategy for making rice production more economical and attractive. The detailed report of this activity is published in the RNR Journal.

5.1.5 An assessment of the adoption of recommended fertilizer rate in rice

Inorganic fertilizers are inevitable in increasing rice production in general and for improved varieties in particular. In Punakha and Wangdue Dzongkhags, although the use of inorganic fertilizers in rice is wide spread, the productivity stood at 4.8 and 3.6 t/ha respectively (Department of Agriculture 2010). This is mainly because of unbalanced fertilizer use (only urea) and poor timing of applications (not enough in early crop growth and possibly late growth). Based on numerous Farmer-Extension Fertilizer Use Trials conducted in Punakha and Wangdue Dzongkhags, NSSC has prepared and published the fertilizer recommendation guide for

important crops with the intention to provide some general guidance on the type and rate of fertilizer to be used on various crops.

Considerable amount of resources has been invested by NSSC to come up with the fertilizer recommendation rates both for local and improved rice varieties. However, no study has been done so far to assess the adoption status of these recommendation rates by the farmers. This study was therefore an attempt to assess the adoption rate of the fertilizer rates in rice recommended by NSSC. The study was conducted in Punakha and Wangduephodrang Dzongkhags. A household survey was conducted with 119 households. Descriptive statistical tools were used to investigate factors influencing the adoption of the fertilizer rate.

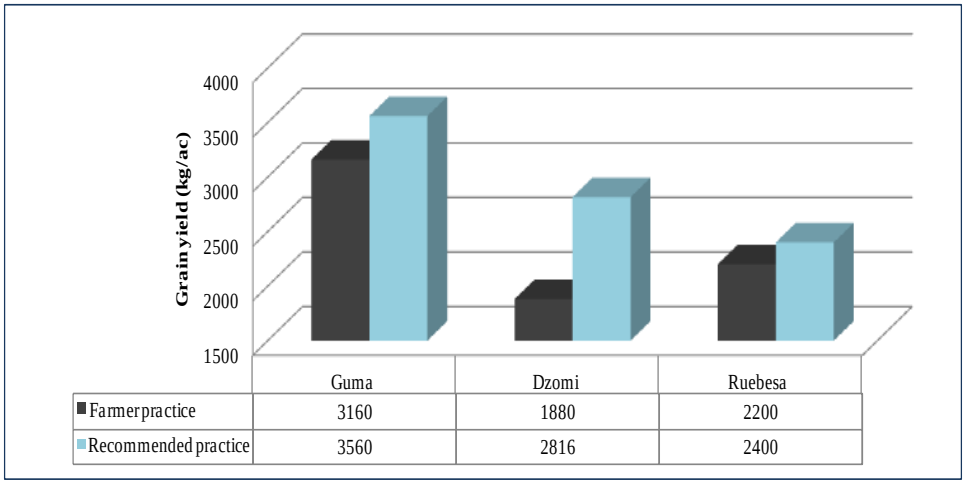
The survey findings revealed that although majority of the respondents use inorganic fertilizers in rice, none of them have adopted the fertilizer rates recommended by NSSC. While NSSC has recommended an application of 61 kg/ac of urea, 100 kg/ac of SSP and 27 kg/ac of MoP, most farmers (78%) who use fertilizers in rice, the mean application rates are 42.44 kg/ac of urea and 46.14 kg/ac of suphala. None of them use balanced fertilization with the recommended amount. The main reasons for not adopting the recommended rate are "un-affordability" and "unavailability" of the fertilizers. While most respondents lack the cash to purchase fertilizers, some are constrained by fertilizer unavailability as and when required. Most respondents use rates lower than the recommended rates; while few respondents reported to use rates higher than what has been recommended. Other factor that contributed to the non-adoption of the recommended rate is the lack of awareness about the recommended rate. Although farmers do not use recommended fertilizer rates, the fertilizer use trend is reported to be increasing by majority of them. Main reasons reported are declining of soil fertility and the need to compensate for farmyard manure application. The survey results therefore indicate that fertilizers are inevitable in rice cultivation among the respondents and the fertilizer use trend is equally increasing. However, the main fertilizer use issue identified is the use of unbalanced and lower rates than recommended rates. With farm labour shortage and declining soil fertility, the challenge is huge to maintain the sustainability of soil fertility and rice productivity with the current fertilizer application practice.

The detailed report of this case study is published separately as the RNRRDC Bajo Technical Paper No. 8.

5.1.6 Demonstration of fertilizer recommended rate on rice

Inorganic fertilizers are important in rice production particularly to optimize yield of improved varieties. The varieties in Punakha and Wangdue are predominantly improved ones with IR 64 as the mostly grown cultivar in the valley. Although the use of inorganic fertilizer in rice is wide spread in the valley, the productivity from Punakha and Wangdue in 2010 stood at 4.8 and 3.6 t/ha respectively (RNR Statistics 2010). One of the main rice production issues in the valley is one of unbalanced fertilizer use (only urea) and poor timing of applications (not enough in early crop growth and possibly late growth). As a result farmers are not deriving optimum yield and the economic benefit from their use of fertilizers with a possible associated loss in production.

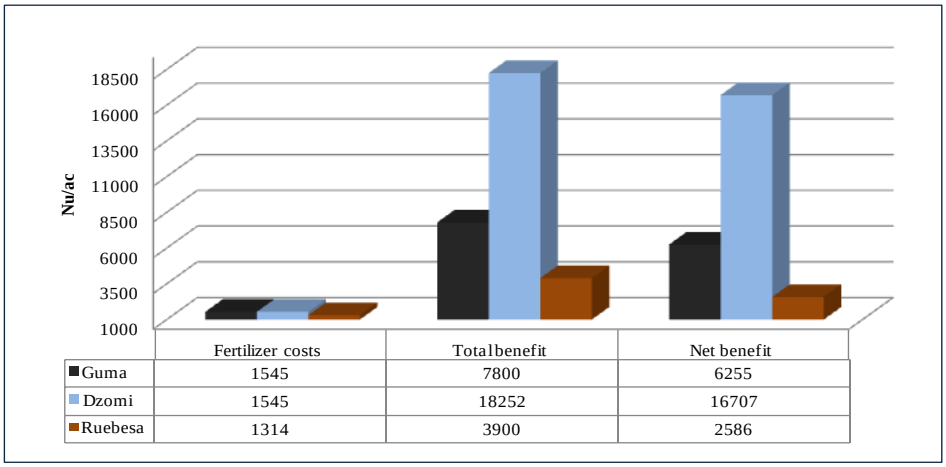
Thus demonstration of recommended inorganic fertilization rate on rice was conducted with the objectives to demonstrate the recommended rate of chemical fertilizers on rice in Punakha and Wangdue Dzongkhags, and to evaluate the yield difference between recommended and farmers' practices of fertilization. The demonstration was carried out in Guma and Dzomi geogs of Punakha and Rubesa geog of Wangdue Dzongkhag. Single large plots covering an area of 0.5 to 1 acre was used for the demonstration without replication. Recommended fertilizer rate of 28:16:16 NPK kg/ac on improved rice variety was demonstrated, wherein all of the P and K and half of the N was applied as basal dressing with the other half N as top dressing at peak tillering stage.



	Guma	Dzomi	Ruebesa
Farmer practice	3160	1880	2200
Recommended practice	3560	2816	2400

Figure 9: Effect of recommended fertilizer rate on rice yield

The other management was kept similar to farmer practice. The effect of recommended practice was compared with farmer practice of fertilization Figure 9. In Punakha, both the collaborating farmers used rice variety IR 64, while in Wangdue local variety called *Kashmer* was grown. The effect of the recommended fertilizer rate on rice yield is very high in Dzomi geog with a yield difference of 936 kg/ac, although the overall productivity is relatively low when compared with the productivity of Guma goeg. This could be because of the high weed infestation with Shochum ((*Potomogaton distinctus*). In Guma, yield difference between the recommended and farmer practice of fertilization is about 400 kg/ac, while in Rubesa the difference is only 200 kg/ac. In Rubesa, the smaller difference between the treatments could be because of not applying the urea top dressing. As local varieties are prone to lodging, the crop already showed lodging symptom before top dress application and thus the farmer refused to apply urea top dressing, thinking that he may not get good harvest. Overall, the results suggested that with simply applying the right fertilizer dose as per recommendation, rice farmers in Punakha and Wangdue Dzongkhags can make an attractive net benefit as presented in Figure 10.



	Fertilizer costs	Total benefit	Net benefit
Guma	1545	7800	6255
Dzomi	1545	18252	16707
Ruebesa	1314	3900	2586

Figure 10: Costs benefits of recommended fertilizer rate in rice

The results clearly indicates that a rice farmer spending merely few hundreds of ngultrum on buying fertilizers can easily make a good net benefit even with the cultivation of local rice varieties. This not only helps in increasing productivity per unit area that will ultimately contribute toward achieving national goal of alleviating poverty, but will have a huge

impact on ensuring sustainable soil fertility. With decreasing in rice growing area and increasing demand in rice to feed the growing population, the challenges to fill the gap is huge. Punakha and Wangdue are two important rice growing areas both in terms of area and production. With little bit of effort to sensitize the rice farmers on the importance of the application of right amount and time of fertilization in rice it can make a huge contribution towards achieving rice self-sufficiency.

5.1.7 Study on the soil fertility and pest disease management in potato production in Phobji and Gangety

Phobjikha and Gangtey geogs are known for potato. They are the largest potato producers in Wangduphodrang Dzongkhag. However, the production did not come without a cost. Farmers in both the geogs are known to apply high amounts of chemical fertilizers, fungicides and herbicides to increase potato production. A study done by RDC Bajo in 2004 showed that there is already Phosphorus build up in the soils of Phobjikha valley. Furthermore, there are many cases of farmers applying higher dose of fertilizers, fungicides and herbicides with the belief that higher dose means more effective. To confirm and validate the above statements, a survey was done with the following objectives:

- To find out the types of chemical fertilizers, fungicide and herbicide used.
- To assess the rate, time and frequency of application.
- To see if there are changes in the rate and frequency of application over the years.
- To identify the reasons for the change in the rate and the frequency of application.

To get a representative sample population for both the geogs, all the chewogs in each geog are selected for the study. From each chewog, 30 percent of the total households are selected randomly for interview. Therefore, a total of 83 households from Phobjikha geog and 68 household from Gangtey geog were interviewed. Data were compiled and entered in an Excel spread sheet. Data analysis will be done and the findings will be published as technical paper.

5.2 IPM Research

5.2.1 Monitoring fruit fly emergence and population trend in mango

The fruit fly monitoring study was carried out in the royal orchards at Kamichu and Baychu. The trial was implemented in 2010 with the objective to study the mango fruit fly population trend. In 2012, a total of 15 pheromone traps were set up on 2nd of March. The first fruit flies were trapped on the 3rd of March, 2012. The mean fruit flies trapped during the season was 1373.29 ±1164.26. The maximum and minimum fruit flies trapped during the season are 3387 and 7 respectively. This indicated that there is a great variation in number of fruit flies trapped during the season. Least number of fruit flies was trapped in the month of March (Figure 11). The population trend remained almost the same during the month of March. The number increased gradually from April to May with highest recording on 4th May. The highest recording could be because of the replacement of the old traps during the preceding week i.e. on 27/4/2012. New pheromone lure were highly effective in attracting the large number of mango fruit flies. The population then decreases gradually after 4th May. This study showed that, mango fruit flies appeared from last week of March with highest population in May and June. The population increased as the fruits start ripening.

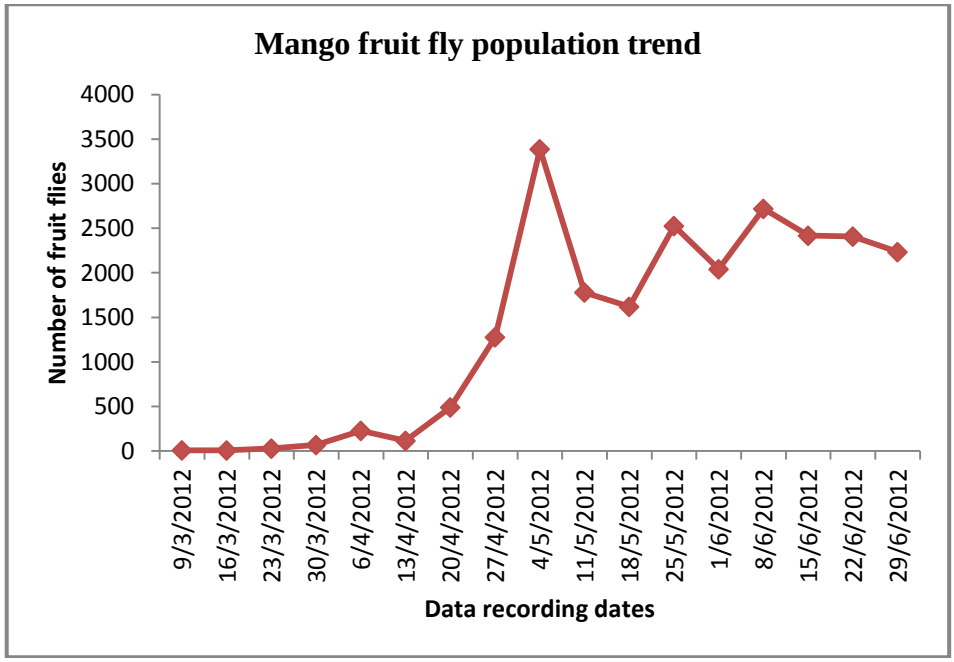


Figure 11: Number of fruit flies trapped during the season

5.2.2 Wheat trap nursery

The wheat rust trap nursery was set up in the year 2011-2012 to collect information on the epidemiology of yellow, leaf and stem rust and on the behavior of resistant and susceptible varieties tested under different environmental conditions.

Each entry of the nursery was planted as unreplicated single metre row length, 30 cm apart. Three grams of seed were sown in each entry. There were five experimental plots and the spacing between plot to plot was maintained at 50 cm. Altogether, 425 entries were received from International Centre for Agricultural Research in the Dry Areas (ICARDA). Of the total entries, 80 lines were from Sixth International Yellow Rust Trap Nursery 2011-2012 (6^{th} IYRTN-12), 260 lines from Eleventh Regional Bread Wheat Key Location Disease Nursery for central, West Asia and Caucasus (11^{th} RWKLDN-CWAC-12) and 85 lines were from Seventh International Stem Rust Trap Nursery 2011-2012 (7^{th} ISRTN-12). According to the protocol, distinction had to be made between no visible infection (O) and escape from the disease by earliness (eE) or lateness (eL). Inorganic fertilizer at 15:15:15 kg ha^{-1} was applied as basal dose. Crop, during the entire growth cycle was hand weeded twice and

irrigation was done for four times. The disease incidence was monitored throughout the growing cycle with the main data recorded during the mid tillering stage as per the protocol.

Secondly, among the tested lines of Sixth International Yellow Rust Trap Nursery 2011-2012 (6th IYRTN-12), Morocco as susceptible check was found to be highly susceptible to yellow rust along with few other cultivars among the lines of 6th IYRTN-12. It was found that 100% (85 entries) of the lines (including the susceptible check) did not exhibit any stem rust infection. However, partial virulence of yellow rust infection was observed in most of the lines tested for stem rust while some lines being moderately susceptible to leaf rust during the later phase of the crop growth stage. Durum and cultivar Triticale & Cham 6 were found to be resistant to all the three types of rust diseases.

The IPM sector also participated in the wheat rust disease survey which was carried out in collaboration with NPPC. The results of the survey have already been reported in the Field crops sector.

5.3 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 placed high priority for the development of agriculture sector. In the past, emphasis has been laid on the provision of modern high yielding 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 is seen to have the potential to 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 the Bhutan 2020, Gasa was the first Dzongkhag to be declared as the organic Dzongkhag in 2004. Gasa was considered as remote, however, with the road access, it has potential and opportunity in marketing organic produces. The National Organic Program (NOP) under Ministry of Agriculture and Forests (MoAF) has provided substantial support for both the extension staff and farmers in terms of inputs, capacity building and infrastructure development in support of organic farming in the

Dzongkhag. However, the adoption rate of organic technologies was observed to be very low with very limited organic produce coming in the market.

Accordingly, deliberation was made regarding the progress of Gasa organic program during the Agriculture Review and Planning workshop held at RNR-RDC Bajo in January, 2012. RDC Bajo agreed to adopt Gasa as the organic research-outreach program site. A multi-disciplinary team led by the Program Director conducted consultative meetings with the farmers of Gasa mainly to review the past plans, activities, progress made and constraints faced in organic farming. Besides, there was an urgent need to explore alternatives and best practices of organic farming particularly on pest, diseases and crop nutrient management.

Although inputs in terms of materials, technical, financial and capacity building were provided to the farmers by NOP and other agencies, there are no measurable outputs in terms of organic produce coming from the Dzongkhag. This was reported mainly because of technical incompetence among the stakeholders at different stages of implementation of the program. There was inadequate linkages and coordination amongst stakeholders with no proper organization designated to lead the program. Basically, the underlying factor was lack of coordination in effective implementation of the organic program coupled with inadequate technical competence among implementers.

Accordingly RDC, Bajo decided to lead the organic program at Gasa Dzongkhag in collaboration with other relevant organization such as NOP, NPHU, DAMC and Dzongkhag RNR agriculture sectors with the mission to enhance income and livelihood of farmers. The main objective of the organic research out-reach program is to build technical competence of the farmers in organic farming and to build a viable organic farming business for Gasa farmers to increase cash income for improving the rural livelihood. Based on the objectives, participatory action plan has been developed and the following activities were initiated.

5.3.1 Commercial vegetable production and marketing

In the past farmers faced problem in marketing their produce mainly because of two reasons. The quantity each household produce was not profitable for them to take to other markets like Thimphu and Punakha. However, the quantity was more than enough for Gasa buyers due to

lesser population. To address this issue, cultivation of vegetables at larger scale has been planned and implemented. In addition, Gasa being at higher altitude, it has advantage of producing summer vegetables during off-season which will fetch good price.

Vegetable seeds of cabbage, cauliflower, broccoli, beans, pea, radish, carrot, mustard green, coriander and lettuce were provided for summer production in both the geogs. A total of 22.4 acres of dryland was brought under vegetable cultivation (11.70 acres in Khatoe and 10.70 acres in Khame).

Hands-on training on vegetable cultivation and pest disease management was imparted at household level. Cut worm, lopper and caterpillar were mentioned as main pest in vegetable cultivation. Accordingly farmers were advised to apply organic formulations as and when required.

5.3.2 Asparagus production

During the past years, NOP provided farmers with asparagus seedlings for large scale production, however due to management issues and technical incompetence only few farmers could manage to produce asparagus for household consumption only. Most importantly, farmers were not aware of the value of this crop at initial stage and thus the crop did not get adequate attention from the farmers.

Owing to the agro-ecological condition of the Dzongkhag, asparagus production is seen as the key for enhancing income. There is a high potential for increasing the cultivation of asparagus for consumption as well as for marketing. About 20000 asparagus seedlings were distributed to 18 farmers covering 2 acres in Khatoe and Khamae geogs of Gasa.

5.3.3 Potato late blight monitoring

Potato is one of the main cash crops of the Dzongkhag and it is the crop grown by farmer on large scale. However, there were cases of farmers losing the crop to potato late blight. While there is proven control measure for the disease, research has stepped up to carry out frequent monitoring. At Khatoe geog, almost all potato field were affected, however the blight damage is only on foliage. Fields which were severely affected, owners were advised to uproot the affected plants and bury them.

Moderately affected fields were sprayed with fungicide copper oxychloride 50% WP. Around 5 acres of potato field was sprayed with the fungicide. Two knapsack sprayer machines were issued for Khatoe and Khamae geogs. Farmers were advised to harvest mature tubers and keep for curing. Crop cut was carried out at Zomina village where the crop was affected severely. The average yield in the village was 8.3 t/acre.

5.4 Water Management Research

Water Management Research (WMR) is a small unit under Farming System Research Sector. The primary mandate is to conduct topical research to address water management issues for food production. Besides research the unit also provides RNR Engineering Services for RDC Bajo and other sister agencies in the region. Over the years the unit has implemented more development than research activities. The unit lacks critical mass of human resources for implementing consistent water management research activities. However, there is no definite line separating research and development. This report provides overview of the activities implemented during the last two financial years.

5.4.1 Baychu Irrigation Channel Construction Feasibility Study

Phangyul is one of the 15 Geogs under Wangdue Dzongkhag. It is situated on the upper reaches of the left bank of Baychu and Dangchu River. The geog has an area of 2800 acres of which 70% is covered by forest and about 24% consists of arable agriculture. Rice is the main staple crop grown during summer. The geog has about 1,000 acres of wetland of which only 637 acres are cultivated owing to scarcity of irrigation. The settlements in the geog are scattered over 18 villages which are 1000 to 2000m above the sea level.

The Context of the feasibility study

a) Problems of water scarcity

Rice production in the geog is mainly constrained by scarcity of irrigation water. Scarcity is caused by lack of perennial water source within the geog. Despite the geog having five channels with irrigation channel density of 56m per acre of paddy field, water shortage is very acute in the geog. The degree of water scarcity is reflected by longer irrigation water rotation period of 21 days. The other key indicator of scarcity is the completion of rice transplantation season. Generally, farmers in Punakha and Wangdue complete rice transplantation before

4th day of the 6th Bhutanese month. According to the farmers if the transplanting is delayed beyond this date the production will not be worth the effort. But the farmers in Phangyul have no option but to go several weeks beyond this date to complete their rice transplantation. This is one reason why the paddy yield in this Geog is very poor.

In winter most of these irrigation channels run dry because of small water source. Even if the entire source is diverted into the channel it will be all lost through seepage and evaporation just few kilometers down the channel. As a result even livestock face drinking water shortage during winter. Farmers reported that some of their cattle even died in the past due to lack of drinking water.

b) Proposal for construction of Baychu Irrigation Channel

In mid 2010, the Minister of Agriculture and Forestry visited Phangyuel Gewog to discuss about the water scarcity problem and to identify intervention measures. The outcome of the visit was a proposal for construction of irrigation channel that will bring water from Baychu passing through Kazhi Geog. Preliminary alignment survey using clinometers was conducted by Engineering Sector of Wandue Dzongkhag. The survey confirmed that the proposed channel alignment passes through Kazhi and Komathang villages under Kazhi Geog. The construction of channel is expected to cut through several agriculture lands, footpaths, farm roads and possibly few houses. Further, the farmers claim that the geology in the geog is not very stable and overflow of channel water poses high risk for land degradation which would trigger soil erosion, landslip, and gully formation.

c) Objection from Kazhi Geog

Since the proposed channel alignment passes through several villages in Kazhi Geog, there were mixed feelings amongst the farmers as to the benefits and problem it would bring to the villages. Those villages predominantly with dryland agriculture felt the proposed channel will definitely benefit them. On the contrary those villages with adequate access to irrigation water felt the construction will damage their wetlands. Overall, Kazhi Geog feels negative impacts are more than the positive benefits and did not provide clearance for the construction.

To minimize the impact on the wetlands, Dzongkha Administration Wangdue (DAW) proposed pipes which will be buried below the ground. Further, affected land will be compensated with land. Farmers were still not confident with the option and the farmers claimed it would be

difficult to give clearance even for conducting feasibility study. Accordingly DAW reported the outcome of the negotiations to the Ministry of Agriculture and Forests. The ministry directed RDC Bajo to explore alternative options for addressing the issue.

d) Water Harvesting

RDC Bajo proposed water harvesting as the next feasible option for improving water availability in Phangyul Geog. The proposal was to construct water storage facilities like farm ponds, tanks and common reservoirs to store water when available to be used when required. Concurrently, there is a need to improve existing irrigation channels or even construct new ones to bring water from where it is available to where it is required within the geog. Further, pumping of irrigation water from lower reaches of the Geog (Baychu) was also considered. However, farmers of Phangyul were not very convinced of such proposals as they saw comparatively better advantage in construction of Baychu Irrigation. Hence, they insisted on bringing water from Baychu through construction of gravitation channel.

e) Decision of 10FYP Mid-term Review

Meanwhile, the issue was discussed during Wangdue Dzongkhag 10FYP mid-term review meeting. The meeting decided that proper feasibility study be conducted. Without the feasibility study there no basis for decision to be made. The Dzongkhag was asked to initiate the study and it requested for technical support from RDC Bajo.

f) Feasibility Study

Besides assessing the feasibility of bringing irrigation water from Baychu through gravitational conveyance system to Phangyul, the study was required to quantify the amount of arable land that would be affected.

The channel alignment survey was started on 23 May 2011 from Damchoethang (intake point). The labour contribution for clearing bush for the survey was provided by Phangyul farmers on daily wage rate of Nu100 per day. When the survey reached Komathrang village (completed 15.87 km corresponding to CH317) the survey was stopped temporarily to enable farmers to carry out rice transplantation. The survey was resumed on 15 August 2011 (CH318) and completed on 13 September 2011 (CH680).

Longitudinal channel bed slope of 1:500 (2m drop per km) was considered to establish the channel alignment starting from pre-identified

intake point at Damchothang. The alignment on the ground was identified using levelling equipment. Every chainage interval and cross slope was measured using clinometers and a reference peg was placed to enable the alignment location later. In addition, information on number of trees based on various girth classes was collected at every chainage. Information on road crossing, irrigation channel crossing, stream crossing and any other physical features that would be affected by the construction were collected.

Findings of the study

a) General findings

During the field survey two old irrigation channels were discovered. The older one which was built many generations ago has its intake point about 1.5 km downstream of the currently proposed intake point. According to the farmers, their ancestors made a big celebration to mark the occasion of completion of the construction. A monkey appeared from nowhere during the celebration. Their ancestors thought it was a bad omen and killed the monkey. On the following day there was no water in the new channel. They went to the source to check the problem. At the source they saw a big snake which blocked the water indicating that the local deity who appeared as monkey was not willing to give water to the people.

According to the farmers second channel was constructed two to three decades ago through government support. Intake of this channel is about half a kilometer upstream of the currently proposed channel intake. The cement lining works are intact in some sections. The channel ends on ridge above the Kazhi School. According to some farmers, this channel came into disuse due to drying of the source. While others mentioned that some of the farmers bribed the engineer during the alignment survey to reduce the bed slope of the channel to move the alignment upslope to reach upper part of the village. As a result bed slope was not sufficient to create flow in the channel which led to failure of the project.

These two cases indicate that people have made attempts to bring irrigation water from Baychu in the past but were unsuccessful. Hence, there is a crucial lesson that needs to be learnt from these two cases to ensure that the proposed project does not become another history of failure.

b) Good maintenance of Lhachu Irrigation Channel

During the field survey, it was observed that existing irrigation channel (Lhachu Youwa) for Phangyul Geog is well maintained. The level of maintenance work done is one of the best so far observed in the country. The channel banks were cleared of vegetation, comparatively less sediments in the channel, and farmers place high priority for maintenance work. They carry out routine maintenance twice in a year. In other parts of the country farmers face difficulty even to maintain once in year.

c) Command area

The wetland area under Phangul Geog is projected as 637 acres (DAW-2011) while agricultural statistics indicate 629 acres (DoA-2009). The older statistics put it at 988 acres (MoA-JICA 1996). These variations are inevitable as most of studies were done in different context and time. Hence for this study potential command area of 1000 ac was considered. This figure was assumed because there are many areas where wetlands are left fallow. Further there are many potential areas that can be converted into wetland if irrigation water is available.

d) Water requirement and channel cross-section

The stream flow rate at Damchoethang at proposed intake point was measured twice using current meter. Table 48 indicates that the average flow in February 2011 was about 760 liters per second. There was some rainfall on the previous night. The stream flow declined to 688 liters per second as dry season peaked around May.

Table 48 Baychu stream flow measurement

SN	Date	Time	Q (l/s)	Rainfall previous night	Data collected by
1	17-Feb-2011	11:32 AM	749	About 10mm	TG, Indra & Jigme Zangmo
2	17-Feb-2011	1:01 PM	774	About 10mm	TG, Indra & Jigme Zangmo
3	23-May-2011	3:00 PM	688	Some	TG, [a]Dorji & Farmer

[a] GAO Phangyoul

For this study irrigation water diversion requirement of 2 lit per second per ha (0.80 lps per acre) was considered which translates to total requirement of 800 lps for total command area of 1000 acres. Since the minimum dry season flow of the source is about 688 lps it was desirable

to design the irrigation channel section based on minimum flow available at the source. Therefore the design flow rate of 700 lps was considered.

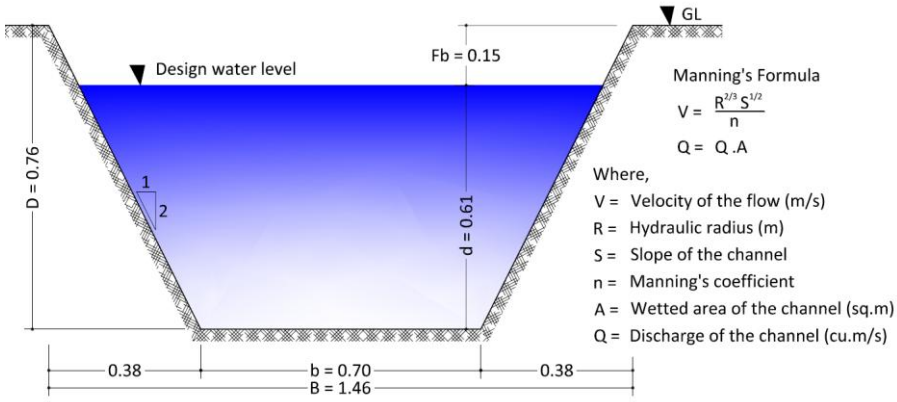


Figure 12 Trapezoidal channel section

The channel cross-section was determined using Manning's formula. Design parameters used were (a) design discharge 700 liters per second, (b) channel bed slope- 1:500, and (c) Manning's coefficient of roughness of 0.017 (cement plaster with float finished). Trapezoidal channel section with side slope of 1:2 (H:V) was used instead of rectangular section owing to its higher hydraulic efficiency. The designed section is shown in Figure 12.

e) Channel Alignment

After finalizing the location of the intake point for the proposed channel at Damchoethang (27.57955˚N, 90.05288˚E, elevation 2,158m, error ±3m) channel alignment was initiated. The longitudinal bed slope of 1:500 (2 m drop per kilometer) was used to determine the alignment. The alignment intersected with Lhachu Irrigation Channel at a distance of 29.75 km from the intake. From this point the alignment followed the Lhachu channel till tail ends in Phangyul Gonpa which is 34.0 km from the intake. This alignment indicates that the proposed channel will be able to benefit all the command area under five irrigation channels in Phangyul.

Table 49 Physical features along the channel alignment

Physical features	Count of features	Length (m)		Length (m)	Remark
		Min	Max		
Stream crossing	32	1	10	97	
Drainage crossing	18	1	5	34	
Gully crossing	10	5	25	97	
Irrigation channel (main)	3	1	10	13	
Irrigation channel (dist)	3	1	3	5	
Farm road crossing	4	6	10	32	All in Kazhi Geog
Footpath crossing	8	1	1	8	
Rocky area/rock outcrop	39	5	50	898	2.6%
Marshey area	8	6	50	209	0.6%
Earth cutting	595	-	-	28,357	83.4%
Along Lhachu channel	1	-	-	4,250	12.5%

The proposed channel alignment pass to various kinds of physical features as indicated in Table 49. Around 2.6% of the channel length has to cut through rocky area or cliff faces. The most difficult cliff is situated at distance of 1.95 km from the intake. About 100 m of pure rock cutting will be required at this point. Within Kazhi Geog the channel has to cross farm road at four different locations, however there are no farm road crossing in Phangyul Geog.

f) Cost of construction

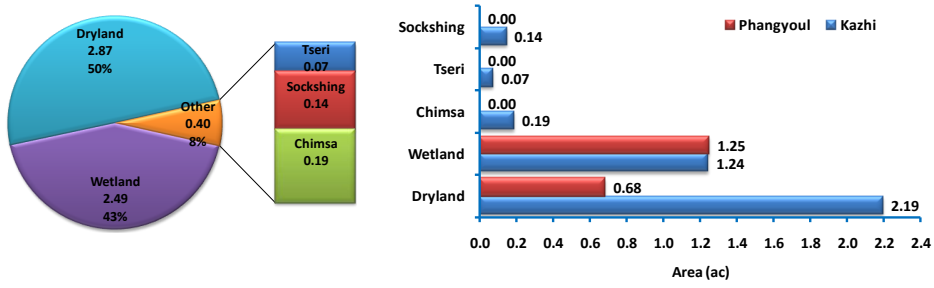
Table 50 Summary of cost estimate for channel construction

Description of work	Estimated cost		Remark
	(Nu)	%	
Clearing jungle	451,020	0.7	
Formation cutting	10,415,946	16.1	
Channel lining	47,243,263	73.1	
Intake structure	717,871	1.1	
Road/ footpath crossing	177,840	0.3	
Irrigation channel crossing	81,726	0.1	
Stream crossing	772,581	1.2	
Drainage line crossing	278,715	0.4	
Gully crossing	1,088,491	1.7	
Retaining wall	3,400,000	5.3	
Total cost	64,627,453	100	

The cost for the construction of proposed 34 km Baychu Irrigation Channel is estimated at Nu 64.63 million. Amongst the various structures that need to be provided, cement lining work comprise highest cost of 73.1% of the total, followed by 16.1% for formation cutting and rest of the cost for construction of intake, retaining walls and cross structures.

g) Impacts on arable land

The impact on the agriculture land in this case is defined as the agriculture land area that would be occupied by the construction of the proposed channel. Based on the survey finding a total of 5.76 acres of agriculture land owned by 28 households will be impacted by the project of which 3.83 acres are under Kazhi Geog and 1.93 acres under Phangyul. Based on the landuse type, the highest impacted is dryland comprising of 50% of the affected land followed by wetland of 43% and the remaining 8% includes Chimsa (0.19%), Sockshing (0.14%) and Tseri (0.07%) as indicated in Figure 13 *Expected impact on arable land due to proposed channel construction, (a) impact by land type, and (b) impact by land type and geog.*.



(a) *(b)*

Figure 13 ***Expected impact on arable land due to proposed channel construction, (a) impact by land type, and (b) impact by land type and geog.***

Figure **13** *Expected impact on arable land due to proposed channel construction, (a) impact by land type, and (b) impact by land type and geog.*It shows impact on dryland is three times in Kazhi than in Phangyul, while the impact on wetland is almost equal. Table 51 shows that irrigation channel passes through 10 villages affecting total of lands of 28 households. The number of households whose land will be impacted is 25 and 5 in Kazhi and Phangyul Geog respectively. There are three cases where the channel passes through Chimsa in Kazhi Geog. First one is in

Dambjithang of 0.07 acres belonging to Mr. Cahdor Rinchen, second and third are in Bjaktey village of 0.11 and 0.005 acres belonging to Mr. Namgay Sithup and Tashi Tshering respectively. In case of Tashi Tshering the channel passes through the courtyard of his house.

Table 51 Summary of expected impact on arable land due the proposed channel construction

Village	Geog	No.of HH	Area by landuse type (sq.m)					Total area	
			[a]	[b]	[c]	[d]	[e]	(sq.m)	(ac)
Dambjithang	Kazhi	3	281	1,251	0	0	0	1,532	0.38
Kamlazhing	Kazhi	1	0	1,644	0	0	0	1,644	0.41
Bjaktey	Kazhi	6	468	3,313	0	0	202	3,983	0.98
Lungsigong	Kazhi	1	0	945	0	0	0	945	0.23
Lumchey	Kazhi	3	0	1,716	576	0	0	2,292	0.57
Phuntshobjee	Kazhi	1	0	0	0	0	785	785	0.19
Komathrang	Kazhi	8	0	0	0	293	4,038	4,331	1.07
Hampakha	Phangyul	3	0	0	0	0	4,013	4,013	0.99
Selagang	Phangyul	1	0	0	0	0	1,035	1,035	0.26
Nabeesa	Phangyul	1	0	2,757	0	0	0	2,757	0.68
Total		28	749	11,626	576	293	10,073	23,317	5.76

Note: [a] = Chimsa, [b] = Dryland, [c] = Sockshing, [d] = Tseri, [e] Wetland

h) Environmental impacts

About 24 tree species are found along the channel alignment. The most abundant species are Rhododendron, Zenrtru, Sisi, Ghum, and Oak, while least are Changshing, Cypress, Omshi and Khamtse (Table 52).

Table 52 Tree species found along the channel alignment

SN	Species	Kazhi	Phangyol
1	Berberis	Y	Y
2	Betula (rhus ssp.)	N	Y
3	Bluepine	Y	Y
4	Chirpine	Y	Y
5	Cypress	N	Y
6	Erythiana	Y	Y
7	Gama	Y	Y
8	Gatsashing	Y	Y
9	Ghum	Y	Y
10	Kaashi	Y	Y
11	Khamtse	Y	Y
12	Khashi	Y	Y
13	Lumam	Y	Y

SN	Species	Kazhi	Phangyol
14	Lumam	Y	Y
15	Oak	Y	Y
16	Omshi	Y	Y
17	Puyam	Y	Y
18	Rhododendron	Y	Y
19	Schima wallichii	N	Y
20	Sisi	Y	Y
21	Sokey	Y	Y
22	Thom	Y	Y
23	Zenque	Y	Y
24	Zenrtu	Y	Y
	Yes, Y =	20	23
	No, N =	4	1
	Total =	24	

Table shows that total of 3,309 trees will be affected by the construction of the channel. Forty-three percent of the trees needs to be removed that are of sapling size (DBH less than 9.9 cm), followed by 34% in DBH 10-19.9 cm, 19% in DBH 20 – 29.9cm class, and very small percent above DBH class 30 - 49.9 cm and above. The pattern of DBH class distribution is similar between the Kazhi and Phangyoul, however the number of trees that would be affected in Kazhi geog is twice more in Phangyul.

Table 53 Number of trees that would be impacted due to the construction of proposed channel by geog

SN	Category name	DBH Class (cm)	Kazhi		Phangyul		Total	
			Count	%	Count	%	Count	%
1	Sapling	< 9.90	1,009	42	411	45	1,420	43
2	Dangchu	10 - 19.9	790	33	335	37	1,125	34
3	Tsim	20 - 29.9	513	21	110	12	623	19
4	Cham	30 - 49.9	82	3	40	4	122	4
5	Drashing	50 +	8	0	11	1	19	1
	Total		2,402	100	907	100	3,309	100

Feasibility Assessment

Using the survey results and secondary sources the parameters for feasibility indicator were determined. These parameters and corresponding feasibility scores are summarized in Table 54. A subsequent section provides discussion how these parameters were derived and corresponding scores were awarded.

Table 54 Feasibility assessment

Type	SN	Feasibility indicators parameters	*Score
TECHNICAL	A1	Adequacy of the source (available 700lit/s, required 500 lit/s)	4
	A2	Conflict of sharing at the source (on objection)	3
	A3	Stability of the geology (existing irrigation channels are stable)	4
	A4	Is gravity conveyance possible? (adequate head)	4
	A5	Benefit all the farmers in the command area? (99%)	4
	A6	Cost (Nu64.63 million)within the approved budget limit (Nu79.0 million)	4
SOCIO-ECONOMIC	B1	Ratio of number of household benefited to affected (175/28)	4
	B2	Ratio of agriculture land area benefited to affected(637acre/5.76ac)	3
	B3	Cost per unit length of channel (Nu1,901/m)	3
	B4	Cost per unit command area(Nu80,784/ac, Nu.55,000/ac in Nepal)	3

	B5	Cost per household (Nu369,300 per HH)	3
	B6	Cost per person (Nu52,973 per person)	3
	B7	Alternative options Komathrang conflict (many options available)	3
ENVIRON-MENTAL	E1	No. of trees cut per unit length of channel (3,309/34km = 97 trees per km)	4
	E2	Number of trees cut per unit command area (3,309 trees/637 acre= 5 trees)	4
	E3	Number of trees cut per household (3,309 trees/175 HH= 19 trees)	4
	E4	Number of trees cut per person(3,309 trees/1,220 person= 3 trees)	4
ALL	1)	Technical- average	3.8
	2)	Socio-economic- average	3.1
	3)	Environmental- average	4.0
	4)	All	3.7

*Feasibility score: Not feasible = 1, Neutral = 2, Feasible = 3, and Highly feasible = 4.

a) Technical assessment

The adequacy of water at the sources was assessed by comparing the flow rate source (Damchoethang) and diversion requirement at the source. Considering the present context of 50% of 637 acres wetland being under water scarcity situation, the flow rate of 700 litre per second at the source is more than adequate.

With regards to sharing of water at the source, although no study was done, beneficiary farmers claimed that downstream users have not made any objection to their proposal. This may be because stream flow increases as we go downstream. Hence it is feasible for the construction of proposed channel based on the sharing at the source.

Owing to the limited time and expertise no formal survey was done to assess the geological condition of the channel alignment. However, there are many existing irrigation channel in both Geogs almost following the same alignment then it was logical to assume that overall geological conditions would be similar. Since existing channels are all stable and functional it will be logical to deduce that the proposed channel will be stable in terms of geology. Hence it is assessed to be feasible with respect to geological indicator.

The channel alignment survey confirmed that all the paddy fields in Phangyul can be irrigated from the proposed channel through gravity conveyance system except few acres of land above Dayou Gonpa and Hampakha. Fortunately, these areas are very near to upstream part of Lhachu Channel and will not face any significant water problem.

Consequently, construction of proposed channel is determined highly feasible based on the gravity conveyance system.

The cost of the construction was estimated at Nu 64.63 million which is less than the allocated budget of Nu 79.0 million, therefore the proposed project is considered feasible based on allocated financial resources.

b) Socio-economic

For purpose of determining the ratio of households benefited to affected, only households in benefited (175) in Phangyol geog was considered while the number of affected (28) households also included from Kazhi Geog. The ratio stands at 7 which is considered to be highly feasible. Similarly, the ratio of benefited agriculture land (half of 637acre) to affected (5.7) stands at 56 and signifies high feasibility.

The investment cost per unit command area of this proposed channel is estimated at Nu.80,784. This is slightly higher as compared to Nu55,000 per acre in Nepal with a similar setting to Bhutan, however, it is less than much water scarce country like Afghanistan of Nu.92,000 per acre (Dorji & Gyamtsho, 2009). In this case, it is inevitable to have high unit cost as the source is located far away from the command area. As such this indicator is sensitive only when the location of the source is similar distance from the command area. Similarly, the cost per unit length stands at Nu1,901 per running m of channel (Nu 1.9million per km). Hence, it can be stated feasible based on these two indicators. Likewise, unit investment cost based on number of household and population are Nu 369,300 and Nu 52,973 per person. As there is no standard reference for comparing these figures in our context, all of these parameters are assessed to be feasible as the investment cost is within the allocated budget limit.

c) Environmental

On the average 97 trees with DBH ranging from Sapling (< 9.9cm) to Drashing (50 cm +) size needs to be removed per kilometre of channel constructed. Likewise, number of trees needs to be removed per unit command area, per household and per person are 5, 19, 3 trees respectively. As mention earlier there are no standards for assessing these parameters, however the need to cut down on the average is three trees per person for the construction of irrigation channel which is not environmentally damaging. It can be further argued that there are several irrigation channels in the area that were constructed in the past by cutting down trees, and we still have the environment as pristine as it were in the

past. Further, the benefit of this irrigation channel may last many generations. Hence, based on these arguments all the parameters are assessed to be highly feasible.

d) Overall assessment

The outcome of the feasibility assessment for the construction of proposed channel is summarized in Table 54. The result indicates that the overall feasibility score of 3.7 which is in between feasible and highly feasible. Amongst the three broad indicators environmental feasibility indicators scored the highest of 4 followed technical at 3.8 and least of 3.1 by socio-economic.

Conclusion

Based on the findings and scope of the study it can be concluded that the construction of the proposed Baychu Irrigation Channel to convey irrigation water from Damchoethang to command areas in Phangyul and Kazhi Geogs is feasible technically, socio-economically and environmentally. However, owing to the nature and size of this project there are many stakeholders with diverse stake in it. It definitely demands a proper stakeholder analysis to ensure that the interests of every individual are properly addressed to make this project not only successful but bring continued benefit to the farmers in Kazhi and Phangyul Geog.

Recommendations

Based on the insight gained from this study following recommendation are provided to enable project to realize its goals.

1) ***Application of democratic principles***: In theory it might be possible where 100 percent of the stakeholders can reach to a common agreement. But in reality we can hardly achieve this level of decision as the stake and interest of individuals vary. Therefore, it is essential to adopt democratic decision making process wherein decision based on majority should be pursued.

2) ***Tunneling of channel in the conflicted sections***: Tunneling of irrigation conveyance system is a technically viable option in case negotiation with the conflicted farmer groups fails. According to Yoder (1994), tunneling of irrigation channels was done by farmers in Bali, Indonesia and Nepal using traditional tools and technology. Although construction cost of this technology is ten times more than open channel base on per unit length this is offset by reducing overall length of the channel, reduce water loss, reduction of

subsequent maintenance and operation cost. This technology can be adopted in affected villages to by-pass the agriculture land, unstable section of the channel and even to reduce the length around the winding ridges.

3) ***Cost reduction measures***: In case this project becomes viable to implement, there are many areas where proper designs need to be carried to improve the performance of the irrigation system. A good design can not only rationalize investment but also reduce the cost. One area to be considered is reducing the primary channel section as channel approaches the tail end command area. Another area to be considered is to reduce the construction cost by increasing longitudinal bed slope of the channel which will reduce the cross-section.

4) ***Motorable service road***: Since the scale of this proposed irrigation channel in terms of length is very big and probably going to be longest in the country (34km), conventional management practice may not be effective. Hence, there is a need to mechanize the maintenance and operation of the channel. For this purpose it is crucial that there is a motorable service road. Although, incorporating service road will increase the investment cost, but it will justify the additional investment in the long run through reduction of the operation and maintenance cost.

Follow-up Actions

After the finalization of the feasibility study a number of events took place which is discussed hereafter.

a) Presenting the findings to the public

The findings to the feasibility study report was presented and discussed with the public of Kazhi in the Geog Office on 05 December 2011. The study reported that total of 5.76 acres of private land belonging to 28 farmers in Kazhi and Phangyul will be affected by construction of 34km long Baychu Irrigation Channel. The affected land use categories consist of Dryland (50%), Wetland (43%), Chimsa (3.2%), Sockshing (2.5%), and Tseri (1.3%).

Kazhi public maintained their initial position of not allowing the channel to pass through their geog claiming that the channel will only generate adverse impact to their livelihood without generating any benefit to them. Those groups of farmers whose lands will be directly affected by the construction claimed that on top of having small land holdings, the

construction will not only further reduce their land holding but also fragment it making the farming more difficult. On the other hand, those groups of farmers whose land although will not be directly impacted by the construction claimed that there is a risk of irrigation channel triggering land slips and erosion which will impact their land, farm roads and houses in the future. Therefore, they are not willing to allow the construction even if the issue of land compensation is addressed.

Accordingly, the DAW reported the views and concerns of the Kazhi Geog to the higher authorities for seeking direction.

b) Water act and swapping of water source

As the negotiation between Phangyul and Kazhi Geogs were approaching stalemate status, National Environment Commission (NEC) passed the Bhutan Water Act 2011. A team of officials from NEC accompanied by officials from DAW and RDC Bajo made another attempt to negotiate the issue on 21 March 2012. The provision of the Act was explained to the public of Kazhi Geog. According to the act no one has power to stop the construction of irrigation channel even through private land as long as the land is compensated as per the provisions of the Land Act. As the public realized that they have no room to disallow the construction through their land, they suggested the swapping of water source to minimize the impact to their land. Kazhi farmers proposed the water source at Chuzamo currently used by Chungsakha, Dongkha, Yampaykha and Komathrang could be diverted into Lhachu channel through construction of about 4km long new channel. The combined flow would be able to address the water scarcity issue faced by four Cheogs of Phangyul Geog. The proposed Baychu channel should end at Damina about 9 km from the source.

c) Reaction of Phangyul Geog

A team of officials from DAW and RDC Bajo led by Dasho Dzongda visited Phangyul Geog to present and discuss the proposal for swapping water source with the GYT member of Phangyul Geog on 04 April 2012. The GYT members accepted the idea of changing the sources but were concerned about the adequacy. According to the farmers Chuzamo source is very small and will not improve the water availability. Therefore, they proposed instead of Chuzamo the next bigger source called Sebjana be given to them. After the meeting, team walked to Wampeykha from where a bird's eye view of Komathrang village can be seen to familiarize with the site orientation of the village and its

surrounding water sources. A report was submitted to NEC for further direction on the issue of changing water as suggested by Phangyul Geog.

d) The decision as of 01 August 2012

On 01 August 2012 officials from NEC, DAW, RDC Bajo and GYT members of Phangyul and Kazhi Geog visited the Chuzamo and Sebjana water sources led by Dasho Dzongrab. After the field visit meeting was conducted in Kazhi Geog Office to discuss the proposal of swapping of Sebjana source amongst the team members. Generally Kazhi Geog accepted the proposal but water at the source should be shared equally as there are famer whose land cannot be irrigated by proposed Baychu Irrigation Channel. Therefore, it was agreed that both the sources Chuzamo and Sejana should be shared equally between Phangyul and Kazhi. The sharing will be done only after the completion of the construction of Baychu channel. This sharing remains conditional only such that in case Baychu channel fails to deliver water to Kazhi Geog, the geog has full right to reclaim their water source. Further, initial five years after the construction of the Baychu channel, Phangyul Geog has to be supported in maintenance work as well.

5.4.2 Renovation of Gyensa Irrigation Scheme

Renovation of Gyensa Irrigation Scheme (RGIS) was supported by Accelerated Bhutan's Socioeconomic Development (ABSD) project with a budgetary allocation of Nu 3.75 million. This project was planned to be implemented by RNR Engineering Division (RNR-ED), Department of Agriculture (DoA). However, due to the limited number of engineers in the division, DoA directed RDC Bajo to implement departmentally based on the National Irrigation Policy (NIP) 1992 guidelines. Although this was a development activity, RDC Bajo decided to implement it by making critical observations to assess the efficacy of the NIP 1992 in the light of emerging situation of farm labour scarcity. The lesson learnt will be of critical value in identifying new direction for the future.

Background

Gyensa is a small village under Toep Geog and comprising of 9 households. The village has scattered settlements over three small villages namely Umling, Gyensa (main village), and Shongraykha. The village is connected to Thimpu-Lobesa highway by 5km farm road. Agriculture is the main source of livelihood in the village. According to Irrigation Inventory 2009 the village has 58 acres of wetland where rice

is cultivated as main season crop in summer while vegetables are produced during winter season.

a) Irrigation water scarcity

Drinking and irrigation water shortage is the main problem faced by the village. Water scarcity is mainly caused by small source aggravated by inefficient and inadequate water management infrastructures. Since the village is situated on the upper ridges of the Tobeyrongchu, the village does not have access to bigger and reliable irrigation water source where water can be brought to village by gravitational conveyance system. A small spring water source situated about 4 km away from the main village is the only existing irrigation water source.

Traditionally built 6 km long earthen channel convey irrigation water from the source to the village. The conveyance efficiency of this channel is very poor owing to high seepage and leakages. During peak dry season water simply fails to reach the village. Despite the existence of irrigation channel the village is far from being termed as having assured irrigation system. As the water availability is both inadequate and unreliable agriculture production system in Gyensa is comparable to rainfed system.

b) ABSD Project Support

Since food production in the village is mainly constrained by water scarcity in the village, local government decided to improve the conveyance efficiency of the channel to increase water availability. Accordingly, the proposal which was submitted to the Ministry of Agriculture and Forest was agreed to be supported through ABSD project with Nu 3.75m.

Planning of the renovation project

a) Process

Due to the limited engineers in RNR Engineering Division, DoA directed RDC Bajo to implement the RGIS. On 16 November 2010 RDC Bajo requested Dzongkhag Agriculture Officer (DAO) Punakha to organize meeting with the Gyensa farmer to consult and draw action plan for implementing the project. The consultation meeting and field survey was completed by 16 December 2010. Through a participatory field survey approach beneficiary farmers were asked to identify and prioritize critical areas and sections of the irrigation channels that need to be improved. For research interest, the information on existing physical infrastructures was also collected and document.

Following the field survey drawings and estimates were prepared based on the priorities identified by the farmers. By 06 January 2011 technical and administrative sanction to implement the project was accorded by DoA. The summary of planned quantity of work to be implemented over the following two financial years is presented in Table 55. The preparation of drawing and estimates were completed by first week of January 2011.

b) Plan

As per the initial plan 1.25km length of irrigation channel representing 22% of the total length of the irrigation channel was planned to be lined with cement followed by 0.27km (4.7%) to be provided with HDPE pipes. Most of these pipe line works was planned to replace old broken pipes and wooden flumes at several locations. The plan also included construction of proper intake structure, several road crossings, drops structures, division chambers and pipe inlet/outlet structures.

Table 55 Quantity of work planned for two years project duration

	Priority 1 (Year 1)			Priority 2 (Year 2)		
Description	No. of Sites	Length (m)	%	No. of sites	Length (m)	%
Stable earthen section	0	0	(0.0)	0	0	(0.0)
Cement lined section	5	889	(15.6)	6	364	(6.4)
Footpath crossing	1	1	(0.0)	0	0	(0.0)
Division box	0	0	(0.0)	32	96	(1.7)
Drop structure	0	0	(0.0)	2	6	(0.1)
HDP pipe	2	54	(0.9)	4	216	(3.8)
Pipe inlet chamber	2	21	(0.4)	1	2	(0.0)
Pipe outlet chamber	2	4	(0.1)	3	6	(0.1)
Timber check dams	0	0	(0.0)	0	0	(0.0)
Total length	-	969	(17.0)	-	690	(12.1)

The cost of implementing the plan was estimated at Nu2.5211M. In the first year only Nu1.0M was planned and implemented while the remaining was to be spent during the second year.

c) Implementation modality

Cost sharing is the main focus of the NIP 1992. According to the policy major irrigation development or renovation work the government should

cover the cost of (a) material cost that are not locally available which includes cement, (b) transportation up to nearest road head, and (c) payment of skilled labour at prescribe government rate. On the other hand beneficiary farmers will (d) provide local material, (e) provide free labour contribution, (f) and cover the cost of local transportation. The intention of this cost sharing mechanism is to inculcate the sense of ownership and to reduce capital cost on the part of the government.

Table 56 Cost sharing pattern for RGIS project.

Work/structure type	Unit Rate	Year 1 (2010-11) Qty/Unit	Year 1 (2010-11) Amount	Year 2 (2011-12) Qty/Unit	Year 2 (2011-12) Amount
Cement lining	1,400	600 m	840,000	289 m	404,600
Water division structure	5,400	15 No	81,000	15 No	81,000
Drop structure	6,700	-	-	2 No	13,400
Footpath crossing	4,200	-	-	3 No	12,600
Stream crossing	14,900	-	-	3 No	44,700
HDPE pipe- D225mm	1,500	108 m	162,000	216 m	324,000
HDPE pipe socket- D225mm	450	18 No	8,100	36 No	16,200
Pipe inlet structure	3,500	3 No	10,500	4 No	14,000
Pipe outlet structure	2,400	3 No	7,200	4 No	9,600
RCC Post Type-H2.5	4,300	24 No	103,200	56 No	240,800
RCC Post Type-H2.0	3,300	6 No	19,800	8 No	26,400
RCC Post Type-H1.5	2,500	6 No	15,000	8 No	20,000
Intake structure	67,000	1 No	67,000	-	-
Total		100 %	1,313,800	100 %	1,207,300
Community contribution[a]		19 %	254,650	15 %	183,798
ABSD contribution[b]		81 %	1,059,150	85 %	1,023,502

[a] Labour, local material, and local transport

[b] Material, skilled labour, and transport up to nearest road

Findings

a) Characteristic of the water source

Gyensa irrigation channel water source is called Yonkana. The flow rate of the source was measured using cut-throat flume on 14 January and 16 February 2011. The flow rate was 11.0 and 11.5 litre per second respectively. There is second source about 850 m downstream of the main source along the channel. The flow of this source was 2.2 and 1.9 litres per second which was measures about the same time. According to the farmers the yield of the main source does not vary much during dry and wet season. Contrary to this, the yield of the second source is highly dependent on rainfall. Water at the main source is diverted into the channel by means of a temporary stone wall. Beneficiary farmers claim

that this source solely belongs to them. Hence the flow is completely diverted into the channel.

b) Existing channel infrastructures

The reason for surveying existing irrigation infrastructure was to set baseline information for the irrigation scheme. This information will serve as the bench mark for assessing the impact of any improvement work done on the scheme. Summary of the channel section types before renovation work are presented in Table 57. From a total length of 5.7 km 95.5% (5.42 km) of it is earthen section, followed by 2.7% of pipeline and about 1% comprising of cement lined section. About 40m length of the channel comprised of wooden flume delivery water across rock outcrops or crossing over gullies.

Table 57 Gyensa Irrigation Channel section type before renovation work.

Channel section type	No of sites	Length (m)	%	Remark
Earthen	12	5,420	(95.1)	
Earthen covered with soil[a]	1	30	(0.5)	
Wooden flume	3	40	(0.7)	
Pipe- HDP/PVC	4	156	(2.7)	
Cement lined	2	18	(0.3)	
Cement lined covered with slab	2	29	(0.5)	
Cement lined- FP slab crossing	1	2	(0.0)	
Cement lined- partially (CCE)	1	5	(0.1)	
Total length		**5,700**	(100.0)	

[a] From the excavation of farm road

The intake of Gyensa irrigation channel is situated at 89°49.615' east longitude and 27°30.242' north latitude at an elevation of 1920 m. The channel alignment follows counter line starting from the intake for a distance of about 1.5km. In this stretch, the longitudinal channel bed slope is very low which has resulted in heavy siltation reducing the channel capacity creating conditions for overflows, leakage and seepages. These factors have reduced the conveyance efficiency of the channel.

The channel alignment from 1.5 km to 1.9 km mark either runs down the slope or follows down the natural drainage lines. In this section channel drop by around 80 to 100m resulting forming a very steep longitudinal slope. In absence of any properly designed drop structures the kinetic

energy of the flow has resulted in formation of deep gullies and water pools.

The alignment from 1.9 km to 3.0 km roughly follows counter line. In this section the bed slope is more than the first stretch. There were no signs of sedimentation, but due to high velocity of the flow heavy scouring action had deepened the channel in general and formed several pools along the channel length.

The alignment of channel section between 3.0 km to 3.25 km runs down the slope at a very high gradient. Owing to the high energy of the flow a very deep gullies and pools are formed over the time. At some sections, the gullies are as deep as 3.0m. The conveyance loss is very high in this stretch of the channel. During 2011 and 2012 rice transplanting season, it took more than three to five week for the irrigation water to pass through these gully section. This situation arises when the irrigation channel is left dry for longer duration. This was the case for last two rice transplanting season wherein channel had to be kept dry for renovation work.

From the end of the gully till the channel reaches the main village, the alignment follows partly counter line and partly runs down the slope. No major problems were observed in this stretch. Within the village irrigation water is conveyed through areal HDPE and PVC pipelines supported by wooden post. The pipelines are generally aligned along the paddy field risers or bunds. Due to the improper construction of the pipelines, and failure of wooden post due to decaying, the pipelines were either broken or filled with silt. As PVC pipes are exposed to the sunlight it has become brittle and ultimately failed.

From the main village to the tail end of the command area Shongraykha village water is conveyed through open channel aligned along the counter line. As the gradient of the channel suits the soil type there is neither any major sedimentation nor any scouring in the channel section.

c) Water sharing pattern

Owing to water shortage in Gyensa, the water is shared on a rotational basis. One share of irrigation water is defined as 100% of the flow in the channel diverted for 24 hours starting from 5 pm to 5 pm following day. Although there are only nine households in Gyensa, irrigation water share is divided into 15 shares corresponding to rotational period of 15 days. The amount of water share is based on the landholding size which ranges from maximum three to minimum of quarter share.

Irrigation water sharing starts from the first day of the fifth Bhutanese Month. For the first one week one farmer situated at the upstream part of the scheme takes the full share, however this farmer does not get any subsequent shares for the entire season. After the first week of the fifth Bhutanese Month normal rotation among eight household commences. The sequence of sharing is determined through lucky dip process after each rotation period. Table 58 indicates a typical sharing pattern. Water rotation period of 15 days implies that higher degree of water scarcity against normal duration of 7 to 10 days is acceptable condition for optimal rice production.

Table 58 A typical irrigation water sharing pattern under Gyensa Irrigation Scheme.

Farmer's Name	[a]HH #	[b]Water share	Sharing group	Water turn	# of plots	Area (Langdo)	Area (ac)
Aum Dechen Zangmo	9	8	10	0	-	-	
Ap Sangchu	1	3	1	1,2,3		[c]33.0	8.26
Dasho Dendu	3	3	3	4,5,6		[c]33.0	8.26
Tan Dorji	2	2	2	7,8		[c]23.6	5.89
Jangtoe Namgay	4	2	4	9,10	12	24.0	6.00
Wangdi	5	1	5	11	2	18.8	4.70
Ap Bokhu	6	1	6	12		8.0	2.00
Thinley Gyem	6	1	7	13		[c]14.1	3.52
Lhamo	6	½	8	14	7	11.0	2.75
Gyem Lham	6	½	8	14	8	9.0	2.25
Tobgay	7	½	9	15	7	8.9	2.23
Thinley Gyem	8	¼	9	15		[c]7.0	1.74
Tobgay	8	¼	9	15		[c]7.0	1.74
Total/average	9	15	10	-		197.3	49.3

[a] Same household with different gung number.
[b] One water share is defined as 100% of the flow in the channel diverted for 24 hours starting from 5 pm to 5 pm following day.
[c] Area estimate base on the correlation of known landholding size and corresponding water share, [A = 9.478 x (Watershare) + 4.5951]

Output of the renovation work

a) First year

The renovation work started from source by February 2011. The construction of intake structure consisting of 20 m of diversion wall, and

flow control structures were complete before initiating the lining of the channel. As longitudinal bed slope of the channel was not uniform, the re-adjustment of bed slope was done for the first 50 meter of the channel. This readjustment required filling and cutting of the channel profile thus increasing quantity of the work. This was done to improve uniformity of the channel section thereby improving the capacity. Subsequently, 180m of channel length was completely cement lined. The lining work included excavation of soil, providing stone soling, followed by PCC, RRM walls and plastering works. In addition, excavation and providing of stone soling for about 100 m of channel length was also completed. Except for the stone and aggregates all other material had to be transported manually from the nearest road head which is 1½ hours walk. The renovation work was stopped by the end of June to allow farmers to start rice transplanting.

However, two of the farmers agreed to work on the construction of pipeline on one of the distribution channel belonging to them. This work was a request to be implemented during rice season to avoid the damage of left over cement. The over ground pipe line construction work included construction of RCC post replacing wooden post, fixing of pipes and construction of pipe inlet and outlet chambers. A total areal pipeline (225mm diameter) length of 36 m support on 12 RRC post (200x300mm) of average height of 2.5m were constructed. However, inlet and outlet structure could not be constructed due to limited labour.

b) Second year

In the second year, the farmers prioritized that they needed to complete the pipeline construction work within the village first and subsequently continue from the previous year's lining works. The work was started on 08 January 2012. Accordingly, total areal pipeline (225mm diameter) length of 180 m support on 34 RRC post (200x300mm) of average height of 2.5m, and four chambers were constructed. The chambers included one inlet, outlet and two intermediate or distribution.

After the completion of above pipeline work, the lining work was resumed on the main channel from the previous year's completion point. About 139m of channel was completely lined, 7m was lined by providing wall on one side, and stone soling work for 200m of the channel length was completed. Unfortunately, the channel lining work had to be stopped by 02 May 2012 due to unavailability of cement in the market although; they had one more month free before they need to engage on rice cultivation.

c) Emergency pipe request

As usual, the irrigation water sharing for 2012 rice season was started on the first day of the 4th Bhutanese month corresponding to 21 May 2012. Few weeks after, farmers informed RDC Bajo that irrigation water did not reach their mainly village. All the flow that was diverted from the source could reach as far as first village. By 11 June 2012 farmers requested for pipes to convey irrigation water by-passing the gullies. Accordingly, RDC Bajo surveyed the gully sites, prepared drawings and estimate and forwarded the proposal to Department of Agriculture for approval. On 15 June 2012 approval was accorded to implement the proposal. The first load of HDPE pipe (88 numbers of pipes of each 6m length of 180mm diameter of 4kg/sq.cm) was delivered to the village. The second load of pipes (77 numbers of pipes of each 6m length of 180mm diameter of 4kg/sq.cm) and matching HDPE socket was delivered to the village on 27 June 2012. Immediately, the work on the laying of the pipes was started. By the time it was half way through heavy rainfall and the runoff generated increased the flow in the channel enabling the irrigation water to reach the village. Farmers decided to stop pipeline laying work for time being and continue after the completion of rice transplantation season.

d) Overall output

Table 59 Summary of output of Gyensa Irrigation Channel renovation

Name of the structure	Unit	Year 1	Year 2	Total	Remark
Intake structure					
Diversion wall	m	20.0	-	20.0	
Control structure	#	1	-	1	
Cement lining					
Cement lined- Complete	m	180.0	139.0	319.0	
Cement lined- One side wall	m	-	7.0	7.0	
Surface/areal pipeline construction					
Pipeline (HDPE- D225mm-6kg/cm^2)	m	36	180		
RCC Post-300x200mm of 2.5m av. height	#	1	1	2	
Pipe inlet chamber	#	1	1	2	
Pipe outlet chamber	#	1	1	2	
Pipe intermediate chamber	#	1	1	2	
Sub-surface pipeline					
Pipeline (HDPE- D180mm- 4kg/cm^2)	m	-	990	990.0	
Pipe inlet chamber	1	-	1	1	
Pipe outlet chamber	1	-	1	1	
Pipe intermediate chamber	2	-			

[a] Same household with different gung number.

Through this project, 319 m of channel is lined with cement, 261 m of areal HDPE pipeline was constructed, 990m of high seepage channel section was replaced by sub-areal HDPE pipeline, four pipe intermediate chambers, three pipe inlet, two outlet chambers, and one irrigation channel intake control structure with 20 m long diversion wall was constructed. The details are summarized in Table 59.

e) Direct expenditure

The summary of direct expenditure incurred in implementing this project is stated in table. In direct expenditure in terms of technical service, travel and DSA are not included within this statement.

Table 60 Expenditure summary for Gyensa Irrigation Channel renovation work.

Cost sharing	Sub-total amount	Total amount	Remark
Project (80%)	-	1,708,833.17 (80%)	
Material	1,477,585.89 (69%)		
Implements & tools	24,575.00 (1%)		
Transportation	79,947.00 (4%)		
Skill labour	126,725.28 (6%)		
Community [a]	-	427,208.29 (20%)	
Total project cost	-	2,136,041.47(100)	

[a] Cost of community contribution is derived from 20:80 established while preparing the estimate. The actual cost of community might be higher due the higher wage rate of Nu.350 compared to BSR-2011 rate of Nu.178.76 per day.

Lessons learnt

a) Limited labour availability

Since the National Irrigation Policy 1992 requires the beneficiary farmers to contribute free labour for irrigation channel development work, like in other parts of the country Gyensa village has limited farm labour. There are only 9 household with fifteen water shares. The average active labour force is 1.6 person per water share or 2.5 person per household. This equates to maximum annual labour availability of about 8,760 labour days.

In reality, all the household labourers are not available for working in the project. At least one active labour force has to be engaged in looking after the day to day running of the household (rearing livestock, agricultural activities, and participating in the meetings etc). Few

households who are not residing in the village had to entirely hire the labour on daily wage basis. The minimum wage rate in the village is Nu300 with lunch. The wage rate including lunch will amount to not less than Nu400 per day per person. It was observed that even those households who reside within the village had to hire labour from outside the village when they had to attend to other emergencies.

b) Narrow project implementation period

For irrigation renovation work the effective project implementation period starts only after the harvesting of rice season corresponding to 10th Bhutanese Month (BM) and has to be stopped for rice season with start of raising nursery (corresponding to middle 3rd BM). Although rice transplanting starts by the beginning of 4th BM since the village does not have alternative irrigation water source for growing nursery. Therefore, irrigation channel has to be functional from 3rd BM. This results in effective project implementation period of only 5½ months (165 days) equivalent to total labour force availability of 2475 days.

In the first year project could not be started earlier than February 2011 due to the time required for releasing the budget. However, in the second year starting of the project was again delayed due to the internal-conflict in the alignment of pipeline in one of the distribution channel despite everything was ready. On 10 October 2011 one of the farmers on whose land the distribution pipeline was constructed claimed that the RCC post construction used more land than it was occupied by the timber post in the past. The conflict dragged on for several months and finally beneficiary farmers resolved that conflict by end of December 2012. The work was started by 08 January 2012 based on the agreement signed among the beneficiary farmers on 03 January 2012.

In the second year, when the project was making good progress, the shortage of cement supply in the market disrupted the progress. The cement stocked for the project was exhausted by one and half month before the actual project period. In the hope of cement supply to be normalized, the renovation work which did not require cement continued till end of April 2012. By 02 May 2012 the work was completely stopped as cement was not available. Hence, effective project implementation period was very short.

Conclusions

Initially, farmers were exited to know that government allocated Nu3.75M for renovation of Gyensa Irrigation Scheme. They expected their channel problems would be solved. Accordingly, they supported in the development of very optimistic plan which included cement lining of about 1.0 km of the channel length, replace all the existing old pipelines, wooden flumes, construction of proper distribution chambers, drop structures, and permanent intake structures.

Apart from the completion of the construction of permanent intake structure and pipelines, the lining works, construction drop structures, and distribution chambers remains under-achieved. The main reasons for under achievement were (a) limited labour availability in the village, (b) short project implementation period, (c) the context in which National Irrigation Policy 1992 was formulated does not apply to present context, and (d) inappropriate planning.

While the farmers' expectations remain partially fulfilled against the set target, the experiences and lessons learnt from the implementation of the project will go a long way in terms of finding better directions for implementing similar project in the future.

DEVELOP-MENT ACTIVITIES

6 DEVELOPMENT ACTIVITIES

6.1 National Rice Development Program

RDC Bajo, being the National Coordination Centre for field crops Research and Development has made tremendous strides in rice commodity development program. Under the aegis of Accelerating Bhutan's Socio-economic Development (ABSD) Initiative for rice productivity improvement program, the centre coordinates activities spanning across four cluster Dzongkhags which were identified as potential rice growing districts viz. Sarpang, Samtse, Samdrup Jongkhar, Wangdue and Punakha valley. The ABSD activities for rice commodity program which started from 2010 is currently in full swing and various interventions have been initiated to enhance rice productivity and production towards commercializing rice farming in the country. So far, ABSD program has been able to cover about 4075.1 ha area through various interventions such as farm mechanization, supply of higher yielding varieties of seeds, farmer to farmer seeds, improved cultivation practices, soil fertilizer management including training of farmers and extension officials.

Besides the regional rice commodity development program, the centre coordinated various rice commodity activities outside the region as highlighted in the following heads.

6.1.1 Signing of rice MoU

As part of National rice commodity development program, RDC Bajo has coordinated signing of Memorandum of Understanding (MoU) between the Department of Agriculture and the Dzongkhags Administrations of Sarpang, Samtse, Samdrup Jongkhar, Wangdue and Punakha for rice productivity improvement program. The MoU signing for rice charter was necessitated to clearly define

roles and responsibilities, and general obligation of the parties concerned of the Dzongkhag and the Agriculture Department to improving working system and coordination during implementation of activities in the field.

6.1.2 Rice Production and sale

The Chuzargang Agricultural Farmers Cooperative (CAFCO) at Chuzargang geog under Sarpang Dzongkhag continued to do well over the past few years after its inception in 2010. With coordinated efforts from the central agencies and RDCs within the department in collaboration with the Dzongkhag, the working system of CAFCo is said to have improved manifold and the cooperative is performing at self sustainable mode. In 2011-2012 fiscal, CAFCo has earned a gross income of Nu. 1,199,850 through rice business as detailed in Table 61.

Table 61. Rice sale information of CAFCO (2011-2012).

SN	*Variety*	*Head Rice*	*Broken*	*Bran*	*Brown rice*	*Total*
1	Winter paddy	44000	5672	5168	0	54840
2	Champa	436975	4410	13248	0	454633
3	Khamtey	56175	200	2248	0	58623
4	Kalobog (Jeera)	159705	0	3560	35100	198365
5	Chotimasino	362970	200	8200	1935	373305
6	Kalobog (bold)	48600	420	1344	0	50364
7	Ranjit	8800	500	200	175	9675
8	*Gross Income*	1,117,225	11,402	33,968	37,210	1,199,805

Source: Chogyal, mill manager, CAFCO

6.1.3 Demonstration and supply of HYV seeds

Availability and accessibility to quality seeds has been a perennial problem for the Bhutanese farmers. In 2011-2012, the Department of Agriculture supplied improved rice seeds comprising of 5-6 varieties to the tune of 63.18 tons to the Dzongkhags based on the agro-ecological zonations (Table 62). The most basic way of increasing grain yield is through the use of quality seeds of high yielding varieties. Samtse Dzongkhag, having the largest rice area, was supplied the highest quantity (22.2 tons) of seeds, followed by Sarpang with 12.9 tons. Samdrup Jongkhar received 10.02 tons while Wangdue-Punakha valley received 18.025 tons.

Table 62. Supply of improved rice seeds to the ABSD cluster Dzongkhags

Dzongkhag	Variety	Quantity (kg)
Sarpang	Bhur Ray Kaap1	4,340
	Bhur Ray Kaap 2	4,990
	Br-153	500
	Bhur Kambja1	980
	Bhur kambja 2	530
	IR-64	600
	Khangma Maap	1,000
Sub-total		**12,940**
Samtse	Bhur Kambja 1	4,900
	Bhur Kambja 2	4,600
	Bhur Ray Kaap1	4,000
	Bhur ray Kaap2	5,500
	BR-153	3,200
Sub-total		**22,200**
S/Jongkhar	Bhur Kambja 1	980
	Bhur Kambja 2	540
	Bhur Ray Kaap1	2,640
	Bhur ray Kaap2	3,260
	BR-153	2,600
Sub-total		**10,020**
Wangdue	IR-64	7,520
	Khangma Maap	440
	Bajo Maap 1	275
	Bajo Maap2	250
	Bajo Kaap1	250
Sub-total		**8,735**
Punakha	IR-64	7,980
	Khangma Maap	160
	Bajo Maap1	350
	Bajo Maap2	250
	Bajo Kaap1	550
Sub-total		**9,290**
Grand total		**63,180**

6.1.4 Farmers' Field Days

To create awareness and promote use of improved seeds, farmers' field days were conducted in collaboration with the Dzongkhag EAs. Farmers' field days were also conducted wherever improved technologies have been demonstrated such as demonstrations of sesbania green manures, balanced fertilizer, etc. Altogether, 27 nos of field days were conducted including the regional ones as detailed below:

- Sarpang: 7 field days on improved seeds and fertilizer management benefiting 282 farmers
- Samtse: 9 field days on improved seeds and fertilizer management benefiting 290 farmers
- S/Jongkhar: 3 field days on improved seeds and fertilizer management benefiting 294 farmers

6.1.5 Soil fertility management

Poor soil fertility management has been found to be one of the leading causes of dwindling grain yield in rice. Efforts have been initiated to demonstrate and encourage use of pre-rice sesbania green manuring as a low cost plant nutrient for rice. In 2011-2012l, a total of 4066 kg sesbania seeds have been distributed to the farmers across 4 ABSD cluster Dzongkhags which is double the quantity supplied in the previous year.

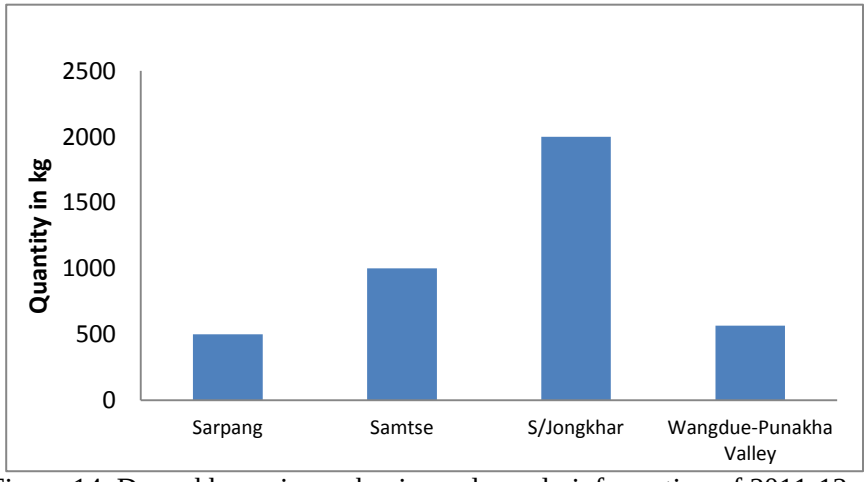


Figure 14. Dzongkhag wise sesbania seed supply information of 2011-12

Samdrup Jongkhar dzongkhag was supplied the maximum quantity of green manure to encourage organic rice production and in line with the 'S/Jongkhar Initiative' of the government. Apart from promotion of sesbania green manure, demonstrations on balanced fertilizations were carried out with awareness programs such as field days and campaigns.

6.1.6 Plant Protection services

Plant protection is one key area requiring special attention to reduce the crop losses to insect pest and diseases, and increasing the grain yield. Over the past few years, NPPC and RDCs have started to work vigorously to create awareness and trained field colleagues on IPM. The EAs have stepped up field monitoring and pest surveillance in the fields using the basic kits provided by NPPC. Also, NPPC and the Dzongkhags have also started on-farm demonstrations on pest control including major weeds.

6.1.7 Farm mechanization

Farm mechanization is one most important components of rice commercialization program. It is seen as an answer to farm labour shortage in the rural communities and drudgery associated with rice farming. Various interventions have been initiated and over 1000 acres of rice area have been brought under mechanization (Table 63).

Table 63. Summary of farm machineries procured and deployed for ABSD

Dzongkhag	Sarpang	Samtse	S/Jongkhar	Wangdue-Punakha	Total
Power tiller	5	3	2	3	13
Tractors	17	5	2	2	26
Water pump	2	1	2	2	7
Poly House	4	6	2	6	18
Transplanter	6	3	2	3	14
Weeder	1	1	0	1	3
Reapers	6	1	2	0	9
Threshers	0	1	5	0	6
Milling machine	1	0	0	0	1
Total	42	21	17	17	

Major activities under farm mechanization includes procurement and deployment of machineries in the farmers' field, institution of machinery hiring system including training of farmers and EAs on operation and maintenance of farm machineries. Highlights of specific activities implemented as part of the department's farm mechanization drive are as follows.

6.1.8 Installation of poly houses for tray nursery

A total of 18 polyhouse sets were procured and supplied by AMC which were installed and used for raising tray nurseries. Records maintained by AMC show that 6 sets of poly houses were supplied to Samtse, 6 for Wangdue-Punakha valley, additional 4 sets for Sarpang, and 2 for S/Jongkhar (Bangtar area). In view of erratic weather pattern, such poly houses were required for raising rice nurseries, and during the off seasons, the structures could be best used for producing vegetable crops. In wangdue-Punakha, the poly sets were given to Farmers of Lobesa under Baap geog to support the recently formed farmers cooperative viz.' Lobesa Sonam Nyamley Tshogdey'cooperative'.

6.1.9 Demonstration of mechanized harvesting

The rice mechanization program, spearheaded by AMC and in collaboration with RDCs and Dzongkhags has demonstrated mechanized rice harvesting operations for the first time in Samtse (Yoeseltse and Ugyentse) and Samdrup Jongkhar (Pemathang and Phuntshothang geogs) Dzongkhags. A total of 9 reapers/rice harvesting machineries were procured and were pressed into service and harvested rice spanning approximately over 200 acres in Pemathang and Phuntshothang geogs of Samdrup Jongkhar, and 30 acres in Yoeseltse and Ugyentse geogs of Samtse Dzongkhags. Such activities were just the beginning and as rice commercialization activities pick up, more

interventions especially mechanized rice farming will be more fully realized towards increasing the rice yield. Farmers in Sarpang Dzongkhag (Chuzargang, Umling, Taraythang, Shershong, Dekiling and Bhur) have also started using reapers for harvesting their rice saving much of their time.

Demonstration of mechanized rice transplanting

Besides Sarpang Dzongkhag where rice mechanization has already picked up, mechanized transplanting were demonstrated in Samdrup Jongkhar, Samtse and Wangdue-Punakha valley. While rice transplanting operation is just beginning in Southern Dzongkhags, approximately 25 acres of rice paddies were transplanted using transplanters at Baap geog under Punakha Dzongkhag. Plans are in place to demonstrate this activity in two geogs of Samdrup Jongkhar (Pemathang and Phuntshothang), and two geogs in Samtse (Ugyentse and Yoeseltse). Our first observation and conclusions were that the demonstrations on mechanized transplantation saw huge enthusiasm from the farmers as they have never seen such technology before. This particular activity was intended to create awareness on the farm mechanization and it is hoped that the farmers will take up mechanized rice farming and enhance rice productivity besides reducing farm labour drudgery in the years to come.

Demonstration of lift irrigation

In the areas where there is an acute shortage of irrigation water, the department encourages establishment of lift irrigation systems. The year 2011-2012 was a not bountiful year for the farmers of Punakha-and Wangdue as the Dzongkhags experienced severe drought like situation delaying rice plantation. Amongst others, the farmers of Baap geog with vast stretches of rice paddies were the most affected. But with the launching of rice commercialization and mechanization at Lobesa under

Baap geog, RDC Bajo in collaboration with AMC and the Dzongkhag have been able to help some farmers of Tshokhorna chewog which is located towards the tail end of the two existing irrigation channels. As part of demonstration of lift irrigation we pumped water from Puna Tsangchhu and irrigated about 12 acres of land belonging to 5 households. This initiative has also been able to bring back about 1 acre of fallow land to cultivation is encouraging.

RDC Bajo supported a farmer of Guma geog under Punakha Dzongkhag to irrigate SRI demonstration plot by pumping water from PunaTsangchhu. In addition to this, over 15 acres of rice field was irrigated through lift irrigation at Rarow (Toewang geog) in Punakha Dzongkha where there was acute shortage of water and rice transplanting was delayed.

6.1.10 Capacity Development

Capacity building of both EAs and farmers are being seen as most important component for bringing about improvement in agronomic

practices. Very specific need based trainings were provided to EAs and farmers as briefly described in the following heads.

Farmers training on rice tray nursery

As part of mechanized rice farming, farmers' training cum demonstrations on tray nursery was organized in the geogs where mechanized rice farming has been initiated. Farmers were provided skills such as seed soaking, incubation, seeding in trays, tray preparation and tray management. The tray nursery was necessitated for mechanized transplanting and such activities were carried out at Pemathang and Phuntshothang in S/Jongkhar, Yoeseltse and Ugyentse in Samtse, Baap geog in Wangdue-Punkha valley.

For Wangdue-Punakha valley, tray nursery training cum demonstration was organized at three chewogs of Baap geog, i.e. Yuwakha, Esukha and Tshokhorna. Tray nursery technology, being totally new to the farmers of the geog/region, almost all the farmers in the locality took keen interest to see the technology demonstration and training program. The tray nurseries were raised in the poly houses for 15 days before transplanting in the field. Altogether, 39 farmers (21 male and 18 female) were trained at Baap Geog of Punkaha alone. The farmers have raised tray nurseries for estimated 25 acres of wet land this season.

Farmers training on operation and maintenance of farm machineries

With the support of AMC, a total of 71 farmers were trained on operation and maintenance of farm machineries (21 farmers were from Sarpang, 27 from Samtse, 12 from S/Jongkhar and 11 from Wangdue-Punakha valley). RDCS, Dzongkhags and central programs within the department of Agriculture in collaboration with AMC has plans to continue training of more farmers to facilitate mechanized rice farming.

In-country farmers' study tour

RDC Bajo organized a three day in-country study tour for the farmers of Lobsea under Baap geog in Punakha Dzongkhag to Chuzagang, i.e. Chuzagang Agricultural Farmers Cooperative (CAFCo) in Sarpang Dzongkhag. The tour was for the benefit of the members of recently formed "Lobesa Sonam Nyamley Tshogdey" and the officials of Baap geog and altogether benefited 42 people (18 male and 24 female). The

main objectives of this program were: (i) to interact with the office bearers of CAFCo and take up the experiences of CAFCo which is supposed to be first agricultural farmers cooperative in the country, (ii) to ' see and believe' the functioning of CAFCo including the rice milling and processing facilities established at Chuzagang, and (iii) to expose and increase farmers' awareness on group dynamics and functioning system.

Rice Production training for EAs

Under the Department's initiative to improve rice productivity and production, capacity building of extension agents is featured as top priority. The department has already initiated EAs trainings for the Southern Dzongkhags and plans to provide refreshers course to EAs of 200 geogs of the country.

RDC Bajo organized three day training on rice production to the EAs from major rice growing Dzongkhags of Wangdue, Punakha, Tsirang, Dagana and Gasa Dzongkhag. The training was, in fact, a comprehensive refresher course on rice production covering 3 major subjects inclusive of rice agronomy, soil fertility and nutrient management, and insect pests of rice. 39 EAs attended (13 female and 26 male) the training. The main objective of the training was to provide our field colleagues with fundamental information of rice science and updated knowledge on rice production management system.

In addition to this, NPPC also organized a three day IPM course for the EAs of Samtse, Sarpang and Samdrup Jongkhar at RDC Bhur. The training focused mainly on the emerging diseases and pest management of rice crop and 25 EAs have attended this training program.

NSSC in collaboration with the Dzongkhag Agriculture office, Samtse also organized farmers training on balanced fertilizer management and pre-rice green manuring at Yoeseltse and Ugyentse geogs benefiting 89 households.

6.2 Horticulture

6.2.1 Assorted fruit crops production demonstration at Lungtsegang

Lungtsegang is a village in Tsholingkhar Gewog, Tsirang. This Chiwog has inadequate irrigation facilities for paddy cultivation and limited cash income source. Farmers expressed interest to grow fruit crops and it was relayed to us through Dzongkhag agriculture extension. We conducted consultative meeting with farmers of this village, geog administration and dzongkhag agriculture extension in which it was decided that RDC-Bajo will adopt this village to demonstration the assorted fruit production. The meeting also identified list of priority fruit crops based on agro-climatic suitability. The renovation of irrigation channel was agreed to be supported by Dzongkhag agriculture extension. The objective of this joint research-extension collaborative activity on assorted fruit crops promotion was to demonstrate the technology of fruit production through the concept of group farming practices for the poverty alleviation.

The farmers were provided hands-on-training in orchard layout and designing in the month of June 2009. The fruit plants were provided free of cost by RDC-Bajo. The farmers training on planting, manure application, mulching and after care of fruit crops were provided at the time of planting. The fruit tree planting was supervised jointly by researcher and geog extension agent until its completion. The participatory follow up action plan were drawn up and data collection will be done as and when needed.

The monitoring and evaluation of the program was done jointly by extension and researchers. The survival rate of fruits plants was more than 90% and vegetative growth of plants is good despite lack of irrigation. Further, the center provided 185 grafted seedlings for gap filling in 2011. As of now, the planted fruits have established and a few mango plants started fruiting. Except for few pests (bugs), no major pests were observed. As a prophylactic measure, the cow slurry was sprayed.

6.2.2 Improvement of fruits nursery and plant propagation

In the light to citrus HLB disease epidemic in the country, we have improved the fruit nursery in the institute with improved insect proof structure and very minimal contact with soil to avoid soil borne diseases. The planting materials of various fruit crops are being produced in the centre mainly for meeting the requirement of on-farm testing of promising fruit cultivars and promoting the released fruit cultivars through research outreach program in a focus or adopted villages. The nursery management and plant propagation techniques assessment go side by side with crop variety introduction and evaluation. The propagation techniques successfully tested and planting material of various fruits and nuts crops multiplied are as under in Table 64.

Table 64: Plant propagation technique and planting materials produced

Crop	Grafted plants produced (no)	Grafting technique	Seedling from seeds (no)
Mango	25	Approach	30
Citrus	460	Side veneer	1000
Pear	147	Whip	100
Walnut	270	Whip	500
Pecan	10	Whip	150
Passion fruit	0	Seedling	300
Guava	0	Seedling	180
Bajo apple	42	Whip	60
Avocado	23		122
Persimmon	32	Whip	80
Grapes	0	Cutting	200
Pomegranate	200	Cutting	150
Apricot	23	Whip	30
Peach	33	Whip	500
loquat	10	Whip	50

These planting materials are supplied to research outreach communities with the aim to demonstrate improved orchards with superior planting material and also used to evaluate for their suitability in the farmer's field. In addition these improved fruit orchards will be used as source of healthy scion wood for further multiplication to meet the demand of in the locality.

6.2.3 Regional private fruit nursery promotion

Fruit production in Bhutan suffers from many constraints. The production in some fruit crop has decrease over the years. One of the major causes of decline in production is shortage of quality seedlings. There is huge seedling demand across the country. Therefore, horticulture sector of RDC Bajo has promoted private nurseries within the west central region of Bhutan. These private nurseries produce high quality seedlings that would meet the increasing seedling demand within the region and across the country. The other objective is to demonstrate the nursery techniques at farmers' field level for increased income generation and livelihood enhancement.

The promotion of private nurseries started in 2009 after the issue on seedling shortage in the country was discussed in Research-Extension workshop in 2008. The promising farmers coupled with their interests were selected to take up private nursery. The chosen farmers were initially backstopped technically by the experts from our center. The nursery men were then trained for operation. As of now we have promoted about 5 nurseries in different Dzongkhags within the region as shown below in Table 65.

Table 65 Private nurseries established in west central region

Village	Number of nursery	Geog	Dzongkhag	Year of establishment
Palokha	1	Rubesa	Wangdue	2010
Tshokorthang	1	Nahi	Wangdue	2009
Beteni	2	Mendrelgang	Tsirang	2008
Tashithang	1	Tashithang	Dagana	2010
Nobgang	1	Talo	Punakha	2012

The nursery operators were initially trained on propagation methods. They were also supported with the grafting materials and scion woods. Simultaneously, the mother blocks have also been established for all the nurseries except for Tashirthang. Most of the nurserymen were trained on walnut propagation as it is quite difficult to propagate. Annually horticulture team from RDC Bajo technically supervises during propagation and monitor at regular interval. Once the private nurseries are able to operate independently, they are then connected with National

Seed Center (NSC). Thus private nurseries are the contact nursery growers for NSC.

In this financial year (2011-12), the team from RDC-Bajo along with the nursery operators technically backstopped in walnut grafting for more than 6300 seedlings in five private nurseries. The exact timing for propagation varied with location. At Rubesa, the grafting of walnut was carried out towards early spring (mid March) when the environment becomes ambient for graft union formation. At Nobgang, the walnut was grafted towards late spring (early May) when the temperature rises. The detail of soft shell walnuts grafted in private nursery is as shown below in Table 66.

Table 66: The number of walnut grafted by private nurseries

Nursery	Number of seedlings grafted	Graft success at 1st monitoring	Expected income (Nu @ 80 per seedlings)
Rubesa, Wangdue	2400	98 %	188,160.00
Nahi, Wangdue	420	89%	29,904.00
Upper Beteni, Tsirang	846	96%	64,972.80
Lower Beteni, Tsirang	550	93%	40,920.00
Nobgang, Punakha	2300	97%	178,480.00

As of now, RDC Bajo has promoted five private nurseries. Although not registered, two private nurseries (Tshokorthang and Benteni) are currently operated independently. RDC Bajo has withdrawn the technical support since 2011. These private nurseries are already linked with NSC. Annually, more than 5000 grafted walnut seedlings are produced from private nursery. This year, about 6500 grafted walnut seedlings will be produced from these private nurseries. Thus, the huge demand for quality seedlings is currently being made. On the other hand, four other nurseries (Nobgang, Rubesa, Upper Beteni, Loduma) are currently being looked after by the experts from RDC Bajo. Technical support will be continued for few more years. The program has not only created awareness of nursery techniques among farmers but also generated cash income. Further, the quality grafted seedlings were made available to farmers for better yield and production.

6.2.4 Kiwi Fruit Demonstration Orchard

Kiwi is a famous temperate fruit and it had been found in wild since olden days in our country but its domestication was not done or tried by anybody till date. The center could not conduct on station trial since our centre lies quite at a sub tropical area. We have a small adaptive trial going on at RDSC Tsirang and it had started fruiting from this year. With the aim to make aware of the kiwi fruit to the people, the centre had recently taken up for the production demonstration at Thinleygang, Toeb geog under Punakha Dzongkhag. The area is about half an acre with 35 kiwi plants. The layout was done in the last season and we could complete plantation only this year because of the unavailability of planting materials on time. The rooted cuttings were planted with a distance of 5mX5m. The plants are at early vegetative growth stage with very vigorous vine growth (figure). The vines are trained on trellis system. All other inter cultural operations are being carried out for last season. The relevant data collection and other reporting will be done as scheduled.

6.2.5 Top working campaigns

Bhutan has diverse agro-climatic zones suitable for growing diverse kinds of fruits. This is mainly due to variation in altitude, rainfall patterns and the aspects. This variation even within a small location has favored for the growth of different varieties of fruit across the country. It is not uncommon to observe few fruit trees at backyard in each and every household in Bhutan. However, most of the fruits in farmers' field are local cultivars that are of inferior quality. These local varieties remained unpopular among the growers and consumers despite many improved cultivars being released and available for cultivation. Somehow the improved technology and high quality cultivars have not reached to the farming community probably because of lack of proper communication and grafting materials. Therefore, the horticulture sector of RDC-Bajo with support from extension official has carried out top-working campaign in various locations within the west central region with following objectives: to replace inferior local cultivars with high quality improved fruits and nuts and demonstrate available technology at shelf in farmers' field through farmers participatory approach

Scion woods of different fruit and nut cultivars were collected from the germplasm mother block maintained at the research center, Bajo. The

scion woods collected included persimmon, peach, pear, apricot and walnut. Modified side veneer and bark grafting propagation techniques were deployed at the time of topworking. The activity was initially started in 2009 at Tseza under Dagana Dzongkhag and Taksha-Silli under Uma geog, Wangduephodrang dzongkhag. Later, similar program was replicated at Drakten geog under Trongsa Dzongkhag. Also in collaboration with geog extension, whole geog top-working campaign was conducted towards February and March in Phangyul under Wangdue and in Kabesa geog under Punakha dzongkhag. The programs were organized by the geog extension officials while technical support and scion woods were provided by Horticulture sector of RNRRDC Bajo.

The campaign consisted of both theoretical and practical sessions. The theoretical discussion was held separately for the farmers of different villages where the farmers were imparted with the knowledge on the importance and scope of top-working. At both locations, the campaign was for a week long. At Phangyul under Wangdue dzongkhag, the theory session lasted for two days. The top-working in the field was done by farmers along with a competent group leader. The groups were made based on the location of their houses in the villages. Each group was then entrusted with certain area for top-working. The pictures below show the farmers of Phangyul attending theory session of Top-working technique in presence of a resource person.

Similarly, farmers for Kabesa were also briefed on top-working technique and its benefit at RNRR-EC, Kabesa geog. They were then grouped for the practical top-working purposes. After a desired level of skills being learned by farmers, they were taken for field grafting in different chiwogs. Similar procedure was repeated in Kabesa geog under

Punakha dzongkhag. A total of 35 members attended the top-working campaign.

Similar top-working of fruits were done in Tseza geog under Dagana dzongkhag in 2009. Soft shell walnut was the main crop being topworked. Later in 2010, with the directives from Department of agriculture, walnut topworking was conducted at Samcholing village of Draten under Trongsa dzongkhag. The program at Tseza and Drakten is continued and annually the research team long with extension officials carries out monitoring.

The top-working campaign or program has been very effective in transferring of available technology to farmers' field. Our experience from Tseza and Draken has shown that farmers are more convinced on top-working of soft shell walnut. More farmers have started raising rootstocks (local cultivars) in the backyard. Also, more and more improved fruit cultivars are made available in market indicating that the rural income generation is enhanced. The total number of scion wood used varied greatly depending on proximity of residents and the villages. In Phangyul alone, a total of 520 scion woods were used in this season.

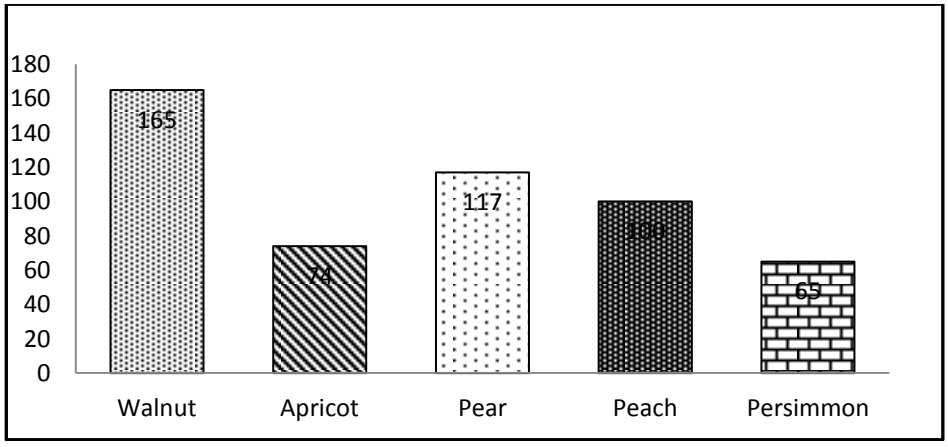


Figure 15: Different fruits topworked at Phangyul in 2012

At Kabesa, the campaign covered all the five chiwogs. The total number of different scion woods used during at Kabesa is as shown in Table 67.

Table 67 Improved scion woods top worked at Kabesa, Punakha

Chiwogs	Number of scion wood				
	Walnut	Pear	Apricot	Persimmon	Peach
Tongsina	24	12	27	24	33
Rangrikha	5	9	10	4	8
Choiteningpa & Eusakha	23	25	28	28	25
Sirigang	34	36	26	27	20
Petari	19	26	16	19	17
Total	105	108	107	102	103

As a follow up, 42 walnut trees were top-worked in 2012 at Drakten geog of Trongsa Dzongkhag. Twelve scion woods were on the failed trees of initial year while 30 were on new rootstock. Also, 38 other fruits trees were top-worked in this season (2012) which included pear, persimmon, and peaches. The graft failure of last year was mainly due to carelessness of the farmers as most of the trees were found unattended. Tseza under Dagana is also one area were the local fruits have been top-worked. The success in the previous years has raised the eyebrows of farmers. As follow up and continuity to the program, top-working was continued. A total of 156 trees were top-worked in this season of which 117 trees are soft shell walnut. At present, all the top-worked trees have come out successfully. The success percentage in terms of graft take is 100% in Phangyul while it is about 90% in Kabesa at our first Monitoring.

Almost every household grows different fruit trees at back yard of their houses across the country. However, the fruit are mostly local cultivars that are in general inferior in quality. Further, despite the availability of many improved fruit cultivars at the research station, technology has not reach to the farmers in the field. This program was focused on mainly demonstration of improved fruit cultivars at farmers' field through top-working of local cultivars with improved varieties. At the same time, the program was to improve the existing fruit by top-working it with available improved varieties. The program was carried out in collaboration with the dzongkhag and geog agriculture. The improved scion woods were collected from the germplasm mother block established at RDC-Bajo. The program has gained the attention of farmers in many places. The outcome of the program is immense as improved fruit can be seen in market now. Further, farmers are also aware on availability of improved fruit cultivars besides increasing rate

of technology adoption. Horticulture sector of RNRRDC Bajo will continue with such program in future.

6.3 Farming System

6.3.1 Soil

Technical backstopping to sustainable land management program at Loduma is continued. The village has a total of 85 acres dry land of which about 80% has brought under sustainable land management practices through implementation of various land management technologies. In the capacity building font, farmers were trained on compost making, summer and winter vegetable production, maize seed selection, maize storage pest identification and management measures, and grafting, budding and top-working of fruits. Furthermore, a total of 25 farmers were sent on study tour for two weeks. The main objective of the tour was to learn and share experiences through interaction and visual observations.

To enhance farmers' cash income source, a total of 200 mango seedlings, 50 guava seedlings and 50 banana suckers were supplied to the farmers. These fruit plants were planted along contour lines. In addition, seeds of different vegetables both for summer and winter were provided to all the farmers. While some farmers managed to produce enough for selling, most have harvested enough for home consumption only.

Although maize is the main staple food of the farmers, yields are very low (535 kg/ac). Commonly grown maize variety is local (small cob with white flint). To help change the variety, a total of 480 kg Yangtsipa maize variety seeds were provided to the farmers. Two numbers of Silos (500 kg capacity) were also provided to the farmers. These Silos will be used by the farmers for storing maize seeds. Technical backstopping and overall coordination work will be continued for another year to complete the sustainable land management planned activities.

Green manure seed production

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 2011-12, the sector has produced a total of 1500 kilograms of Dhaincha seeds and supplied to Dagana, Tsirang, Tsirang Sub-Centre and in Lobesa rice commercialization farmers. Seed production is done in the empty fields which are not occupied by other sectors. The activity will be continued to meet the seed requirements of the client Dzongkhags for trial purpose.

Capacity Development

In collaboration with co-sectors, Loduma *Sashing Zingchoung Tshokpa* farmers were trained on composting, vegetable production, maize seed selection and storage, top-working and grafting of fruit crops and soil fertility management for maize production. In addition, the sector has participated in the capacity of a resource person to give refresher course on soil fertility management for rice production to the agriculture extensions staff of the ABSD program sites in the region and hands on training on sustainable land management for farmers of Bjena geog under Wangdue Dzongkhag.

Support to Co-Sectors

In addition to planned activities, the sector has supported co-sectors in site selection, problem prioritization; action plan development and group formation for research out-research program sites in Dagana and Gasa. Furthermore, the sector has assisted in farmer group formation and action plan development for Citrus Ordinance implementation in Drujeygang geog of Dagana Dzongkhag.

Vermi-compost

A total of 1300 kilograms of vermi-compost has been produced and provided to vegetable sector to use for trial purpose and to office surrounding beautification area. Materials used for vermi-composting are rice straw, cow dung and farmyard manure. Under Bajo's climatic condition, using the above mentioned materials, vermi-compost can be produced within 45 – 60 days. Seed earthworms are brought from NSSC, Simtokha. Some locally collected worms are also added to increase the population. Vermi-compost sample analysis was done to see the nutrient content. All the macro nutrient content is very high while the pH is very low. This activity will be continued to serve as vermi-composting demonstration to the farmers visiting the centre.

6.3.2 IPM

Procurement and issuance of PP chemicals

The sector procures maintain and issue PP chemicals to co-sectors and client Dzongkhags on need based. Based on the indent placed during the year 2011, PP chemicals were procured for the year 2011-2012 from the National Plant Protection Centre, Semtokha. In addition, the sector has purchased herbicides called Sunrice and Topstar from Siliguri, India for trial purpose.

Attending to Ad-hoc field request

The sector attended to the field based request from Wangdue dzongkhag agriculture sector with regard to the pests/diseases outbreak on potato at Shelly village under Rupeisa geog. The problem was identified as late potato blight. Blight problem was observed in patches in few farms. In addition, lots of cut-worm damages were observed. Farmers were advised on the following recommendations:

- Field sanitation through the removal of weeds
- Roguing infected potato plant and burning or burying.
- Hilling up the potato plant to control the further tuber damage by cutworm

- Application of Mancozeb 75 WP (fungicide) sprays @ 2g/litre of water at an interval of 10–14 days till harvest to control the blight disease (Om, 2011).
- Spraying with Chlorpyriphos 20 EC @ 4ml/litre of water to control the cutworm and looper.
- Planting disease free and good quality seed only.
- Crop rotation.
- Increasing the plant spacing (plant to plant 30cm and row to row 70cm).

Protocol Services to Visitors

In addition to the IPM planned activities, the sector has assisted in providing protocol services to the farmers and extension visitors of the centre.

6.3.3 Irrigation

Renovation of farm irrigation channel at RDC Bajo

As part of the planned activity farm irrigation system renovation work below the highway was implemented during this financial year. Detail survey, drawings and estimates were prepared. Subsequently, technical sanction was accorded by Department of Agriculture. As this activity was funded by ADB it required to follow their tendering process. Accordingly tender document was prepared based on ABD tendering procedures. The work was awarded to M/s Sanga Construction (CDB#2500) through open tendering process at a contract price of Nu986,665.29 with a implementation period of 120 days (completion date 10 June 2012). Awarding of additional work and owing to the shortage of cement supply in the market the project duration was extended by 14 days (29 June 2012). However, the firm manage to complete by 24 June 2012. The final amount of work done was Nu967,631.88.

Renovation of farm channels at RDSC Tsirang

Farm irrigation channel renovation work at RDSC Tsirang was implemented in this financial year. Detail survey, drawings and estimates were prepared, and the proposal was submitted to Department of Agriculture for according technical sanction and administrative approval

to implement the work. Tender Documents was prepared after getting necessary approval from the department.

The implementation of this work was awarded to M/s GNH Builders (CDB#4675) through open tendering process at a contract price of Nu1,013,456.38 with a project implementation period of 130 days. The contract agreement was signed on 07 February 2012. The project was officially started on 17 February 2012 and was stipulated to be completed on before 24 June 2012.

However, due to the shortage of the supply of cement in the market and hindrance caused by the rainfall the project period was extended till 13 July 2012. Even this extension the firm could not complete work due to continuous rainfall. The work was actually completed on 07 August 2012 which was delayed by 25 days. Accordingly, liquidated damage of 0.05% on the final work amount was imposed on the firm.

Water supply & compound lighting system

Construction of water supply and compound lighting for National Citrus Nursery and Repository Block at RDSC Tsirang was implemented as an ad-hoc activity. The activity included conducting survey, preparation of drawings and estimate, seeking of technical and administrative approval, preparation of tender document, conducting open tendering, monitoring and passing of the bills. The work was awarded to M/s Druk Nono Construction (CDB#5562) through open tendering process at a contract price of Nu598,295.89. The project duration was 95 days which was started on 21 February 2012. The project was actually completed early on 26 April 2012 against stipulated completion date on 26 May 2012. The final amount of work done was Nu566,051.00.

Improvement of approach road at RDSC Tsirang

Construction of approach road to National Citrus Nursery and Repository Block at RDSC Tsirang was implemented as an ad-hoc activity. The activity included conducting survey, preparation of drawings and estimate, seeking of technical and administrative approval, preparation of tender document, conducting open tendering, monitoring and passing of the bills.

The work was awarded to M/s Ruden Construction (CDB#5261) at a contract price of Nu1,051,054.70 through open tendering process. The project officially started on 21 February 2012 which was stipulated to be completed within 73 days (04 May 2012). Owing to the nature of work like road basecourse and side drain which could not be implemented

simultaneously (road side drain had to be constructed after the completion of road work), and shortage of cement supply in the market the project duration had to be increased by 52 days. Even with extension of the project period the actual completion (03 July 2012) was delayed by 8 days. The final amount of work done was Nu733,341.

Construction of water supply line to ESP Colony

The proposal for the construction of municipal water supply line to the ESP Colony at RDC Bajo was proposed in 2008. However, owing to the budgetary constraints it could not be implemented until this financial year. The work comprised of construction of three tap stands connected by 170 m of GI pipeline network, valve chambers and installation of water meters. The total cost of the activity was estimated at Nu78,893.00. This activity was implemented departmentally.

Repair of water tank at RDC Bajo

Water reservoir tank for RDC Bajo was damaged by earthquake on 18 September 2011. The soil below the tank has partially subsided which has weakened the foundation and cracks has developed on the walls. This led to seepage of water from the tank which has further weakened the foundation. Besides loss of water through leakage, there was immediate risk of slope failure. As part of the temporary measures, the leakage was controlled by providing plaster on the damaged walls. The cost of repairing the tank was estimated at Nu1,264. The work was implemented departmentally.

Rectification of cow-guard at RDC Bajo

The cow-guard near the main gate of RDC Bajo failed to stop stray cattle entering into the research area. The rectification work comprised of increasing the length of the depression chamber by about 0.5 m. Therefore, one side of the depression wall was dismantled and reconstructed, and two additional lines of GI pipes were provided and fixed. The work was implemented departmentally.

Maintenance of staff residence at RDC Bajo

A proposal for implementing annual maintenance work for staff residence was developed. The proposal development included survey, preparation of drawings and estimate. Measurements of all the building structures were carried out to produce drawings for room plans, elevations, details of doors and windows, plinth and drains. The survey identified areas where maintenance work was required. Based on these

information estimates were prepared. The work was estimated to cost Nu135,800. However, owing to limit budget actual implementation was done on priority basis. Since the buildings were old and leakages from the roofs were affecting the underlying structures, it was decided to paint roof and white wash external walls of all the residence. In addition few other structures were like doors and windows were replaced. The roofing structure of the two of the external toilets was replaced completely. Similarly, maintenance work of staff residence at RDSC Tsirang was also implemented.

Monitoring of construction works

a) Construction of Zero Energy Cold Store

The construction of Zero Energy Cold Store (ZECS) at Dagapela was awarded to M/s Lhanam Pelmo Construction at contract price of Nu2,739,029.32 by National Post-harvest Centre, Paro. The project had to be completed within 10 months starting from 10 February 2012. Routine monitoring and verification of are done by engineering unit of RDC Bajo. The amount paid in the first running bill was Nu1.0M and about 45% of the work was completed by the end of the financial year.

b) Construction of Range Office at Nobding

The construction of Range Office under Wangdue Dzongkhag was awarded to M/s DW Construction at contract cost of Nu.2,224,599.00 by Lobeysa Forest Division. The project was officially started on 10 May 2012 and stipulated to be completed by 20 November 2012. Routine monitoring and verification of are done by engineering unit of RDC Bajo. The amount paid in the first running bill was Nu1.5M and about 75% of the work was completed by the end of the financial year.

c) Construction of Range Office at Punakha

The construction of Range Office under Punakha Dzongkhag was awarded to M/s Radak Construction at contract cost of Nu.2,175,730.88 by Lobeysa Forest Division. The project was officially started on 10 May 2012 and stipulated to be completed by 20 November 2012. Routine monitoring and verification of are done by engineering unit of RDC Bajo. The amount paid in the first running bill was Nu1.5M and about 30% of the work was completed by the end of the financial year.

Plans and proposals developed

This section provides a profile of plans and proposals developed within the plan period. Although, most of these activities are not implemented, it

is being presented here to reflect the time and resources spent by the WMR sector in developing these proposals.

Proposal for RDC Bajo & RDSC Tsirang

a) Farm irrigation channel improvement work

Based on the direction from Department of Agriculture for improvement of farm infrastructure, a proposal for irrigation channel improvement within research farm above the main office was prepared. Accordingly site surveying, preparation of drawing and estimate was done to finalize the proposal. The proposal comprised of lining channel, construction of trash screen structures, water division chambers and irrigation channel-farm road crossing structures. This plan was estimated to cost Nu992,729. After the proposal was ready, the management prioritized that the farm irrigation infrastructures development should be done on the research farm area by the riverside. Accordingly, new proposal was developed for the prioritized area starting from survey to finalization of the estimate.

b) Office building construction at RDSC Tsirang

A proposal for construction of new office building for RDSC Tsirang was prepared for budgeting. A rough plan drawings and quick estimate were made to develop the proposal. The cost was estimated at Nu7,230,000. Owing to limitation of budget resources in the government the plan was not approved.

c) Water Harvesting Study at Matalungchu

Study was conducted to assess the feasibility of constructing on-stream water storage reservoir. The study indicated that proposed site had poor storage capacities which will not justify the investment. During the field survey, upstream part of the proposed site was also explored. It was found that those sites have good potential for reservoir construction with high storage capacity. However, due to poor access to the site wherein access road needs to be relatively longer involving heavy rock cutting will increase the cost substantially. As a result the allocated budget was too less to cover these cost and project found unfeasible to be implemented within this financial period. However, the farmers are very optimistic that the reservoir will address irrigation water scarcity problem.

Proposal for RSC Bajo

a) GI Chain-link fencing at RSC Bajo

The proposal for construction of GI Chain-link fencing for Regional Seed Center (RSC) Bajo was prepared. The proposal development activity included preparation of drawings and estimate for the work. The estimated cost of the work was Nu1,086,200. It was prepared based on the BSR-2009 with a cost index of 47.07% over Phuntsholing base town.

b) Approach road & Parking Resurfacing Work at RSC Bajo

Based on the request from DSC Bajo, the proposal for resurfacing of approach road and parking at RSC Bajo was prepared. The proposal development activity included conducting site survey, preparation of drawings and estimate. The estimated cost of the work is 768,600.00 which were prepared based on the BSR-2009 with a cost index of 31.81% over Phuntsholing base town.

c) Renovation second stage pumping station at RSC Bajo

As requested by RSC Bajo, the proposal for renovation of second stage pumping station was prepared. Site survey, drawings and estimate were prepared. The cost of this renovation work was estimated at Nu89,480. The renovation work included construction of pump house, improvement of sump by providing RRM wall lining, and providing barbed wire fencing around the pond.

d) Renovation drying shed at RSC Bajo

RSC Bajo requested to develop proposal for renovation of drying shed. Site survey, drawings and estimate were prepared. During the survey it was confirmed that the half of the floor, plinth protection and drain for the drying shed was damaged due to the settlement of the underlying soil. This had happened because the half of the drying shed is construction on filled up soil. The cost of this renovation work was estimated at Nu135,030. The renovation work included re-construction of plinth protection and drain, repair of half of the floor area.

Activities Implemented in 2010-11 financial year

This section presents the profile of those activities that were implemented in 2010-11 financial year, however got excluded while preparing the report.

Engineering services for RDC Bajo

a) Resurfacing of approach road and parking at RDC Bajo

Blacktopping of approach road and parking at RNR RDC Bajo was a planned activity with an approved budget of Nu3.785million. Accordingly, WMR conducted survey, prepared drawings & estimate, implemented and completed the work. The cost of the work was estimated at Nu3,784,695/- base on BSR-2009 with cost index of 44.74% over Phuntsholing. The work was implemented by M/s Karma Construction (CDB#2350) based in Tsirang through open tendering process at a contract price of Nu3,293,588. The final amount paid was Nu2,956,187 based on the final measurement of the work done. The scheduled completion date was 10 April 2011; however the work was completed on 03 April 2011.

b) Construction of Cool chamber shed wall at RDC Bajo

Construction of Cool chamber shed wall at RNR RDC Bajo was an adhoc activity implemented by WMR Sector. The management decided to re-appropriated the budget savings from resurfacing of approach road and parking at RDC Bajo. The cool chamber shed was initially constructed without external wall as specification provided earlier. However, after setting up the chamber it was realized that there was a need to have external wall to provide protection against vandalism. Therefore, WMR unit was asked to implement the wall construction work. As such WMR prepared drawings & estimate, and technical sanction was sought from the Department of Agriculture. The cost of the construction was estimated at Nu212,600.00 base on BSR-2009 with cost index of 44.69% over Phuntsholing. Due to limited time, the work was tendered out through limited bidding process. The work was awarded to lowest bidder M/s Nordenma Construction (CDB#4184) at a contract price Nu210,005.50. The final amount paid was Nu210,005.50 based on measurement of the work. The work was completed on 23 June 2011 against the scheduled completion date of 24 June 2011.

c) Proposal for Garage cum farmer's guest house construction

RDC Bajo has not only been important destination for showcasing RNR technologies, but also seen as a place for the farmers to halt overnight. Over the years many groups of farmers have visited RNR RDC Bajo as part of the study tour program. An old meeting hall was being used for their accommodation. Therefore, management felt that there is a need to

provide a better accommodation then the existing facilities. Hence, WMR was drawing and estimate for construction of garage cum farmer guest house at RNR RDC Bajo. The cost for construction of the infrastructure was estimated at Nu3.286million.

d) Proposal for farm infrastructure development at RNR RDC Bajo

WMR prepare proposal for farm infrastructure development for RNR RDC Bajo as per the direction from DoA. The works included development of lined irrigation network with proper division or outlet structures, farm road networks with base course and paved footpaths. Accordingly, WMR carried out alignment survey for the infrastructure development, and prepared drawings and estimate. The total cost was estimated at Nu12.6M. Table 68 provides the detail breakup of the cost. The proposal was submitted to the department.

Table 68 Summary of quantity and cost in Nu for farm infrastructure improvement work at RNR RDC Bajo

Description of work	Quantity	Rate	Amount
Farm road with base course (3.0m width)	2903 m	2,545	7,388,135
Farm footpath (1.2m width)	455 m	1,130	514,150
Irrigation channel (400x400mm)	833 m	1,585	1,320,305
Irrigation channel (300x300mm)	1695 m	1,279	2,167,905
Junction box (800x800x600mm)	16 No	3,877	62,032
Culvert Type C1[a]	26 No	11,514	299,364
Culvert Type C2[b]	5 No	2,202	11,010
RCC Slab[c]	90 No	2,202	198,180
RCC Slab[d]	10 No	11,514	115,140
Field outlets	130 No	500	65,000
De-silting camber with screen	4 No	15,000	60,000
Drip irrigation[e]	2 ac	90,000	180,000
Sprinkler irrigation[e]	2 ac	100,000	200,000
Total amount (in Nu.)			**12,581,221**

[a] Irrigation channel & farm road crossing
[b] Irrigation channel & footpath crossing
[c] Slab for power tiller crossing over irrigation channels
[d] Slab for tractor crossing over irrigation channels
[e] Horticulture area & office landscape irrigation

e) Bajo Irrigation Channel: Annual maintenance work

Annually RDC Bajo, RBA Tencholing and Bajo farming community carry out annual maintenance work for Bajo Irrigation Channel. WMR

with the representatives of the farmers lead by the water guard conducted survey to determine kind of maintenance work needed. Based on this survey findings drawings & estimate for implementing the work was prepared. For 2011 season the total cost of implementing the maintenance works were estimated at Nu.90,200. In accordance with the past arrangement material and transportation cost up to the nearest road head point was shared equally between RBA and RDC-Bajo while Bajo farming community contributed labour. The main types of work implemented for 2011 season included lining, increased channel capacity, and construction of retaining walls on some section of the channel.

Engineering services for RDSC Tsirang

a) Proposal for renovation of farm irrigation channel at RDSC Tsirang

Farm irrigation channels in RNR RDSC Tsirang were old and had low conveyance efficiency. As a result RDSC Tsirang has requested for complete relining of the channel. For budgeting purpose, WMR prepared drawings and estimate for renovation of farm irrigation channels in RNR RDSC Tsirang. The cost of the renovation work was estimated at Nu1,015,060/-.

b) Farm boundary barbed wire re-fencing at RNR RDSC Tsirang

Some section of the farm boundary fencing has become ineffective due to ageing. With a request from RDSC Tsirang, WMR prepared drawings and estimate for farm boundary barbed wire fencing. About 1.8 km of farm boundary was proposed fenced at an estimated cost of Nu1,541,260.

c) Building maintenance work at RNR RDSC Tsirang

WMR prepared drawings and estimate for office building maintenance work at RNR RDSC Tsirang. This work was estimated to cost Nu50,700/- based on BSR-2009 with a cost index of 32.04% over Gelephu.

d) Proposal for reconstruction of drinking water intake wall at RDSC Tsirang

Heavy monsoon rainfall has caused landslip above the drinking water source of RNR RDSC Tsirang. This has damaged the intake water collection wall. WMR prepared drawings and estimate for reconstruction of the wall. This work was estimated to cost Nu20,200 which was derived based on BSR-2009 with a cost index of 54.31% over Gelephu.

Engineering services for RSC Bajo

a) Proposal for approach road & parking blacktopping work at RSC Bajo.

With a request from Regional Seed Centre Bajo, WMR carried out survey, prepared drawings and estimate for approach road and parking blacktopping work at RSC Bajo. The quantity of area to be blacktopped was estimated at 1,071sq.m and stone edging of 393m long. The work was estimated to cost Nu768,600/- derived based on BSR-2009 with a cost index of 31.81% over Phuntsholing.

b) Farm boundary GI chain-link fencing work at RSC Bajo.

Upon request from Regional Seed Centre Bajo, WMR prepared drawings and estimate for farm boundary GI chain-link fencing work. The quantity of fencing length was established at 453m which was estimated to cost Nu1,086,200/- based on BSR-2009 with a cost index of 47.07% over Phuntsholing.

Engineering services for others agencies

a) Study on irrigation channel-urban development conflict at Lobesa

Beneficiary farmers of Upper Lobesa Irrigation channel had put a petition to the Ministry of Agriculture and Forests. They stated that the new channel alignment work within Lobesa urban area which was being implemented with the initiatives of Punakha Dzongkhag through the support of Punatshangchu project was not properly levelled. The channel bed level about 20m downstream of the intake point of the local source was higher and farmers were worried that water will not flow properly. They also stated that the Lobesa urban-residents dump both solid and liquid waste into the channel. Accordingly, Department of Agriculture directed WMR sector at RDC Bajo to carry out the investigation study. As directed the field investigation was carried out.

The study showed that the new channel alignment work was being implemented by the contractor who was also implementing other infrastructure improvement work in the urban area. It was also observed that the bed slope was higher at the downstream part of the channel, but was it was not significant to completely block the channel as the level of wall could be increased. On the issue of polluting the irrigation water, it was found that the irrigation channel in Lobesa urban area passes under several buildings. Solid waste, waste water from kitchen and toilets were found to be drained into the channel. At one location even the sewage

was drained into the channel. Farmers have reported that in the past, solid waste blocked the channel several times and they had to clear it. Since the channel in urban area is mostly covered under the slab or under the road or building, accessing the block section is very difficult. In general, irrigation water gets polluted by the Lobesa urban area, and maintenance of channel had become difficult due to poor accessibility. Detail report of the investigation was submitted to the Department of Agriculture.

b) Assessment of flood damage on Taklai Irrigation Scheme

On the night of 26 August 2010 there was flash flood in Taklai River which had damaged the Taklai Irrigation channel. A team from RNR Engineering Division, RDC Bajo and Taklia Irrigation Staff visited the site and made assessment of the damage, developed plan of actions for rehabilitating the damage. The flash flood had washed away intake structure and about 370m section of the irrigation channel including the 5.0m high retaining wall (gabion) that supported the overlying high level irrigation canal starting just 120m downstream of the intake structure. The detail report was submitted to the Department.

c) Survey and design of new irrigation scheme for Shangana

WMR Sector was engaged for conducting survey for construction of new irrigation channel in Shangana Geog. The new irrigation channel is expected to benefit three villages namely Jaree-gang, Chong-zhee-kha and Ja-zhee-kha. The villages have existing irrigation channel fed by local water source called Damgay-rong-chu. Since this source is small it is not sufficient to meet the water requirement for paddy cultivation. Therefore, to supplement the local source farmers have proposed to trap Tabee-rong-chu located about 3.0km away from the village.

The channel alignment survey was done through the technical support from RNR Engineering Division using Total Station. Farmers contributed free labour for clearing the bushes which took about 10 days to complete.

Conclusion

Although, Bhutan is very rich in water resources, unfortunately most of the rural farmers are facing irrigation water shortage problem. This paradoxical situation exists because Bhutan lacks adequate physical infrastructure to manage this rich water resources. The physical infrastructures include construction of new irrigation channels wherever feasible and improvement of existing ones, utilization of river and underground water resources through development of lift irrigation system. Such infrastructures will help to bring water from where it is

available to where it is required. In addition to above infrastructures there is also a need to develop water storage infrastructures like farm pond, on/off-stream dams, multi-purpose hydroelectric dams that would enable us to manage temporal water deficit. These storage facilities will enable us to store water when it is available and use it when it is required. Development of water conveyance and storage infrastructures in appropriate will combination will enable Bhutanese farmers to manage rich water resources to their advantage. Hence, WMR's increasing engagement in improvement of water management infrastructure is a positive indication that unit's efforts are geared towards serving the needs of our farmers.

6.3.4 Research Communications Sector

The Research Communication sector is mainly responsible for disseminating successful research results of all research disciplines of the centre to the extension system of various departments for their adoption and adaptation. It is largely done through extension leaflet distribution, organizing study visits in the centre, field days, review workshop and online information sharing. The sector also coordinates the maintenance of technology parks in the extension centre for demonstrating the successful technologies. Besides, it is also a focal sector for imparting training and backstopping the farmers groups formation and supporting school agriculture program in the region.

Publication of news letter, leaflets and Annual Report

The production of Bajo Muensel was stopped by the Department of Agriculture as the production of newsletter was centralized to ICS, henceforth. This was done mainly to stop the duplication of articles and save budget. This sector was involved in the publication of the Annual report 2010-11of this centre.

Coordinate centre visit by farmers, students and official guests

During this fiscal year 2011-2012, this centre has been visited by various groups of visitors comprising of farmers, students from various schools and College of Natural Resources, Dzongkhag RNR Extension staff, Research Assistants and other training institutes. Learning objectives of

visitors varies from one group to another but in general they are interested on the relevant technologies available in this research centre.

Table 69 Farmer visitors to the center

Farmer Visitors	Date	Organizing Dzongkhag	Participants			Total
			Male	Female	EAs	
CFMG	10-Jan-12	Tsirang Dzongkhag	17	0	2	19
Livestock Farmers	17-Jan	Zhemgang	26	3	2	31
Forestry Sector	27-Jan	Langthel & Drakten, Trongsa	13	7	2	22
Livestock Farmers Grtoup	28-Jan	Trashiyangtse	7	17	5	29
Livestock Group	1-Mar-12	Tsirang Dzongkhag	16	6	2	24
Forestry Farmers Group(CFMG)	17/3	Chukha Dzongkhag	16	13	1	30
Livestock Farmers Grtoup	20/3	Gasa Dzongkha	12	4	1	17
Dairy Farmers Group	20/3	Samdrupjonkhar	20	0	2	22
Livestock Farmers group	26/3	Trongsa	14	2	1	17
RA'S from Wenkhar	26/3	Wenkhar	15	0	8	23
General Study Tour group	6-Mar	Haa	15	5	2	22
Plant Inspectors(BAFRA)	8-Mar	BAFRA, Wangdue	7	3	0	10
Farmers Study Visit	9-Mar	S/jonkhar	15	0	1	16
CFMG, Chapcha	6-May	Chukha Dzongkhag	40	20	2	62
Tshlingkhar CFMG	7-May	Tsirang Dzongkhag	10	0	1	11
Livestock Farmers Group	14-May	Haa Dzongkhag	18	0	2	20
Livestock Farmers Group	21-May	Dagana	17	0	2	19
BDFC Farmers Group	19-Jun	Bumthang and Zhemgang	40	0	0	40
Farmers Study Visit	4-Jul	Mongar	13	1	2	16
Farmers Study Visit	22-Jul	Mongar	22	0	2	24
			353	**81**	**40**	**474**

It has been found that farmers were more interested in seeing new crop varieties which are high yielding. Extension personnel are also keen on new technologies and information related to those technologies, while students were happy to see whatever is available in the field during the visiting season.

Our centre is also frequented by dignitaries from various organizations both inside and outside the country. This year's visitors are listed in Annex 7.1.

Technical support to the existing farmers group

For the last two years coordinated by our centre and supported by RDTC, Zhemgang, we conducted two trainings on Record keeping & Leadership and Planning for the executive members of farmers group of this region. Some of the beneficiaries included:

1. Rukha Sanam Shinglhan Tshokpa of Sthan geog, Wangduephodrang
2. Phuensum Gongphel Tshokpa, Limbukha geog, Punakha
3. Drongsep Yargay Tshokpa of Dunglagang geog, Tsirang
4. Tsalu Tshokpa , Dorona geog, Dagana Dzongkhag
5. Hongbab Tshokpa of Khibesha geog, Dagana Dzongkhag
6. And Gongphel Tshokpa of Mendrelgang geog, Tsirang.
7. Nahi Farmers Group (Nabesa and Tshokhorthankha), Wangduephodrang.

Farmers group within the region are expected to perform well specially those involved in the production of vegetable as they are fetching a premium price for vegetable with the stoppage of vegetable import from India and there is already a huge local market created by the Punatsangchu Project.

Extension methodology research

Although no serious research work had been done by this sector, other sectors have already embarked on the outreach program based on the focus of the program and Communication sector has been actively involved in the group dynamics and record keeping in form of audio visuals. Since three years back, RDC Bajo had embarked on an Outreach Program in the far-flung communities. A community is selected and supported in terms of input and technical backup for a fixed period of time. This program aims at improving the food self sufficiency in a sustainable manner and raise the living standard by increasing cash income through cash crop production at semi commercial level. Group formation is a part of the process adopted to efficiently utilize the inputs from outside, to improve their bargaining power and gain easy access to inputs.

Although some results of the Outreach Program like that of Salamji are outstanding, the outcome of other such Outreach Programs is yet to be studied to reach to a conclusion.

Development of model Technology Park in Dzongkhag

RDC Bajo has been providing small amounts of inputs required by the technology park like fertilizer, seed, plastic sheet, poly-tube whenever they required. Visits have been made to all the technology parks of this region to discuss on the issues and problems and communicated back to the office. The main issue of the Technology Park is the mainstreaming of the budget in the Dzongkhags. Till date both material and technical support had been provided by the projects (ASSP) and RC Bajo. Once the projects are withdrawn Dzongkhags are not in a position to keep the activity ongoing. In most of the geog extension personnel are facing the dilemma of looking for seasonal labor without a budget in the Dzongkhag. In most of the existing Technology Parks, activities are not at all impressive despite the number of years of its existence. Before any further Technology Parks are replicated in the other geogs a serious study needs to be done to find out whether the existing Technology Parks are actually having its desired effect on the community. In the coming year it has planned to study performance of such Technology Park and its effect on the farming communities.

Information Management

Under this program, detailed lists of RNR publications produced by RDC Bajo as well as publications shared by other sister RDCs have been collected. Library cataloguing is being continued as usual.

RDC Bajo is trying to maintain a Regional level database from the next year hopefully with an additional database manager in place. Presently the Communication sector is just manned by a single person and no additional staff could be availed to enhance the performance of this sector.

7 Annexes

7.1 Visitors to the centre

Date	Name of the visitor	Address	Purpose of Visitor
13/07/2011	Dr. Sushil Pandey (Sr. Agri. Economist)	IRRI, Los Banos, Laguna, Philippines	Rice Variety Tracking Project monitoring visit
10/08/2011	Dr. B.M.Prassanu (Director Global Maize Program) Dr. G- Ortiz Ferrara Dr. Dilli B. KC Dr. Nirmal Gadal	Nuirobi, Kenya Nepal	Monitor Maize research on Gray leaf spot and Turcicum leaf blight.
22/08/2011	HRH Dasho Ugyen Jigme Wangchuk, Professor Pierre & his students	Thimphu	Visit to know more on SRI & Irrigation.
14/09/2011	Dr. Tadashi SATO, Associate Professor Graduate School of life Sciences	Tohoku University, Japan	To learn about rice research in Bhutan.
14/09/211	Seven member delegates from Dept of Agriculture Extension.	Thailand	To learn more about the Agriculture system & identify areas of Cooperation.
28/10/2011	Dr. Eric Malezieuk, Research Unit Director. Dr. Guy Trebuil Pierre FABRE (Director)	Agri. Research for Development, France Department of Environments & Societies	Field visit and feasibility study for collaboration with CIRAD
30/11/2011	Dr. Greg Johnson Consultant Pramod Kumar Aggarwal (Regional Program Leader)	Horticulture Development, Australia. IWMI New Delhi , India	To improve the management of land and water resources for food & environment.
2/03/2012	Dr Ibrahim Md. Saiyed	SAC/ SAARC-Australia Project, Bangladesh	Field Visit
10/03/2012	Yasuhiro Takahashi Fuminobu Nishida (Associate Professor)	Akita University, Japan	Field visit
13/03/2012	Thirteen Students from the School for International Training (America)	America	Site visit to the Centre

16/04/2012	Dr. Krishna Joshi (CARIAD) and Dr. A.K. Joshi (CIMMYT)	CIMMYT- South Asia Office. Singha Durbar Plaza Marg, Bhadrakali, Kathmandu, Nepal	Monitoring of wheat trials-CIMMYT.
17/04/2012	Gordon Cisar (Associate Director) Professor Robert F Park (Director of Rust Research Plant Breeding Institute) Ten Staff from NPPC,	Cornell University University of Sydney, Australia. Thimphu	Wheat rust surveillance team.
01/05/2012	Yukio Ikeda, Ph.D. Economics Masashi Takano, Manager	Consultant, International Cooperation Development, Japan Social System Consulting Department, Nomura Research Institute, Ltd. Japan	Food & Nutrition Survey JICA for project proposal development

7.2 Training, meetings and workshops

Date	Name	Place	Purpose
25-26/07/2011	Mahesh Ghimiray	New Delhi	Meeting on "Building climate Resilience for food security & Rural livelihoods"
1-12/08/2011	Tenzin	Paibare Institute, Philippines	Training on "DRDP finance & accounts personal at Paibare Institute.
15-1/08/2011	Mahesh Ghimiray	SEARICE, Philippines	Meeting of BUCAP Project
9-7/09/2011	Tshering Wangchen	Los Banos, IRRI , Philippines	Rice Breeding Course
6-10/09/2011	Gyambo Tshering & Sangay Tshewang	Kathmandu, Nepal	3rd Annual Review meeting on CSISA wheat breeding.
15-24/09/2011	Lhab Gyem	Nepal	Study Tour on "Community Based Seed Production on Maize"
19-23/09/2011	Thinley Gyamtsho	Nepal	Workshop on "using climate change scenarios & Analogues for Designing Adaptation Strategies in Agriculture"
16-29/11/2011	Kinga Lham & Legjay	Nepal	Training on "wheat improvement & Pathology"
17-26/12/2011	Pasang Dorji	Chaingmai, Thailand	Sympoisum on Sub-Tropical and tropical fruits & nuts.
24-25/10/2011	Sangay Tshewang	Kathmandu, Nepal	Meeting on Future prospects of pulse production in SAARC Countries.
7-19/11/2011	Pema Yuden	Athang ICTEH, Thimphu	ICT using PHP/MySQL web.2.0
21-22/11/2011	Tshering Wangchen	Hyderabad, India	SAARC meeting on oilseed production through improved technologies
12/12/2011 to 5/01/2012	Thinley Gyamtsho	Jain irrigation Ltd India	Training on "Advance Irrigation "
2-28/01/212	Deo Raj Pradhan, Needup & MB Rai	Samthang, Punakha	Basic Vehicle maintenance & Operation.

24/02/2012 to 10/03/2012	Sangay Tshewang	India	Collaborative research work on wheat Rust surveillance (Symposium)
23-24/03/2012	Mahesh Ghimiray	Kalinga Institute of Industrial Technology, Orissa, India	Meeting on Tracking improved varieties in south Asia (TRIVSA project)
23-30/03/2012	Singey Phub	Nunsel Institute , Paro	Data Management & Basic Stat.
5-18/04/2012	Tshering Wangchen	IRRI, Philippines	Institutional visit to IRRI for rice breeding and selection.
26/03/2012 to 14/04/2012	Gyem Lham	CMI, Phuntsholing	Basic Library management System & Networking
2-30/04/2012	Singye Phub & Pema Lhamo	Dzongkhag Language Institute, Thimphu	Training on Dzongkhag Linx & letter writing
10-14/04/2012	Thinley Gyamtsho	New Delhi	To participate in India Water Week Conference
26/04/2012 to 5/05/2012	Kinley Dorji	Thailand	Training on citrus nursery management & mother tree propagation.
2/04/2012 to 5/05/2012	Yeshey Dema	Thailand	Study tour on rice research and production
27/04/2012 to 12/05/2012	Yeshey & Yeshey Zangpo	Nepal	Study tour on land management
14-16/05/2012	Sonam chhophel, Cheku Dorji & Om prakash Ghalley	Thimphu	G2C SDS user Training
10-27/05/2012	Gyambo Tshering & Sangay Tshewang	Australia	Study visit to Australia
3-30/05/2012	Pema Yuden	Phuntsholing	Training on “Linux server Administrator”
20-25/05/2012	Birkha Bdr. Tamang	Kushbainager, Karnataka, India	Training on “Coffee Plantation”

7.3 Financial progress

Budget and Expenditure report for 2011-2012 for RDC Bajo				
OBC	**Particular**	**Budget**	**Expenditure**	**Balance**
1.01	Pay and Allowances	11,444,000.00	11,441,273.00	2,727.00
2.01	Other Personnel Emolument	1,903,000.00	1,902,515.00	485.00
11.01	Travel-In country	3,809,000.00	3,498,937.00	310,063.00
12.01	Utilities-Telephones, Telex, Fax, E-mail, internet	420,000.00	389,278.00	30,722.00
12.02	Utilities-Telegram, Wireless Transmission, Postage	40,000.00	40,000.00	
12.03	Utilities-Electricity, Water, Sewerage	103,000.00	103,000.00	
14.01	S & M- Office Supplies, Printing, Publications	234,000.00	234,000.00	
14.02	S & M- Medicines& Laboratory Consumables	50,000.00	43,272.60	6,727.40
14.03	S & M- Fertilizer, Chemicals, Manures Inoculants	153,000.00	153,000.00	
14.04	S & M- Seeds, Seedlings	310,000.00	268,261.50	41,738.50
14.06	S & M-Uniforms, Extension kits,	248,000.00	231,224.00	16,776.00
14.07	S & M- Text Books, Library Books, Stationeries & Sports item	64,000.00	60,182.00	3,818.00
15.01	Maintenance of property -building	195,000.00	192,228.00	2,772.00
15.02	Maintenance of property-vehicles	1,127,000.00	1,116,425.65	10,574.35
15.05	Maintenance of property-equipment	130,000.00	125,639.00	4,361.00
15.06	Maintenance of property-plantation	72,000.00	69,857.40	2,142.60
15.07	Maintenance of property-Computer	17,000.00	4,800.00	12,200.00
15.09	Maintenance of property-Water supply, Sewerage, Play field	130,000.00	66,438.00	63,562.00
17.01	Op.Exp- Advertising	170,000.00	150,026.50	19,973.50
17.03	Op.Exp- Transportation	70,000.00	47,900.00	22,100.00
17.04	Op.Exp- Energy/Propulsion charge	51,000.00	12,126.02	38,873.98
17.08	Op.Exp- In country meeting and celebration	1,50,000.00	146,628.00	3,372.00
24.03	Contribution- Provident Fund	1,004,000.00	1,004,000.00	
25.01	Retirement Benefits	195,000.00	195,000.00	
	Total:		**21,496,011.67**	**592,988.33**

RGOB Contribution for Tsirang for the year 2011-2012				
OBC	**Particular**	**Budget**	**Expenditure**	**Balance**
11.01	Travel- Incountry	450,000.00	450,000.00	
12.01	Utilities-Telephones, Telex, Fax, E-mail, internet	70,000.00	15,239.50	54,760.50
14.03	S & M- Fertilizer, Chemicals, Manures Innoculants	50,000.00	34,757.00	15,234.00
14.04	S & M- Seeds, Seedlings	50,000.00	50,000.00	
14.06	S & M-Uniforms, Extension kits, Linens	60,000.00	50,160.00	9,840.00
14.07	S & M- Text Books, Library Books, Stationeries and Sports item	28,000.00	7,925.00	20,075.00
15.01	Maintenance of property -building	72,000.00	57,068.00	14,932.00
15.02	Maintenance of property-vehicles	211,000.00	169,707.88	41,292.12
15.05	Maintenance of property-equipment	30,000.00	5,590.00	24,410.00
15.06	Maintenance of property-plantation	28,000.00	6,180.00	21,820.00
15.07	Maintenance of property- Computer	35,000.00	350.5	34,649.00
17.03	Op.Exp- Transportation	20,000.00	6,373.00	13,627.00
	Total:		**956,161.97**	**272,838.03**

7.4 Meterological information

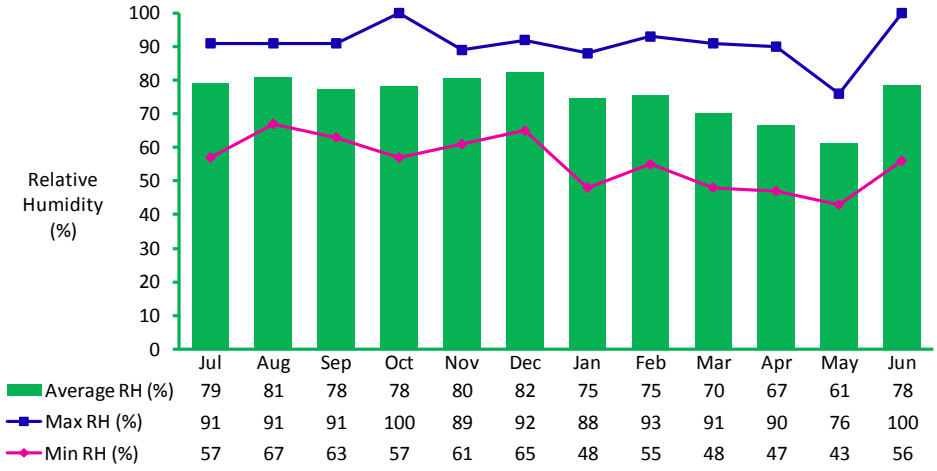


Figure 16: Average, maximum, and minimum relative humidity at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

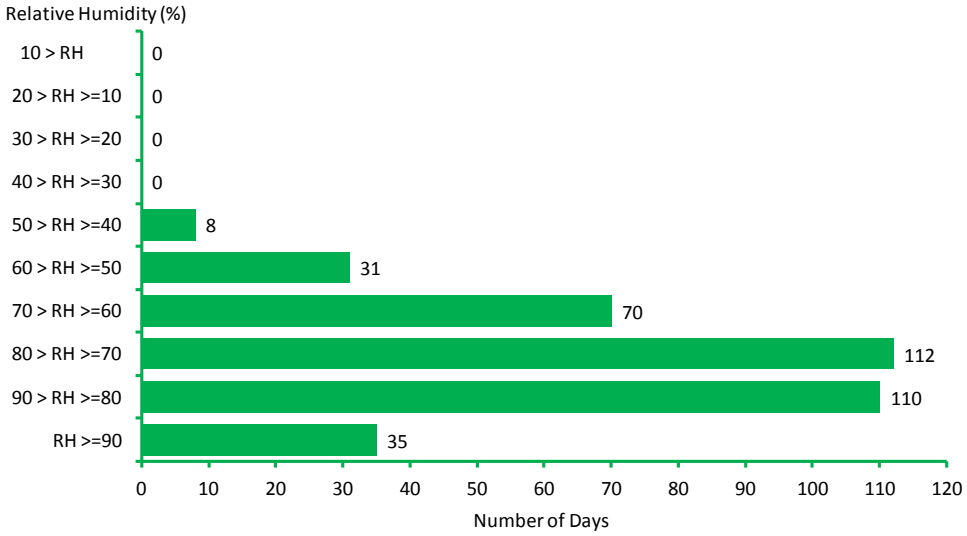


Figure 17: Distribution pattern of relative humidity at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

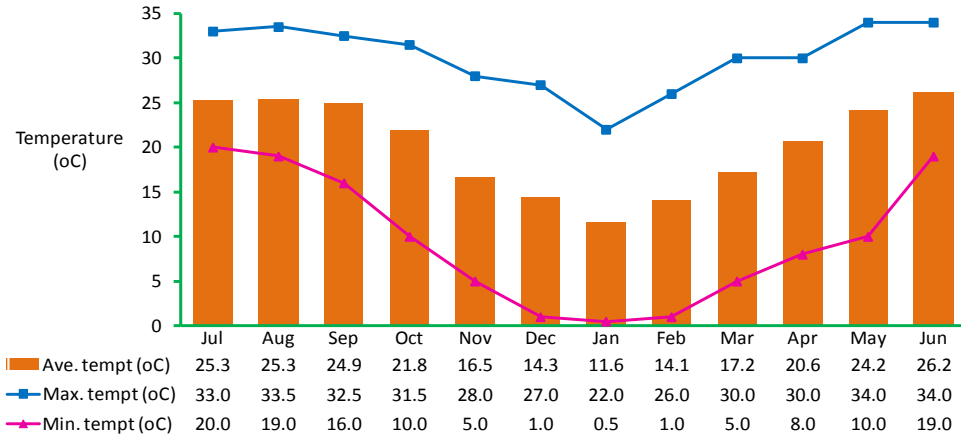


Figure 18: Monthly average, maximum and minimum temperature at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

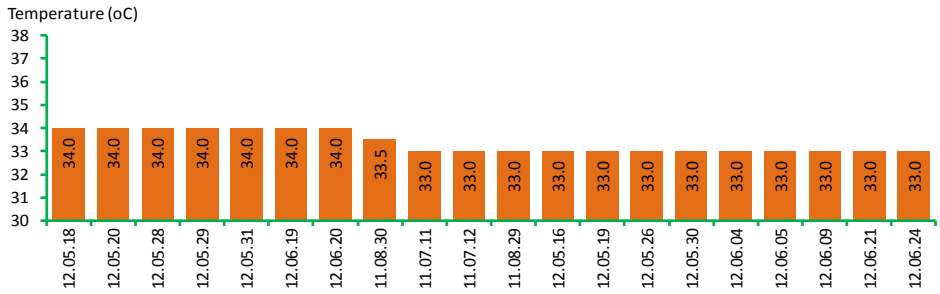


Figure 19: Maximum temperature: Highest 20 days at RC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

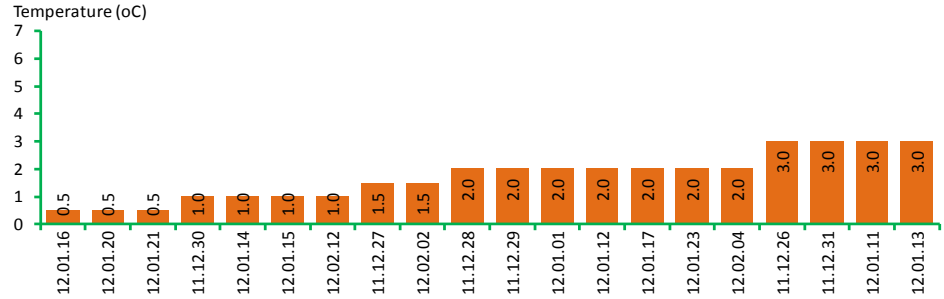


Figure 20: Minimum temperature: Coldest 20 days at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

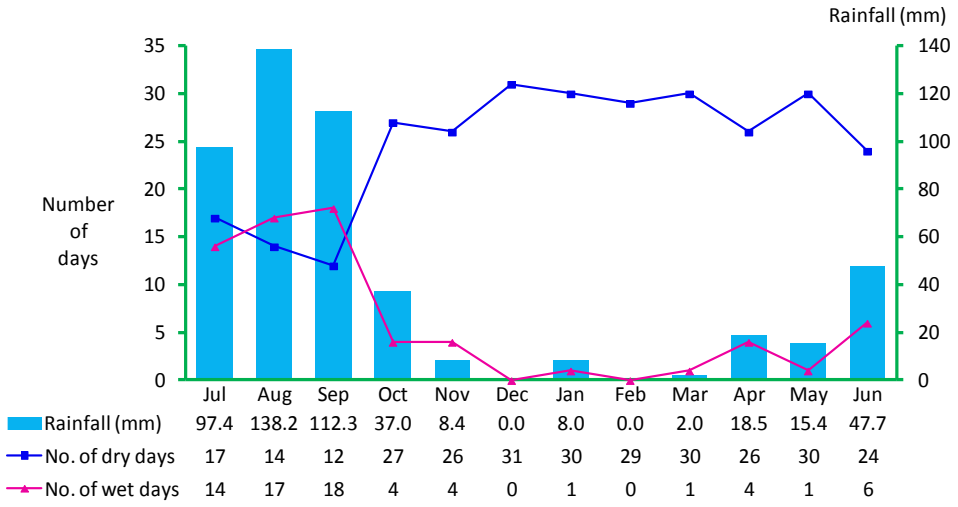


Figure 21: Monthly rainfall, number of wet and dry days at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

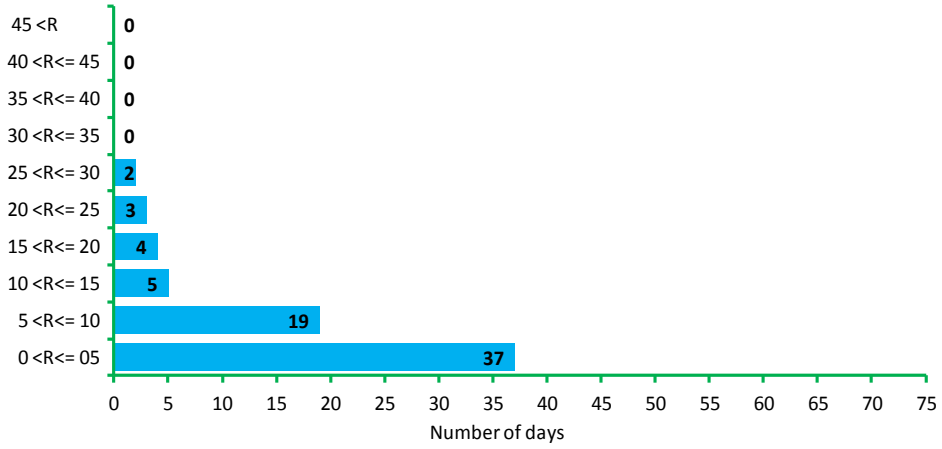


Figure 22: Rainfall intensity distribution at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

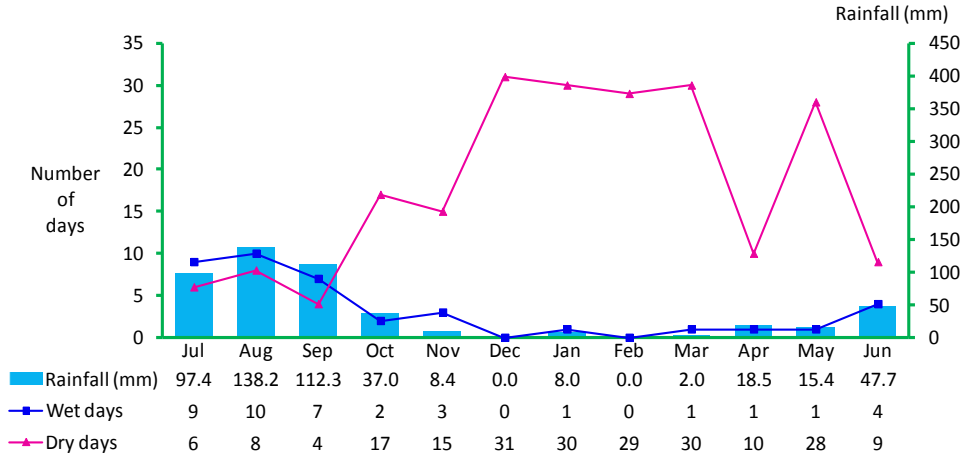


Figure 23: Monthly maximum number of continuous wet and dry days at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

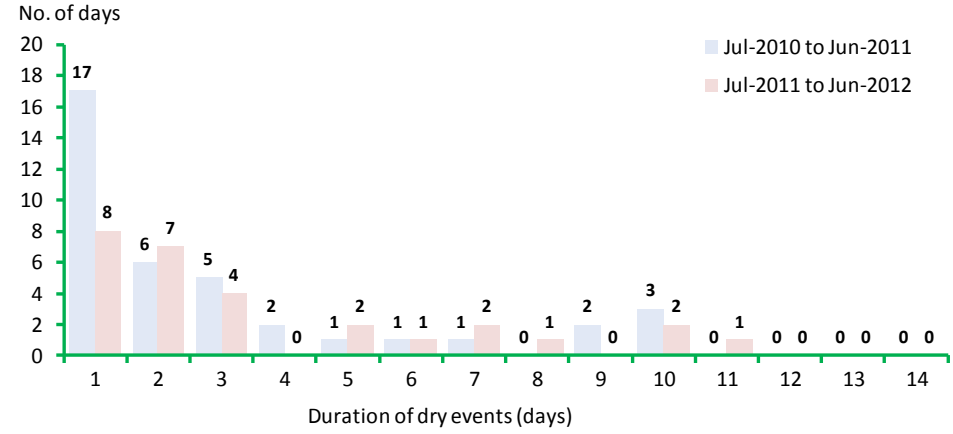


Figure 24: Pattern of dry events at RDC Bajo (July 2010-June 2012).

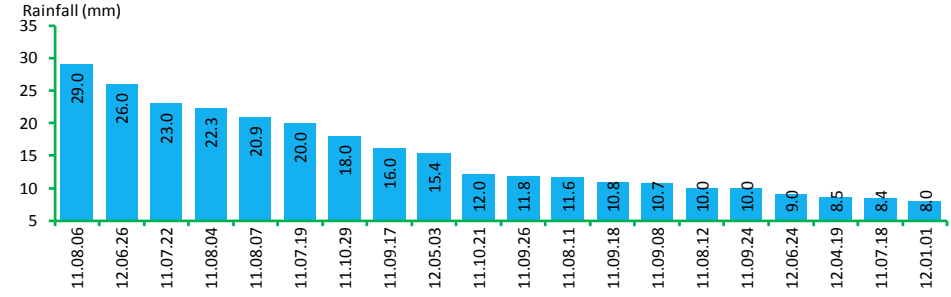


Figure 25: Highest 20 rainfall days at RDC Bajo (July 2011-June 2012).

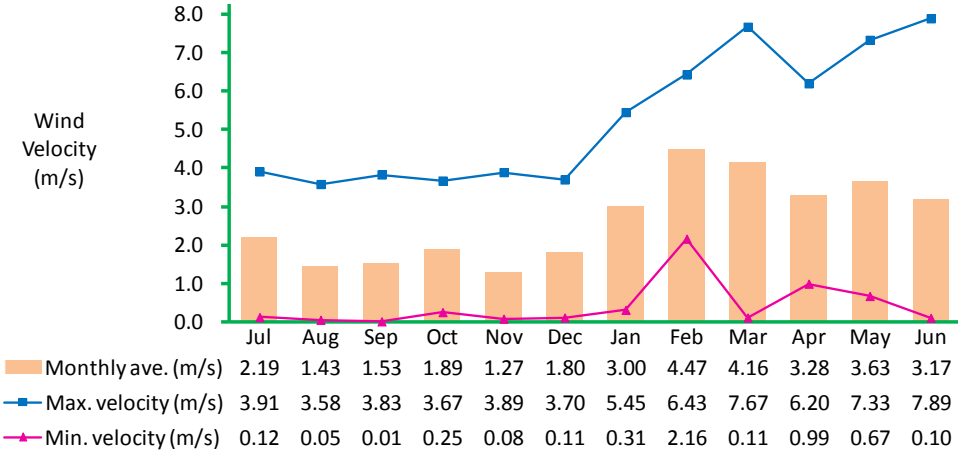


Figure 26: Monthly average, maximum and minimum wind speed at RDC Bajo (July 2011-June 2012). *Source: Bajo Meteorology Station*

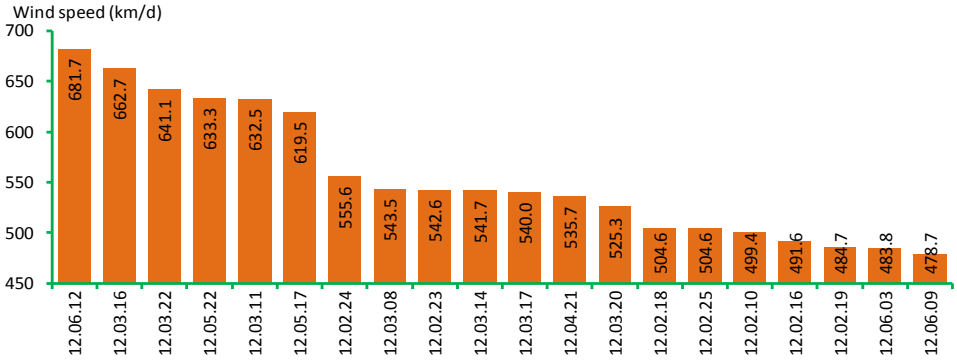


Figure 27: Twenty highest wind speed days at RDC Bajo (July 2011-June 2012).

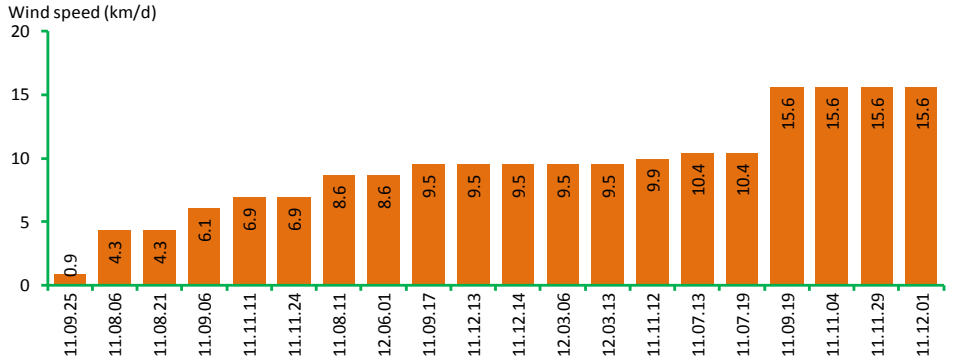


Figure 28: Twenty lowest wind speed days at RDC Bajo (July 2011-June 2012).

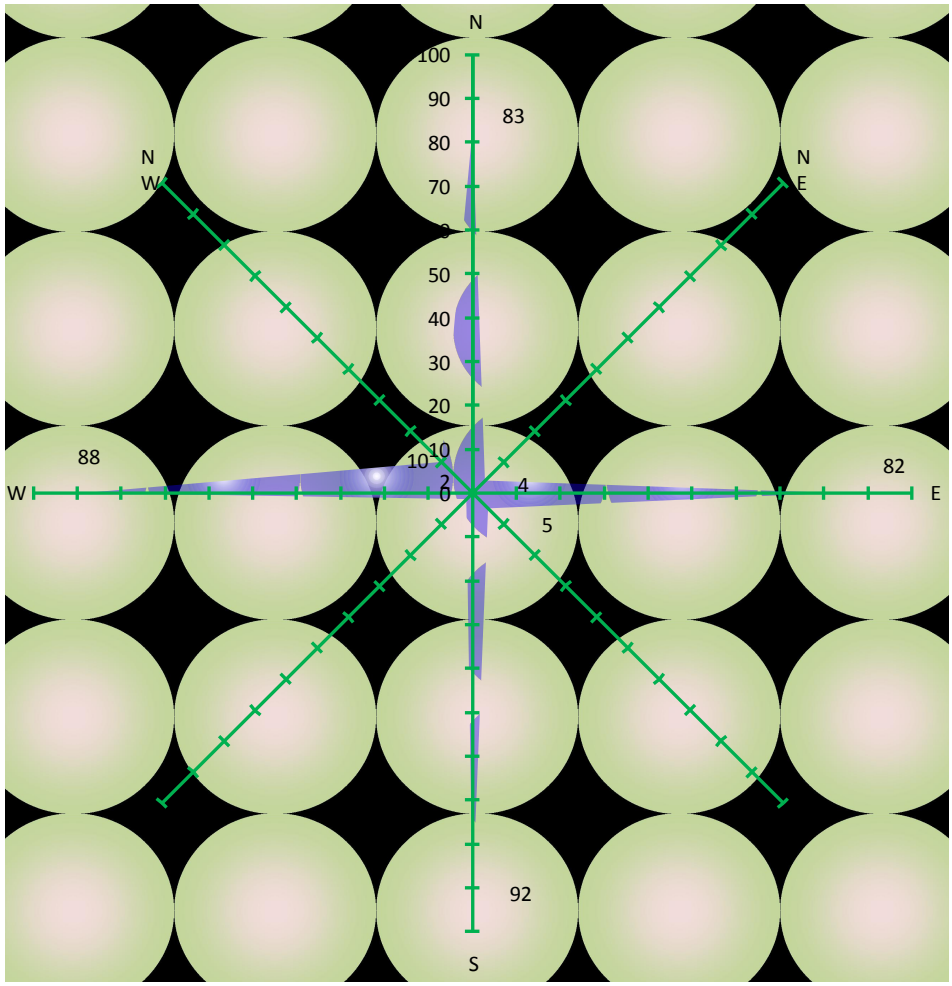


Figure 29: Annual direction pattern at RDC Bajo (July 2011-June 2012).
Source: Bajo Meteorology Station

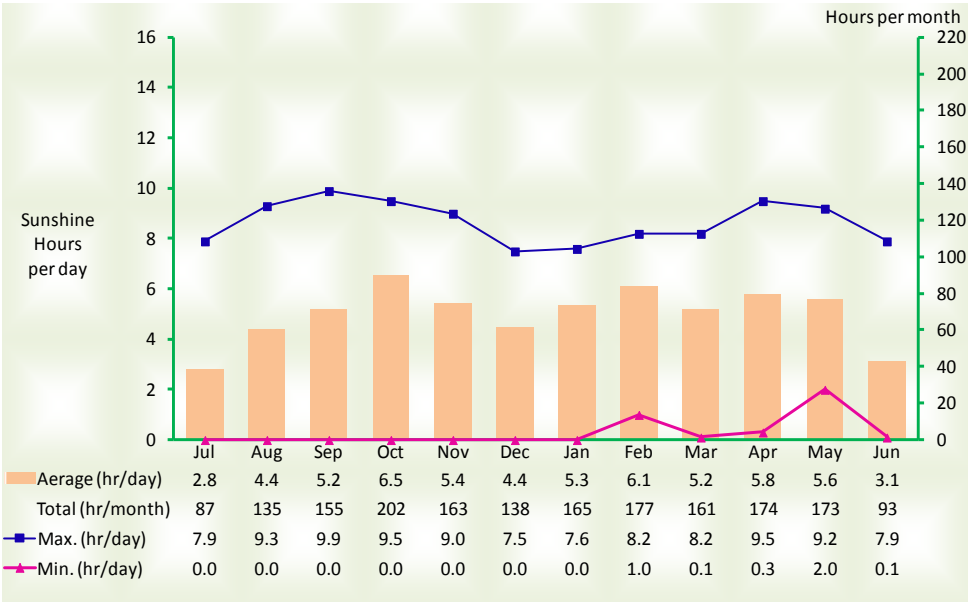


Figure 30: Monthly total, maximum, minimum and average sunshine hours at RDC Bajo (July 2011 - June 2012). *Source: Bajo Meteorology Station*

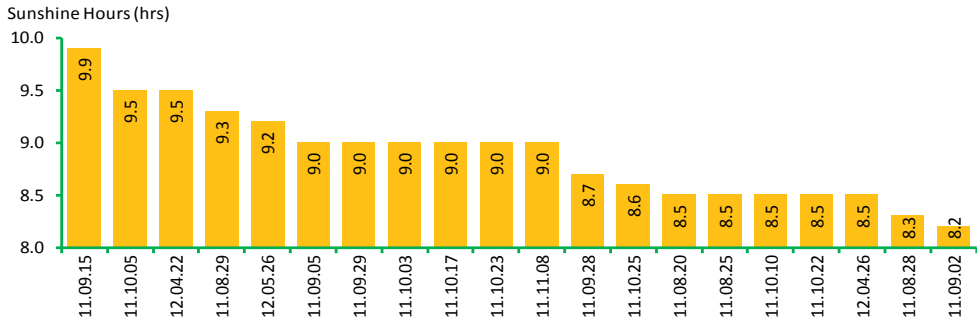


Figure 31: Sunshine hours: Top 20 highest sunshine hour days at RDC Bajo (July 2011 - June 2012). *Source: Bajo Meteorology Station*

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 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.