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RENEWABLE NATURAL RESOURCES RESEARCH CENTRE
BAJOTHANG, WANGDUE PHODRANG
"Walking the Extra Mile"

Annual Report 2005-2006

Edited by:

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&
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COUNCIL FOR RNR RESEARCH OF BHUTAN
Ministry of Agriculture
Royal Government of Bhutan

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FOREWORD

We are pleased to publish the 21st Technical Report of RNRRC Bajo since the Centre was established in 1984. This report is slightly different from earlier ones as it has been agreed at the CoRRB level to standardize the reporting format across RNRRCs. All the future reports will follow this standard format.

Basically, the report is a summary of the research activities carried out within a year from July to June coinciding with the RGoB's financial year. In addition to research activities, the report also highlights the human resources, financial progress, visitors to the centre and the annual weather summary.

Research and development activities are often inseparable. Although the basic mandate of the Centre is to generate relevant technologies, their appropriateness, use and applicability in the field needs to be tested and promoted. The Centre is thus involved in actively applying the generated technologies in partnership with the dzongkhag extension system. We strongly feel the field testing of technologies as our obligation so that refinement could take place wherever necessary. Building stronger linkages and partnerships with extension colleagues thus becomes imperative.

We hope this report serves as a useful reference to everyone involved in agrarian and rural development.

Tashi Delek!

Sangay Duba
Program Director

ABOUT THIS REPORT

This is the 21st technical report produced from this Centre since 1984. Unlike the earlier reports that were based on calendar years, the present report follows the RGOB's financial year that runs from 1 July to 30 June. This report refers to crops sown in November and harvested in April-May with respect to winter crops like wheat, oil crops and vegetables. The summer crops are mostly planted in June-July and harvested in October-November. Some experiments are reported completely while others are ongoing and interim results are reported.

This report follows the style of the preceding reports, wherein program-wise presentation is followed. For instance, results from the Field Crops research are presented followed by Horticulture, Livestock, Forestry and Systems Resource Management.

Abbreviations used in this report are listed in the following pages. The report uses the International System of Units (SI) with few exceptions. Control or check normally means an untreated control. Grain yield is calculated as rough rice at 14% moisture content (mc), wheat at 12% mc and oilseeds at 8% mc.

Yield refers to grain yield unless otherwise stated. Fertilizer amounts are given in terms of elements (N, P, K, Zn etc) and not in the older conventional oxide formulations.

Pedigrees are indicated by a slant bar (/) rather than by multiplication sign (x). Unless otherwise stated, the morphological characters of rice and insect pest damages are based on scales in the 'Standard Evaluation System for Rice' published by IRRI, Philippines.

TABLE OF CONTENTS

List of Tables

ABOUT THIS CENTRE

Established in 1982 as the Centre for Agricultural Research and Development (CARD) basically to undertake research on rice and rice-based crops, it was renamed as the Renewable Natural resources Research Centre (RNRRC) in 1995 to incorporate research on livestock and forest that are inseparable components of the Bhutanese farming systems. The Centre is located at Bajo (1300m) in Wangduephodrang, which is about 70 km west of the capital Thimphu.

RNRRC Bajo is designated as the co-ordinating Centre for Field Crops (cereals, oil crops, and legumes) Research and Water Management Research at the national level. At the regional level, this Centre is mandated to undertake relevant research for its client Dzongkhags of Wangduephodrang, Punakha, Gasa, Tsirang and Dagana in arable agriculture, livestock and forestry. The Centre has a 64 acre research farm. Recently, the facilities of the Centre have been upgraded with the construction of the new administrative cum laboratory building.

The Centre undertakes an intensive program of research and extension through its on-farm research program; training of extension personnel and farmers; and other interdisciplinary activities both at the national and local levels. It introduces, adapts and develops technologies suitable for the local agro ecological environments and helps farmers raise their standard of living through increased incomes and sustainable farm production. Research is based on the policy guidelines of problem orientation, disciplinary and inter-disciplinary focus, relevance, environmental and institutional sustainability and equity. Research strategies aim at improving the productivity, profitability, stability and sustainability of farming systems while conserving the fragile environment and fostering development of an integrated crop-livestock-forest system.

RNRRC Bajo receives technical support and improved germplasm from IRRI, AVRDC, CIMMYT, ICRISAT, ICARDA, CIP and a number of other regional agricultural institutes. In addition to the RGOB core budget for recurrent expenditure, the Centre also receives support in the form of field and laboratory equipment, vehicles, technical expertise etc. from IDRC-SDC through EPINARM project, RNR-ESP, BG-SRDP, BUCAP through NBC, CIRAD and other development projects of the region.

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ACRONYMS

ADLO	Assistant Dzongkhag Livestock Officer
AET	Advanced Evaluation Trial
AVRDC	Asian Vegetable Research and Development Center
a.i.	Active ingredient
BL	Blast
CAN	Calcium Ammonium Nitrate
CARD	Centre for Agricultural Research and Development
CIMMYT	International Maize and Wheat Improvement Centre
cm	centimetre
CV	coefficient of variation
DAT	Days after transplanting
FFS	Farmer Field School
FLW	Flowering
FYM	Farmyard manure
gm	gram
ha	hectare
P.ht.	Plant Height
ICRISAT	International Crops research Institute for the Semi-Arid Tropics
ICARDA	International Centre for Agricultural Research in the Dry Areas
IDRC	International Development Research Institute
IET	Initial Evaluation Trial
IPM	Integrated Pest Management
IPNS	International Plant Nutrient Study
IRRI	International Rice Research Institute
K	Potassium
LSD	least significant difference
m	meter
MAT	maturity
MoA	Ministry of Agriculture
MP	Murate of Potash
MPTS	Multipurpose Tree Species
N	Nitrogen
NASEPP	National Seed and Plant Program
NPPC	National Plant Protection Centre
No.	Number
n.s.	Not significant
P	Phosphorus
PET	Production Evaluation Trial
PRET	Pre-production evaluation trial
RCB	Randomised complete block
RGOB	Royal Government of Bhutan
RNRRC	Renewable Natural Resources Research Centre
s.e.	Standard error
S.E.D.	Standard error of difference
sqm.	Square meter
SSP	Single Super Phosphate

EXECUTIVE SUMMARY

FIELD CROPS

Ever since the start of the field crops research, the main aim is to increase the productivity of cereals (rice, maize, wheat and minor cereals), oilseeds (rapeseed-mustard) and grain legumes (soybean and groundnut) through identification, adaptation and development of appropriate technologies including varieties and their management. In 2006, a total of 22 activities were done, inclusive of both on station and on-farm. The on-farm activities were implemented in collaboration with respective agriculture sectors of client Dzongkhags and farmers.

Rice being the principle crop, research was focused to increase its production through usage of suitable varieties and adoption of improved practices. Yield potential, medium height (100-120 cm), optimum maturity (130-150 days) and resistance to pests and diseases were the criteria used for selecting a variety. At the station, AET consisted of 18 test lines including the checks. Analysis showed that RHS 351-19CX-7CX-2CX yielded the highest with grain yield of 8.64 t/ha. A total of 24 test entries were evaluated through IET of which DIANSHAO 3 yielded highest with grain yield of 9.73 t/ha. In observation nursery, 164 lines were tested base on the aforementioned criteria. The promising lines were identified for further evaluation.

On-farm research on rice included evaluation of mid altitude varieties and testing high altitude varieties at Khotokha and Shellay. Amongst the mid altitude varieties, B2983B-SR-85-3-2-4 yielded highest with 6.91 t/ha. In the high altitude regions, Paro China performed better (average 1.14 t/ha) than Khangma Maap (0.07 t/ha).

In wheat, 207 advanced lines from Nepal and 5 lines from BARI were tested. The disease susceptible and low yielding varieties were rejected while the promising entries were selected for further evaluation. Disease ratings on IDTN and SAARC Rust Trap Nursery were also done. Mustard lines from BARI and *Brassica juncea* were evaluated for yield, pests and disease resistance. Analysis showed that there was no significant yield difference amongst the varieties. In grain legumes, 8 soybean varieties received from different sources were tested on-station. Japanese Black Grade LL yielded the highest with 0.97 t/ha followed by Chinese Black Variety 2 with 0.77 t/ha.

HORTICULTURE

The main objective of horticulture research in RNRRC-Bajo is to identify appropriate technology and information thereby improving quality and yield of vegetables, nut crops, low chilled temperate fruits and subtropical fruits. The research focus is mainly on broadening the genetic base of priority horticultural crops through introduction, diversification and selection from local diversity, improved crop production and post-harvest technologies and improved seeds and plant propagation techniques. Besides, the focus is also on reaching out the improved varieties and crop production technologies through on-farm demonstration and research outreach programme where researchers work directly with the farmers in selected communities. Main approach of information

dissemination is through publication, trainings of farmers and dissemination of information by agriculture extension system. Some of the highlights of horticulture research programme of this centre in 2005-2006 are as follows:

- Under the variety improvement of fruits and vegetables, the centre identified varieties of one pomegranate, two guava, three mango and two local beans for release for general cultivation. Nationally coordinated walnut and chestnut variety evaluation trials were established in all the regions.
- Through the research outreach programme, location specific fruit crops (walnut model geog) on a trial basis were promoted in all villages in Nahi geog and pear in Beteni village for commercial production with the objective to evaluate their performance and commercialize promising species in future.
- The sector supported five RNR technology park development in Damji, Phobjikha, Chubu, Dagapela and Mendelgang with improved and superior vegetable seeds, peach, pear, walnut, apricot, guava, Bajo apple, almond, temperate apple and chestnut varieties.
- Participatory evaluation of fruits and vegetable are on-going and 11 demonstration orchards were established in the region.
- Breeder seeds of 22 vegetable cultivars that were released from the centre were maintained and seeds supplied to DSC as mandated.
- In March 2006, a research paper titled “Effect of time of grafting on walnut graft success under different altitude ranges” was published in the international journal Acta Horticulturae, International Society for Horticulture Science, based in Belgium.
- Support and technical recommendations were provided to the client Dzongkhags of this region and to the policy makers of MOA.

LIVESTOCK

The livestock research program started in the region with the inception of RNR Research programs in 1994. Since then, the livestock program remained focused on feed and fodder research owing to the critical feed shortages in winter for the livestock owners in the region. The sector maintained pace and progress in carrying out fodder research (on-station and on-farm) as a need based research in solving winter fodder shortages in the rice-based system. In the wetland areas, the introduction of oat has improved the fodder availability in winter.

The main objectives are to develop more productive and sustainable livestock options to strengthen crop-livestock research creating synergistic effect on enhancing productivity in this sub-sector. The scarcity of animal feed and green fodder for cattle especially during winter months is still a problem for many livestock owners. Some of the major constraints are lack on fodder resources to mitigate the increasing fodder requirement for cattle from limited land available for fodder production and the competing primary crops. Considering these critical issues, the sector had given major emphasis on feed and fodder research in trying to address some of those problems.

During 2005-06, the sector has taken up 17 activities (11 nationally coordinated and 6 regional) in total. Out of these, 8 were new and 9 on-going. The 17 activities also included,

11 on-station and 6 on-farm collaborative trials. 12 out of 17 activities were feed and fodder related and 5 were on breeding and management. During 2005-06, 4 activities were reported as completed and 13 activities were ongoing. Besides, the sector has also set up 3 new fodder trials and herbarium in Research Sub-Centre, Mithun, Tsirang.

Over the years, the livestock research has expanded to cover activities under the sub-program breeding and management and socioeconomics and marketing. Under breeding and management research program, efforts were also put in to document information on socioeconomics of goat raising, yak herd monitoring scheme and local fodder trees species. About 70% of the livestock research carried out was on feed and fodder and 30% on breeding and management. The on-farm research programs were implemented and monitored jointly by research and extension.

FORESTRY

As in the earlier years on-station activities that include multiplication, propagation and evaluation of multi-purpose tree species (MPTS) continued with newer accessions. Diverse local species of trees, shrubs and grasses of economic importance to the farmers were evaluated for their potential as agrofrestry species. Additional extension leaflets describing the propagation and management techniques were developed for species with economic value but manifesting difficulties while propagating. An interdisciplinary farmland management in Salamji village of Tsangkha Geog in Dagana was also initiated and various agroforest technologies were applied at the site.

In terms of mainstream forestry research the centre remains guided by national priorities, particularly those of the Department of Forests (DoF), the main client, and as directed by the forestry research coordinating centre at Yusipang. Prescribed burning in the Chir pine forest will be one the most important activities that the centre would undertake. Initial start to establish the plots are already underway.

The broadleaf forest dynamics research will be continued at Rimchu forest management unit (FMU) as a research forest. Research activities such as regeneration dynamics, permanent sample plot study, grazing ecology and a host of related research can now be conducted in close collaboration with the Forestry Research coordinating centre, RC, Yusipang, Divisional Office Wangdue and the College of Natural Resources (CNR), Lobeysa.

SYSTEM RESOURCE MANAGEMENT

Community Based Natural Resources Management (CBNRM)

During 2005-06 most of the activities in Lingmuteychu watershed were continuation of the previous year. In order to improve the livelihood of the farming community and the farm house, activities focused to improve farm production and enhancement of farmers' capacity in sustainable management of natural resources in a participatory and through collective action among the watershed communities.

For livelihood improvement, on-farm trial on high altitude rice variety (MP-3) was tried for its yield and farmers' acceptance at Limbukha and farmers preferred the variety and have promoted in larger scale. Due to traditional water sharing practices, Dompola community received their irrigation water late and to evaluate its effect on rice yield, joint evaluation through crop-cuts were continued, intermittent irrigation to demonstrate farmers on efficienct use of irrigation water was also conducted in farmers field at Dompola and Omteykha. *Shochum* hand weeding was continued for economic analysis.

As an outreach program, Nabchey village in the watershed was adopted and some of the proven research technologies were taken as on-farm for participatory assessment and livelihood enhancment. Some support on marketing of fruit seedlings from private nursery at Omteykha was emphasized for additional income generation in the watershed.

Watershed level management committee formation was initiated through companion modeling using role-play game, a participatory tool for creating awareness, understanding and negotiation on field reality problems.

Integrated Plant Nutrient System (IPNS)

IPNS research was continued with the aim to bringing together the research, the extension and the farmers to improve farmers' soil fertility management systems through an integrated plant nutrient systems approach. The general objectives were to study farmers' soil nutrient management practices, improve upon them and to develop appropriate and affordable technologies that will improve the productivity of the land without depleting the soil resources.

A number of FEFUT trials were conducted on rice in Tsirang Dzongkhag. The general objectives of these trials were to compare farmer practice and recommended practice in terms of rice yield, soil and plant nutrient status. Results indicated that soil nutrient status was significantly different in different geogs with over all low soil fertility status in all the four geogs. The effect of different treatments on soil nutrient status was not significant. Soil pH was within low to medium range. Available P and K, organic matter and CEC were low both before and after the trial. The effect of different treatments on the rice yield was not significant, however, the crop yields in different geogs and of the two varieties were significantly different.

A total of 78 composite soil samples were collected and analyzed from randomly selected potato fields in Phobjikha. The main aim of this study was to obtain a better understanding of the soil fertility status in those fields and then relate it to the potato yield-declining problem in the Valley. Soil samples were analysed for soil pH, percent organic carbon, total Nitrogen, available Phosphorus, available Potassium, exchangeable cations and texture. Results showed that the overall soil fertility status was moderate with an indication of Phosphate built up in some soils.

Soil samples were collected and analyzed annually from 11 randomly selected fields in Limbukha. The main aim of this activity was to see if repeated cultivation of potato after rice in the same field has any negative impact on soil fertility. Crop cuts were taken both for

rice and potato annually and results were reported in annual report 2003-2004. The main concern from the soil analysis results is the potassium [K] content. The available K is within very low-to-low range in all the sampled fields. This probably indicates either an insufficient application of K mineral, small soil K reserves or high K fixation capacity of the soils. Based on these findings, a simple fertilizer trial was conducted on potato, using different rates of K with fixed rate of N and P. The focus of this trial was to see if K is the limiting factor for low potato yields in some of the sampled fields. The results showed that there were no significant differences between the treatments used.

Water Management Research (WMR)

Water Management Research strives to raise productivity of existing rice-based irrigation schemes through improvements in water delivery and diversify the range of irrigated crops. With the increasing understanding of the water resources management issues over the years, the sector has felt the need to focus on the holistic management of the water resources. Some of the focus areas are management of water resources at the watershed level, integrated management of the allied resources, and development of sustainable systems through the enhancement of the local capacity.

Water resource management training was conducted to address the water scarcity problem in Nabchee. It helped the community to understand the problem and develop action plan. Water harvesting activity was initiated. Community recognized the need to develop the local resources management plan to ensure resources degradation is curtailed in future. “Role Playing Game” (RPG) at the Lingmutey Chu Watershed was conducted to help the seven communities in the watershed to understand the resources dynamics, how an isolated social behaviour produces negative impacts on the physical environment there by affecting all the communities in return. The aim of the process was to develop a common understanding on irrigation water shortage problem and develop a common strategy to address the problem in the watershed. The out come of the workshop was the agreement to address water shortage problem by developing a common management plan and instituting management committee at the watershed level.

Besides the research activities the sector is also engaged in infrastructural development works. During 2004-05, the sector completed infrastructure work worth Nu.5 million.

Agricultural Economics

Social and economic research is a fairly new area particularly at the MoA. Research in this area at the RNR-RCs started in early 1998 and 1999 with the placement of a new agricultural economist. The main objectives of the agricultural economics unit under the farming systems are:

- to undertake economic analysis of new technologies such as rice weed control options, fertilizer application levels, chilli blight control methods etc.
- Collection and analysis of data for calculation of costs and benefits of particular enterprises
- Policy and marketing research

Some of the major research activities undertaken by the agricultural economics unit in 2005 -06 were:

- Economic analysis of rice production in the Punakha, Wangdue, Tsirang and Sarpang. The main aim of this study was to determine the cost and returns of rice production in these Dzongkhags that fall under diverse agro-ecological zones.
- A diagnostic survey was carried out in Goenshari geog under Punakha Dzongkhag with the aim of understanding the practices, problems and the opportunities of the farmers. Based on the information that were gathered interventions were designed.
- The Field crops and Agricultural economics sectors of RNRRC Bajo were given the task to undertake the study on Commodity Chain Analysis. This study, undertaken by the DoA in collaboration with FAO was done with the objective to conduct a thorough analysis of the commodities that hold promise as potential growth engines for agricultural and rural development. The four commodity chains chosen for this analysis include two cereal chains (rice and maize) and two horticultural chains (potato and oranges). These commodities are analyzed in detail with a pro-poor focus using the Commodity Chain Analysis (CCA) methodology. The results of these analyses will form the basis for the preparation of project and program proposals for further development of selected commodity value chains in the next five year plans.
- Impact assessment of improved technology study was carried out through out the nation. A separate report titled as “Adoption and impact of improved maize technology in Bhutan” is being published.

Integrated Pest Management (IPM)

Post restructuring of Council of Research and Extension (CORE) to Council for RNR Research of Bhutan (CoRRB) linkage with National Plant Protection Centre (NPPC) ceased in terms of research needs and technical support. However the Plant Protection sector liases with NPPC for service inputs such as plant protection chemicals and extension advisory services. At the regional level, the sector continues to provide need-based technical plant protection services to the client Dzongkhags through field visits, disease-pest verification, surveillance and monitoring. The 2005-2006 fiscal year saw the sector research on on-going trials such as on-station *Shochum* management campaign, citrus fruit fly management via fruit drop collection, and rice blast evaluation through use of trap nurseries in blast hot spot areas in the Dzongkhag. *Parthenium* weed managment campaign continues to be implemented form June through October each year in the west-central region.

Mr. Sangay Wangdi, Research Officer who was away on study leave from September 2004 – September 2005 at the University of Reading, United Kingdom to attend a 12-month MSc. Course on Tropical Agricultural Development (Crop Protection) returned after successful completion of the course and resumed his duty in October 2005.

Extension Program

This year saw a change of designation of EPO to ROTP and finally to RRCO, which slightly affected the sector's role in determining mandate as per the designation. However, the sector performed almost the same mandate as erstwhile EPO, with more concentration on packaging research technologies. A total of 8 research results were packaged in the form of extension leaflets and disseminated to all concern EAs of the region, besides distributing to relevant RNR institutions of MoA. A basic ground development and technology demonstrations were set up as Technology Park (TP) in all five Model RNR ECs of the region, despite of issues and problems of budget and clear cut roles of Dzongkhag and RC for the development of TP. The sector initiated a study on technology adoption, which under progress and awaiting complete questionnaires. The sector also formed one farmer group in Limbukha besides constant monitoring of Dompola savings group. As usual, the sector organized the important annual features of RCs; the pre-regional meeting and the Annual Review and Planning Workshop. The sector coordinated the dissemination of information to about 20 study groups visiting from different Dzongkhags.

FIELD CROPS RESEARCH

1 FIELD CROPS RESEARCH

1.1 Rice Research

1.1.1 Advanced Evaluation Trial (AET)

AET consisted of 18 test entries in 2005, out of which 14 were crossbred lines and 4 were local and standard check varieties. The objective of AET was to identify suitable varieties with high yield potential, medium height, optimum maturity and resistance to prevailing pest and diseases for mid-altitude rice growing regions. The trial was laid out in a randomized complete block design with three replications. Seedlings were transplanted in 10 m^2 plot and spacing of 20 x 20 cm was maintained. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha with half the N as top dress at panicle initiation. Butachlor 5G was applied at the rate of 1.5 kg a.i./ha after 2 days of transplanting to control the weed. At later crop period hand weeding was done depending on weed pressure. Grain yield was estimated from a harvest area of 5.04 m^2 and grain moisture content was standardized at 14%.

Analysis of various parameters was done by using GENSTAT software. Amongst the test lines, RHS 351-19CX-7CX-2CX yielded the highest (8.64± 0.39 t/ha), followed by NR 10291 with (8.34 ± 0.39 t/ha) and (7.32 ± 0.49 t/ha). Several other crossbred lines produced yields higher or comparable to standard check IR 64 (Table 1). Local check Zakha yielded low with grain yield (6.3 ± 0.39 t/ha). Occurrence of insect pests and diseases was negligible during the season. The best performers from this trial will be evaluated in the farmers' fields in the ensuing season.

Table 1: Agronomic traits of entries in AET, 2005

Variety	50% flw (days)	Tiller No.	Plant height (cm)	Grain Yield (t/ha)
RHS 351-19CX-7CX-2CX	119	12	100	8.64
NR 10291	117	16	101	8.34
NR 10291	121	15	101	8.31
IR 64683-87-2-2-3-3	116	17	99	8.09
NR 10276	115	19	131	7.86
YOU MI 18	126	11	104	7.75
NR 10353	126	15	107	7.64
IR17146-97-1-2-1-3	115	12	99	7.58
CH 5	124	12	122	7.07
CT 9737-5-2-1-2-4P-M	119	14	97	7.05
RHS 33025-CX-3CX-024	125	12	101	6.87
BR4656-1-2-3-2	123	14	113	6.79
Khumal 6	118	16	143	6.76
MK 9-87	125	13	104	6.54
Bajo Kaap 2	123	13	100	8.67
Bajo Maap 2	115	19	112	5.96
IR 64	122	16	96	8.32
Zakha	119	19	127	6.30

CV (%)	0.4	4.7	0.9	2.9
LSD	5.32	3.79	8.09	0.80
F pr.	< 0.001	<0.001	< 0.001	< 0.001

1.1.2 Initial Evaluation Trial (IET)

IET consisted of 24 test entries consisting of local and check varieties. The test entries were mainly of advanced introductions and breeding lines intended for identification of promising materials in terms of grain, optimum maturity, and resistance to pests/diseases. The trial was laid out in a randomized complete block design with three replications. Seedlings were transplanted in 10 m^2 plot and spacing of 20 cm x 20 cm was maintained. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha, with half the N top-dressed at panicle initiation. Butachlor 5G was applied at the rate of 1.5 kg a.i/ha to control weed pressure. Hand weeding and irrigation were done whenever necessary. Grain yield was obtained from a harvest area of 5.04 m^2 and grain moisture content was standardized at 14%.

Analysis of variance (ANOVA) was used to analyze the data. Results are in Table 2. Amongst the test lines high yielder were DIANSHAO 3 (9.73 ± 0.56 t/ha)), CAN 8023 (8.92 ± 0.56 t/ha) and PSB RC 74 (8.87 ± 0.56 t/ha). Other lines too yielded appreciably. No significant damage due to insects and diseases were observed. The selected lines need to be further evaluated in the following season to ascertain its yield and other performances.

Table 2: Performance of entries in IET, 2005

Variety	Days to flowering	50% Tiller No.	Plant height (cm)	Grain Yield (t/ha)
DIANSHAO 3	123	10	109	9.73
CAN 8023	125	12	125	8.92
PSB RC 74	118	12	116	8.87
IR 73907-53-3-2-2	128	14	94	8.83
CT 6163-8-9-5-2-M-84-M	122	8	98	8.56
N 30	122	10	101	8.47
TOX 981-10-3-2	117	15	108	8.4
IR 73008-138-2-2-2	117	11	99	8.23
IR 74052-165-3-2	134	9	127	8.23
ITA 304	130	13	91	8.04
UPR 1561-6-3	123	10	88	8.02
IR 72176-140-1-2-2-3	118	13	103	7.97
TOX 3107-39-1-2-1	132	14	92	7.97

IR75282-10-3-3-2	121	17	102	7.86
OM 1271	117	10	119	7.71
IR 74295-22-2-2-2-3	121	11	108	7.43
BURDAGOL	128	10	96	7.34
CAN 8487 {CNA8487}	116	17	96	7.04
GUI-4-XUAN	109	12	100	6.75
M1-6148 UL	114	18	97	6.65
Bajo Maap 2	111	15	119	5.52
Bajo Kaap 2	122	17	102	8.87
IR 64	118	10	96	8.26
Zakha	117	19	126	5.33
CV %	0.8	10.1	2.4	12.7
LSD	4.54	6.11	28.01	1.13
F pr.	< 0.001	0.025	0.158	< 0.001

1.1.3 Observation Nursery

There were a total of 63 test lines in observation nursery. An improved variety, IR 64 was also included. These test lines were selected from the IRRI-INGER nursery of the previous season. The treatments were laid out in single plot of 10 m^2 with the spacing of 20 x 20 cm. The objective of the observation nursery was to evaluate the performance of the test lines in terms of yield, maturity period, adaptability, pests and diseases resistance. Inorganic fertilizers were applied at the rate of 70: 40: 20 NPK kg/ha. To control the weeds, Butachlor was applied at the rate of 1.5 kg a.i./ha. Hand weeding and irrigation were done as per the necessity.

Crop cut was taken from a harvest area of 5.04 m^2 from all the treatments. The highest yield was of 8.8 t/ha while the lowest was 4.36 t/ha (Table 3). No major pests or diseases incidence were observed during the cropping season. The good performing entries are selected for further evaluation in replicated trials in the coming season.

Table 3: Agronomic traits of Observation nursery

Variety	Plant Height (cm)	Yield (t/ha)
SPR85089-2-1	94	5.01
SPR85163-5-1-2-4	102	6.49
GROVENI	96	6.02
RCPL3-6	98	7.04
C5224-B-2-1-1	95	6.3
WAT 316-WAS-B-51-3-1-4-2	81	6.39
IR 73013-95-1-3-2	92	6.18
IR72903-121-2-1-2	89	6.78
WAT 310-WAS-B-28-8-3-3-3	88	8.75
CAN 8619	91	7.06
TOX 3440-47-6-2-1-1	101	5.81
65002	87	7.29
TOX 981-11-2-3	81	6.23
CNAX 4409-5-3-2-1-B	105	7.09
IR 59547-235-3-3	90	7.6
CT9868-3-2-3-1-4P-M	92	8.0
CT9737-8-15-3-2-4P-M	92	7.43
RCPL3-2	94	7.0
PK4553-42-1-1 (KS50020)	112	5.59
TOX3133-59-1-2-4	88	7.63
YN96-5010	93	8.3
TOX3145-TOC-34-2-3	109	6.0
JING-XIAN 89	100	7.47
XI23	110	8.75
IR 74642-195-1-3-2	92	8.72
IR 74646-96-2-3-3	91	7.8
PSB RC2 (IR32809-26-3-3)	72	7.47
IET 13183	138	6.49
CAN 8642	93	5.84
ZHI 20-5	102	8.8
ADRON-111	103	8.51
SHWE WAR TUN	99	5.71
C5442-B-1	90	6.59
TOX3081-36-2-3-1	77	7.82
DIAMANTE	80	8.46
IR 73435-7-2-3-2	81	7.61
PR28322-PJ19-2B-15-5	92	7.48
SHANYOU 63	89	5.12
IR 73004-83-2-2-3	86	6.96
PSB RC2 (IR 32809-26-3-3)	79	5.25
CAN 7830	86	5.78
C5457-B-1	94	6.97
CT6163-8-9-5-2-M-85-M	93	7.56
CH2	86	7.28
TOX3749-34-3-1	90	6.43

IR74271-41-2-1	75	6.63
TOX85C-C5-127-2	93	5.85
IR 73435-97-3-3-1	82	7.48
IR 73435-43-3-3-2	83	7.16
ORYZICA LLANOS 5	87	6.82
IR 59557-109-1-2	87	6.35
CAN 8721	87	6.33
N29	98	6.08
ITA410	86	7.16
C5216-B-3-1-1	91	6.36
PK 3161(KS49701)	106	4.36
IR 73436-37-3-2-2	78	7.37
GUI SI XUAN	96	8.27
C4842-2-2-1-1	99	7.74
PR26703-3B-PJ7	91	8.56
YN1850-176-1-5-1	94	5.96
IR 73712-68-3-1-2	95	6.35
IR 73933-12-2-1-2	99	7.83
IR64	95	7.9

1.1.4 INGER Nurseries

This trial mainly consisted of introduction from IRRI. There were a total of 100 entries including the local and standard checks. Evaluation was done in a single plot of 10 m^2 for yield, adaptability, pests and diseases resistance and other agronomic traits. Spacing of 20 x 20 cm was maintained between the rows while inorganic fertilizers were applied at the rate of 70: 40: 20 NPK kg/ha. Butachlor was also applied at the rate of 1.5 kg a.i./ha. Hand weeding and irrigation were done as per the necessity.

The highest observed yield was of 8.58 t/ha (Table 4). Majority of the test lines yielded appreciably high. Field rejection was done for the disease susceptible (like Blast) line. The good performing entries are selected for further evaluation.

Table 4: Agronomic traits of INGER Nurseries

Variety	Days to 50% Flowering	Plant Height (cm)	Grain Yield (t/ha)
SKAU23	93	107	8.47
CN1227-3-13-53	104	95	6.86
IR50	104	87	7.26
IR73930-33-2-3-2	127	87	7.22
IR77179-86-2-3-2	127	81	5.45
IR74293-95-1-1-2-2	119	80	4.92
PSB RC2(IR32809-26-3-3)	127	84	6.21
IR71677-161-2-3	119	74	4.99
GAN-WAN-XIAN 23	119	83	5.67
IR71694-28-3-3	118	91	4.97

Zakha	112	112	5.99
CN1225-5-9-8	101	83	4.68
IET14845(RPP12-33-3-2-2)	137	94	5.64
SKAU5	90	98	3.53
IR72	118	72	5.92
ANFC-5	119	83	7.19
IR73689-31-1	104	87	4.35
IET15392(RP3120-15-12-9-4)	101	84	5.94
IR 64	119	93	4.31
RGL2332(Pre-release culture)	149	80	2.98
ITA414	131	73	5.81
IR71121-35-1-1-1-2	104	73	4.29
IR50	101	70	5.00
MTU1061	149	71	2.44
IR78126-1-2-1	119	81	5.74
CN1223-5-4-9-2	119	111	4.93
PSB RC2(IR32809-26-3-3)	121	74	5.33
IR77298-5-6	112	84	7.06
IET15391(RP3135-17-12-8-8)	119	92	5.76
WAB189-3-HB	107	91	3.49
IR 64	112	90	6.85
MTU1042	131	97	6.42
BW328-2	112	79	8.24
94005-TR1574-1-1-1		Blast observed	
Zakha	107	123	6.09
ANFC-3	107	97	6.92
IR73439-11-1-3-1	121	83	6.12
MTU1561-4-1-1-1	114	93	6.16
IR72	119	93	4.68
IR72860-98-3-2-1	119	94	6.28
MTU1010	111	93	10.1
ANFC-4	114	93	8.36
IR 64	111	84	7.78
IR69132-17-2-2-2	107	88	5.86
ANFC-1	111	91	8.06
SKAU27	87	91	2.72
Zakha	107	120	6.56
IR77496-31-2-1-3	107	93	6.07
IR69736-145-1-2-3-3	118	90	7.53
IET11768(RP2397-432-106-48)	104	83	7.58
IR50	100	73	6.39
CN1081-3-13-23	131	84	4.62
AT362	118	90	7.36
CN1223-14-110-5	114	78	6.29
PSB RC2(IR32809-26-3-3)	121	75	6.31
IR73707-45-3-2-3	118	89	6.75
IR77500-1-2-2-3	117	96	6.19

XIANG ZAO XIAN 12	107	108	4.77
IR72	114	77	7.44
MTUII112-52-1-1	119	87	6.53
IR72158-116-6	131	80	7.21
IR73305-14-2-2	104	80	7.22
PSB RC2(IR32809-26-3-3)	112	73	5.69
CN1229-9-3-2-5	107	71	6.17
OM1270	112	79	6.29
IET14846(RPP12-38-2-3-1)	114	88	7.16
IR72	93	75	7.69
CN1224-70-75	104	82	8.01
IR73691-14-1	97	79	5.56
IR77504-36-3-3	119	83	6.9
Zakha	107	113	6.87
BG304	97	90	6.69
IR 74654-6-1-2-2	132	89	6.15
CN1223-18-54-20	131	84	6.14
IR50	100	78	5.88
BG305	104	86	6.49
IR74300-141-1-2-3-3	112	88	6.22
IET11771(RP223597-82-19)	104	84	8.19
IR 64	119	84	8.38
IR72997-159-2-2-1	137	92	7.01
MTUII110-9-1-1-1	146	96	4.54
IR76187-10-2-1-1	112	94	5.73
Zakha	111	117	6.28
CN1225-10-10-3	107	80	8.24
94008-TR1577-3-1-1	93	81	5.36
IR72158-148-4-2-6-2	107	82	8.18
IR72	114	74	7.58
PR26873-PJ21-2-1	111	84	8.55
GIRI (CN846-30-3-1)	107	93	5.64
IR73689-76-2	101	93	7.61
PSB RC2(IR32809-26-3-3)	107	74	6.48
IR77186-122-2-2-3	118	82	7.35
IR74963-262-5-1-3-3	114	94	7.4
BG358	111	102	5.42
IR 64	107	86	8.05
CT8470-22-13-2-M-5P	111	79	5.98
VASUNDHARA(RGL2358)	107	78	5.89
RP1959-60-79	111	90	6.36
IR50	101	75	6.86
SKAU105	100	114	7.79

1.1.5 Evaluation of Aromatic Rice

A total of 23 varieties of Aromatic Rice that were collected from Wangdue and Punakha valleys and received from different sources were evaluated in terms of yield potential, height, maturity days and other agronomic characteristics. Aromatic rice is indispensable for some religious functions and important occasions. The varieties were planted in a single observation plot of 5m x 2m with the spacing of 20cm x 20 cm. Inorganic fertilizers were applied at the rate of 40:40:20 NPK kg/ha and Butachlor @1.5 kg ai/ha to control the weeds.

1.1.6 Selection of population of crossbred lines

Commonly cultivated local varieties from different regions (Eastern and West central region) of Bhutan were crossed with improved varieties in order to improve the yield potential of otherwise low yielding locals. Crossbreeding of locals with improved parents was expected to enhance the yield potential and at the same time conserve the genetic traits of the locals preferred by farmers.

A total of fourteen F2 populations of crossbred lines were raised in single large plots and subjected to selection at the station. Substantial amount of seeds of each accessions were collected for further selection and evaluation. Below are the details of F2 crossbred lines selected at Bajo research centre.

Designation	Parents
1. IR 80484	IR 65598-112-2/Dago Yangkum
2. IR 80485	IR 65598-112-2/Local Yangkum (red)
3. IR 80486	IR 65598-112-2/Attey
4. IR 80487	IR 65598-112-2/Choti Masino
5. IR 80488	IR 65598-112-2/Sukhimey
6. IR 80489	IR 65598-112-2/Sungsung (red)
7. IR 80490	IR 71684-36-3-3-2/Dago Yangkum
8. IR 80491	IR 71684-36-3-3-2/Local Yangkum (red)
9. IR 80492	IR 71684-36-3-3-2/Attey
10. IR 80493	IR 71684-36-3-3-2/Choti Masino
11. IR 80494	IR 71684-36-3-3-2/Sukhimey
12. IR 80495	IR 71684-36-3-3-2/Sungsung (red)
13. IR 80496	IR 71684-36-3-3-2/ Golingpa
14. IR 80497	IR 71684-36-3-3-2/Choti Masino

1.1.7 Demonstration of released varieties

For the purpose of technology dissemination to farmers, extension and visitors a demonstration plot consisting of 12 released rice varieties were established at the research station. Below are the lists of varieties planted and demonstrated.

Varieties:

1. Bajo Kaap 1
2. Bajo Kaap 2
3. Bajo Maap 1
4. Bajo Maap 2
5. IR 64
6. IR 20913
7. Khangma Maap
8. Khumal 2 (Khangma Kaap)
9. Yusi Ray Maap
10. Yusi Ray Kaap
11. BR 153
12. M 54

1.1.8 Seed Maintenance and production of released varieties

A total of 1675 number of samples of nucleus seed of 11 released rice varieties were collected for producing basic and pre-basic seeds. Besides, a total of 3428 kg of basic and pre-basic seeds of 15 varieties were produced for supply of breeder seed to DSC and further research use (Table 5 and 6).

Table 5: Nucleus seed produced in 2005

Variety	No. of samples
SPR-87036-7-1-1-2	130
Guojing -4	150
Bajo Maap 1	165
IR 64	201
Bajo Maap 2	200
Bajo Kaap 1	110
Bajo Kaap 2	155
Mama	100
Total	1211

Table 6: Pre-basic and Basic seed produced (Kg) in 2005

Variety	Pre-Basic (kg)	Basic (kg)	Total (kg)
Paro china	-	120	120
SPR 87036-7-1-1-2	40	70	110
Guojing 4	55	340	395
Bajo Kaap 1	85	460	545
BW 293	-	65	65
Bajo Kaap 2	60	600	660
Zakha	-	25	25
IR 64	110	475	585
Bajo Maap 2	65	600	665
Mama	40	-	40

Khangma Maap	-	110	110
Bajo Maap 1	70	350	420
Machapurcharey 3	-	230	230
IR 20913	-	365	365
B 298 B-SR-85-3-2-4	90	165	255
K. B	-	140	140
T-23	-	30	30
Total	615	4145	4760

1.1.9 On-farm Trials of Mid-altitude Rice Varieties

The three mid-altitude rice varieties (GUOJING 4, SPR 87036-7-1-1-2 and B2983B-SR-85-3-2-4) were further evaluated in 2005 under farmers' management practices to critically analyze the yield performances and ascertain its adaptation in the mid altitude regions of different locations. It has been 3 years of evaluation as an on farm trial after rigorous on station testing and their performance found to be satisfactory and yield consistent.

Toewang, Kabji and Zomi under Punakha Dzongkhag and Maphina, Ruchikha and Thangu under Wangdue Dzongkhag were selected as these areas represent mid altitude region. The trial was laid out in single large plots with existing traditional varieties in adjacent plots as the check. All operations and management of the trials were done by cooperator farmers as per their own practices, with timely monitoring from extension staff and researchers.

Crop cut was taken from an area of 6 m^2 during the harvest time to measure the grain yield. B2983B-SR-85-3-2-4 yielded the highest with the mean yield of 6.91 t/ha (Table 7) and it is more preferred by farmers for being red variety and maturing early. It will be evaluated in the coming season too to further ascertain its performance over sites and over the years.

Table 7: Performance of Mid altitude On-farm rice trial

Variety	Sites						Yield (t/ha)
	Zomi	Tewang	Ruchikha	Thangu	Maphina	Kabji	
GUOGING 4	6.79	6.53	6.28	9.50	5.23	5.98	6.71
B2983B-SR-85-3-2-4	7.27	6.07	8.85	8.40	5.73	5.17	6.91
SPR 87036-7-1-1-2	7.27	6.75	7.18	9.50	4.97	5.75	6.9
Local	5.8 Zakha	6.45 IR 64	4.77 IR 64	8.40 IR 64	4.37 Maap	4.00 Dawa Maap	

1.1.10 High altitude Rice trial (Khotokha and Shellay)

The trial was initiated at Khotokha (2660 masl) and Shellay (2530 masl) with the aim to study the adaptability and performance of rice in high altitude region. The trial was implemented in collaboration with Agriculture sector of Wangdue Dzongkhag.

Two farmers were selected covering an area of one langdo in each valley. The varieties consisted of two high altitude varieties namely Paro China and Khangma Maap. The nursery was sown in last week of February in pollytunnel and transplanted in first week of May. The trial was harvested on 10th November, 2005.

The overall performance of the varieties in both the valleys was not good. Crop gave luxurious vegetative growth, profuse tillering, delayed maturity and partially filled grains in most of the terraces. This is probably due to virgin soil as paddy has been never grown before, cold injury during flowering and late transplanting. The alternatives could be transplanting at appropriate time (mid April) to coincide the flowering with high temperature and sacrificing the first terrace/making basins at entry of irrigation water to escape from cold injury. The crop cut results in both the valleys are given in Tables 8.

Table 8: Crop cut results (t/ha) at Khotokha and Shellay

Variety	Khotokha	Shellay
Paro China	1.56	0.72
Khangma Maap	0.07	*

**Khangma Maap was all sterile without any fertilized grains*

1.1.11 BUCAP activities in the West-Central region

The BUCAP activities for west central region coordinated by National Biodiversity Centre and facilitated by RNRRC, Bajo for 2005 had been successfully implemented in the project sites with the broad objective of conserving and developing agricultural biodiversity. In addition to the existing sites, Damji under Khame geog in Gasa Dzongkhag and Samthang and Rukha under Adang geog in Wangdue Dzongkhag were also included as BUCAP sites from 2005. A baseline survey at Damji and diagnostic survey in Adang geog were done prior to implementation of activities.

The main activities for 2005 included rice Farmers' Field School, participatory variety selection and maize seed selection training at Tsirang. The activities were undertaken in keeping the broad objectives of BUCAP through facilitating farmer's access to improved varieties, broadening genetic base of the crops in the locality and inducing participatory varietal selection thereby contributing to conserving and developing agricultural biodiversity.

Participatory Varietal Selection at Thangu

In addition to the 3 promising lines identified by the FFS in 2004, another promising variety namely B2983B-SR-85-3-2-4 was also included to check its performance. Transplanting was done on 26th June, 2005 in a single large terrace with the involvement of FFS participants. A basal dose of 10 kgs Suphala was applied besides broadcasting 2

kgs of Butachlor after transplanting. Other management practices were carried out by the farmer as per their local practices.

A field day was conducted at the time of harvest where the FFS participants jointly select the variety as per their preference and interest. Majority of them were in favour of B2983B-SR-85-3-2-4 since it is a red variety which fetch more price in the local market besides having good yield potential (Table 9). It is also an early maturing variety and gives more straw yield than their existing local variety and IR 64. Another preferred variety to the participatory farmers was Guojing-4 because of its high yield and bold grain shapes.

Table 9: Crop cut results at Thangu (2005)

Variety	Grain Yield (t/ha)
GUOJING 4	9.50
SPR 87036-7-1-1-2	9.50
IR 64683-87-2-2-3-3	9.50
B2983B-SR-85-3-2-4	8.40
IR 64	8.40

Participatory Varietal Selection at Nob Sechekha, Guenshari

This activity was aimed to select the variety jointly by the FFS participants after phenotypic observation and yielding ability. Yusiray Kaap and Khangma Maap were rejected by the FFS participants due to their low yielding nature in their locality. The varieties tested were Yusiray Maap, PP-2-38-4, Machapuchrey–3, Phulaychu (local) and Buna Naap (local).

A field day was conducted at the time of harvest where the FFS participants actively took part in taking crop cut and threshing activities. Phenotypic acceptability test was also conducted for the participants to understand the preferences of farmers to a particular variety. All the members phenotypically accepted Machapucherey-3 as the best variety among the tested varieties. Crop cut results (Table 10) revealed that Machapuchrey-3 was the highest yielder followed by Yusiray Maap. Phulaychu, a local variety was the lowest yielder. Machapucherey-3 has been adopted by ten farmers after its introduction in 2004.

Table 10: Crop cut results 2005

Variety	Grain Yield (t/ha)
Machapucherey	6.9
Yusiray Maap	6.5
Buna Naap	5.8
PP-2-38-4	5.3
Phulaychu	5.1

Seed maintenance

In response to the seed selection training imparted, members carried out seed selection from standing field by timely rouging the off types, rejecting diseased and pest infested plants and maintaining good agronomic practices. The seeds selected by the members

are multiplied in the host farmer and later distributed among themselves during the cropping season. This has become an important activity as it has paved the way for increased production through quality seeds. The seed maintenance activity was continued this year too and seeds of two traditional varieties Phulaychu and Buna Naap were maintained. As usual farmers will be taking their respective shares at the time of sowing.

Shochum Campaign

Shochum, *Potamogeton distinctus* had been a noxious weed for the rice farmers and continue to be a threatening weed for rice production. It is practically impossible to control the weed by any available herbicide or by few hand weeding since it is deep rooted and multiply by rhizomes. Its aquatic nature helps the weed in germinating when irrigation is given to the paddy field. The repeated and vigorous hand weeding by removing all its underground parts like shoots and rhizomes seems to help in reducing the plant population and ultimately its multiplication in the subsequent seasons. Hence there was a need to sensitize the farmers on rice yield loss due to Sochum and activate them on timely and adequate number of hand weeding for its management. Keeping all these in view two Sochum campaigns were conducted.

The campaign was conducted with the aim to create awareness to the farmers about the repeated hand weeding in managing sochum and see the impact of repeated hand weeding in Sochum management in comparison to the unweeded fields. The regular FFS participants, agriculture extension agent and research personnel participated in a day long campaign. The participants felt that the weed pressure was comparatively low as that of previous year and it must be attributed to twice intensive hand weeding in the last cropping season. FFS participants were urged and reminded to carry out hand weeding intensively in their respective fields as what it was done in the FFS plots.

Participatory Varietal Selection at Damji

Six different varieties of paddy namely Gyamja Maap, Giru Gam, Phulaychu, Buna Naap, Khangma Maap and Machapucherey-3 were sown in a co-operative farmer's field. The six varieties included the existing traditional varieties in their locality, some traditional varieties that were introduced from other regions of same altitude and some improved varieties that were recommended for high altitude region. The trial was transplanted on 5th June, 2005 along with the FFS members. No inorganic fertilizers or herbicides were applied in keeping the principle of organic farming.

A field day was conducted at the time of harvest to assess the yield and farmers' preference about the varieties. Phulaychu, a traditional variety introduced from Secheykha, Guenshari yielded the highest with 5.9 t/ha while their local variety Gyamja Maap yielded the lowest with 4.7 t/ha. The results of the crop cut of different varieties are presented in Table 11.

Table 11: Crop cut results (2005)

Variety	Grain Yield (t/ha)	Remark
Gyamja Maap	4.7	Dominating local variety
Machapucherey-3	5.8	Improved introduced variety

Phulaychu	5.9	Local variety introduced from Secheykha.
Buna Naap	5.4	Local variety introduced from Secheykha
Giru Gam	5.0	Dominating local variety
Khangma Maap	5.5	Improved variety cultivated by one farmer

Participatory Varietal Selection at Rukha, Adang Geog

Rukha being one of the remotest villages have never been accessed to improved varieties and farmers have been cultivating the traditional ones from immemorial times. Hence two improved varieties IR- 20913 and Bajo Maap-1 were included for PVS in addition to their local variety Ray Naam. Nursery of Bajo Maap-1 was sown on 21st May, 2005 while IR 20913 being early maturing variety was sown on 2nd June, 2005. Both the varieties were transplanted on 8th July after completing their local variety transplanting. The varieties matured early than their local varieties and came to harvest on 9th October, 2005. Crop results showed that IR-20913 was the highest yielder followed by Bajo Maap-1. Their local variety Ray Nam yielded the lowest (Table 12).

Table 12: Crop cut results at Rukha (2005)

Variety	Grain yield (t/ha)
IR-20913	6.3
Bajo Maap-1	6.2
Ray Naam	3.3

Participatory Varietal Selection at Samthang

The activity in this village included introduction of 2 improved rice varieties in addition to their local variety Attey. The improved varieties were IR-64 and Bajo Kaap-2 which are recommended for mid altitude areas. Arrangement was made by delaying the nursery sowing and transplanting to coincide the flowering and maturity of improved varieties with that of their local varieties. Nursery sowing was done on 1st June which was a month later than their local nursery sowing. Improved varieties were transplanted on 8th July which was at the end of their local transplantation.

Amongst the PVS varieties, IR 64 yielded the highest followed by Bajo Kaap-2. Attey was the lowest yielder as shown in Table 13.

Table 13: Crop cut results at Samthang (2005)

Variety	Grain Yield (t/ha)	Remark
IR 64	4.8	Improved variety
Bajo Kaap-2	4.3	Improved variety
Attey	2.8	Local variety

Picture 1: Participants using pedal thresher that was supplied through BUCAP project

Maize seed selection training in Tsirang

With the financial assistance from BUCAP, maize seed selection training was conducted in Tsirangtoe and Rangthaling geogs of Tsirang Dzongkhag. The training was a followup of last year's training imparted to the agriculture extension agents of the Tsirang Dzongkhag in order to address the issues of seed degeneration and improper seed selection method.

The trained agriculture extension agents imparted the trainings to the farmers of their respective geogs. They highlighted the causes of seed degeneration like genetic impurity, loss of viability, varietal mixtures, incidence of pests and diseases and use of same seeds over years. They also briefed about the symptoms of poor quality seeds viz. poor or un-uniform germination, variation in cob sizes and shapes, mixed types or different colours of kernels and poor yield. Technical aspects of good seed production like rouging the abnormal plants or detasseling them on right time, selection of desirable character plants for seeds before harvest, selection of cobs with fully covered husks and proper post harvest storage were also explained to the participating farmers. Practical demonstration on seed selection from the standing field was also conducted for the easy understanding and benefit of the farmers.

A total of 40 farmers from aforementioned geogs participated in the day long training. The agriculture sector of Tsirang Dzongkhag and farmers extended their gratitude to BUCAP for the financial assistance and look forward for such continued support in the future.

1.2 Maize Research

1.2.1 Sweet Corn Adaptation Study

The trial was carried out simultaneously at the station of all the RNRRCs with an objective of studying the feasibility of growing sweet corn variety in terms of yield performance and resistance to pest and diseases. The trial was laid out in single large plot as observation and row to row spacing of 75cm and plant to plant spacing of 50 cm was maintained. Two to three seeds were planted per hill. Inorganic fertilizers were applied at the rate of 60:30:20 NPK kg/ha in three splits. Half N and full P2O5 and K2O were applied as basal dose at the time of planting and remaining half N as top dressing in two equal splits at an interval of 25 days consecutively. Hand weeding was done depending on weed pressure to control the weed growth.

Crop cuts were taken from the sample area of 7 m^2. No significant damage due to insects and diseases were reported from the test sites. The results are presented in Table 14.

Table 14: Agronomic traits of Sweet corn, 2005

Site	Days to 50%Flowering	Plant height (cm)	Yield of green cobs (t/ha)
RC Bajo	63	171	7.13
RC Wengkhar	89	239	10.51
RC Jakar	150	-	6.59
RC Yusipang	124	220	1.8

1.2.2 Pop Corn Adaptation Study

The study was carried out at the station of RNRRC Yusipang and Bajo to evaluate the performance of pop corn variety in terms of adaptability and yielding ability in the test sites. The trial was laid out in single large observation plot and a row to row spacing of 75cm and plant to plant spacing of 50 cm was maintained. Two to three seeds were planted per hill. Fertilizers were applied at the rate of 60:30:20 NPK kg/ha in three splits. Half N and full P2O5 and K2O were applied as basal dose at the time of planting and remaining half N as top dressing in two equal splits at an interval of 25 days consecutively. Hand weeding was done depending on weed pressure to control the weed growth.

At Bajo on station, it took 88 days to attend 50% flowering while average height of the plant was 169 cm. The average number of cobs per plant was 2 and yielded 2.25 t/ha (Table 15) of green cobs from sample area of 7 m^2. However at RNRRC Yusipang, the crop gave poor germination without any tasseling and grain formation even from those few germinated plants.

Table 15: Agronomic traits of pop corn adaptability trial, RC Bajo 2005

Location	50% (Flw)	Av. plant height (cm)	No of ears/plant	Grain Yield (t/ha)

Bajo	88	169	2.13	2.25

1.3 Wheat Research

1.3.1 Observation Trial of Nepal Advanced Lines (NAL)

The trial consisted of 207 test lines that were received from Nepal. The objective of the trial was to assess the performance of these varieties under Bhutanese agro-ecological conditions in terms of yield, disease resistance and other agronomic traits. The trial was laid out in an area of $6m^2$ with the spacing of 20 x 20 cm. Inorganic fertilizer was applied at the rate of 60:30:20 NPK kg/ha with half a dose of N top dressed at 65 days after germination. Hand weedings were done depending on the weed pressure and irrigation given as per the crop need.

Amongst the lines, BL3128 yielded the highest with yield of 1.28 t/ha followed by BL3083 with yield of 1.27 t/ha. Field rejection for the Rust susceptible lines have been already done besides rejecting the poor yielder from further evaluation. The results of the trials are presented in Table 16.

Table 16: Agronomic traits of pop corn adaptability trial, RC Bajo 2005

Lines	50% flw days	Maturity Days	Plant ht. (cm)	Yield (t/ha)	Remarks
BL3071	101	150	85	0.79	-
BL3072	101	150	84	0.75	10 – 15 % yellow rust
BL3079	98	147	87	0.38	Heavily infected
BL3082	98	150	79	0.79	80% Yellow rust
BL3083	98	145	81	1.27	-
BL3088	101	150	73	0.29	Mild rust
BL3090	102	150	81	0.50	Mild Yellow rust
BL3093	102	148	71	0.93	Moderate Yellow rust
BL3099	102	148	71	0.83	-
BL3100	102	150	68	0.82	Mild rust
BL3102	102	148	64	0.70	Severe rust
BL3103	102	148	71	0.60	-
BL3108	102	150	61	0.25	-
BL3111	101	150	77	1.09	-
BL3112	96	147	89	0.83	-
BL3115	98	147	81	0.77	-
BL3116	98	147	68	0.65	-
BL3118	96	144	85	0.70	-
BL3121	96	145	92	1.18	-
BHIRKUTI(Check)	96	147	68	1.20	-
BL3122	96	147	75	0.88	-
BL3124	101	150	76	1.18	-

BL3125	98	150	87	1.16	-
BL3126	98	147	89	0.93	-
BL3128	96	150	86	1.28	-
BL3131	96	150	75	0.93	Moderate Yellow rust
BL3134	96	150	76	0.82	Moderate Yellow rust
BL3135	104	157	83	0.75	Moderate Yellow rust
BL3136	96	145	59	0.63	Moderate Yellow rust
BL3138	96	145	56	0.60	Mild Yellow rust
BL3140	101	152	85	0.62	-
BL3141	102	152	74	0.62	-
BL3143	98	145	61	0.55	-
BL3144	98	150	69	0.62	-
BL3150	102	150	74	0.18	Moderate Yellow rust
BL3152	96	148	68	0.62	Moderate Yellow rust
BL3153	96	148	70	0.82	Moderate Yellow rust
BL3154	96	145	69	0.53	50% Yellow Rust
BL3156	96	145	74	0.55	50% Yellow Rust
BL1887 (Check)	102	157	81	0.95	-
BL3158	102	150	62	0.87	-
BL3160	104	150	58	0.58	-
BL3162	101	150	69	0.70	-
BL3163	101	150	85	0.65	-
BL3166	104	157	65	0.90	-
BL3167	102	152	59	0.77	-
BL3168	101	150	78	0.58	-
BL3169	101	150	68	0.37	-
BL3174	96	145	73	0.78	-
BL3177	96	147	80	0.53	-
BL3178	98	150	79	0.50	-
BL3179	98	150	67	0.42	-
BL3182	105	157	71	0.47	-
BL3183	102	150	77	0.47	-
BL3185	104	157	86	0.47	-
BL3188	102	152	75	0.42	-
BL3189	105	157	67	0.40	-
BL3190	98	150	79	0.55	-
BL3192	101	150	77	0.75	-
BL1473 (Check)	98	150	78	0.52	-
BL3193	109	152	79	0.53	Moderate Yellow Rust

BL3196	108	157	83	0.52	Moderate Rust	Yellow
BL3200	102	150	76	0.68	Moderate Rust	Yellow
BL3201	102	152	71	1.03	Moderate Rust	Yellow
BL3204	96	150	87	0.87	-	
BL3205	104	150	76	0.73	-	
BL3206	101	150	79	0.82	-	
BL3209	105	155	79	0.62	-	
BL3211	102	152	72	0.42	-	
BL3213	102	150	60	0.30	-	
BL3215	101	150	71	0.33	-	
BL3216	98	147	73	0.60	-	
BL3218	98	150	82	0.75	-	
BL3219	101	150	75	0.60	-	
BL3220	102	152	80	0.62	-	
BL3221	101	150	78	0.62	-	
BL3223	101	150	75	0.78	-	
BL3230	109	157	67	0.52	-	
BL3233	104	150	72	0.35	-	
NEPAL297(Check)	102	150	67	0.58	-	
BL3241	102	150	84	0.52	-	
BL3243	105	155	75	0.28	-	
BL3244	102	150	67	0.38	-	
BL3246	104	152	66	0.62	-	
BL3247	98	147	63	0.28	Moderate Rust	Yellow
BL3249	98	150	52	0.12	-	
BL3250	101	147	65	0.17	-	
BL3258	98	145	72	0.22	-	
BL3260	101	148	73	0.15	-	
BL3261	98	150	62	0.25	Severe Yellow Rust	
BL3262	101	150	62	0.15	Severe Yellow Rust	
BL3263	101	147	58	0.06	Severe Yellow Rust	
PBW65/2*PASTOR-CGSS97Y00036M-099TOPB-067Y-OO9M-OO9Y-OO9B-16Y-OB	98	147	58	0.5	-	
PBW65/2*PASTOR-19Y-OB	98	147	64	0.65	-	
PBW65/2*PASTOR-20Y-OB	102	150	63	0.50	-	
PBW65/2*PASTOR-25Y-OB	102	150	57	0.52	-	
HUW234+LR34*2//PRL	101	150	62	0.37	-	

/VEE=10						
HUW234+LR34/PRINIA	98	150	60	0.37	-	
IA0216	105	155	75	0.37	-	
ANNAPURNA-1(Check)	108	157	63	0.33	-	
QUP8002-00	102	152	50	0.40	-	
PBW299	104	155	57	0.18	-	
PARWAZ-94	101	150	62	0.37	Moderate Rust	Yellow
SW895124*2/FASAN	98	152	64	0.48	-	
W462/VEE/KOEL/3/PEG//MRL/BUC	98	150	74	0.83	-	
ALTAR84/AESQUARROSA(219)//3*ESDA – CMSS92YO1875M-16Y-010M-010Y-4KBY-5M-OY-2KBY-OKBY-OM	104	159	84	0.80	-	
ALTAR84/AESQUARROSA(219)//3*ESDA-5KBY-1M-OY-18KBY-OKBY-OM	102	159	77	0.48	-	
ALTAR84/AESQUARROSA(219)//3*ESDA-5KBY-3M-OY-3KBY-OKBY-OM	102	157	75	0.63	-	
PASTOR/3/VEE?5//DOVE/BUC	102	152	55	0.35	-	
CEP14/CMH81.137//2*THB/3/BOW/PRL//BUC	101	148	65	0.47	-	
CHOIX/STAR/3/HE1/3*CNO79//2*SERI	101	155	64	0.30	-	
KAUZ//SERI/CEP80120	101	152	55	0.42	-	
SW89.2089/KAUZ	102	152	47	0.18	-	
CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/3/VEE?7/BOW/4/PASTOR-CMSS93BO1854T-O4OY-8Y-O1OM-O1OY-010M-7Y-OM-5KBY-OKBY-OM	98	150	64	0.47	-	
CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/3/VEE?7/BOW/4/	98	145	66	0.37	-	

PASTOR-8Y-OM-5KBY-OKBY-OM						
CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/3/VEE?7/BOW/4/PASTOR-10Y-OM-5KBY-OKBY-OM	96	144	53	0.17	-	
COQ/F41.70//CNDR/4/NAR59/3/FN/K58//N/5/PHO/6/2*KAUZ/7/GALVEZ/WEAVER	96	144	51	0.27	-	
PBW343*2/KUKUN	101	150	56	0.37	-	
INQALAB91*2/KUKUN	104	159	62	0.47	-	
BHRIKUTI(Check)	105	159	60	0.52	-	
INQALAB91*2/TUKURU-CGSS99B00015F-099Y-099M-099Y-099M-29Y-OB	109	159	80	0.50	60% Yellow Rust	
INQALAB91*2/TUKURU-36Y-OB	104	157	63	0.28	-	
INQALAB91*2/TUKURU-49Y-OB	102	155	64	0.53	-	
OPATA/RAYON//KAUZ-CMBW90Y3180-0T0PM-3Y-010M-010M-010Y-6M-015Y-0Y-4KBY-0KBY-OM	102	150	62	0.58	-	
OPATA/RAYON//KAUZ-10M-015Y-0Y-3KBY-0KBY-OM	102	155	70	0.52	-	
W462//VEE/KOEL/3/PEG//MRL/BUC	101	150	71	0.78	-	
CHOIX/STAR/3/HE1/3*CNO79//2*SERI	104	157	62	0.37	-	
PBW65/2*SERI.1B	108	157	69	0.70	-	
PRL/2*PASTOR	102	152	68	1.13	-	
HUW234+LR34*2/PASTOR	104	152	59	0.58	-	
BL2922	108	157	64	0.25	-	
BL2932	104	152	60	0.63	-	
BL2935	105	155	66	0.48	-	
BL2936	108	157	76	0.83	-	
BL2982	109	159	96	0.75	-	
BL3001	105	152	85	0.53	-	
BL3002	102	152	82	0.47	Moderate Rust	Yellow
BL3004	98	150	81	0.68	Moderate	Yellow

					Rust
BL3020	98	150	80	1	-
BL1887 (Check)	105	159	76	0.73	-
BL3021	102	150	75	0.65	-
BL3023	102	150	65	0.40	-
BL3025	101	152	64	0.42	-
BL3054	101	150	69	0.22	-
BL3063	101	150	68	0.23	-
BL3065	98	150	62	0.48	-
BL2748	98	145	67	0.33	-
BL2774	96	144	61	0.27	Moderate Yellow Rust
NAC/VEE//CATBIRD-BD(DIN)850S-ODI-ODI-ODI-1D1-(1-10)DI-RC1DI	102	150	56	0.17	-
NAC/VEE//CATBIRD-RC8DI	101	150	57	0.35	-
NAC/VEE//CATBIRD-10D1-(1-10)DI-RC1DI	101	152	53	0.45	-
ND/VG9144//KAL/BB/3/YACO/4/CHTL/5/BAW824(RL6043/4*NAC)	101	150	52	0.18	-
BAW897*2/CATBIRD-BD(DIN)104098B-ODI-HRDI-RC5DI	102	152	58	0.33	-
BAW897*2/CATBIRD-RC8DI	102	150	56	0.23	-
NAC/VEE//CATBIRD-BD(DIN)85097S-ODI-OBD-HRDI-RC3DI	102	152	56	0.40	-
NAC/VEE//CATBIRD-RC6DI	102	152	58	0.33	-
BAW378//BB/TOB//CNO67/3/HUAC/4/TIRESEL/3/BB/PL//SX/5/ICTAL-123	98	150	65	0.58	-
ICTAL 123/3/RAWAL87//VEE/HD2285-BJO9586-OJO-3JE-OJE-HRDI-RC2DI	101	150	64	0.58	-
ICTAL 123/3/RAWAL87//VEE/HD2285-RC3DI	98	145	66	0.38	80% Yellow Rust
BL1473 (Check)	98	147	71	0.55	-
ICTAL	98	150	67	0.75	-

123/3/RAWAL87//VEE/ HD2285-RC5DI					
BAW966	101	150	72	1.08	-
BL2890	105	155	63	1.06	-
BL2892	102	155	71	0.75	-
BL2906	98	144	74	0.63	-
BL2920	101	150	57	0.27	-
BL2927	102	157	61	0.32	-
BL2935	102	157	60	0.22	-
BL2979	108	159	72	0.40	-
BL2980	102	152	61	0.33	-
BL2981	104	155	73	0.77	-
BL2995	102	155	73	0.72	50% Yellow Rust
BL3010	104	157	64	0.58	-
BL3018	101	150	78	0.58	-
BL3037	101	150	79	0.55	-
BL3046	101	150	69	0.50	-
BL3064	98	150	66	0.48	-
BL2807	101	150	64	0.05	-
M758064/2*6TA876//EMS-6TA876/3/6TB219/6TA876/4/RONDO/2*ERIZO-11/5/ONA-2*2/NIMIR-4	105	164	70	0.16	-
NEPAL 297 (Check)	101	150	60	0.28	-
PASTOR/3/MUNIA//CHEN/ALTAR84/5/CNDO/R143/ENTE/MEXI-2/3/AEGILOPS SQUARROSA	98	147	59	0.48	30% Yellow Rust
BABAX*2/PRL	98	148	60	0.32	70% Yellow Rust
KAMBARA 1-CGSS95B00016F-099Y-099B-099Y-099B-25Y-OB-OSY	101	152	72	0.37	Severely affected
AJAIA-12/F3LOCAL(SELETHIO.135.85)//PLATA-13	102	152	58	0.48	Mild Yellow Rust
KAMBARA 1-020Y-OB-OSY	98	150	68	0.52	-
MILAN/AMSEL	102	152	57	0.38	-
BOW/URES//KEA/3/SITE	104	157	67	0.47	-
MILAN/MUNIA	102	150	59	0.28	-
JUN//MAYA/MON/3/PGO/4/MILAN	101	148	58	0.25	-

MILAN//PSN/BOW-	102	150	63	0.35	-
MILAN//PSN/BOW-1PZ-OY	101	150	53	0.28	-
PAT24/ALD//DOVE/BUC/5/GOV/AZ//MUS/3/DODO/4/BOW	108	157	65	0.47	-
MILAN/AMSEL//CBRD	104	150	51	0.32	-
TNMU/MILAN//MILAN/SHA7	101	150	67	0.65	-
WK 1444	101	150	73	0.20	-
WK 1334	104	155	65	0.55	-
WK 1308	108	157	63	0.30	-
CMH 843379/CMH78578/MILAN	102	150	58	0.28	-
WEAVER/4/NAC/TH.AC//3PVN/3/MIRLO/BUC	102	150	56	0.65	-
ANNAPURNA-1 (Check)	101	150	63	0.67	-
PASTOR/KAUZ	101	152	59	0.47	-
CNDO/R143//ENTE/MEX12/3/AEGILOPS SQUARROSA (TAUS)/4/WEAVER/5/2*KAUZ	101	150	57	0.83	-
CMH82A.1294/2*KAUZ//MUNIA/CHTO/3/MILAN-CMSS94YYO2299T-030Y-0300M-0100Y-0100M-4Y-8M-0Y-16Y-OB	104	155	65	0.52	-
CMH82A.1294/2*KAUZ//MUNIA/CHTO/3/MILAN-41Y-OB	104	155	61	0.53	-
FALKE*2/BISU/3/CHEN/AESQUA(TAUS)//BCN	102	150	69	0.63	-
MILAN/KAUZ//PRINIA	98	147	72	0.67	-
OPATA/RAYON//KAUZ/3/TOBA97	102	150	59	0.50	-

1.3.2 International Disease Trap Nursery (IDTN) Trial

The main objective of the trial was to monitor the rusts disease incidence, potential changes in virulence to leaf and yellow rusts of wheat under Bhutanese agro-ecological conditions. The trial consisted of 114 entries and was laid out in a row of 1 m length, maintaining 40 cm spacing between the varieties. Inorganic fertilizer of 60:30:20 NPK

Kg/ha was applied with half a dose of N top dressed at 65 days after germination. Regular hand weeding was done to suppress weeds. Results of the trials are presented in Table 17.

Table 17: Observations of IDTN Trial

Entry no	Observed date leaf/ yellow rust scoring	Observed date leaf/ yellow rust scoring	Observed date leaf/ yellow rust scoring	Observed date leaf/ yellow rust scoring
	28/3/2006	7/4/2006	28/4/2006	4/5/2006
1.	25% leaf rust	60% leaf rust	70% leaf rust	75% leaf rust
2.	30% leaf rust	60% leaf rust	75% leaf rust	75% leaf rust
3.	7% leaf rust	40% leaf rust	60% leaf rust	60% leaf rust
4.	7% leaf rust	60% leaf rust	75% leaf rust	80% leaf rust
5.	2% leaf rust	60% leaf rust	75% leaf rust	80% leaf rust
6.	10% leaf rust	70% leaf rust	70% leaf rust	80% leaf rust
7.	15% leaf rust	65% leaf rust	68% leaf rust	90% leaf rust
8.	10% leaf rust	70% leaf rust	65% leaf rust	77% leaf rust
9.	5% leaf rust	50% leaf rust	65% leaf rust	67% leaf rust
10.	20% leaf rust	65% leaf rust	70% leaf rust	75% leaf rust
11.	50% leaf rust	90% leaf rust	95% leaf rust	95% leaf rust
12.	10% leaf rust	70% leaf rust	70% leaf rust	75% leaf rust
13.	7% leaf rust	60% leaf rust	75% leaf rust	75% leaf rust
14.	7% leaf rust	60% leaf rust	67% leaf rust	67% leaf rust
15.	Nil	30% leaf rust	63% leaf rust	65% leaf rust
16.	Nil	30% leaf rust	60% leaf rust	60% leaf rust
17.	5% leaf rust	45% leaf rust	70% leaf rust	75% leaf rust
18.	5% leaf rust	45% leaf rust	60% leaf rust	60% leaf rust
19.	15% leaf rust	60% leaf rust	60% leaf rust	60% leaf rust
20.	17% leaf rust	60% leaf rust	67% leaf rust	70% leaf rust
21.	5% leaf rust	30% leaf rust	92% leaf rust	96% leaf rust
22.	10% leaf rust	40% leaf rust	60% leaf rust	60% leaf rust
23.	3% leaf rust	40% leaf rust	70% leaf rust	80% leaf rust
24.	Nil	40% leaf rust	70% leaf rust	70% leaf rust
25.	Nil	30% leaf rust	55% leaf rust	57% leaf rust
26.	Nil	30% leaf rust	60% leaf rust	60% leaf rust
27.	Nil	15% leaf rust	55% leaf rust	55% leaf rust

28.	Nil	25% leaf rust	80% leaf rust	100% leaf rust
29.	Nil	5% leaf rust	35% leaf rust	70% leaf rust
30.	Nil	7% leaf rust	35% leaf rust	40% leaf rust
31.	Nil	7% leaf rust	35% leaf rust	48% leaf rust
32.	Nil	10% leaf rust	60% leaf rust	65% leaf rust
33.	Nil	50% leaf rust	65% leaf rust	70% leaf rust
34.	Nil	5% leaf rust	30% leaf rust	35% leaf rust
35.	Nil	20% leaf rust	30% leaf rust	30% leaf rust
36.	Nil	40% leaf rust	65% leaf rust	70% leaf rust
37.	Nil	30% leaf rust	60% leaf rust	70% leaf rust
38.	10% leaf rust	60% leaf rust	70% leaf rust	75% leaf rust
39.	50% leaf rust	90% leaf rust	Leaves dried	Leaves dried
40.	15% leaf rust	45% leaf rust	100% leaf rust	Leaves dried
41.	Nil	5% leaf rust	60% leaf rust	90% leaf rust
42.	Nil	5% leaf rust	70% leaf rust	96% leaf rust
43.	2% leaf rust	15% leaf rust	15% leaf rust	25% leaf rust
44.	50% leaf rust	95% leaf rust	Leaves dried	Leaves dried
45.	40% leaf rust	85% leaf rust	Leaves dried	Leaves dried
46.	6% leaf rust	80% leaf rust	Leaves dried	Leaves dried
47.	7% leaf rust	75% leaf rust	Leaves dried	Leaves dried
48.	5% leaf rust	65% leaf rust	98% leaf rust	100% leaf rust
49.	Nil	5% leaf rust	Leaves dried	Leaves dried
50.	45% leaf rust	80% leaf rust	Leaves dried	Leaves dried
51.	Nil	5% leaf rust	97% leaf rust	100% leaf rust
52.	Nil	5% leaf rust	95% leaf rust	98% leaf rust
53.	Nil	5% leaf rust	90% leaf rust	100% leaf rust
54.	Nil	8% leaf rust	85% leaf rust	95% leaf rust
55.	Nil	8% leaf rust	85% leaf rust	95% leaf rust
56.	20% leaf rust	65% leaf rust	Leaves dried	Leaves dried
57.	Nil	8% leaf rust	55% leaf rust	85% leaf rust
58.	Nil	5% leaf rust	80% leaf rust	100% leaf rust
59.	Nil	5% leaf rust	60% leaf rust	100% leaf rust
60.	Nil	3% leaf rust	80% leaf rust	100% leaf rust
61.	Nil	6% leaf rust	80% leaf rust	100% leaf rust

62.	Nil	5% leaf rust	70% leaf rust	94% leaf rust
63.	Nil	5% leaf rust	50% leaf rust	85% leaf rust
64.	Nil	5% leaf rust	80% leaf rust	100% leaf rust
65.	Nil	5% leaf rust	50% leaf rust	85% leaf rust
66.	Nil	2% leaf rust	50% leaf rust	90% leaf rust
67.	Nil	3% leaf rust	50% leaf rust	85% leaf rust
68.	Nil	10% leaf rust	95% leaf rust	100% leaf rust
69.	Nil	10% leaf rust	85% leaf rust	98% leaf rust
70.	70% leaf rust	95% leaf rust	Leaves dried	Leaves dried
71.	65% yellow rust	90% yellow rust	Leaves dried	Leaves dried
72.	50% yellow rust	95% yellow rust	Leaves dried	Leaves dried
73.	50% yellow rust	95% yellow rust	Leaves dried	Leaves dried
74.	7% yellow rust	90% yellow rust	Leaves dried	Leaves dried
75.	20% yellow rust	85% yellow rust	Leaves dried	Leaves dried
76.	10% yellow rust	75% yellow rust	97% yellow rust	100% yellow rust
77.	Nil	10% yellow rust	85% yellow rust	100% yellow rust
78.	50% yellow rust	90% yellow rust	Leaves dried	Leaves dried
79.	45% yellow rust	90% yellow rust	Leaves dried	Leaves dried
80.	45% yellow rust	85% yellow rust	95% yellow rust	100% yellow rust
81.	45% yellow rust	90% yellow rust	Leaves dried	Leaves dried
82.	Nil	10% yellow rust	65% yellow rust	90% yellow rust
83.	Nil	5% yellow rust	77% yellow rust	95% yellow rust
84.	15% yellow rust	80% yellow rust	Leaves dried	Leaves dried
85.	30% yellow rust	90% yellow rust	Leaves dried	Leaves dried
86.	10% yellow rust	80% yellow rust	97% yellow rust	100% yellow rust
87.	Nil	70% yellow rust	98% yellow rust	100% yellow rust
88.	Nil	20% yellow rust	95% yellow rust	100% yellow rust
89.	Nil	90% yellow rust	100% yellow rust	Leaves dried
90.	Nil	90% yellow rust	98% yellow rust	100% yellow rust
91.	40% yellow rust	95% yellow rust	Leaves dried	Leaves dried
92.	37% yellow rust	95% yellow rust	Leaves dried	Leaves dried
93.	45% yellow rust	95% yellow rust	Leaves dried	Leaves dried
94.	Nil	70% yellow rust	95% yellow rust	100% yellow rust
95.	20% yellow rust	90% yellow rust	Leaves dried	Leaves dried

96.	5% yellow rust	35% yellow rust	97% yellow rust	100% yellow rust
97.	Nil	5% yellow rust	80% yellow rust	95% yellow rust
98.	Nil	5% yellow rust	85% yellow rust	95% yellow rust
99.	20% yellow rust	85% yellow rust	Leaves dried	Leaves dried
100.	3% yellow rust	35% yellow rust	98% yellow rust	100% yellow rust
101.	3% yellow rust	30% yellow rust	94% yellow rust	100% yellow rust
102.	Nil	10% yellow rust	97% yellow rust	100% yellow rust
103.	Nil	5% yellow rust	95% yellow rust	100% yellow rust
104.	Nil	5% yellow rust	100% yellow rust	Leaves dried
105.	25% yellow rust	85% yellow rust	100% yellow rust	Leaves dried
106.	Nil	10% yellow rust	90% yellow rust	100% yellow rust
107.	2% yellow rust	60% yellow rust	97% yellow rust	100% yellow rust
108.	Nil	3% yellow rust	60% yellow rust	90% yellow rust
109.	Nil	3% yellow rust	85% yellow rust	96% yellow rust
110.	Nil	5% yellow rust	85% yellow rust	98% yellow rust
111	2% yellow rust	20% yellow rust	93% yellow rust	100% yellow rust
112	5% yellow rust	25% yellow rust	90% yellow rust	100% yellow rust
113	15% yellow rust	75% yellow rust	Leaves dried	Leaves dried
114	5% yellow rust	55% yellow rust	100% yellow rust	Leaves dried

1.3.3 SAARC Rust Trap Nursery

This is a collaborative activity among the SAARC nations. The prime objective of the activity was to monitor potential changes in virulence of leaf and yellow rusts of the wheat crop at regional and global level. The trial consisted of 20 entries which were laid out in an area of 4 square metres (2mx2m). Inorganic fertilizer of 3 kgs SSP, 1 kg urea and 1 kg MoP were applied as basal dose. Irrigation was given as per the crop requirement and hand weeding was done depending on weed pressure. The results of the trials are given in Table 18.

Table 18: Observations of Rust Trap Nursery

Entry No	Observed date	Observed date	Observed date	Observed date	Observed date
	28/3/2006	7/4/2006	20/4/2006	28/4/2006	4/5/2006
1	5% rust	20% rust	50% rust	70% rust	95% rust
2	Nil	10% rust	60% rust	90% rust	100% rust
3	5% rust	12% rust	65% rust	90% rust	100% rust
4	Nil	5% rust	50% rust	70% rust	90% rust
5	Nil	Nil	45% rust	70% rust	90% rust

6	7% rust	12% rust	70% rust	90% rust	95% rust
7	30% rust	60% rust	80% rust	95% rust	100% rust
8	Nil	10% rust	40% rust	50% rust	80% rust
9	20% rust	60% rust	65% rust	85% rust	90% rust
10	7% rust	40% rust	65% rust	75% rust	85% rust
11	20% rust	60% rust	70% rust	90% rust	95% rust
12	5% rust	20% rust	30% rust	55% rust	90% rust
13	13% rust	35% rust	55% rust	80% rust	95% rust
14	10% rust	65% rust	70% rust	90% rust	100% rust
15	Nil	10% rust	40% rust	55% rust	80% rust
16	Nil	5% rust	50% rust	65% rust	90% rust
17	Nil	5% rust	50% rust	65% rust	90% rust
18	16% rust	55% rust	70% rust	85% rust	100% rust
19	5% rust	35% rust	80% rust	85% rust	95% rust
20	70% rust	90% rust	95% rust	100% rust	100% rust

1.3.4 Observation trial of BARI wheat

The trial consisted of 8 varieties that were introduced from Bangladesh. The main objective of the trial is to assess the performance of BARI wheat under our environment. The trial was laid out in a RCBD design with 3 replications in a plot size of 15 m^2. A spacing of 20 cm x 20 cm was maintained while inorganic fertilizer at the rate of 60:30:20 NPK kg/ha was applied. Half of the N was top dressed at 45 days after germination. Irrigation and hand weedings were done as per the crop requirement.

Analysis of variance showed that Shatabdi yielded the highest with 0.74 t/ha followed by Sourav with 0.62 t/ha (Table 19).

Table 19: Agronomic traits of BARI Wheat

Variety	Plant height (cm)	Yield (t/ha)
Gourav	68	0.52
Sourav	63	0.62
Shatabdi	68	0.74
Protiba	60	0.34
Kanchan	67	0.49
Bajoka 1	66	0.28
Bajoka 2	80	0.36
Sonalika	76	0.3
CV %	5.2	24.2
LSD	6.19	0.19
F pr.	< 0.001	0.001

1.3.5 Seed production and maintenance of released lines

A total of 315 kgs of seed of three released varieties were produced and maintained at research centre for supplying breeder's seed to Druk Seed Corporation and further research use. The details of production are listed in Table 20.

Table 20: Wheat seed production in 2005

Variety	Quantity (Kg)
Bajoka-1	68
Bajoka-2	90
Sonalika	157
Total	315

1.4 Oilseeds Research

1.4.1 Mustard Observation Trial of BARI Lines

The trial was conducted with an objective to assess the performance of the BARI Lines under Bhutanese agro-ecological conditions in terms of yield, pests and disease incidence and other agronomic traits. The trial was laid out in RCBD design with three replications. The trial consisted of eight varieties including four released varieties as the standard checks. FYM @ 2 tons/acre and inorganic fertilizers of 20:20:0 NPK kg/ha were applied. Frequent hand weedings were done to prevent the crop from weed dominance and irrigations given as per the crop need.

Analysis showed that there was no significant yield difference amongst the varieties (Table 21).

Table 21: Agronomic traits of BARI lines

Variety	Days to flowering	50% Plant height (cm)	Seed Yield (t/ha)
BARI 6	55	39	0.024
BARI 9	49	34.7	0.038
BARI 11	55	78.7	0.092
Sonalika sarisha	60	59	0.032
Bajo peka 1	55	72.3	0.164
Bajo peka 2	60	44	0.029
T-9	60	35.7	0.009
M-27	47	37.7	0.032

1.4.2 Introduction trial of Brassica juncea

Five early maturing *Brassica juncea* varieties were evaluated along with 4 check varieties to see their adaptability, yield potential and other agronomic traits. The trial was laid out in an area of 15 m^2 and randomized with 3 replications. A spacing of 30 x 10 cm was maintained while inorganic fertilizer of 20:20:0 NPK Kg/ha was applied. Irrigations and hand weedings were done as per the crop need with timely monitoring of crops for pests and diseases incidence. Analysis revealed that there was no significant yield difference amongst the varieties (Table 22).

Table 22: Agronomic traits of *Brassica juncea*

Variety	Days to 50% flowering	Plant height (cm)	Seed Yield (t/ha)
Zang 1	64	84.3	0.27
Zang 2	61	89.3	0.39
Zang 3	68	82.7	0.28
Zang 4	64	82	0.20
Zang 5	64	111	0.46
Lumley Local	48	53.7	0.29
T-9	50	42.7	0.22
Bajo Peka 1	44	86.7	0.41
Bajo Peka 2	50	62	0.30

1.4.3 Performance of lines from mass selection

The main objective of this trial is to evaluate the performance of lines subjected to mass selection. The trial was laid out in a single observation plot of 15 m^2. Inorganic fertilizer at the rate of 60:40:00 NPK kg/ha was applied to the trial plot beside timely weeding and carrying out other agronomic practices. A total of 24 selections were made from the whole lot (Table 23).

Table 23: Selection numbers of Mustard

Local mass selection	Seed Yield (gm)
Bajo selection 1	29
Bajo selection 2	8
Bajo selection 3	25
Bajo selection 4	21
Bajo selection 5	8
Bajo selection 6	33
Bajo selection 7	134
Bajo selection 8	149
Bajo selection 9	87

Bajo selection 10	45
Bajo selection 11	58
Bajo selection 12	25
Bajo selection 13	19
Bajo selection 14	6
Bajo selection 15	2
Bajo selection 16	13
Bajo selection 17	77
Bajo selection 18	19
Bajo selection 19	25
Bajo selection 20	35
Bajo selection 21	26
Bajo selection 22	52
Bajo selection 23	123
Bajo peka 1	260

1.5 Grain Legumes

1.5.1 Soybean Research

Soybean seeds received from different sources were tested at RNRRC Bajo as an on-station trial. The trial was laid out in an area of 4 m^2 with three replications. A spacing of 50 cm x 10 cm was maintained while fertilizer of 20:60:0 NPK kg/ha was applied as basal dose. Irrigation and hand weeding were done as per the necessity. Amongst the tested lines Japanese Black Grade LL yielded the highest with 0.97 t/ha followed by Chinese Black Variety 2 with 0.77 t/ha which is higher than check variety. Japanese Black Grade L too yielded appreciably at 0.51 t/ha (Table 24). The performance of these promising varieties need to be studied further.

Table 24: Agronomic traits of Soybean varieties

Variety	50% Flw days	Plant ht (cm)	Nodulation count	Pods/ plant	Seed wt. (t/ha)
Japanese Black Grade LL	59	64.1	48	32	0.97
Nepal 2	54	39.3	50	33	0.46
Japanese Black Variety 1	59	64.9	48	28	0.43
Japanese Black Grade L	57	55.3	51	32	0.51
Chinese Black Variety 1	54	35.5	58	34	0.43
Bragg (Check)	58	55.4	58	39	0.64
Chinese Black Variety 2	56	54.7	53	30	0.77
Nepal 1	57	54.1	57	37	0.48
LSD	1.853	29.99	14.84	9.46	0.144
CV %	0.3	32.4	2.9	4.1	2.3
F probability	< 0.001	0.397	0.647	0.301	< 0.001

HORTICULTURE RESEARCH

2 HORTICULTURE RESEARCH

2.1 Subtropical fruits and low chilled temperate fruits and Nuts

2.1.1 Variety Improvement

Guava variety evaluation trial
The guava variety trial was established in 1995. The varieties evaluated were pink flesh, Thai Giant, Alahabad Safeda and local variety. The main objective of the trial was to assess the variety suitable for the mid altitude. Two potential varieties were identified for release for general cultivation and the trial is terminated. The detail report of this trial can be found in annual report of this centre for financial year 2004-05. Guava germplasm (mother plant) will be maintained in the centre for future use as mandated.

Pomegranate variety evaluation trial
The pomegranate variety evaluation trial was established in 1995. The variety includes Beedana, P5 75, Amar shurin, Chawla and Khanduri kaldi. The objective of the trial was to evaluate the promising varieties for mid dry sub tropical ecological zone. The single plot design was followed for the trial layout with three plants for each treatment. Perfomance parameters like vegetative growth, precocity, cropping habit, fruit quality, yield and pests & diseases incidence were also studied. Considering all the fruit quality and characteristics, yield performance and pest tolerance, Khandari cultivars performance was good under Bajo condition. Khandari cultivar may be recommended for release for general cultivation since there is no any pomegranate cultivar released formally as yet. On-station pomegranate variety evaluation trial is terminated and pomegranate cultivars will be maintained in the scion wood collection block. For detail trial report, refer annual report 2004-05.

Kiwifruit Characterisation and documentation
The kiwifruit is native to China and centre of diversity of the genus *Actinidia* is in the mountain ranges of southwestern China (Ferguson, 1984). Kiwi fruit is unknown to most of the people in Bhutan. However, few kiwi enthusiasts in Thimphu have one to two exotic kiwi plants in their garden. No systemic research efforts have been made to evaluate the potential of kiwi growing in Bhutan and no work has been done on our wild kiwi fruits available in the country. Of late there is a growing interest on kiwifruit production and it was therefore decided during the 6th Horticulture Coordination Meeting that RNRRC-Bajo should take a lead in the documentation of wild kiwifruit in the country. Horticulture research program therefore initiated the study of wild kiwifruits of Bhutan with an objective to identify diversity of wild kiwifruit in Bhutan and to document it. The study was also aimed to select potential varieties from local diversity, possible germplasm collection and utilization in the future.

Horticulture researchers of RNRRC-Bajo coordinated this study which was done nationwide through the support of other RNNRCs and Dzongkhag agriculture extension. The study covered all regions and major naturally kiwifruits growing sites in the country. Primary information about existence of local kiwifruit in the Dozngkhags in various regions was collected by the respective RNRRCs from Dzongkhag agriculture extension

and farmers. Based on the primary information, one to two naturally growing kiwifruit sites in each Dzongkhag were selected as the actual study sites. Researchers made transact walk in the sites, and kiwifruit plants were identified and characterized based on morphological features of vine, leaves and fruits and marked at least a vine of different type per site for collection of other relevant data. Second round of visit to identified and marked kiwi types in each site was made for monitoring the stage of fruit growth and to predict the time of fruit ripening. Collection of fruit sample, photo of fruit and kiwifruit plant with leaves for each type was done in the third visit to the site and analysis of kiwifruit once back to station. Data were collected on the agro-ecological sites and kiwifruit types based on morphological aspect of vines, leaves, fruits (floral features where possible) and fruit quality aspect were also noted.

The wild kiwifruit occurs naturally in the forest of Bhutan and plant is known by different vernacular names in different parts of Bhutan such as *Yogchu* in Khengkha and *Tekiphal* in Nepalese.

Morphological characteristics and variation in wild kiwifruit of Bhutan

We recognized three distinct wild kiwifruits types (Picture 2, 3 & 4); two are brown hairy plants that resemble improved and commercial kiwifruit cultivars while the other is different. The vine is deciduous like grape vine, flowering is seen in late April to June and fruit ripening season is earlier in lower elevation and later in higher altitudes. The fruit size vary from small to large, fruit shape are oval, oblong, cylindrical and has a thin



Picture 2, 3 & 4

brownish-green skin with a fuzzy surface, often with spotted lenticels. The flesh is distinctively light green, with tiny purplish seeds surrounding a white core. It was also observed that it is naturally multiplying by ground layering under the cover of leaf mould.

Kiwi fruit belongs to the family *Actinidiaceae* and genus *Actinidia*. The genus *Actinidia* is described in detail by Grierson *et al* (1984) in Flora of Bhutan, Volume 1 part 2. It is botanically considered as functionally dioecious scrambling shrubs with simple hairs, pith often chambered, flower unisexual, solitary or many in cymes. Male flowers have well-developed stamens (two-third as long as petals) and rudimentary ovaries with minute styles. Female flowers have well developed ovary and 15-20 styles, stamens only one third as long as petals or apparently well developed but with anthers empty or containing

only sterile pollen. Fruit is a berry and it is oblong, cylindrical, globose often spotted with lenticels. Two species of *Actinidia* found in Bhutan forest are described below.

***Actinidia callosa* (Lindley)**

It is a climbing shrub fully covering the companion trees and is as tall as 7-10m, stem glabrous or with a few soft simple hairs and often pith conspicuous lenticels. Leaves ovate-elliptic, acunate, base rounded, margin finely serrate, glabrous lateral veins 7-10 pairs, petiole 2-4cm. Found solitary flowers and in 2-5(-12)-flowered cymes. Sepals ovate, obtuse, ciliate. Petals white, obovate and rounded. Fruit oblong, cylindrical and size vary from 3.1 x 2.7cm to 1.6 x 1.1cm, bearing persistent sepals at base, usually brown-pubescent at first but later purplish and covered with circular brown lenticels. Fruit weight vary from 25 gm to 110g. This species is found in Tsirang, Dagana, Wangdue, Chukha, Thimphu, Punakha, Gasa, Trongsa, Monggar, Tashigang and Zhemgang districts under margin of cool broad-leaved forest, 1400-2500m. Fruiting season is from May-October.

***Actinidia strigosa* Hook F. & Thomson**

Similar to *A. callosa* but the young stems, petioles and midribs beneath usually densely covered with spreading brown bristles up to 3mm. Found in Monggar, Trongsa, Thimphu, Zhemgang at altitudes ranging from 2550-2750. Fruiting season is from May-June.

***Actinidia* intermediate specimen**

There is a possibility of finding third species of kiwifruit in the country. We had observed two distinct sites in Dochula and Gesarling in Dagana where kiwifruits are distinct from other places. Kiwi found in Gesarling in Dagana (Picture) has oblong fruit shape but pointed at the styler end, average fruit weight is about 25-30g, size 1.7 x 1.4cm and found in cluster (cyme). Unlike others species, it takes support of tall trees and grows more than 20 m. Kiwi found in the Dochula area under Thimphu (Picture 4) has similar characteristics to *A. callosa* and *strigosa* except the fruit shape. Fruit shape is round to globoid and fruit size is about 1.4 x 1.6 cm to 1.8 x 1.9cm and weigh about 30-35g

Picture 5

Climatic conditions where wild kiwi is grown naturally

Wild kiwifruit is found in Dagana, Tsirang, Monggar, Tashigang, Trongsa, Zhemgang, Chukha and Thimphu, Wangdue. Punakha and Gasa Districts at a wide elevation range from 1400 to 3000masl and under wet and mild summer and cold winter conditions. The plant seems to require lots of humidity and performs well under humid condition as the above locations receive a lot of rainfall

Picture 6

generally. Kiwi plants are generally found in the open road side, open sites in the forest and growing among the small trees and shrubs where it can grow taller so that its is not shaded by the surrounding trees (Picture 6). Plants seem to require a lot of sunshine, humidity and lots of soil moisture as it was found growing in such types of environment. Forest soil to sandy loam is the soil type observed where kiwi plant is naturally growing.

Propagation

RNRRC-Bajo and Wengkhar conducted trial on its propagation. One year old shoots cutting are rooted under ambient condition and soil, sand and compost mixture was used as growing medium. No growth hormone was used. Callus formation and high rooting capacity was observed. Experiment was also done to evaluate the graft compatibility with the improved kiwifruit, wherein scion of wild kiwifruit is grafted on to the improved kiwifruits. It was found out that it is graft compatible with the improved variety of kiwifruit that has been introduced. Therefore, wild kiwifruit can be propagated through cutting as well as by grafting. There exist a potential for selection of varieties from local diversity, possible germplasm collection and utilization in future and may be potentially used for kiwifruit breeding programme in future.

Social and economic aspects

Information on social and economic aspects of plants and fruits in particular are collected while survey was done. Plant grows in abundance and it is one of the common fodders as the cattle browse well on its leaves. Excepting the people of the eastern region, kiwi fruit has no major social or economic value and uses in the lives of people in the country. However, in the east, fruits are popular among the cow herders and they have great deal of knowledge on the wild kiwifruit type, growing sites, harvesting time and process of ripening. Women and children in Merak and Sakten harvest fruits before wild animals and birds devour them at maturity. They then ripen fruits artificially at home by placing them among the food grains in grain boxes. Kiwifruit is released in the local market in December and January when there are hardly any fruits around. There are few instances of Bhutanese farmers collecting fruits in large quantities to sell it across the bordering state of Arunachal Pradesh, India. Hunters use fruit as a bait to lure deer; animals get attracted by the aroma of ripening fruits and fall prey to the hunters.

Mango variety evaluation trial

Mango is a tropical fruit and it does well at or below 800 masl altitude. Commercial investment in mango production in Bhutan is recommended only in low valleys at or below 800 masl or in southern plains and foot-hills. In Bhutan small scale and poor quality mango is being produced in places as high as 1500 masl. However, it is not recommended to go for commercial production under such conditions to avoid financial losses since there will be difficulty in marketing of poor quality mango in the domestic market. There is also a stiff market competition from Indian late or off-season mango cultivars coinciding with the mango harvest from Bhutan. However, Bhutanese growers have shown lot of interest on the mango production in the country particularly in the mid altitudes area like in Mongar, Wangdue, Punakha, Zhemgang and Tashigang. Some growers have started investing on mango not heeding technical advice of the Ministry of Agriculture. This has led to introduction of mango cultivars from India and the mango variety evaluation trial was established to select the best variety for mid altitude areas.

The varieties under test were introduced from India: Chausa, Himsagar, Langra, Gulabkhas, Amarpali and Deshari. The trial was established in 1995 and single plot design was followed for the trial layout with three plants for each treatment. A spacing of 8m x 8m was kept between plant to plant and row to row. The young plants were protected from frost by placing a straw thatch over them in the winter. No systematic pruning is done. The removal of dead wood and the thinning of over-crowded and mis-shapen 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 to control weed growth. Basin preparation is done twice, once in spring and another in autumn after the crop is harvested and fertilizer application and mulching followed immediately. For all the varieties, same amount of FYM applied in winter and varying dose of chemical fertilizer appropriate to the size or age of the tree were applied in the spring prior to flowering and top-dressing of nitrogen fertilizer was done in autumn, after crop harvest. From the 8th year of crop establishment, 0.5kg of urea, SSP, MoP were applied to all the cultivars. Performance parameters like vegetative growth, precocity, cropping habit, fruit quality, yield, pest and disease incidence were also recorded. Flowers that appear during the first two to three years after planting were removed.

Two cultivars, Chausa and Gulabkhas, did not survive under Bajo conditions and may be due to climatic condition. The stunted plant growth was observed for Dashehari, Langra and Himsagar while Amarpalli showed normal size plant growth. First flowering was observed in 3 years after planting and first cropping was allowed 4 years after planting. Morphological and fruit characteristics, fruit quality and average yield of all these cultivars are presented in Tables 25, 26 and 28.

Table 25: Morphological characteristics of mango cultivars

Cultivars	Tree appearance	Bloom time	Harvest time
Himsagar	Semi vigorous	Mid March to April	2nd week of August
Dashehari	Semi vigorous	Mid March to April	2nd week of August
Langra	Vigorous	Mid March to April	3rd week of August
Amarpalli	dwarf	Mid March to April	2nd week of Sept.

Table 26: Fruits characteristics and quality aspect of mango cultivars

Cultivars	Shape	Diameter (cm)	Length (cm)	Flesh color	Skin color	Taste	TSS
Himsagar	Oblong	8.3	9.9	Yellow	Light green & smooth	Sweet	15.5
Dashehari	Oblong	6.4	10.1	Orange	Light green & smooth	Sweet	18
Langra	Oblong	7.3	9.3	Yellow	Light green and smooth	Sweet	18
Amarpalli	Oblong with pointed tip	`10.9	8.1	Yellow	Green & smooth	sweet	20

Table 27: Average yield (kg/tree) trend of mango cultivars

Cultivar	2000	2001	2002	2003	2004	2005	2006
Himsagar	7.9	6.6	11.3	0	12.3	3.5	27
Deshari	4.5	9.43	7.5	10.1	15.8	4.3	9.7
Amarpalli	7.25	3.1	10.8	0	24.3	25.7	10.5
Langra	0	6.52	1.6	13.8	6.3	8.6	12.6

Desheri (Picture 7) and Himsagar were harvested in mid August and observed as the earliest maturing cultivars followed by Langra (Picture 8) under Bajo condition. The late variety Amarpalli (Picture ture 9) was harvested in second week of September and also it


Picture 7, 8 & 9

was the sweetest variety compared to all other cultivars. Amarpalli is a dwarf cultivar and recommended for high density planting. Other than Langra, vegetative growth of other cultivars is comparable to dwarf variety Amarpalli under Bajo condition. Invariably, the fruit coloration is poor under Bajo condition and it remained green to light green in colour even after ripening. This may be major limiting factor for successful marketing of mango produced in mid altitude of Bhutan as fresh table fruit thereby limiting the expansion of its cultivation. The same mango cultivars produced in India are glossy and attractively yellow in colour. However, the taste and TSS content of mangoes produced under Bajo condition is comparable to Indian mangoes. Therefore, mango production for processing and local market may be possible in mid regions of our country. On-station mango variety evaluation trial was terminated and promising mango cultivars were maintained in the scion wood block as mandated.

No major insect pests and diseases were observed till last year in the station trial but from this year light infestation of fruits by fruit fly for all the cultivars was observed. However, in the farmer's field in Punakha-Wangdue valley pandemic *Phytopthora*, gummosis and die back diseases kill the plants and mango brown hopper was also observed.

To conclude, mango is a tropical fruit and it does well at or below 800 masl altitude. Commercial investment in mango production in Bhutan for fresh fruit market may be recommended only in low valleys at or below 800 masl or in southern plains and foot-hills. In Bhutan small scale and poor quality mango is being produced in places as high as 1500 masl but it is technically not recommended to go for commercial production for fresh fruit market as there is no full fruit colour development and there may be difficulty in marketing other than in domestic market. However, it is feasible to farm mango in the

mid hills (1300masl and below) for the processing industry if processing industry ensure the market as the fruit eating and processing quality are reasonably good. Recognizing that there is a huge potential for mango production in Southern Bhutan, Dashehari as early, Langra as mid and Amarpalli as late mango cultivars are recommended to release for general cultivation in Bhutan.

Maintenance of Fruits mother plant or Scion 'Bank'

The mother plant or scion 'Bank' of newly released Bajo apple, Bajokham-1 & 2, Bajokhamchu-1, Bajolea-1, Bearss, Bajo apple, Perlette, Muscat of Alexandria, Drake, Texas, Dhebar Bhadan and Kagzi for general cultivation are being maintained in this Centre as mandated. We had informed DSC and private nursery growers the availability of mother plants of these crops. We also maintained 28 citrus cultivars as a germplasm collection and sufficing the sources of scion wood.

Production Management

Top-working: Alternative method for walnut orchard development

Picture 10

Walnut orchard development though small in Bhutan has gain momentum with the commencement of 8th five year plan as it appeared one of the priority commodities for the horticulture development in the country. The walnut orchard is being developed as of now from seeds that have resulted to a huge variation in the orchard yields, nut size and quality (Picture). These seeds probably were imported from India, Tibet, European countries and America. The grafting techniques have been studied and successfully demonstrated for use by the Druk Seed Corporation and Private Nursery Growers but there is no walnut mother plants established anywhere in the country to be used as a scion wood for vegetative propagation. In eastern and central Bhutan, private nursery operators are being promoted by Ministry of Agriculture and they are producing and supplying soft-shell walnut seedlings through Dzongkhags to the farmers for orchard establishment. Beside the walnut orchard promotional program, walnut seedlings are grown by private nursery growers in the different parts of the country and are being distributed to the farmers for orchard development. But we need to discourage the supply of seedlings to avoid undesirable inherent characteristics of seedling plants (> 50% of soft shell seedling orchard produces hard shell walnut) and to derive the benefit of uniformity, precocity and trueness to type of the grafted plants. If at all seedlings are to be supplied to the farmers, it has to be done in large scale and developed a walnut orchard in a concerted areas so that it will be easy to top-work them with superior soft-shell walnut when they are 2-3 years old.

Inadequate outstanding cultivar (mother plants) as the source of scion wood for mass grafting is the biggest constraints in the development of walnut industry in the country. However, recently horticulture research programme selected 17 good cultivars of soft shell walnut from the open pollinated seedling trees or local diversity across different agro-ecological zones and two superior cultivars released for general cultivation. This cultivars needs to be grafted and planted as walnut mother plants for scion wood production. Therefore, it is important for the research institute to look into the possibilities of identifying walnut production technology which is easy, quick and cheap without losing much time while the "National Walnut Mother Plants" for scion wood production are being established in research centre, DSC and private nursery growers. To this end, an observation trial on top-working of existing and new seedlings walnut orchards was done.

Picture 11 & 12

Top-working is a process when comparatively older rootstocks are grafted or budded at the higher level (1m above the ground) in the production field (Picture 14). It is usually adopted for the conversion of wild large seedlings into production of commercial plants or inferior cultivars to improved ones or to provide pollinizers.

The dormant scion wood of improved and released cultivars (Kanthel selection & Yusipang-2) was cut from parent tree quite in advance, waxed and stored in the refrigerator at 4°C after proper packing till the time is appropriate for top-working. The top-working was done in mid of March for lower elevation (1300-1899 masl) and in second week of April in higher elevation (1900-2300masl). Varying age of 2 to 10 years old local walnut seedlings trees (*J. regia*) in the farmers' orchards which are poor quality and hard-shell were top-worked with improved cultivars. The plants to be top-worked were growing actively at the time of top-working. Top-working (Picture 13) was done for younger trees while frame-working or grafting of branches (Picture 14) can be easily practiced for older trees. Three to five branches with wide angles and the projection in all the directions are retained and frame-worked. The other branches on the tree are removed.

Picture 13 Two year old walnut seedling orchard ready for top-working

Picture 14 Top-worked

Two approaches of walnut orchard improvement

and development were studied in the farmers' field. First, the existing local walnut or improved seedling trees which turned out to be hard-shelled were top-worked. In the second approach, local hard-shell walnut seedlings were transplanted in the orchard (Picture 13) and top-worked when they are 2 years old (Picture 14). Nursery grafted walnut trees were planted along the seedling trees so as to serve as control.

Bark grafting was used as a technique either for top-working or frame-working. After bark grafting, the open wounds were covered by the grafting wax and in some cases re-waxing was done. The graft union portions were wrapped with thick polyethylene plastic and stump were white washed to protect from the sun burn. The suckers or water shoot from stock were removed as and when it appears. Staking of the successful top-worked plants was done to avoid breakage by strong wind. The plastic covering the graft union were removed once the union formation is complete and growth constriction is visible by releasing the pressure of successful union by cutting the plastic from one side.

Picture 15 One year after operation

The frame working of walnut seedling trees resulted to 90% graft take while top-working particularly younger trees resulted to graft take of 85-90% and of about 70-80% for older trees in altitudes of 1300-2300 masl. Fruiting commences after 2-3 years of top-working regardless of age of the stock trees (Fig 15 & 16). Frame-working or grafting of branches is desirable in comparison to top-working of grown up trees, for quicker healing of wounds, higher graft take, earlier production and higher yields. The thick plastic wrapping around the graft union encourage callus formation and hastened the tissue union and wound healing process. To protect from the sun burn, the stem portion needs white washing and no shoot other than the scion should be allowed to grow on the plant. Added advantages of top-working are, since the rootstock is already well established, the scions make rapid growth and commences bearing earlier than the nursery grafted and transplanted trees. Low survival rate and slow growth were observed for the nursery grafted walnut plants and then transplanted in the production field.

Picture 16 Young & dwarf walnut

Picture 17 Prolific production after 2 years

Domestic animal damage was prominent on the top-worked trees prior to completion of graft union formation than the nursery grafted trees.

Sap bleeding is a problem in walnut top-working especially when it is done in early spring which can be avoided by heading back the stock before two weeks of actual operation, complimented by withholding irrigation. In severe cases the slanting cuts through bark into the wood can be made on the rootstock just below the grafting point; if any bleeding in future, it occurs through these cuts after grafting.

Since a large number of young seedlings trees producing inferior quality nuts are abundant in the farmers' field and a low survival rate and slow growth of nursery grafted or budded plants was observed in the production field. Top-working seems to be appropriate and useful choice for reaching the newly released superior cultivars to the farmers for improving the poor quality producing orchards and also for new walnut orchard development. Top-working is the best for seedling trees of between 2-5 years old and frame-working can be safely practiced for seedling trees of above 5 years old, where wound healing is easier, higher percentage of graft take, earlier production and higher yield were obtained compared to nursery grafted and transplanted trees.

It is best to plant the wild local walnut seedlings in the production field and latter top-working with desired scion cultivar for walnut orchard development in majority of potential walnut production area in the country (area with elevation of 1300 to 2300 masl). However, this same technique of walnut orchard development in the country cannot be practiced in an area with elevation above 2300mmasl due to unsuitable temperature for walnut grafting (top-working). In such areas, nursery grafted walnut seedlings should be used as the planting materials for walnut orchard development.

Economics of Improved Persimmon Processing, Packaging and Presentation

Farmers in Punakha-Wangdue Valley grow mostly astringent type of persimmon cultivars (*Aundeybom, Pemchen & Lamchu*) in their homestead. Among Punakha-Wangdue valley, Nobgang village is known for persimmon production and marketing of fresh and dehydrated fruit products. Most farmers have trees ranging from 4-40 numbers per household. It is also one of the major cash income generating crops. Of late farmers from Nobgang reported problems of persimmon marketing. RNRRC-Bajo and Punakha Dzongkhag agriculture staff had held a discussion with Nobgang persimmon growers with an aim to understand the limiting factors that are affecting the persimmon production in the village. Farmers are constrained with the following in furthering their persimmon production and business.

- Unable to sale production as fresh fruit
- Poor quality of dehydrated fruits products
- Low market price of dehydrated fruits (Nu. 40-50/kg)
- Poor shelf-life of dehydrated fruits
- Present cultivars are processing persimmon (astringent type)
- Lack of method to process under wet weather condition

Among the above issues, problem of persimmon dehydration and marketing are identified as an important issues affecting the growers since this type of persimmon is good for

processing although farmer sell as fresh fruit when it is fully ripened. Short shelf life is the characteristics of this type of persimmon when it is fully ripened and ready for harvest. Domestic market for fresh fruit is sensitive to over supply and fruit cannot be stored once harvested.

Farmers of Nobgang had developed dehydrated fruit slices with skin intact, sun dried, packed in gunny bags and marketed in Thimphu local market. The dehydrated persimmon products are mainly purchased by Bhutanese of Tibetan origin in the first month of Bhutanese calendar and after that no market exists for the product. The dehydrated persimmon gets spoiled by mould fungus growth since the product is packed in gunny bags. The product is very poor in quality and fetches as low as Nu. 40-50 per kilogram of air dehydrated product. This price is very low when compared to the local fresh fruit market price of Nu. 5 per piece of large fruit and Nu.5 per two pieces of small fruits. Farmer instead of having added advantage by producing and selling dehydrated persimmon where drying recovery is about 25 to 30%, they run into losses compared to fresh fruit marketing.

Researchers from RNRRC-Bajo have developed a new method of persimmon processing, packaging and marketing which was discussed with the farmers in the consultative meeting. Farmers showed interest but the experimental processing and packaging methods have not been tested for their suitability and acceptability under farmers' situation. Therefore it was agreed that this study be conducted in Nobgang village. The initial trial was conducted with only two farmers identified by the growers themselves while rest of the households would only participate if the trial is successful and appropriate under their condition. Up-scaling of this activity at the community level may be done by the Dzongkhag agriculture staff in the following years if this brings positive social, economic and technological changes and if community is convinced of its potential benefits.

The objectives of this programme are:

- To develop different grades of dehydrated persimmon products.
- Participatory evaluation of benefit of improved methods of persimmon processing, packaging and marketing of different products.
- And provide hand-on training on improved method of persimmon processing, packaging and presentation of products to the consumers.

Picture 18 Ezi dryer used for dehydration

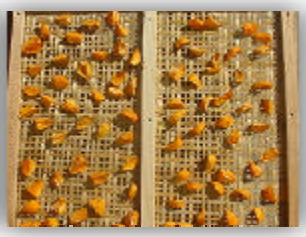
Treatments were:

1. Improved method of natural sun drying of different products
2. Improved NPHC electrical dryer for dehydration of different products
3. Ezi dryer for dehydration of different products
4. Below the roof -shade drying of whole fruit

We identified two willing and co-operating farmers in Nobgang who produce persimmon and have problem of marketing their produce. The trial processing, packaging and marketing of dehydrated persimmon products was conducted with these two farmers. These two farmers were given hands on-training of persimmon processing, packaging and presentation of product to consumers. Two Farmers had processed different grades of dehydrated products using improved method of dehydration (Picture & 9) under the technical guidance of RNRRC-Bajo and Dzongkhag Agriculture staff.

Picture 19: NPHC improved electrical dryer

The fruits are harvested when fully colored, ripened but firmed. If the fruits are soft it is very difficult for processing particularly producing dehydrated fruit rinds or slices. Leave a bit of the branch attached to the stem while harvesting the fully colored but hard and astringent persimmon so as to form cross bar of 'T'. The fruits are washed in running water to remove any adhering materials. Fruits are then peeled using simple kitchen knife or potato peeler. The whole fruit is peeled, loop a piece of string around the base of the



Picture 20, 21 & 22: Fruit splits, Whole fruit & Fruit rings

'T' and tie the whole fruits to a rope as shown in Fig 19 and dehydrated naturally. The fruits splits are prepared by peeling and splitting the astringent persimmons fruits into four or more depending on the fruit size (Picture 10). Prepare the fruit slices or rings by slicing them into thin round slices (Picture 12) with and without skin intact. The fruit peel/skin as a bi-product is used nutritiously as animal feed. Lay the rounds slices or fruit rings and splits either on improved simple dehydrator trays prepared from locally available bamboo for electrical dehydration or on bamboo mats and leave in open space for natural solar dehydration. Cover the trays or mats containing persimmon products in natural drying with nylon net or need manual guarding it from birds and animal feeding. The products were protected from rain by covering over with tarpaulin. A more complex procedure is to watch until the persimmons turn brown. Start gently over turning the splits and slices to promote even drying if products are dried under the sun and this process is not required for improved electrical dehydration. For electrical drying once the products are placed inside the dryer trays, set temperate at 35^{o}C or 45^{o}C as appropriate and electricity was on until the product is leathery dry. Once the fruit becomes leathery, remove them from the strings or trays and/or mats. Packed and sealed in plastic bags of capacity 100g and heap it in a clean storeroom or boxes. Leave it for curing of products (sugar crystallizes

especially on whole fruit surface) for couple of weeks and is ready for marketing. Data on time taken for peeling of fruits which is only additional works in the improved methods of persimmon processing were noted. The dehydration time required both for natural sun drying and for improved electrical dryer were recorded. The products quality of both processing methods was assessed. The trial marketing of different products was done in Supermarket & retail shop in Thimphu and Wangdue respectively. The economic assessment of farmers and improved method of persimmon processing were done with help of agriculture economist of this centre.

All the local persimmon varieties (*Aundeybom*, *Pemchen* and *Lamchu*) become soft when ripened. It must be dried when they are fully colored orange yet still hard and astringent. If we wait for the fruits to soft ripe and astringency to disappear at the time of harvest, it is not suitable for processing as fruit burst on peeling and slicing. Though fruits are astringent at the time of harvest, the fruits astringency is slowly disappeared during the process of drying. The drying process sweetens persimmon to chewy pieces of near candy ever any confectioners produced. The local perismmon cultivars like *lamchu* (small) and *Pemchen* (medium) are suitable for drying into whole fruits while *aundeybom* takes very long time for drying.

The time taken for natural sun drying and using improved electrical dryer (NPHC & Ezi dryer) and drying recovery rate of various persimmon products are given in Table 1. The time taken for peeling of fruit prior to dehydration and processing waste products are documented in Table 28. The products packaging, labelling, pricing and consumers rating are given in Table 29.

The whole fruits took the longest to dry while fruit rings or slices dried up in the shortest time under Nobgang weather condition regardless of the different drying methods. Imported electrical Ezi dryer is not suitable for drying of fruit splits and whole fruits since the space between the crates are small but it can be used for drying of fruit slices. Improved NPHC electrical dryer is preferred by the farmers over the imported Ezi dryer as former is suitable for drying of all rgades of persimmon products, meat and other fruits and vegetables.

The whole fruits or fruit plits and slices become leathery when twisted, then they are ready for packaging. The dried fruits products are packed and presented in the plastic bags of 100g capacities and sealed with label inside indicating the product specification and prices (Pic 23-25). They turn white as the sweating sugar crystallizes on their surface particularly for whole fruit dehydrates.



Picture 23, 24 & 25: Fruit slices with skin removed, Fruit splits & Whole fruits

Pricing of different products is in concurrent to the product quality as per researcher and consumer perception and rating. However, we found that consumers' perceptions are congruent with quality standards developed and presented by the researchers. Among the various persimmon dried products, whole fruits is rated very excellent, good for fruit splits and fruit slices with skin peeled off, poor for fruit slices with skin intact (farmers practices) and of course fruit peel/skin is rejected as a dessert. Our intension is to produce pickle out of persimmon peel and it gives natural orange-red colour to the pickle. The other dehydrated persimmon products make a very tasty treat for any time, place or occasion. Put some in a dish on your desk. Add them into cookies, cakes and puddings.

Picture 26: Fruit slices (skin intact)

Table 28: Time taken for dehydration of persimmon and drying recovery rate

Different persimmon products	Time taken for drying (hours)					Drying recovery (%) at about 12% moisture level
	Natural open Sun drying	Under the roof natural drying	Ezi dryer at 45 C	Improved NPHC dryer at 45 C	Improved NPHC dryer 35 C (hours)	
Whole fruits	185-190	Not suitable (mould fungus)	Not suitable	Case hardening in 24 hours	120-130	29.2
Fruit splits	120-125	,,	24	36	72-80	26.8
Fruits slices with peel removed	80-90	,,	10	12	48-50	24.6
Fruit slices with peel intact	80-90	,,	10	12	48-50	24.6

Table 29 : Time taken for peeling of 1 kg fruits and processing waste percentage

Different types of persimmon	No of fruits per kg	Average time taken for peeling (minutes)	Average time taken for slicing (minutes)	Processing waste (%)
Aundaybom	4 to 5	3	2.4	17.4
Pemchen	10 to 11	5	4.5	18.3

Lamchu	15 to 16	10	8.6	19.2

Table 30: Products packaging, pricing and their quality rating

Dehydrated products	Net weight (gm)	Price (Nu.)	Consumers rating
1. Whole fruits	100	20	Excellent
2. Fruit splits	100	20	Good
3. Fruits slices with peel removed	100	20	Good
4. Fruit slices with peel intact	100	10	Poor
5. Fruit peels	100	5	Rejected as dried product

The trial marketing indicated that the products are readily acceptable with consumers against the imported dehydrated fruits products from India and Thailand. Products quality and packaging is comparable to those of imported ones. The economic assessment of dehydrated products were done and presented comparson of return

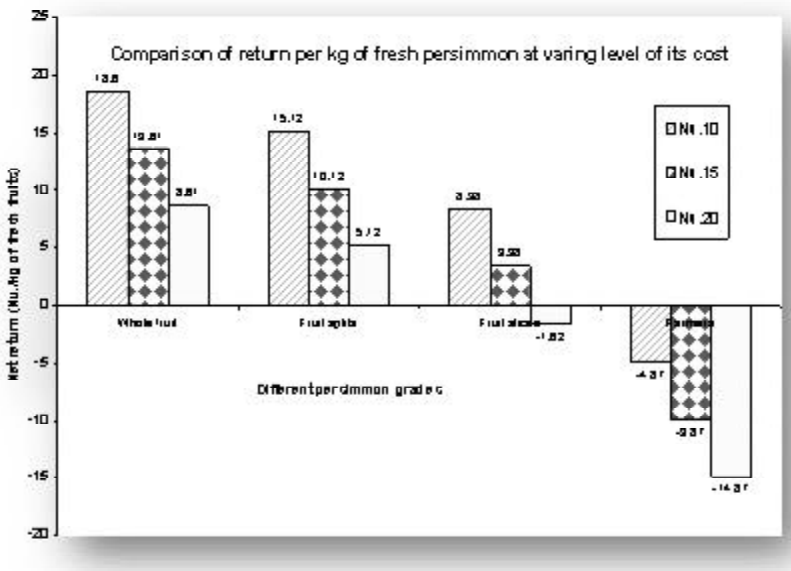


Figure 1 Comparison of return per kg of fresh persimmon at varying costs

per kg of fresh persimmon basis (as shown in the graph) The whole dehydrated product gave the highest return, followed by fruit splits and least by the fruit slices on fresh fruit market basis. However, it was found farmers practices of fruit dehydration, packaging and marketing runs into loss or in other words there is no value added by the processing

of fruits and marketing. The advantage of improved method of persimmon processing, packaging, marketing over farmers practices are:

- It is clean, hygienic and suitable
- Good presentation of product
- Better price-3-4 times higher return than the farmers' product
- Good consumer's acceptance
- Comparable to any other imported international products-market competitiveness and sustainability
- Farmer prefer improved NPHC dryer to imported electrical dryer (Ezi dryer)

In the light of all these advantages, it is recommended improved NPHC electrical dryer for processing over natural sun drying and imported Ezi dryer. Farmers of Nobgang fabricated about 27 numbers of NPHC dryer with support from NPHC, research and Dzongkhag agriculture extension on cost sharing basis. Farmer, however, has expressed concern on the power consumption of electrical dryer but it is easily offset by the higher return of high quality dehydrated products. Now, furthering participatory persimmon processing, packaging and marketing has to be done by the farmers in close collaboration with Dzongkhag agriculture extension.

Nursery management and plant propagation

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 programme 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 areas under in Table 31.

Table 31: Grafting technique and no. of promising fruits and nuts cultivars produced

Crop	Grafting Technique	No. of planting materials produced	Remarks
Sub-tropical apple	Whip	300	All the planting materials are used for establishing on-farm demonstration and on-station research trials. Some of the planting materials also made available to Schools, Dzongkhag administration and other Govt. organization on request.
Disease free Citrus rootstock	T-budding	400	
Peach	Whip	200	
Apricot	Whip	100	
Walnut	Whip	200	
Pecan	Whip	500	
roostocks and grafts			
pear	whip	100	
mango	Cleft	50	
Grapes	cuttings	100	
Pomegranate	Cutting	100	

Guava	seedlings	100	
Passion fruit	seedlings	600	
Citrus rootstock	Different Rootstock	100	All these rootstock will be used for propagating the promising cultivars that are to be used for establishing on-farm demonstration orchard and/ or research outreach program.
Walnut rootstock		500	
Avocado rootstock		50	
Apple rootstock		100	
Peach rootstock		300	
Apricot rootstock		200	
Pear rootstock		200	
Persimmon	Rootstock	50	
mango	Rootstock	100	

Research out reach program

Walnut as Cash Crop in Nahi Geog

His Excellency, Lyonpo Sangay Ngedup, Agriculture Minister during his visit to Nahi geog observed limited cash crop development activities in the geog despite the geog's access to market through 12km road connecting to the National highway. RNR RC Bajo and Dzongkhag agriculture extension, Wangdue was instructed to promote cash crop development in the geog based on the farmer's interest and technical suitability. Horticulture researcher, Wangdue Dzongkhag extension and Geog Extension Agent had organised a consultative meeting with the people of Nahi geog. Gup, Mangi-app and farmers from the all villages under Nahi geog participated in the discussion with the team. Participatory tools were used during the consultative meeting and the meeting decided two-prong approaches to improve the household nutrition and income as follows:

First by improving the backyard poor quality local pear, persimmon and walnut through top-working technique using improved and superior fruit cultivars; second via the promotion of commercial production of walnut with an aim of creating **"Model Walnut Geog"** for improving the household income of Nahi farmers. Considering the interest of the farmers, it recommended promotion of improved walnut production in all villages. In addition to walnut production, pecan nut for Hebesa village and commercial production of potato in Nabesa village is recommended. The size of walnut orchard ranges from a few trees to an area of 2 acres. In total there are 36 farmers taking up the commercial scale walnut production beside other farmers who are interested in homestead level

Picture 27

walnut production.

Improving the quality of backyard fruit crops

Picture 28

According to the farmers there are poor quality local pear, walnut and persimmon in their homestead and it was decided to improve the existing backyard orchard through top-working with improved fruit varieties. We have conducted on-farm hands-on training cum campaign on topworking of inferior and poor quality local walnut, pear and persimmon in April 2006 for Wangdue Dzongkhag Extension staff and interested farmers of the Nahi geog. Training session consisted of lecture and discussion, on-farm practical session and on-farm practical session in campaign mode (Picture). Horticulturist of RNRRC-Bajo briefed and demonstrated to the EAs and farmers on the availability of the additional new horticulture technologies such as improved fruits cultivars, crop production technology and the technique of topworking of fruit crops as one of the fastest methods of reaching improved fruits cultivars from lab to land. Towards the end of class room session, groups of 6 participants guided by a horticulturist of RNRRC-Bajo was formed and each group was provided with scion materials, grafting tape, cool box, other necessary grafting tools and a farmer guide. They were then assigned certain numbers of farmers and villages to be covered for topworking of local inferior fruit trees with the consent of the farmers (detail in Table 32). The topworking results were good with about 83.3% successfully topworked fruit trees.

Table 32 : Number of trees top worked in Nahi geog, Wangdue

Sl. No	Name of farmer	Walnut	Pear	Persimmon
Nabesa				
1.	Dendrup	2	-	1
2.	Karma Gyeltshen	1	-	-
3.	Tandin Lhamo	4	2	-
4.	Tshering Samdrup	2	-	1
5.	Namgay	1	-	-
6.	Kinley	-	1	5
7.	Namgay Bidha	1	1	3
8.	Kinleam	-	-	1
9.	Migma	8	1	1
10.	Tshomo Gem	-	-	1
11.	Tandin Bidha	1	2	1
12.	Kesang Dema	-	1	-
13.	Tshering	5	-	-
14.	Pema	1	2	-
15.	Kinga	6	-	-
16.	Kota	14	-	-
17.	Delma	1	-	-
18.	Phub Dorjee	2	-	-
19.	Sangay Zam	1	-	-

20.	Kinley	1	-	-
21.	Yuden	1	-	-
Esa Wom				
22.	Dema	3	1	1
23.	Chado	3	2	-
Esa Gom				
24.	Gyeltshen	8	-	2
Hali				
25.	Kota	4	-	2
26.	Karma	2	-	2
Hebessa				
27	Selden	9	-	-
28	Kinley Yangzom	1	1	1
29	Pema	3	-	1
30	Sangay	-	2	-
31	Kota	-	2	-
32	Tshering	2	-	-
33	Sangay Tenzin	3	2	-
34	Chimi Dorjee	-	2	-

Promotion of commercial walnut production: model walnut geog

Picture 29 & 30

In whole of Nahi geog, farmer reported existing local hard shell walnut in their backyard and in the fringes of farm land. Nahi farmers are interested and willing to invest on walnut production as the cash crop in the geog. In March 2006, horticulture researchers and extension agent of that geog provided farmers hands-on training on layout and planting of walnut orchard for the interested farmers of this geog. 37 farmers attended training and 1210 walnut sapling planted (Table 33). Of this 472 walnut were supplied by RNRRC-Bajo and remaining were generated or collected by farmers themselves from farmland fringes. Topworking of these walnut orchards will be done after 2 years of its orchard establishment.

Table 33 : List of farmers and number of walnut sapling planted

Name of the farmer	Village	No. of plant	Remarks
Tshering Wangchuk	Tshokathang	100	50 grafted walnut
Ugyen Dema	Tshokathang	29	
Dema	-do-	60	
Sonam wangdue	-do-	70	20 grafted walnut
Karma	-do-	19	
Gyem Dorjee	-do-	21	
Changlam	-do-	23	
Yeshey Dem	khujurla	16	
Dorjee Penjor	-do-	14	
Lako	Tshokathang	20	
Bajob	Hali	10	
Nima	-do-	50	
Kota	-do-	35	
Gyeltshen	-do-	40	20 grafted walnut
Pema	-do-	60	
Wangchuk	-do-	60	
Khandu	-do-	35	
Dema	Esa gom	50	
Gomchen	-do-	23	
Gyeltsen	-do-	150	
Kotala	Nabesa	25	
Pema	-do-	70	
Cheten Dema	-do-	7	
Dorjee	-do-	6	
Phub Dorjee	-do-	15	
Sangay Zam	-do-	11	
Yuden	-do-	16	
Rinzin	Phuntshogang (Nabesa)	6	
Wangmo	Tashithangka (Nabesa)	30	
Tandin Lham	-do-	30	
Tshering Samdrup	-do-	14	
Sarim	-do-	14	
Gangla	-do-	12	
Kinley	-do-	110	
		1210	

Alternative cash crops to Beteni and Thangrey villages, Tsirang

His Excellency, the Hon'ble Agriculture Minister Lyonpo Sangay Ngedup along with RNR officials from headquarters, RNRRC-Bajo and Tsirang Dzongkhag paid a day visit to Beteni Geog in Tsirang Dzongkhag on 16th June 2005. To improve the nutritional and food security of people of Beteni geog the Hon'ble Minister instructed RNRRC-Bajo and Dzongkhag agriculture extension to promote and supply fruits crops in the following cropping season. Subsequently, a meeting was held in Beteni geog on 15th August, 2005

between the Dzongkhag agriculture extension, RNRRC-Bajo and farmers of Beteni geog to discuss about the fruit crops promotion in the geog. The meeting decided two-prong approaches to improve the household nutrition and income. The first approach is to improve the existing backyard orchard through top-working with improved fruit varieties particularly local pear. The second approach is up-scaling or commercialization of walnut and pear production in Beteni.

Improving the Tsirang local pears

The hands-on training cum campaign on topworking of local pear for all Dzongkhag agriculture extension (15 EAs) and 46 farmers of Tsirang Dzongkhag was conducted on 4th to 6th April, 2006. At the end of lecture session, groups of 6 participants were formed

Picture 31, 32, 33 & 34

and each group was guided by a horticulturist of RNRRC-Bajo. Each group was provided with scion materials, grafting tape, cool box, other necessary grafting tools and a farmer guide. They were then assigned certain numbers of farmers and villages to be covered for topworking of local fruit trees. The details of pear, walnut and persimmon topworked by the horticulturist, participant extension agents and farmers of this village are given in Table 34. The result of topworking is reported very good with about 98% graft success.

Table 34: Number of trees top worked in Beteni and Mendelgang villages, Tsirang

Name of farmer	Walnut	Pear	Persimmon
Dorji Tshering	-	7	-
Pema Lham Sherpa	-	5	-
Pema Chaki sherpa	-	4	-
Dawa Sherpa	-	2	-
Pasang Sherpa	-	4	5
Migma Sherpa	-	3	-
Karsang Sherpa	1	4	-
Tashi Sherpa	-	4	-
Tseten Sherpa	-	3	-
Kongley Sherpa	-	2	-
Karchung (DLO)	-	2	-
Phurba Sherpa	-	7	-
Pemba Sherpa	-	6	-
Dawa tshering	-	1	-
Dawa Delma	-	**3**	-
Aku Dorji	-	2	-
Rinju Sherpa	-	5	-

Lhakpa Sherpa	-	5	-
Karsang Dorji Sherpa	-	4	-
Rinchen Sherpa	-	8	-
Lhakpa Rinzin	-	2	-
Yeshey Sherpa	1	2	-
Lha Deki Sherpa	-	4	-
Sonam Zangmo	1	3	1
Dawa Sherpa (chimi)	-	3	1
Passang Wangmo	-	2	-
Nima Sherpa	1	5	-
Yeshey Sherpa	-	3	-
Pema Wangdi	-	2	-
Chogyel Sherpa	-	3	-
Pema Sangay	-	1	-
Phub Rinzin	-	3	-
Migma Sherpa	-	4	-
Mon Maya Tamang	-	1	-
Khem Prasad Gurung	-	2	-
Dil Bdr. Gurung	-	3	-
Suk Bdr. Gurung	-	1	-
Tenzin Sherpa	-	2	-
Pasang Sherpa	-	2	-
Pema Gyeltsen	3	5	-
Lengthen Denup(Mendelgang)	-	1	-
RNR geog centre (,,)	-	1	-
Norbu (,,)	-	2	-
Singay Dorji (,,)	-	1	-
Ugyen Nima (,,)	-	2	-
Galay (,,)	-	1	-
Sither Dorji (,,)	-	2	-
Tshering Dorji (,,)	-	1	-
Sangay wangdi (,,)	-	1	-
Tshegay (,,)	-	3	-

Pear and walnut as commercial crops in Beteni village

We supplied 1 plant of improved walnut, pear and peaches/apricot each to all 46 households of Beteni village with an aim serve as source of scion wood for further multiplication. We have also identified two farmers for the production of walnut and pear nursery. These farmers were trained as the private fruit nursery grower and they have sown 4000 walnuts and 3000 pear seedlings which will generate income for themselves and at the same time pear and walnut planting materials for sale in Tsirang and other Dzongkhags.

2.1.3 On going Fruit crops research

The on-going fruits variety evaluation and others trials during the reporting time and are not in reporting stage are:

- Private fruits nursery growers promotion
- Integrated citrus management trial
- Mandarin superior mother plants selection from local diversity

2.1.4 Trainings of farmers and extension personnel

Promotion and training of private fruit nursery growers
We promoted three private fruit nursery grower, one in Omtekha and and two in Beteni, Tsirang, and provided hands-on-training on fruit nursery propagation and management. Omtekha Private Fruit growers have earned about Nu. 21000.00 from the sale of improved and grafted walnut, peach and apricot planting materials to Wangdue and Punakha Dzongkhags as of now. The production of walnut, apricot and peach planting materials is being continued by the Omtekha private fruit nursery grower. Two private nursery growers in Beteni have produced about 4000 walnut and 3000 pears saplings.

Training of Dzongkhag agriculture extension
All the extension staff of Tsirang and Wangdue dzongkhag were given hands-on-training on top-working of pear, walnut, peaches and persimmon. The objective of training was to impart the technical skills and also to provide tools and materials so that once they are back to their geog centre they can continue to practice the skills and popularize the newly released fruits cultivars. The feed back we received from the extension agents was encouraging. In some cases they managed to get reasonably good success in top-working thereby improving the poor quality fruit crops in the farmers fields. We expect extension system to feature and regularize such type activities in their extension system as an annual event.

2.1.5 Translating research into communication materials

Some of the publications and recommendation submitted or produced from our Centre are as follows:

- Topworking: The best method of walnut orchard development in Bhutan, RNR-Journal, MOA.
- Technology for walnut production in Bhutan, VERCON, ICS, MOA website.
- Technology for chilli production in Bhutan, VERCON, ICS, MOA website
- Technology for tomato production in Bhutan, VERCON, ICS, MOA website

2.2 Vegetables

2.2.1 Integrated germplasm development

Carrot variety evaluation trial
It is a nationally coordinated multi-location trial and is being coordinated by RNRRC-Wengkhar. Carrot variety Kurda 5 was introduced from Japan and has performed consistently better than local check in the east. However, its performance in the other region is not studied. The trial kit was provided by RNRRC-East in all the regions to validate its performance across the regions. In this experiment, existing cultivar Early Nantes was used as a local check. The trial was laid out in randomized block design with

three replications. The plot size was $5m^2$ per treatment per replication. All the recommended cultural practices for carrot were followed in the conduct of this trial.

Data was recorded on fresh marketable, non-marketable root yield, size and colour of the root. Eating quality of two carrot varieties was tested. The data were analysed using GENSTAT (one way analysis of variance with blocking) and the mean yield, root size and colour are given in Table 35.

Table 35: Yield and root character of carrot varieties

Varieties	Yield (t/ha)		Root size		Root colour
	Marketable	Non-marketable	Length	Width	
Kurda 5	5.20	1.60	7.40	1.93	Deep orange
Early Nantes	5.93	2.67	6.23	1.47	Orange
S.E.D	0.37	0.40	0.41	0.29	
L.S.D	1.59	1.74	1.76	1.27	
F value	0.18	0.11	0.10	0.25	
CV %	8.20	23.30	7.40	21.00	

Result showed that there was no significant difference (P = 0.05) in mean marketable and non-marketable yield between the two varieties. There was also no significant difference observed on the size of root of two carrot varieties. The colour of the Kurds 5 root was deep orange compared to Early Nantes. The eating quality of Kuroda-5 was found to be better than the local check variety. The seed of Kurda 5 is being multiplied for conducting the on-farm research and promoting in the research outreach program sites.

Egg plant ratoon cropping trial

Brinjal is a popular vegetable grown in the early spring to summer in the rice based cropping system and in late summer season in the upland. Egg plant is a perennial shrubby plant, usually grown as an annual. Newly introduced brinjal variety BARI-1 showed potential for ratoon cropping as it exhibited tolerance to frost and remained alive through out the winter. It is of great interest for upland brinjal production and if it is possible to maintain good plant stands through the winter, it is possible for ratoon cropping for early brinjal production. Therefore, the plants of 2005 brinjal varietal evaluation trial were maintained through the winter for ratoon cropping. The treatments consist of Paro local (local variety from Paro), BARI-1 and 2 (variety introduced from Bangladesh research institute). The trial was design in randomised complete block with three replications. The objective of this trial was to assess the yield potential and fruit quality for these brinjal varieties under ratoon cropping system.

The plants were headed back to encourage side shoot growth on 12th Jan 2006 and placed paddy straw to protect from frost. The paddy straw was removed on 21st Feb 2006 after the danger from frost was over. The plants were top dressed with urea at the rate of 15 kg/ha. After that, weeding and irrigation were done as and when needed. Observations were made on total yield, (non-marketable and marketable) fruit size, plant stand and time of harvest. The data were analysed using GENSTAT and the result are given in Table 36.

Table 36 : Means yield, fruit size and plant percentage survive of brinjal varieties

Cultivars	Mean yield (t/ha)		Fruits size (cm)		Plant stand (%)
	Marketable	Non-marketable	Length	Width	
Paro local	6.60	5.33	10.70	3.93	81.33
BARI-1	7.67	4.20	11.60	3.43	88.67
BARI-2	0.00	0.00	0.00	0.00	0.00
F Probability	0.04	0.27	0.55	0.01	0.053
S.e.d	0.24	0.76	1.22	0.05	1.247
LSD	1.03	3.30	5.44	0.24	1.764
CV%	4.10	19.80	13.90	1.90	7.589

Result showed significant difference (P = 0.05) on the marketable yield, fruit width and plant stand between two varieties. BARI-1 has yielded better quality fruits and higher yield than local check. BARI-1 also exhibited better tolerance to winter frost indicating it can be used for ratoon cropping in mid altitude areas. BARI-2 is highly susceptible to frost and didn't survive in winter and is not suitable fro rationing. When we compared the ratoon crop yield with normal season brinjal yield, there was no significant different between the two. However, further work is required to validate this claim. First harvest was in first week of April for ratoon crop while normal crops usually expected toward the end of May in mid altitudes area. This indicates ratoon cropping might give higher return to the upland brinjal producer by tapping the higher price for early season market. This trial will be continued following season to revalidate the research finding.

Cauliflower variety trial

Cauliflower is the most important and popular vegetable of cole crop. The curds are rich in vitamin C, iron, thiamine, riboflavin and niacin. The young leaves can be used as sag and are rich in iron and calcium. Cauliflower is a thermo-sensitive crop. Varieties differ in their temperature requirement for curd initiation and development. Therefore, evaluation of varieties in different region is important. Two varieties, Wangkher Matocopy 1 and Wangkher Matocopy 2 were notified for general cultivation as they have performed consistently in the eastern region. It was agreed to test these two varieties in multi-location production during last annual horticulture research coordination workshop. We received seeds of these varieties from RNRRC Wangkher for evaluation. Snowball 16 was used as a control. Experiment was laid out in a RCBD, with four replications. Spacing between the rows and plants was kept 50x50 cm and the plot size was 5 sqm. Other cultural practices like fertilizer rate were used as per the recommended practices. Weeding and irrigation was done as and when necessary. Observations were recorded for maturity days, marketable yield, curd colour, weight and size. The data were analysed using GENSTAT and results presented in Table 37.

Table 37 : Yields and horticultural characteristic of cauliflower varieties

Varieties	Yield (t/ha	Curd size		Curd weight	Day to maturity	Curd colour
		Height	Width			
Wengkhar maytocopy 1	17.85	11	16	0.40	89	White
Wengkhar maytocopy 2	11.05	11	17	0.40	89	White
Snow ball 16	19.05	11	16	0.40	89	Pink coloration
S.E.D	1.05					
L.S.D	2.59					
F. Probability	0. 00					
CV %	9.40					

There were statistically significant differences in the total marketable yield between the varieties. Snow ball 16 produced significantly higher marketable yield than other two varieties. The lowest marketable yield was produced by the Wangkhar Matocopy 2 & 1 compared to the local check. Wengkher Maytocopy 1 and 2 produced superior curd quality than local check variety. In contrast to findings from RNRRC-east, the days to crop maturity, curd weight and size of curd of different varieties were not significantly different from each other. Khangma Matocopy-2 is supposed to be long duration and late maturing but it has not shown this feature under Bajo condition. We suspect on the purity of seeds. However, in the light of better curd quality and less un-marketable curds of two new varieties than the local check, it may be recommended to release one of these two varieties for general cultivation.

Vegetable soybean variety evaluation trial

Vegetable soybean can be harvested after the R6 and before the R7 growth stage, while the pod is still green and seeds have developed to fill 80-90% of the pods width. Vegetable soybean requires more water and richer soil than grain soybean, however it can be cultivated easily compared with other vegetable. Vegetable soybean has potential for enriching human diet and is easy to prepare and tastes good. It is prepared by boiling the green immature seed either in pod or shelled.

All vegetable soybean varieties can be grain soybean, however only a few grain soybean can be vegetable soybean. The standardization of vegetable soybean should have large, sweet and tender seeds. Pod should contain at least two seeds and it should have good colour. Light green colour is considered best. Therefore, existing local grains soybean needs to be evaluated for their seed and pod quality to identify suitable vegetable soybean varieties for the country.

This trial was conducted to compare a local grain soybean from Kurtoe with three vegetable soybeans introduced from AVRDC in terms of yield potential, pod and seed quality. The trial was laid out in RCB design and replicated thrice. Plot size was $5m^2$ per treatment per replication and spaced at 25cm plant to plant. Each plot contained two rows with twenty plants per row. Recommended practices for growing beans were followed. Observations were made on total marketable yield (2 and 3 seeded pod) and

important aspect of vegetable soybean quality. The data were analysed using GENSTAT and the results are presented in Table 38.

Table 38: Marketable yield and agronomic character of vegetable soybean varieties

Variety	Yield (t/ha)	Plant size (cm)		3 seeded pod/plant		2 seeded pod/plant		Day to maturity	100 seeds weigh (g)	Pod colour
		Ht.	Widt	Wt. (g)	No.	Wt (g)	No.			
86030-16-6-1	14.33	73.6	61.1	32.2	11.7	114	41.8	80	69.5	Light green
AGS 333	11.33	60.1	61.6	27.8	7.00	261	76.8	80	100	Green
AGS 292	13.00	103.6	90.5	31.1	6.67	258	42.8	80	125	Light green
Kurtoe	15.60	96.1	81.6	19.9	5.07	139	76.4	120	48	Light green
L.S.D	2.23	17.6	12.9	6.80	1.19	103.3	23.1			
S.E.D	0.91	7.19	5.27	2.77	0.49	41.8	9.45			
CV%	8.20	10.6	8.8	12.3	7.8	26.5	19.5			
F. Prob.	0.02	0.003	0.003	0.02	0.001	0.02	0.013			

Kurtoe soyabean produced significantly higher marketable yield (P=0.02) than all other vegetable soybean varieties except from 86030-16-6-1. However, Kurtoe soyabean is not suitable for vegetable soyabean as per the established standard of vegetable soybean since its 100 seed weight is too low and its number of marketable pod in one kilogram is too high. Soyabean vegetable varieties introduced from AVRDC are short duration and have significantly higher 100 seed weight and produce significantly higher number of 2 and 3 seeds pods per plant. Considering all desirable characteristics of vegetable varities such as marketable yield, taste, pod colour and 100 seed weight, introduced varieties seem to be promising and their potential needs to be tested in multi-location under farmer's management conditions.

2.2.2 Production management

Seed potato quality assessment trial

Potato is the most common vegetable in our country. As a cash crop, it is first in term of annual cash earned. For the successful production of potato, seed is the most important factor. Therefore, the use of quality seed is important. Farmers prefer to use their own seed as the cost of seed alone account for almost 50% of the total cost of production. Farmers can produce quality seed potato, as the climate is cool with high altitude in most part of our country. However, they tend to use their own seed year after year without undertaking any measures to avoid seed degeneration. It was reported in the many occasions that seed potato degeneration is a problem in potato farming but it was

unfounded as no formal study was done as ever. Therefore, need was felt to validate this problem in potato farming.

The study was thus initiated and was aimed to assess the effect of different seed source on yield, tuber quality and pest and disease incidence. The different seed sources were from Druk Seed Corporation, Registered Seed Growers and ware potato seed. The experiment design was RCBD with five replications. The planting was done on 20th Feb 2006. Plot sizes were 3x6.25m, with plant-to-plant spacing of 25 cm and row-to-row spacing of 60 cm. Each plot contained five rows with 25 plants per row. Observations were made on yield, quality of tuber and on pest and diseases incidences. The data were analysed with GENSTAT. The results are as shown in Table 39.

Table 39 : Yield, tuber quality and disease rating

Seed source	Black scurf %	Number of stem	Seed size	Large size	Off size	Yield (t/ha)
Register Seed Grower Seeds	9.80	438	10.60	19.0	2.60	16.00
Druk Seed Corporation	10.20	363	6.80	15.0	3.60	13.50
Ware potato seeds	8.20	434	10.0	12.0	4.00	15.00
F.Probability	0.334	0.693	0.219	0.397	0.271	0.817
S.E.D	1.332	96.3	2.124	4.87	0.821	3.83
L.S.D	3.071	222.1	4.899	11.23	1.892	8.83
CV %	22.4	37.0	36.8	50.2	38.2	40.8

There were statistically no significant differences (P = 0.05) in total yield, tuber quality and disease rating within the different seed sources. Highest total yield was produced by RSG seed (16t/ha) followed by ware potato seed. Large and seed size tuber was observed more in RSG. Off size tuber was found more in ware potato seed. Number of stem per plot was found less in DSC seed as the seed potatoes were affected by blindness and thin sprout disorder. In regard to diseases, few symptoms of late blight, wilting and black scurf were observed. Among the symptom, black scurf was prominently more in DSC seed followed by RSG seed.

It was evident from the study that the different sources have no effect on yield, tuber quality and diseases. Potato seed degeneration thus does not seem to be a major problem. However, study may be repeated in the following season to revalidate these trial findings.

***Sha Ema* characterization and purification**

Chilli is the most common vegetable in Bhutan and considered essential in every meal. As a cash crop, it is second after potatoes in term of total annual cash value. In many farming system it is one of the possible sources of cash income for a family, which makes it is an essential crop in the yearly cropping pattern.

Several traditional chilli varieties (landrace) can be found throughout the country. *Sha Ema* is one of the main types. It is a famous variety in Sha geog in the west and its popularity is gaining in other part of the country because of its fruit quality. Therefore, preservation of this variety is important. Seed of this variety is mostly produced by farmers and the purity of seed is in question. Therefore the need was expressed in one of the annual agricultural review and planning workshops to organize a systematic seed purification led by RNNRC-Bajo to maintain both quality and purity and to preserve this variety.

Study was initiated by the centre with an objective to characterize, document and collect pure *Sha ema* and to provide a sound basis for purification, a relevant data like plant characters, fruit orientation, fruit types, immature and mature fruit colour, other quality aspects and yield were collected through crop cut and discussion with farmer. A structured questionnaire survey was done to collect above data. Three villages, namely Jagtey, Komathang and Lengkhepji were chosen as sites from Kashi geog under Wangdue Dzongkhag, as they are the main *Sha ema* growing area. Eleven households were interviewed and out of total respondents, 55% were elderly people above 60 years old, 27% were in the age group of 40 and the rest were in their late 20s. Fruit samples were collected for seed extraction and seed is being used for further on-station seed purification and production.

28% of the respondents described the plants size as medium and remaining said that plants size depends on soil fertility and the management of the crop. Horticultural traits of *Sha ema* described by the respondents are diverse and are as under.

Fruit Shape: Short in length and big in diameter (82% of respondents); Bell shape (9% of respondents) and elongated fruit (9% of respondents)

Immature fruit Colour: Green (91% of respondents) and light green (9% of respondents)

Mature fruit colour: Red (82% of respondents) and bright red (18% of respondents)

Pungency: mild (64% of respondents) and not hot (36% of respondents)

Fruit wall thickness: Thick (73% of respondents) and very thick (27% of respondents)

Yield: yield varies from farm to farm and reportedly range from 8.7 to 20t/ha

Crop cut was not done in chosen sites as there are different types of chilli other than S*ha ema*. Therefore, field observation was done in Bell village, one of main growing areas of *Sha ema* under Kashi geog and plants were selected for fruit sample collection. Data on fruit length, fruit width, average fruit weight, fruit wall thickness, fruit orientation and seed percentage was collected during the field observation. Based on the information obtained from farmers and data collected from the field observation, S*ha ema* can be described as in Table 40. This characteristics and yield parameter will be use as basis for seed purification and maintenance in future.

Table 40 : Yield and characteristics of *Sha Ema*

Plant size	Medium
Fruit orientation	Pendent
Fruit shape	Elongated with blunt tips
Fruit colour (not ripe)	Green
Fruit colour (ripe)	Red
Fruit length	8 cm
Fruit width	2.4 cm
Average fruit weight	23.7 g
% of seed weight	8
Pedicel length	3.1 cm
Fruit wall thickness	0.3 cm
Pungency	Mild
Yield	12-14 t/ha
Number of lobs	3

RNRRC-Bajo has started on-station seed purification, multiplication and variety maintenance. Once purification is complete, seed sample will be provided to DSC for further multiplication and distribution to the farmers. *Sha ema* variety will be maintained in the centre as mandated.

Early chilly production study in Zawa village

A need assessment survey in Zawa was done by RNRRC Bajo together with RNR sector staff of Wangdue. As per the report, the emerging rice-early chilly cropping pattern is taking over the traditional rice-wheat or rice-buckwheat cropping pattern due to higher economic benefits. However, the performance of early chilly was poor in 2005 season. To address this problem they suggested studying and refining farmer's technique of early chilli production.

As per their suggestion, early chilli production observation study was conducted by horticulture sector of RNRRC, Bajo and concerned gewog EA in 2006 season in Zawa village. During our study, we observed farmers technique of early chilli production from nursery, production management till harvesting period. We took note of pest and disease incidences in different growth stages. Our findings and observations on the farmer early chilli production are as given below.

Source of seeds

Seeds were extracted from the dry chilli, which they purchase from local market. They select good colour, shape and disease free dry chilli based on visual inspection for seed extraction.

Nursery site

Usually the nurseries sites were near the production field and are far away from house.

Seedbed

Seedbeds were normally prepared by covering with layer of straw or tree leaves, which were burned before sowing seeds. Time of seeds sowing in nursery is usually done in

November and transplanting is done normally in February. Nursery is raised under poly tunnel. The plastic is opened in one month after sowing. They place plastic over nursery at night. Weeding and irrigation were done as per requirement.

Transplanting method
Farmers use very young seedling for transplanting and planted on beds. The beds height is about 15cm. They follow the spacing of about 10 to15 cm from plant to plant. They irrigate by flooding over the beds. Most of the farmers use urea for topdressing. Some of the farmers also apply suphala during land preparation.

Insect pest and diseases
Damping off symptom was observed in the nursery, leaves curling due to thrips infection were found from early flowering, and infections continue through out the crop stages. Infection of blight diseases and cutworm infestation were also observed.

Shortfall in local practices
In the light of blight disease, bed height of 15cm practice by farmers is too low compared to recommended practices, resulting in poor drainage. Flood irrigation is not appropriate where blight disease is prevalent and it enhances disease development. The plant spacing between plants was too dense; makes cultural operation ineffective and create a congenial environment for blight diseases infection.

From our experiences, farmers keeping nursery in November is too early as the required temperature is not met for seedling growth in winter and as a result seedling were exposed to stress for too long making them susceptible to many pest and diseases. Based on problems and constraints of farmer practices, trial on different sowing time without compromising early harvest and yield with complete packages of early chilly production is needed to be demonstrated. Therefore, a trial will be conducted in the coming season.

Vegetables promotion programme
Vegetable is a major constituent of daily diet. It plays an important role in the health and nutrition of the people throughout the world. Nutritional deficiencies, such as anaemia and vitamin A can be corrected through consumption of dark green leafy and yellow or orange colour vegetables**.** Food availability or supply is only a prerequisite and not a guarantee for good nutrition. Quality of nutrition depends on good food habits. However, promotion of varieties of vegetable is also an important factor for good nutrition.

Vegetable cultivation in Bhutan is imitated to traditional varieties, especially in rural areas. Improved vegetable varieties are generally not grown by many farmers due to limited knowledge on their cultural practices and nutritional value of vegetables and their importance to health. In addition, the consumption of green vegetable is very low.

Research progamme has released host of improved vegetables varieties and others are in the pipline for release. Vegetable promotion program was initiated by the research centre with the objective to introduce nutrition garden for rural household, popularize improve vegetable varieties and promotion vegetable consumption. RNRRC-Bajo has

conducted vegetable promotion and demonstration of nutrition garden in the villages of Rukha and Samthang under Adang geog. Two co-operator farmers, one each from village were selected and given eleven kinds of vegetable seeds for developing nutrition garden. For other farmers vegetable seeds were given according to their choice. The cultural practices from nursery technique to harvesting stage were demonstrated to other farmers in the co-operators garden. To supplement vegetable production, we also explained nutritious value of individual vegetables. Seed were distributed two times, one for summer production and another one for winter production in 2005 and once for summer production in 2006. Farmers' feedbacks were collected on the performance of improved vegetable cultivars at the end of season and feedbacks are positive for improved bean (Chitokha black and RNRRC DW), radish (45 days), bitter gourd and tomato. However, they didn't appreciate lady's finger. Farmers also told that they have gained technical skills on vegetable production and management. It was observed that farmers maintained improved vegetables seed for planting in the following season. According to the feed back from the agriculture extension, vegetable production and consumption in Rukha and Samthang has increased manyfold after the intervention.

Vegetable breeder seed production and maintenance

The responsibility of maintenance of breeder seeds of all released crop cultivars from RNRRC-Bajo was transferred to RNRRCs from Druk Seed Corporation by the Ministry of Agriculture. RNRRCs are mandated to maintain the breeder seeds of the various crops released from their Centre. In this regard horticulture section of RNRRC, Bajo has maintained the breeder seed of vegetable crops released from this centre. Beside the released vegetable varieties we also produce promising vegetable varieties seed so as to make seeds readily available for research purposes, both on station and on on-farm. The status of released and promising vegetable varieties seeds produced and maintained in the centre as in Table 41.

Table 41: Details of breeder seed production

Crop	Variety	Quantity	Remarks
Bean	RNRRC DW	10kg	Distributed to farmers at RNR Expo.
Bean	Chitokha black	10kg	Distributed to farmers at RNR Expo.
Cauliflower	Wangkher matocopy 2	0.4kg	Used for further research and promotion programme.
Carrot	Kuroda 5	0.3kg	Used for further research and promotion programme.
Brinjal	Pusa purple long	0.3kg	50g used for further seed multiplication and purification.
Bean	Top Crop	5.0kg	Available in the stock.
Bean	Pusa Parvati	5.0kg	Available in the stock.
Cauliflower	White Top	0.4kg	200g used for further seed

			multiplication & in vegetable promotional programme.
Carrot	Early Nantes	0.4kg	200g used for further 10seed multiplication & in vegetable promotional programme.
Onion	Bajo Gop-1	0.1kg	Used for further seed multiplication.
Lettuce	Great Lake	0.5kg	200g used in vegetable promotional programme.
Broccoli	Dissico	0.4kg	200g used for further seed multiplication & in vegetable promotional programme.
Radish	Bajo Laphu-1	1.0kg	500g used in further seed multiplication
Japanese Green	Taisai	0.4kg	200g used for further seed multiplication & in vegetable promotional programme.
Pea	Usi	5.0kg	Available in the stock.

On- going seed production and maintenances at the time of reporting are:

- Beans (RNRRC DW, Chitokha black, Borlloto, Top Crop, and Rajma)
- Cauliflower (Wanger matocopy 2 and white top)
- Brinjal (Pusa purple long)
- Radish (Bajo Lhaphu-1)
- Carrot (Early Nantes and Kuroda 5)
- Onion (Bajo Gop-1)

LIVESTOCK RESEARCH

3 LIVESTOCK RESEARCH

3.1 Feed and Fodder Research

3.1.1 Dry Matter Production Trial

The objectives of this trial were to quantify potential dry matter production across a range of environments, generate data for production models and other planning tools and compare yield potential of selected grass species. The species tested were *Pennisetem purpureum, Paspalum atratum, Dactylis glomerata, Setaria sphacelata and Medicago sativa.* The trial was established at Bajo station conditions in July 2002. It was replicated under irrigated and non-irrigated conditions. It is a five years trial to be completed by July 2007.

The average fresh matter and dry matter yields of 2005 were as indicated in the Table 42.

Table 42: Fresh and Dry Matter yield

Treatments	Fresh yield (t/ha)		Dry matter (t/ha)		Dry matter %	
	Irrigated	Non-irrigated	irrigated	Non-irrigated	Irrigated	Non-irrigated
Paspalum	5.45	2.89	2.08	0.84	38.15	29.02
Napier	18.7	10.1	4.88	2.16	26.12	21.36
Setaria	11.5	-	3.68	-	31.96	-
Lucerne	7.9	7.53	2.79	1.99	35.35	26.40
Cocksfoot	0.86	0.26	0.24	0.05	28.23	15.98

The 2005 yield data with 5 harvests in total revealed that both fresh and dry matter yield was highest from Napier under irrigated and non-irrigated conditions. The fresh yield from the irrigated trial was 18.7 t/ha to that of 10 t/ha from non-irrigated. The dry matter yield of 4.9 and 2.2 t/ha was recorded from irrigated and non-irrigated trials respectively. Lucerne though being leguminous forage yielded relatively high fresh biomass and dry matter under both irrigated and non-irrigated conditions. Therefore, under pure stand, Napier and Lucerne have the potential to produce high forage yield. However, mixture of these two could suppress Lucerne due to dominance by Napier. The Cocksfoot being a temperate grass may not perform well under sub-tropical condition as became evident from its fresh and dry matter results. Setaria could be of choice next to Napier among other grass species.

3.1.2 Lucerne variety trial (on-going)

The objectives of the trial were to evaluate production potential of Lucerne varieties over the seasons across the Bhutanese environments and to look at their persistence over the years across the regions. The trial was established in July 2004. It is a RCBD trial with 3 replicates, 20 cm between rows and 0.5m between plots and 1m between replicates. A total of 11 varieties are under evaluation for fresh and dry matter production. The 11

varieties include Kaituna, Venus, PL 55, Prime, Super 7, WL 414, Aurora, SA 35076, SARBU 1, SARBU 2 and Eureka. The trial completes in July 2007.

The 2005 results for fresh and dry matter production were as presented in the Table 43.

Table 43: Fresh and Dry Matter yield

Treatments	Fresh yield (t/ha)	DM %	DM yield (t/ha)
Kaituna	9.51	29.14	2.77
Venus	14.06	25.83	3.63
PL 55	14.56	25.89	3.77
Prime	11.71	28.90	3.38
Super 7	12.08	34.14	4.12
WL 414	11.71	30.06	3.52
Aurora	11.12	28.38	3.16
SA 35076	11.36	29.51	3.35
SARBU 1	14.68	25.00	3.67
SARBU 2	13.2	27.36	3.61
Eureka	14.51	25.10	3.64

The fresh matter yield was recorded highest from SARBU 1 and PL 55 with 14.68 and 14.56 t/ha respectively. The dry matter yield of 4.12 t/ha was recorded highest from Super 7. PL 55 gave of dry matter yield 3.77 t/ha followed by SARBU 1 with 3.67 t/ha. The overall performance during the year was PL 55 and SARBU 1 both in terms of fresh and dry matter yield from among the 11 varieties under evaluation. A total of 6 harvests were done during 2005.

3.1.3 Lucerne seed production trial (on-going)

The trial was established in July 2003 at Bajo station with the objective to evaluate the effect of location, management factors and their interaction on the production of 2 Lucerne varieties for seed production possibilities. The trail completes in July 2007.

The sector produced small quantities of seed during the first year of establishment. However, following that year seed production could not be obtained due to the compounding nature of problems with Lucerne seed production. During the second year of observations, the seed production could have been hampered by pollination failure. Basically the flowering and pod formation took place perfectly but the seed setting was poor. It could have been due to pollination problem as the anther and stigma is totally covered by the curved petal that emerges from the centre of the flower. The pollinating insects fail to open the anther and stigma for pollination. It is now planned to try pollinating with bees on trial basis. Other factors hindering seed production were beyond our control. Besides, seeking expertise on Lucerne seed production methods from Australia could be of help.

3.1.4 Seed production trial of Brachiaria and Paspalum

The objective was to observe the performance of *Brachiaria brizantha* and *Paspalum atratum* for seed production potentials under different Bajo's conditions. It was a single plot design with $100m^2$ plot size. The trial was established on June 15, 2004 and it is a five years trial.

The seed production is in progress. The sector produced 7 kg of seed from *Paspalum atratum* during the first year of establishment. The seed production of *Paspalum* is relatively easy compared to *Brachiaria*. Seed production of *Brachiaria* is difficult because the seed setting and maturing takes place perfectly well but the collection of seed is very difficult. The difficulty is that the seeds either drop or shatter on maturing and while harvesting. To avoid seed drop, alternative like early harvesting was also tried but the quality of seed was very poor.

3.1.5 Evaluation of temperate grass and legume fodder species

The objective of this trial was to evaluate persistence and production potentials of temperate grass and legumes over seasons. It is a nationally coordinated trial replicated across the regions by all RCs. The trial was established under Bajo station conditions in a single plot of $6m^2$ with 0.5m between plots. Sowing was done through broadcast method with SSP application @ 240gm per plot at the time of sowing and in spring the following years till the trial completes. The trial needs weeds control in the initial stages of growth. The trial was established in June 2006 and completes by June 2009.

Soil samples were collected before setting the trial for analysis of N, P, K and pH. The germination and vigour were recorded at 30 and 60 days of sowing. Germination count using $0.25m^2$ quadrants on 30 days was 20, 8, 5 and 10 for Demeter, Prosper, Sardi 7 and Phalaris respectively. The visual rating for vigour was poor. Disease incidences were also observed from time to time.

3.1.6 Germplasm evaluation of temperate fodder species

The objective of this trial was to evaluate temperate and subtropical fodder species at selected sites. The main species under test are Lucerne (SARDI 7), Phalaris (Sirosa), and Tall fescue (Demeter and Prosper). The trial was a single plot design with $4m^2$ and 0.5m between plots. The trial was established in April, 2006. Fertiliser rate of 160 g/plot was applied during establishment. It is a 3 years trial, to be completed in 2009. The germination and vigour were recorded excellent for all the four treatments.

The initial objectives of this trial were superseded by Evaluation of Indian Lucerne varieties trial. Therefore, this trial will be maintained and studied for seed production possibilities only.

3.1.7 Evaluation of Lucerne varieties

The objective of the trial was to evaluate potential of selected Lucerne varieties at different sites. It is a nationally coordinated trial stationed in Mithun. The trial was established in May 2006 and completes by May 2010. The design of the trial is RCBD with three replicates. The treatments include Kaituna, Venus, PL55, WL414, Aurora, SA 35076, SARBU 1 and SARBU 2. The plot size was $6m^2$ with 20 cm between rows and 0.5m between plots and 1 m between reps. SSP @ $40g/m^2$ was applied during establishment and will be applied in spring in the following years. The trial needs weed control from time to time.

The initial observation for germination and vigour after 30 and 60 was completed. The persistence will be measured in spring. The pest and diseases will be recorded at all stages. The trial will be assessed for its fresh and dry matter yield.

3.1.8 Evaluation of Indian Lucerne varieties

The rationale of this trial was that the nationwide germplasm studies over the last decade resulted in release of the Lucerne variety Eureka only. Due to seed production constraint of Eureka, seeds were imported from Australia to meet domestic needs. Of late, Australia had stopped producing seeds of Eureka. This suggests the need to identify alternative variety to Eureka, thus a need to test additional varieties.

The objectives of the trial was to evaluate persistence and production potential of Lucerne varieties over different seasons. The long term objective was to select suitable Lucerne varieties for Bhutanese conditions.

It is a nationally coordinated trial established in May 2006 at Bajo and Mithun. The treatments were PV-18, T-H-P, T-9, Comp 5, Perf-pv and Lucerne 1303. The plot size was 5m2 with 0.5 m between plots and 0.7 m between reps. The control of weeds in the initial stages of growth and the cutting height of 10cm above ground level would be maintained. The persistence and visual vigour rating after 30 days of germination for Bajo and Mithun were as presented in Table 44. The germination count and vigour result of Bajo was better compared to Mithun.

Table 44: Germination and vigour rating

Treatments	Average germination count		Vigour	
	Bajo	Mithun	Bajo	Mithun
T1	29	22	3	2
T2	43	35	2	2
T3	31	28	3	2
T4	36	32	3	2
T5	38	40	2	2
T6	51	48	2	2

3.1.9 Oat germplasm

The livestock sector had received 22 Oat cultivars from RC Yisipang which was received from TAPAFON based in ICIMOD, Nepal. Since the seeds were getting old and losing viability, the sector had sown the seeds in small plots of $2m^2$ to multiply and keep the seed stock. The seeds would be maintained strictly for trial purpose and multiplication but not for release and renaming. Out of 22 cultivars, 7 cultivars were heavily affected by rust, rest of the 13 cultivars produced seed yield ranging from 0.1 to 2.1 kg (Table 45). These cultivars of oat seemed to be performing well under Bajo's conditions. However, it will be tried for few more years to confirm its performance and potential. The period of maturity ranges from 169 days to 204 for Oats and 221 days for Rye under Bajo's conditions.

The sector also produced about 40 Kg of Stempede Oat seeds. It was multiplied from 0.5 kg of seed received form RC Jakar in 2004.

Table 45: Oat germplasm yields

Cultivar	Origin	Seed Qty.	Sowing date	Harvest date	Mat. period (days)	Yield (Kg)
Caraville	Nepal	500	13.10.05	5.5.06	204	1.4
Taiko	Nepal	500		5.5.06	204	1.5
Canadian	Nepal	500		13.4.06	169	2.1
PD2-LV 65	Pakistan	500		5.5.06	204	1.7
Cuscade	Pakistan	500		13.4.06	169	0.7
S-2000	Pakistan	500		13.4.06	169	1.3
NZ Stampede	NZ	500		5.5.06	204	1.9
NZ 1001	NZ	500		5.5.06	204	0.9
NZ 9217604	NZ	500		5.5.06	204	1.4
NZ 0034	NZ	500		5.5.06	204	1.2
Hebei province	China	250		-		affected by rust
Inner Mongolia	China	250		-		affected by rust
AC Juniper	Canada	500		13.4.06	169	0.6
AC Morgan	Canada	500		-		affected by rust
Murphy	Canada	500		-		affected by rust
Jasper	Canada	500		-		affected by rust
Footfill	Canada	500		13.4.06	169	0.3
Walden	Canada	500		-		affected by rust
AC Mustang	Canada	500		-		affected by rust

FOB	Bhutan	500	13.4.06	169	0.05
Naked	Bhutan	250	13.4.06	169	0.1
Rye (Secale cereale)	Bhutan	250	22.5.06	221	0.8

3.1.10 Napier propagation and distribution

The main objective of propagating Napier on-station was to produce sufficient root slips for distribution to any demanding farmers for fodder production and our own clients in the Agriculture sector for soil erosion control through land management campaigns they organise in different Dzongkhags. The preference for Napier is attributed to its fast growing nature and high biomass production potentials. During 2005 alone, more than 20000 Napier slips were distributed. The demand included both for fodder production and degraded farmland rehabilitation work in Salamjee, Dagana and Ritcha, Punakha.

3.1.11 Live Fodder Herbarium

The live fodder herbarium maintained on-station was established in 2001 with 18 legumes, 26 grasses and 6 hedge legumes. The main objective of developing this herbarium was to showcase the species to visitors like farmer study group from different Dzongkhags, students, extension agents, and consultants. The other advantage of having this live fodder herbarium is to make available basic planting materials and seeds that would be required for propagation and multiplication on-farm, for fodder development, soil stabilization on the sloping agriculture land, for bio-engineering works and land campaigns.

Live fodder herbarium development and fodder nursery shed construction in Mithun was completed in May 2006. The objective of setting a herbarium in Mithun was also for showcasing and making available basic planting materials and seeds for the farmers in Tsirang and Dagana. The fodder herbarium was developed with whatever planting materials the sector is maintaining at Bajo. The herbarium developed in Mithun would also demonstrate farmers on how to develop pasture. The first thing that led to the development of herbarium and fodder nursery was to develop the research land in Mithun left uncultivated for many years. Secondly, after the Sub-Centre was reopened in 2005 and there was also a request from the Dzongkhag Livestock Sector to start fodder research works at Mithun since livestock has greater potentials in the Dzongkhag. Therefore, to revive the centre and develop the site the livestock sector established fodder trials, herbarium and constructed a nursery shed.

3.1.12 Grassland monitoring trial in Laya

The immediate objective of this activity was to describe the natural grassland, identification of grass and legume species and to establish a live herbarium. The long-term objective was to monitor trends in production, soil quality, population composition and nutritive value and finally to draw long term natural grassland management strategy and action plan. Only the soil nutrient analysis of the fifth year is reported here.

3.1.13 Soil nutrient analysis

The 20 soil samples each from a depth of 0-10 cm and 10-20 cm were collected during the 5th year of monitoring. A total of 120 soil samples weighing about a kilogram were brought from four different locations at heights ranging from 3000-5000 masl. The soil samples were sent to SPAL for soil nutrient analysis and their results described below.

Site 1: Tsa eko

Topsoil: 0-10cm depth: The overall soil fertility status at Tsa eko was fairly good except for few soil variable values. For all the samples the soil pH fall within very low to low and the available P is very low. Both nitrogen and organic matter percent are within high to very high range. 45% of the samples had very low available K, 40% have moderated and 10% have very high available K content. Of the total, 55% of the samples have exchangeable Ca within very low to low while 45% have moderate to high. Exchangeable Mg falls within very low to low range and exchangeable K is within moderate to high range. All samples showed very low exchangeable Na. Trace elements ranged between very low to moderate. 60% of the samples had moderate CEC while 40% high CEC. Percent base saturation is very low for all the samples. The site soil texture is mostly sandy loam.

Subsoil: 10-20cm depth: Soil sample analysis results did not show much difference in soil nutrient status between the samples collected from 0-10cm depths and 10-20cm depths for this site. All the soil chemical properties have almost same values.

Site 2: Sochung

Topsoil: 0-10cm depth: Soil sample analyses results from Sochung showed that the soil pH falls within low range (4.6 – 5.5). The available P content was very low for all the samples while percentage of organic matter and nitrogen was very high. All the samples have moderate to high available K while exchangeable Ca falls within low to moderate. Exchangeable Mg is within low range and exchangeable K falls within high range. All samples have very low exchangeable Na with low to moderate trace element content. Both cation exchange capacity and percentage of base saturation fall with moderate for all the samples. The site soil texture is sandy loam.

Subsoil: 10-20cm depth: The sub soil sample analyses results revealed that except for soil pH, exchangeable Mg, and exchangeable K, the values of other soil variables remained the same as that of the top soil chemical properties. For the sub soil, the pH was moderate while the top soils had low pH. The exchangeable Mg was within very low range and the exchangeable K was moderate. The soil texture was more of clayey-loam for the sub soil samples.

Site 2: Kuchugo

Topsoil: 0-10cm depth: At Kuchugo the topsoil sample analysis showed that 65% of the samples had very low to low soil pH while only 35% had moderate soil pH. All the samples had very low available P while percent organic matter content was very high. 45% of the samples had low percent nitrogen and 65% had moderate. Available K was within very low to low for all the samples while 45% of the samples had very low to low exchangeable Ca, 30% samples with moderate and 35% had high exchangeable Ca

content. Both exchangeable Mg and K were low to moderate range while exchangeable Na was very low for all the samples. 55% of the samples had low trace element content and 45% had high content. Of the total 30% of the sample had high CEC, 15% had moderate and 55% had low. Percent base saturation was with low to moderate range for all the samples. Site soil texture is sandy-loam.

Subsoil: 10-20cm depth: The subsoil sample analysis revealed that except for soil pH and available K, there was not much difference in soil properties between top soil and sub soil. The results indicate that soil pH was little bit higher in the sub soil compared to the pH of top soil. Most samples showed decreasing available K in the sub soil and the soil texture was more of loamy-sand in the sub soil.

Site 4: Kuchoyachey

Topsoil: 0-10cm depth: Sample analyses results from Kuchoyachey showed that all the samples had low soil pH (4.6 – 5.5). The available P was very low, less that 5ppm and the percent organic matter was very high for all the samples. Percent nitrogen was within moderate range while the available K ranges between moderate to high. Exchangeable Ca was within low to moderate. All samples had low exchangeable Mg with high exchangeable K and very low exchangeable Na. Trace elements ranged between low to moderate while CEC for all samples was moderate. 60% of the samples had low percent base saturation and 40% have moderate. Site soil texture was sandy-loam.

Topsoil (0-10cm depth): For the subsoil the sample analysis results except for soil pH, exchangeable Mg, and K, the status of other soil chemical properties were same as that of the top soil. For the sub soil the soil pH was moderate while for the top soil was within low range. Both exchangeable Mg and K were within very low. Soil texture was more of clayey loam for the subsoil.

The detail report will be produced on completion of second round of soils analysis results in 2010. The next soil nutrient analysis will be done during the last year of trial monitoring in 2010.

3.1.14 Rehabilitation of degraded farmland in Salamjee, Dagana

The objective of this farmland management work in Salamjee was to study the effect of soil erosion and surface run-off control through plantation of different fodder grass and legume species on the contour bunds. It was a multi-stakeholder team approach comprising of researchers, Dzongkhag extension, Donor and the community in rehabilitating degraded farmland in Salamjee under Dagana dzongkhag.

About 2 acres of farmland which was highly critical and prone to soil erosion, landslides and gully erosion were selected for hands-on-training for the community comprising of 16 households in March 2006. The promising species suitable for both binding soils and fodder potentials were planted along the contour strips to reinforce the contour terrace bunds and reduce the surface run-off. The fodder species like *Paspalum*, *Vetiber*, Napier, Lucerne, *Desmanthus*, *Leucaena* were tried. Within three months time after plantation, Paspalum, Napier and Vetiber had shown satisfactory growth. Lucerne, *Desmanthus* and

Leucaena were also growing fairly well. However, for quicker results, *Paspalum*, Napier and Vetiber worked miracle. The roots were already strong enough to accumulate and bind top-soils from surface run-off. This site was well selected within the intention to serve as a demonstration site for the community to continue with remaining works on their own. Additionally, the community would benefit from this site providing them with live planting materials and seeds. To start the work and provide hands-on-training to the community, the sector had taken about 200 Napier root slips, 100 *Vetiber* slips, 100 *Paspalum* slips, and small quantities of *Paspalum*, *Desmanthus*, Lucerne and *Leucaena* seeds. The initial efforts of rehabilitating the small patch of degraded farmland had already created visible impact and community's compliments.

3.2 Breeding and Management Research

3.2.1 Yak herd monitoring

Yak herding is a part of Bhutanese tradition in the high altitude alpine landscape. It plays an increasingly significant role in both agro and ecotourism in the country. The pressure of socioeconomic changes is going to impact on the life of the herders. A yak herd monitoring scheme was planned and started as a nationwide study in the yak rearing areas of the country. The short-term objective of the study was to quantify changes in the socio-economics of the herders over time. It was also intended to generate input for planning yak related research and development on the livelihood of the herders like rural-urban migration. The long-term objective was to sensitise the members under the scheme to become innovative yak herders in initiating various groups such as Yak bull breeders group, pack yak association, organic yak meat production, yak herders eco-tourism, yak cheese processing, packaging and marketing group and to contribute to livelihood development methodology applicable in the alpine mountain eco-systems.

The study for this region was first started in March 2004 with ten herders in Sephu geog under Wangdue Dzongkhag. The scheme will complete in March 2014. With this year, three regular monitoring have been completed. This report entails mostly herd status of the third year.

Herd compositions

The 10 herders had an average of 27 yaks. In a herd, *Pangyak* accounts for 23% of the total herd, lactating 21%, dry 16%, calves and young female of 10.5% each, young male 6% and bull 1% of individual herd. The third year of yak herd monitoring data revealed the herd composition as indicated in the Table 46 below:

Table 46: Herd composition of 10 herds in 2005

Composition	No of heads	Percentage
Castrates *(Pangyak)*	63	23
Lactating *(Ochu)*	56	21
Dry *(Kaam)*/ Pregnants	43	16
Female calves < 1 yr *(Yakhum)*	32	12
Young female 1-3 yr *(Simchu)*	28	10.5
Male calves <1 yr *(Yakhu)*	28	10.5
Young male 1-3 yr *(Sichu)*	17	06

Bull *(Bjul)*	3	01
Total	266	100

Pregnancy and birth

The normal age at which female attains age at first service was about 4 years with inter-calving calving period ranging from 1-5 years. The dry yaks for these yak herders mean the females that were pregnant at the time of monitoring this scheme (i.e. March-May). Therefore, 16% of the herd remains dry which are pregnant at that time of the year.

Mortality

The most common causes of mortality were predation by wild animals mostly leopards, fall-off from the cliff, debility, loss from the grazing sites, death due to old age, theft, birth problem, old age, road accident and water poisoning.

The mortality of castrates was highest with 22%, followed by calves and lactating 20% each and dry 18%. This confers an average estimate of 20% mortality in the herd which is quite a high rate and needs special attention to reduce it. The 20% mortality would mean on an average 5 yaks die per herd every year. This for those resource poor herders was a big annual economic loss. If the mortality of this nature continues, the yak population in Bhutan would suffer threat of population decline. This was a genuine problem of the herders that might require management adjustment and preventive intervention. This problem would be further compounded with fodder shortages which greatly upshot mortality in winter especially.

During 2005 alone, 59% of mortality due to predation was the highest, followed by 24% lost from the grazing sites, debility and birth problem accounted for 4%, 3% mortality resulting from old age and falls from cliff and road accident and sinks in the pond came as high as 2% (Table 47 and Table 48).

Table 47: Mortality in 2005

Category	No	Percentage
Castrates	12	22
Male calves	11	20
Female calves	11	20
Lactating	11	20
Dry	10	18
Total	55	100

Table 48: Causes of mortality in 2005

Causes	No	Percentage
Predation	32	59
Lost	13	24
Debility	2	4
Birth problem	2	4
Old age	2	3
Fall	1	3

Accident	1	2
Sink	1	2
Total	54	100

Yak products marketed

In 2005, various yak products worth of Nu. 11,280 were sold (Table 49). The products sold did not include products consumed at home. Besides the consumable items (cheese, butter, meat), other non-consumable items like raincoat (*charkaap*), blanket (*chomdra*) and kira (*Taja*) traditionally woven cloths out of yak hair were also sold. For hard and soft cheese, their main market was Phuntsholing and Jaigaon, India. Rest of the items was sold mostly in the locality and Dzongkhag town.

Table 49: Yak products marketed in 2005

Products	Unit	Quantity	Price	Amount (Nu)
Hard cheese	Kg	20	45	900
Milk cheese	Garland	194	20	3880
Butter	Sang	20	200	400
Yak meat	Kg	75	200	1500
Rain coat *(Char Kaap)*	No	3	1000	3000
Blanket *(Chomdra)*	No	1	600	600
Kira *(Taja)*	No	1	1000	1000
			Total	11280

3.2.2 Economics of goat rearing in the selected districts of Bhutan

As of now, no research and development activities have been undertaken on goats and economic importance of goat is largely unknown. Need was felt by research and extension to document economics of goat husbandry comparing it with other livestock that are popularly reared like cattle. Therefore, this study aimed to improve the understanding on the economic importance of goats, document to make wider audience and policy makers aware on the role goats play in the farming systems and suggest policy changes if necessary.

The study was carried out and completed in May 2006 in the selected districts of Bhutan mostly in the southern Dzonkhags where goat rearing is common. It was a nationally coordinated activity jointly planned and carried by all RCs in their respective region. The study was carried out in Betini geog of Tsirang dzongkhag and Goshi geog of Dagana dzongkhag.

Picture 35: Stall-fed goats in Tsirang

The sample size of 10 households per geog per dzongkhag focussing the major goat rearing areas was carried out. The 20 households sample survey data revealed that on an

average a flock size of 6 heads per household was most commonly reared by the farmers in the goat gearing areas. The flock composition comprise of adult, young stock and kids as classified in Table 50. Therefore, to strictly maintain a flock size of 4 is very difficult unless only males are reared. Since the farmers need to keep renewing their flock, inclusion of female in the flock is important. So by keeping females in the flock would definitely increase the flock size. Moreover, farmers rear goat strictly for income sake, the flock needs to increase, cull and then sell. The income they generate from goat was small due to small flock size. Therefore, looking from farmers' perspective of income gain from goat raising the flexibility of increasing the flock size up to 10 requires policy support.

Reproduction and management

Most goats are seasonal breeders reacting to shorter day length as a cue for breeding and the need to be stimulated by the presence of males to begin cycling. However, farmers reported breeding usually occurs in the summer and less in winter. The kidding follows 150 days later after mating. Twining is the most common nature of kidding in female goats. One kid crop in a year was common but there were exceptional goats that produce two kid crops a year. The age at first kidding ranges from 12-18 months of age and a kidding interval of 6-12 months. The genetic potential for faster growth with productivity of goats and the goal for reproductive prolificacy (200 % kidding rate per year) were the main merchandisable factors for raising goat as revealed by the goat raisers in Tsirang and Dagana.

The kids reared naturally with their mothers usually grow better than those weaned or bottle fed. In fact kids were raised better as replacement stock, sold for breeding stock, or fattened for meat. Castrations of males were carried out locally at an early age to reduce the stress of the lactating does. Males sold or slaughtered were castrated since meat may have strong flavour intact in it. Shelters were provided by all goat rearing farmers to protect goats from wet and cold chills. About 99 % farmers stall-feed and 1% tether to rear goats due to policy restriction of free-grazing.

A flock comprises of adult doe and buck, billy, nanny and kid. The 20 survey samples data revealed the highest flock of adult does of 34%, followed by 16% of male kids, 14% castrates, 13% female kids, 11% adult buck and about 2-6% of young stock male and female and pregnant doe (Table 50.

Table 50: Flock composition

Composition	No	%
adult doe	40	34
adult buck	13	11
castrate	17	14
pregnant doe	2	2
Young stock- male	6	5
Young stock-female	4	3
Kid- male	19	16
Kid- female	15	13
Total	119	100
Average / hh	5.95	

Marketing

There is currently a strong and increasing demand for goat meat. Goat meat is selling well in the market today. Goat meat, which is 50-65% leaner than beef was the primary product and rest an important secondary one. The *chevon* is considered a gourmet or appealing health food by many health-conscious consumers which are derived purely of plant origin into a perfect and most preferred food for human consumption.

In addition to sales at the farm gate, there are several channels for marketing goats both live and meat. These include private buyers, sales to restaurants and by the owners themselves and through middleman. The farm gate price for live goat was based on live weight which ranges between Nu 400 for a weaned kid to 4500 for a well-built and matured castrate. This was the most convenient way to market their goats.

Private buyers come to the farm or deliver to the desired location through middleman. The middleman would resell the animals live or dressed to consumers. The bargaining skills of the middleman would be an asset in this type of transaction. As revealed by the goat raisers, the peak demands for goat meat occur during festivals, marriage and religious ceremonies.

Profitability of rearing four goats

The simple economic analysis was done for only 4 goats since that is the optimum number Govt. policy allows. However to compare the economic benefits based on the stocking rate, 6 adult goats equal one cow.

The return during the first year of operation with 4 goats gave a net profit of Nu. 2000 after paying back the money borrowed with interest. On including the stock balance of 3 does gave Nu. 5600. A net return of Nu. 7000 can be obtained from the year 2-8 accounting the productive life of females up to 8 years (Table 51).

The economics of goat farming will be compared with other livestock farming especially cattle once all RCs complete with larger survey samples. RC Jakar will produce the detail report. The mortality of a goat is not included for economic analysis as the survey data revealed that the mortality was less than 1 goat. Therefore it is neglected for calculation.

Table 51: Annual enterprise profitability of rearing 4 goats

Input	Quantity	Unit	Rate	Amt.	Yr 1	Yr 2-8
A. Total fixed costs						
purchase of kids	4	no	500	2000	2000	500
construction of shed	1	no	1000	1000	1000	0
purchase of utensils	4	no	50	200	200	0
purchase of rope	4	m	5	25	100	100
depreciation of shed (5 %/ annum)			0	0	0	50
maintenance of shed (10 % / annum)			0	0	0	100

Contingency of total operating costs (5 %)			0	0	0	50
Interest on working capital (10 %)			0	0	0	200
Total, Nu.				3225	3300	1000
B. Total variable costs						
Feeds (maize hulls, rice bran, salt)	150	kg	5	750	750	750
Fodder collection (20 kg/day)		Nu/hr	10	10	547	547
Feed preparation (0.5 kg /4 goat/day)		Nu/hr	2	22	22	22
Medicine /vaccine (free of costs)		Nu.	0	0	0	0
Mortality (nil)		no	0	0	0	0
Miscellaneous exp			0	100	100	100
Total variable costs, Nu.					**1419**	1419
C. Total cost (A+B)					4719	2419
D. Value of production (Gross benefit)						
Total goat – 4 (3 female + 1 male)						
Sale of meat	15	kg	150	2250	2250	3000
Sale of live goat	6	no	1000	6000	6000	6000
Manure	365	kg	2	730	730	730
Stock balance	3	no	1200	3600	3600	3600
Total gross benefit, Nu.					12580	13330
E. Net benefits Nu. (D-C)					7861	10911
F. Principal and Interest					2200	0
G. Balance after paying working capital with stock balance (3 does)					5661	0
H. Net Return					2061	7311

The price per kilogram of chevon ranges from Nu. 100-150 in the rural areas and localities and Nu. 180 in the urban towns. It was the most preferred meat in the market today though its supply in the market was constrained due to policy restriction not allowing the goat raisers to rear more than 4 goats. Even for buying a goat, be it for meat or for rearing, the cost of a goat was determined by the live weight and the prevailing market price of chevon.

Farmer's opinion/suggestion on present goat farming
All 20 farmers interviewed resorted to make the following suggestion on the development of goat farming for greater economic benefits.

- Prefer new breed with faster growth rate, prolific and relatively larger body size
- Need training on improved management practices of goat raising
- Policy support to rear up to 10 goats
- Cross breeding of local goat with other Indian goat breed of hybrid vigour for larger body size, faster growth rate and higher prolificacy.

3.2.3 Performances study of the exotic breeding boars under improved and traditional housing

Nabchey has been identified as the focus village in the watershed by the research centre to initiate research activities that contributes directly in enhancing the household income of the farmers. The pig farming in Nabchhey was the emergent livestock activity from the past with lot of money making opportunities. It was still a major thrust for this focus village. The livestock sector explored the possibilities and the areas of intervention that will help farmers with the help of the geog livestock staff to enhance household income.

As this village had ample experiences in rearing pigs for their sustenance as well a viable option of income generation, the RC felt pertinent to scale up present pig production in this community. There are total of 22 households in Nabchhey, out of which 21 households own and rear pigs of their preference both for meat and piglet production ranging from 1-6 numbers. On an average, there were more than 2 pigs per household totalling to 44 heads from 21 households. At least, 1 to 6 pigs were found reared by the community. These pigs were reared in a traditional housing and feeding system using locally available housing materials and feed resources. Among different management factors, proper housing plays an important role in overall growth and performance of pig.

Till date the effect of different housings on the production and reproduction performance of breeding boar supplied to farmers was not documented. As a first attempt, research felt that it was timely to harvest the information on this aspect that would help in providing technical guidance to planners, policy makers and the pig breeding program within the Ministry.

The objectives were to determine the production and reproduction performances of exotic breeding boars under improved and traditional housing systems to enhance family income and develop group cohesion for sustenance of piggery enterprise.

Experimental design and recording
The experiment was basically to study the effect of improved housing versus traditional housing on the performances of breeding boars. The Dzongkhag livestock sector had procured three exotic boars from Serbithang for the community. The technical housing design and construction of two improved houses were supported by RC Bajo for a cost of Nu 40,000.

Two out of three boars were placed in the improved housing and one in the traditional housing itself. The performance of the breeding boars placed in the improved housing would be compared to the one that was placed in the traditional housing as a control. The feeds consist of traditional feeds locally available at their homes.

The improved housing design for the two exotic boars was looked from different perspectives to serve as model house for pigs of all categories. For a single boar, it served as a house cum exercise yard the breeding boars especially require to avoid fattening. Besides merely comparing the performances among breeding boars, observation on pathological (recording incidences of sickness, lameness, injuries) and physiological (body conditions) measures and effect of housing type on cleanliness or dirtiness of boars will be compared to all pigs in general reared in a traditional housing system newly designed by researchers for Nabchhey pigs. The service rate and progeny born per male would be an important factor to assess the performances to improved housing effectiveness. The research studies on all these aspects would be to assess both the efficiencies of improved housing and performances of the breeding boars at the end.

Performances of breeding boars

A total of 57 piglets were borne from 2 boars consisting of 14 male and 28 females, 13 piglets were found sold. Boar No.2 alone had 43 progenies and Boar No. 3 had 14 (Table 52). Boar No.1 had no progeny born due to poor health after it was handed over to the caretaker. Though the health had improved but it may not be worth keeping for breeding, so the EA was advised to castrate it for fattening and replace with a new boar from the sale of that boar. The performance of 2 boars was found good so far. Within less than a year 57 piglets were born which indicates good performance. There were 86 pigs in Nabchhey which was an average of four pigs per household.

Table 52: Progeny borne result

Boar No.	male	female	sold	Total
2	10	20	13	43
3	04	08	00	14
Total	14	28	13	57

3.2.4 Bee Keeping at Bajo

The main objective of keeping bees at Bajo was to study feasibility and honey production potentials of *Apis mellifera.*

In the beginning of 2005, there were two nucleus colonies revived after first two colonies got wiped off due to logistic and management problems. The two nucleus colonies were performing well early summer. The hive population of bees multiplied tremendously. However, honey harvest could not be done as the colonies were developing during the time of honey flow (early spring to mid summer) in Bajo. The amount of honey whatever produced were left for the bees as the harvest time coincided with monsoon. The honey was not harvested in monsoon because the bees do not go for foraging in search of

nectar and pollen in the rain. During such times, the bees remain inside the colonies and depend on available stock of honey and pollen as food both for adult and broods.

Right after this season was the fall of winter in Bajo. Starting winter in Bajo, hornets started to appear in the holes and cracked portion of earth. During that year, the hornet started to attack bees starting early winter till fall of spring. The measures like guarding the bees, relocating the hives and sealing the entrance were tried, despite all our efforts bees fell easy prey to hornets. The pest like hornet is a big enemy threat to bees though honey production potential is high in Bajo. Some literature says 30 giant hornets can kill 30,000 bees in just 3 hours.

In spite of the threat from hornet, the sector had revived one nucleus again with 2 frames of bees with broods without queen in April 2006. The bees had successfully produced a queen on their own with in a month time. The bees were further divided and made one nucleus colony with out queen and placed in the Lucerne seed production plot by June end to observe bees more as pollinators for Lucerne then honey producers if the menace like predation from hornets and robbing from local bees could be controlled.

FORESTRY RESEARCH

4 FORESTRY

Forestry research program of the centre work in close collaboration with the forest research coordinating centre, RNR-RC, Yusipang; the activities are guided by the national priorities under different sub programs including NWFPs/NTFPs.

4.1 Nursery

The evaluation of multipurpose tree species (MPTS) is ongoing in the mini agro-forestry nursery on station. The selection of species for the evaluation purpose is purely based on the importance and demand for particular species by the public[7]. The priority is mainly for native species with multiple uses that can be found or grown in the homesteads of our clients, though we also conduct trials for certain exotic species as well. [8]

While conducting the trials related to seed and seedlings, we focus mainly on the technical aspects such as seed collection and selection, extraction, soaking, sowing, watering, so on so forth to planting out in the field. This doesn't mean that all aspects are thoroughly studied in all the species because all species do not show same problem. For example, *Ficus roxburghii* seeds are difficult to extract from the figs thus study on seed extraction methods are conducted, while *Simplocus paniculata* seeds do not germinate[9] under normal method of sowing thus different levels of seed stratification and treatment are studied. Basically we use two different types of propagation methods i.e. through seed and by vegetative cuttings (root/shoot/branch/stem/nodes) or rhizomes. The former is used for seed bearing important agro-forest species, while the 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 in the communities.

Though multipurpose tree species evaluation is an on-going activity, some trial have already been terminated for which results are published as extension pamphlets while some more are ready for publications (Table 53). However, it may be noted here that those trials might not have covered all the aspects therefore the specie(s) may again feature in future in any form of publication with updates on earlier aspects or with some other aspects that was not covered in the past.

We also keep seedling stock for purposes other than research i.e. for supply to our clients, for plantation during Social Forestry day celebration and to supplement regional Dzongkhags' needs. Hence we have stock of following species in our nursery (Table 54).

4.1.1 Agroforestry Nursery

The evaluation of MPTS is ongoing in the mini-agroforestry nursery on-station. The species are selected for evaluation taking in consideration the farmer's suggestion of

[7] Any floral species that farmers prefer for certain purpose
[8] Especially the avenue species
[9] Germination success of this important species is a break through

important tree species used in their day to day life. The consideration is mainly taken on the diverse use of our native trees that can be found and grown in our homesteads. In the nursery, technical focused is given on the propagation techniques, raising seedlings, nursery management, and also field plantation. Basically we use two different types of propagation methods i.e. through seed and by vegetative cuttings or rhizomes. Sometimes both the methods are also tried for species which have economic importance in the communities.

Table 53: List of species for which trial is terminated and results published or going to publish soon

Species	Family	Results
Thysanolenea latifolia	Graminea	Extension pamphlets produced
Cupressuss corneyana	Cupressaceae	Extension pamphlets produced
Symplocos paniculata	Symplocaceae	Extension pamphlets produced
Ficus roxburghii	Moraceae	Extension pamphlets produced
Ficus bengalensis	Moraceae	Extension pamphlets produced
Benthamedia capitata	Cornaceae	Extension pamphlets produced

Table 54: List of species for available seedling stocks

Species	Vernacular Name	Family
Ficus religiosa	Jangchu shing Dz.	Moraceae
Ficus benghalensis	Baar Lh.	
Ficus roxburghii	Baku shing Dz.	
Ficus cunia	Khaneu(Lh)	
Morus australis	Sanu Kimbu Lh.	
Sapindus rarak	Nakupaney shing Dz.	Sapindaceae
Dodonaea angustifolia	Dodonaea Co.	
Phyllanthus emblica	Omla shing Dz.	Euphorbiaceae
Callistemon citrinus	Red Bottle Brush Co.	Myrtaceae
Syzygium cumini	Nyasse shing Dz.	Sterculiaceae
Rosa hybrida	Hedge	Rosaceae
Sterculia villosa	Odhal(Lh) Phrang shing(Sh)	Sterculiaceae
Terminalia bellirica	Baru(Dz) Barra(Lh)	Combretaceae
Prunus cerasoides	Wild cherry(Eng)Paiyun(Lh)	Rosaceae
Dendrocalamus spp	Pakshi(Dz)	Gramineae

Diploknema butyraceae	Yeka(Dz) Churi(Lh)	Sapotaceae
Tetradium fraxinifolium	Khanakpa(Lh)	
Quercus glauca	Thorm shing(Dz) Phalat(Lh)	Fagaceae
Quercus grifithii	Sisishing(Dz) Khasru(Lh)	Fagaceae
Benthamedia capitata	Phetshu(Dz) Duckwood(Eng) Ramkatar(Lh)	Cornaceae
Symplocos paniculata	Pantchi(Dz)	Symplocaceae
Bahunia purpurea	Taki(Lh) Pegpeyposhing(Sh)	Leguminosae
Acacia catechu	Khair(Com)	Leguminosae
Flamengia macrophylla	Hedge(Exotic)	Leguminosae
Cupressus corneyana	Tshenden(Dz) Dhupi(Lh) Cypruss(Eng)	Cupressaceae
Oroxylum indicum	Tshampaka shing(Dz) Totola(Lh)	Bignoniaceae
Erithrina arboresens	Chaseshing (Dz) Phaledo (Lh)	Leguminosae
Quercus glauca	Thomshing (Dz) Phlant (Lh)	Fagaceae
Quercus griffithii	Sisishing (Dz)	Fagaceae
Castonopsis species	Sokeyshing (Dz)	Fagaceae

The studies in the on-station nursery in the centre is now diversified with the inclusion of the species that have basic uses such as wild fruits with commercial value, and the tuber crops like tapioca and other medicinal plants.

4.1.2 On-Station Mini Arboretum

With the increasing visitors in the research center from the farm communities, trainees and also the students from different parts of the country, we have started to maintain a mini arboretum to demonstrate different species of valuable trees that are used in our day to day life either in the form of a timber or non wood forest products like fodder, fuel wood, ornamental, edible fruits, and medicines. The other primary objective of maintaining this arboretum is to assess growth parameters of the different multi purpose tree species at the station. At present there are about 17 different species and 29 numbers of plants planted in the arboretum (Table 55). The data for the growth parameters for first year is being collected and maintained in the database.

Table 55: List of MPTS species planted& evaluated in the arboretum

Botanical Name	Local Name	Family	Uses
Syzygium cumini	Jamuna/Nyatshe	Myrtaceae	Timber,fuelwood,edible fruits
Diploknema butyraceae	Cheuri/Yeka	Sapotaceae	Ediblefruits, fuelwood, fodder
Docynia indica	Mail/leetong	Rosaceae	Edible fruits,medicine
Morus australis	Sano kimbu	Moraceae	Edible berries,fodder
Phylanthus emblica	Amala/Omla	Euphorbiaceae	Medicine,fuelwood
Termenallia bellirica	Barra/Baru	Combretaceae	Medicine,timber,fuelwood
Termenallia	Harra/Aru	Combretaceae	Medicine,fodder,fuelwood

chebula			
Prunus cerasoides	Wild cherry	Rosaceae	Ornamental,timber,fruits
Acacia catechu	Khair	Leguminosae	Medicine,fuelwood
Spondias pinnata	Amaroo/Bochong	Mengiferaceae	Medicine,fodder, fuelwood,edible fruits
Symplocus paniculata	Panchi	Symplocaceae	Oilseed, fuelwood
Syzygium formusum	Ambake	Myrtaceae	Edible fruits, timber,fodder
Benthamedia capitata	Fetchi		Edible fruits,ornamental,fuelwood
Oroxylum indicum	Totola	Bignoneaceae	Medicine,fodder,religious
Sterculia villosa	Odal	Sterculiaceae	Thread fiber,fodder,edible seeds
(Tree bean, exotic)	Tree bean	Leguminoceae	Vegetable,fuelwood
Gmelina arbora	Khamari	Verbenaceae	Medicine,timber, fodder

4.1.3 Salamjee Farmland Rehabilitation

With the focus on farmland degradation due to natural calamities in salamjee village under Dagana Dzongkhag, the multidisciplinary team approach for the rehabilitation and sustainable use of their sloppy farmland was initiated from the research center since 2005. In this project individual sectors are actively involved in planning, implementing and monitoring of the ongoing rehabilitation program. The diagnostic survey was conducted and the report was produced and as per the need a work plan with the community was developed and implementation of various activities was started. The sourcing of fund support, group mobilization, agro forestry technologies and rehabilitation of the gullies and slides were some of the major activities done.

So far the activities initiated involved farmland management, group formation, hands-on training on sloppy land development through terracing, hedgerow, stonewall, MPTs plantation, intercropping with fruit trees and the use of the A-frame. Around 3 acres of degraded land was taken up coinciding with the training. There various MPT species, hedgerow species like grass and other woody perennials and also citrus are planted. The work is scheduled to be continued from September 2006 after the harvest of first maize crop when the land is free from cultivation and at the same time when farmers are free from their farm work.

Some of the research objectives are:

- Rehabilitation of degraded farmland through vegetative control measures and maintaining the sustainability in the use of sloppy agricultural land
- On-farm evaluation of promising MPTs and hedgerow species
- Increase farm produce and alleviate the poverty

- Selection of suitable agroforestry technologies for such type of sloppy agricultural land
- Documentation of the whole process involved in sustainable management of the degraded farmland

The following MPTS and hedgerow species (Table 56 and 57) have been already planted as a trial in one of the farmer's field:

Table 56: Hedgerow species including grass and woody perennials

Species	Type	Progress
Flemengia macrophylla	Woody	New sprouts coming & survived around 80%
Paspalum spp	Grass	100% survived with good growth
Vertiver spp	Grass	100% survived with good growth
Nappier spp	Grass	100% survived with good growth
Lucerne	Grass	Only few seeds germinated
Desmonthus spp	Woody	Few seeds germinated
Lucaenea leucocephala	Woody	Few seeds germinated
Guava spp	woody	Doing fairly well & around 70% still survived

Table 57: Multipurpose tree species

Species	Type	Progress
Ficus roxburghii	Woody	100 % survived & high growth rate
Ficus cunia	Woody	100 % survived & high growth rate
Diploknema butyraceae	Woody	100 % survived & high growth rate
Cupressus corneyana	Woody	90% survived & growing well
Benthamedia capitata	Woody	90% survived & growing well
Termenallia bellirica	woody	90% survived & growing well
Tectona grandis	woody	100 % survived & high growth rate
Quercus glauca	woody	100 % survived & high growth rate
Schima wallichii	woody	100 % survived & high growth rate
Acacia catechu	woody	100 % survived & high growth rate
Dendrocalamus spp	Grass	100 % survived & high growth rate
Sapipndus rarak	Woody	Doing fairly well & 70% still survived

The growth parameters for the above listed MPTs species will be assessed yearly to see its growth rate and also to screen out the promising species suitable for such type of land under that altitude and climatic zone. The performance evaluation for the different hedgerow species will also be carried out to screen suitable species.

4.1.4 Ecological effects of fire in Chir Pine forests of Nahi, Wangdue

The Forestry sector in collaboration with RC Jakar with technical input from CORET scientist has planned to establish 12 ecological plots to study the effects of fire in the Chir pine forest of the west-central region as a replication of the similar trial conducted in the east. The study is financially supported by the Bhutan Trust Fund (BTF). The main thrust for implementing such a trial is that the conservationists and the ecologists consider the fire as havoc to forest and its regeneration without considering the species adaptability

and vegetation types. While on the other hand farmers and/or the local dwellers have a history of using fire as a tool to manage their surrounding ecosystem for specific purposes viz. farmers in the east use fire in the Chir pine forest to reduce the regeneration of Chir and increase the production of lemon grass which yields essential oil and like wise farmers in the west especially Punakha-Wangdue valley use fire to improve grazing area, for wild asparagus production and to keep away crop predators.

Historically fire has played an important role in the ecosystems starting from removal/reduction of fuel load accumulation, reduction in diseases and insects attacks, stimulation of natural regeneration, critical nutrient cycling to provide diverse habitat for both floral and faunal species. In many ways, forest fires directed the evolution of ecosystems and for many cultures; those who carried or maintained fire were powerful leaders. Therefore native people throughout the world frequently used fire to alter their environment.[10] Thus the study is designed to yield answers to unclear use of fire in the Chir region in Bhutan.

Objectives
The objectives are to explore the effects of fire in Chir Pine forest ecosystems of Western-Central Bhutan with special reference to regeneration ecology of Chir Pine, the fire induced yield of various grass species for grazing and other competing ground vegetation. The study is based on experimental comparisons of treated plots and the long-term monitoring of these plots.

Hypotheses
Differences in vegetation growth and Chir pine regeneration between:

- burnt and control plots due to different nutrient content, light availability, soil moisture, soil temperature and propagule availability.
- different fire frequencies due to different effects on vegetation recovery.
- different fire intensities due to differing damage to plants and differing levels of soil modification.

Study Methods
Monitoring of vegetation on a regular basis and comparison of different treatments (intensity, frequency, control) using multivariate statistical methods.

Study area
The study area consists of uniform Chir stand along the feeder road leading to Nahi Geog. The slope is moderate to steep facing south. The site is heavily grazed during the autumn and winter seasons and the grasses revive their growth by late spring along with start of the monsoon season. The site is locally called Tshoshau.

Treated plots

Site selection
Only one site has been selected during a reconnaissance exercise conducted by SFD,

[10] Lecture note of Dr. Ronald, Montana University. USA

RC Bajo and RC Jakar in November 2005 in Nahi Geog because of heavy work load and low staff strength.

The following criteria were observed when selecting the site:

- Stand clearly dominated by Chir Pine
- Prescribed fire safety can be ensured – decision to be made by SFD
- Uniform topography
- Uniform stand and under-story composition
- Maximum one hour walk from the nearest road for logistical reasons of prescribed burning

The site is dominated by open Chir Pine forests with trees representing diameter classes up to 70 cm DBH. Openings with abundant sapling stage regeneration are present. The aspect is south with slopes ranging from 20% to 60%. Ground vegetation is dominated by the grass species mainly *Cymbopogon pendulus* and *Heteropogon contortus*, which are locally heavily grazed in the area. Organic layer depth is very low and hardly any coarse fuels are present.

Experimental design

Seasonality, frequency and intensity of fires are the most important factors that the effects of fire depend on. Due to extremely high fire hazard in most regions covered by Chir Pine, prescribed burning is not desired in the spring. Since the overall objective of the study is to determine whether prescribed burning is a suitable fire prevention method in Chir Pine forests in Bhutan and if yes, what prescribed burning regime is most appropriate, the undesired spring burning season was excluded from the experimental design. Accordingly, the study will rely on autumn burning of plots solely and not consider the factor seasonality.

Status result of the trial

We have already established eight plots out of twelve and four more needs to be established and the data needs to be collected in the following season. This is because by the time we got the right place to establish such a plot it was already late for data recording as most of the species have died back.

4.1.5 Rimchu Research Forest (long term research plot)

Rimchu Forest Management Unit under Punakha Dzongkhag has a gross total area of 212 hectares with gentle to moderately sloping topography. The forest falls in the temperate vegetation zone where the forest composition is mainly warm and cool broadleaf and the main species includes *Michelia spp., Castonopsis sp., Quercus spp., Schima wallichii, Cinnamomum spp., Morus macroura, etc.* Logging has occurred since 1996 in accordance with a working scheme prepared as an interim measure to meet the raw material requirement for the local population, urban centers of Punakha and Wangdue and the sawmill at Lobesa. These logged-over areas are characterized by profuse growth of *Macaranga spp.,* with almost no other species regenerating. The acute lack of research into broadleaf forest management has been brought up and discussed in many of the National Forestry Research Coordination Workshop (NFRCW).

Consequently RNRRC, Bajo together with the Bhutan German Sustainable RNR Development Project (BG-SRDP), Lobeysa discussed on the possibility of making Rimchu Forest Management Unit (RFMU) as a broadleaf research forest. Accordingly a framework for the broadleaf forest research in Rimchu has been discussed and prepared following a number of consultative meetings with all the forest planners, managers and researchers by the forestry research coordinating centre, RNRRC, Yusipang containing a comprehensive research plan on the dynamics of the broadleaf forests in Rimchu. This plan was put up to the Department of Forest for approval for which the approval is accorded.

The main objectives behind establishing the permanent research forest is to understand the species recruitment pattern in the long run, see the impact of grazing on the regeneration and its establishment and to finally know the forest dynamics. The forestry sector of this centre together with RC Yusipang and NRTI forestry Faculty laid the plots in Rimchu FMU, with financial assistance from BG-SRDP Project, Lobeysa. Two plots of 2 ha were established in two different forest types, namely the warm and cool broad-leave forest. The recording of data, laying of grazing exclusion plots, fixing permanent plot boundaries will be conducted soon.

SYSTEM RESOURCE MANAGEMENT

5 SYSTEMS RESOURCE MANAGEMENT

5.1 Community Based Natural Resources Management (CBNRM)

5.1.1 On-farm Evaluation of three high altitude rice varieties

In collaboration with RNRRC Yusipang, a trial on evaluation of three high altitude rice varieties was done in Limbukha village with three test promising varieties *viz.* China 2, China 4, and China 7. This trial was established to evaluate the blast disease which continues to be a major problem in the high altitude rice growing area. The main objectives of the trial were to assess the disease resistance, yield superiority of the improved varieties against the landraces and to understand farmers' views on the improved varieties and their future action.

Trial seed weighing 1 kg of test varieties was given to an interested farmer through participatory farmer selection, which was done jointly by geog extension agent and the researcher. The nursery was raised during the month of March 2005 and transplanted in a single plot during June 2005 close to the other landrace and improved varieties *(Machapuchray)* and consequently upon maturity, harvesting and crop-cut was done on 13th October 2005.

The management practices were done by the farmers. FYM was applied at the rate of 60-80 baskets per langdo and top-dressed with urea. Weedicide was applied to suppress the weeds with additional one hand weeding.

Monitoring during different crop stages was done and required data were recorded based on the protocol. Blast scoring was done during the growth stages and upon crop maturity, crop-cut data and farmers' feedback were collected and evaluated. The trial crop-cut results are presented in Table 58.

Table 58: Trial results and comparative yield

Variety/line	Blast score	Average tiller (nos.)	Plant height (cm)	Yield (t/ac)
China 2	0	14	83.6	3.21
China 4	0	17.4	81.25	2.91
China 7	0	14	88.4	2.67
Shengamaap (check)	-	-	-	2.29
Machapuchray		15.6	125.33	3.56

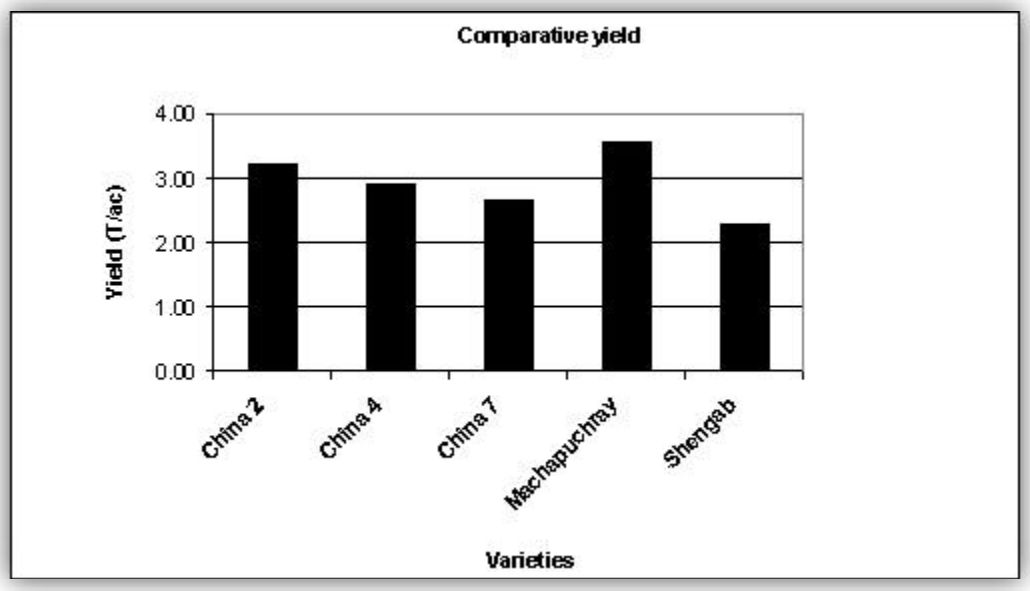


Figure 2: Comparative yield of test varieties

Compared in terms of yield potential, China 2 performed better that the other two varieties and the local check with 3.21 t/acre (Figure 22). But farmers provided feedback that although the grain shape was good most *japonica* varieties are very difficult to thresh, whereas Machapuchray which was promoted during the year 2004 yields better than these three promising China varieties with 3.56 t/acre. Although Machapuchray shatters at maturity, it still has potential for expansion; farmers thresh right after harvest and its cultivation is increasing over the year in Limbukha.

5.1.2 Assessments of improved pig housing

Nabchey village is adopted as a focus village for research out-reach program. It has an age-old tradition in rearing pigs and derives most of the monetary benefit from piggery enterprise alone. There are a total of 22 households in Nabchey village, out of which 21 households own and rear pigs of their preference both for meat and piglet production ranging from 1-6 numbers. These pigs are reared in a traditional housing and feeding system using locally available materials and feed resources. Among different management factors, proper housing plays a critical role in overall growth and performance of pig. Till date the effect of different housings on the production and reproduction performance of breeding boar supplied to farmers is not documented. The detailed report on effect of improved pig housing is available in the Livestock Sector of this report.

5.1.3 Assessment of improved pasture as cover crop in orchard

An assessment of improved sub-tropical pasture as a cover crop was done to suppress local weeds and demonstrate promotion of improved pasture development in orchard to make fodder available. The activity was conducted upon request of the gewog livestock extension worker at the demonstration orchard in Omteykha with four improved sub-tropical fodder species consisting of two grass (*Brachiaria ruziziensis* and *Milinis minutiflora*) and two legume (S*tylosanthes guianensis* and *Medicago sativa*) species.

The required seed mixtures were supplied from research centre for an acre of land and farmer did the management practices. The seeds were sown during July 2005 and routine monitoring was done to assess the germination and survival rate of the improved pasture. The biomass production data were recorded during June 2006 and followed by the dry matter content analysis.

During monitoring and field observations, it was found that molasses (*Milinis minutiflora*) dominated the field and suppressed the local weeds too. The survival rate and the grass-legume ratio are 84:16 based on the plant count per quadrat done during biomass assessment.

The average biomass yield is calculated at 12.8 t/ha based on the yield assessment done by using a 0.5 meter quadrat as shown in Figure 3.

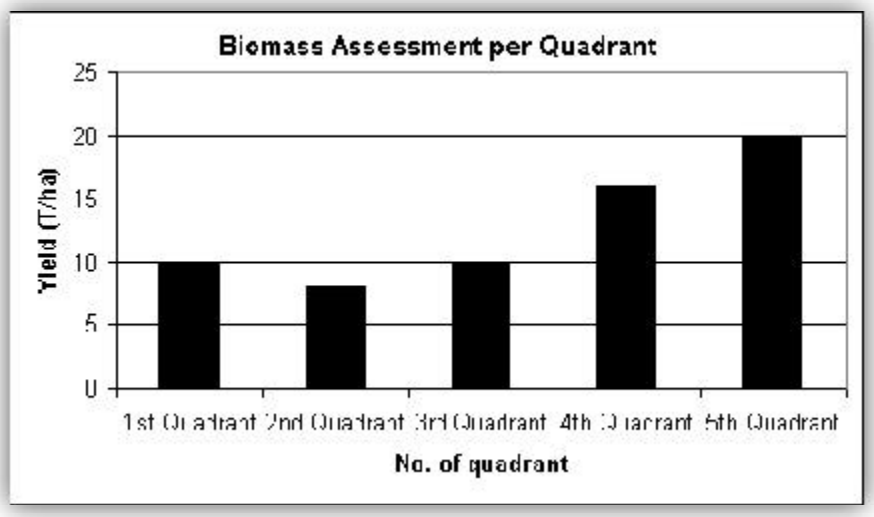


Figure 3: Biomass assessment per quadrant

Dry matter analyses of the species were done and the comparative results are as presented in Table 59.

Table 59: Dry matter production of fodder species at Omteykha

No	Species	Biomass Wt. (gms)	DM Wt. (gms)	DM %	DM Production (t/ha)
1	*Medicago sativa*	62.32	19.02	30.51	3.90
2	*Stylosanthes guianensis*	66.02	20.44	30.98	3.96
3	*Brachiaria ruziziensis*	66.72	18.08	27.13	3.47
4	*Milinis minutiflora*	73.86	23.83	32.27	4.13

The result shows that development of improved fodder in orchards has potential to reduce the local weed pressure besides providing substantial amount of fodder for livestock. There is also a potential for promoting stall feeding and promotion of fodder conservation by making hay and silage for feeding during lean winter season.

5.1.4 Monitoring of Actions of Role Play Game in Lingmuteychu

Companion Modeling Process/Role Play Game in Lingmutey Chhu began since May 2002 in facilitating to resolve the water sharing conflict between Dompola and Limbukha. The outcome of this workshop recommended formation of watershed level management committee and another round of RPG was conducted in April 2005 involving farmers from seven villages of the watershed (refer RC Bajo Technical report). Some of the critical findings of the RPGs are that:

- RPG effectively facilitated self-motivating and non-confrontational interactions among the players;
- Farmers knowledge and understanding of water sharing increased significantly;
- Exchange protocols influenced water use and income more than the rainfall pattern and social networks; and
- Collective mode of communication facilitated in better and frequent exchange of water.

Following the April 2005 RPG at watershed level, a series of routine monitoring was conducted with guided questionnaires to collect farmers' views and analyze farmers' response in formation of watershed management committee. The monitoring reveals that immediately after the RPG workshop on 24th April 05, 74% of farmers who participated in the workshop reported that they conducted meeting in their village to inform the fellow farmers about the outcome of the workshop. 95% of them thought that output of RPG was most relevant and applicable to improve the state of affairs of watershed. Correspondingly 83% of respondents who did not participate in RPG also thought that output RPG is relevant and would have long term impact in NRM. As it was too early to observe of any behavioral changes, only 21% of them felt the changes in terms of understanding about watershed management.

To verify the results, farmers who did not participate in the RPG were also interviewed. 67% (n=18) of them confirmed to hearing about the RPG conducted through the farmer who played the game. Further they were also consulted to identify and nominate Cheog representative in the By-laws drafting group for Lingmuteychu Watershed Management Committee.

One of the highlights of April RPG was the concurrence to implement 3 collective actions at the watershed level; however, those activities could not be implemented for following reasons:

- Difficult to convince other farmers (11%)
- Overlap with other important farming activities (e.g. rice transplanting, development activities (79%)
- No one to initiate (11%)

Those who did not attend the RPG considered the following actions as presented in Table 60 can be done collectively by 7 villages in the watershed.

Table 60: Proposed collective actions by RPG non-participant farmers

Proposed collective actions	Respondent (%)
Proper Management of natural resource in the watershed	39
Planting and Managing Forest for increasing water yield	39
Equitably share available water	11
None	11

Generally, farmers considered lack of natural resource management system (22%) in the watershed as the critical issue in the present context. Another 22% considered forest fire and forest degradation as an important issue. Other issues like shortage of irrigation water, land degradation, access to forest resource were also considered as issues.

In response to strategies to manage the above issue, 39% of farmers viewed management committee as the means to handle the issue. Enhancing the awareness on NRM was suggested by 28% to be a viable approach. Planting of trees and tail end water management were other options.

5.1.5 Rice production and water availability

Rice is the predominant crop in the watershed. Although it is a small watershed (34Km^2) it has a very broad biodiversity of rice. In 2005, 18 rice varieties (4 improved) were cultivated by farmers in the watershed. Among them IR64 was cultivated by majority of the farmers (15) in watershed, followed by Bajo Maap, Eurab and Maap Phogom.

Rice transplanting in 2005 was concentrated within 4th and 5th lunar months. Among the respondents, first transplanting was done on 5th day of 4th month by Limbukha farmer, while Thangu farmer was the last to transplant on 6th day of the 6th month.

Majority of farmers reported that rainfall in 2005 was late. Although rainfall was late, 82% considered the quantity being normal with only 5% reporting excess and 1% less. Some of views on rainfall are presented in Table 61.

Table 61: Views and concerns related to rainfall

Response	% Response (n=33)
Very less rainfall during main transplanting season, and normal during later season	79
Abnormal pattern	6
Worried on maturity	6
Late transplanting	3
Population and degradation	3
Double 9th month	3

With delayed rainfall this season, 73% of the respondents expected rice yield to be low due to delayed transplanting and less water after transplanting. However, 18% of them viewed 2005 as a good year as it is a 'bird year'. Further they think late rainfall will minimize Shochum proliferation thus contributing to higher rice yield. The remaining respondents (9%) who explained that although rainfall started late it was normal in terms of quantity and thus will not have any impact on rice yield.

In response to means to improve water sharing system in the community, in view of the traditionally agreed water sharing system and stream discharge being beyond their control, 55% of the respondents assumed that there is no alternative to improve the present status. In contrast, 45% of them contemplated that with proper management of irrigation canal and allocating water based on land holding could be a way forward to improve water sharing in the watershed.

With Lingmuteychu watershed management committees being framed, while 73% of the respondents anticipated improvement of water management issues, there were 27% who had no idea on how the committee would make any difference in the situation. Some of the actions like source protection, conflict management, assistance, and canal management were possible means for committee to improve the situation.

During 2005 season rainfall was considered late. In the watershed 76% of the respondent considered it 1 month late while 19% thought 14 days late and 5% considered a week late. However, 52% of them considered rainfall quantity to be normal as any other year. Probably because of the spatial variation, 24% thought to be less than normal and for remaining 24% rainfall was considered more than usual.

Although rainfall was late with the normal rainfall quantity, 62% of the respondent thought irrigation water as available in normal time which did not disturb their schedule. The remaining 38% thought they received irrigation water later than past years (7days for 14%; 14 days for 14% and 1 month for 10% respondent).

In terms of quantity of irrigation water, 53% of the respondent reported water to be less. On the contrary, 43% of the respondent reported irrigation water volume to be normal.

Transplanting time and sequence

Figure 4 shows the amount of fields transplanted during their normal transplanting time and delayed transplanting during the season.

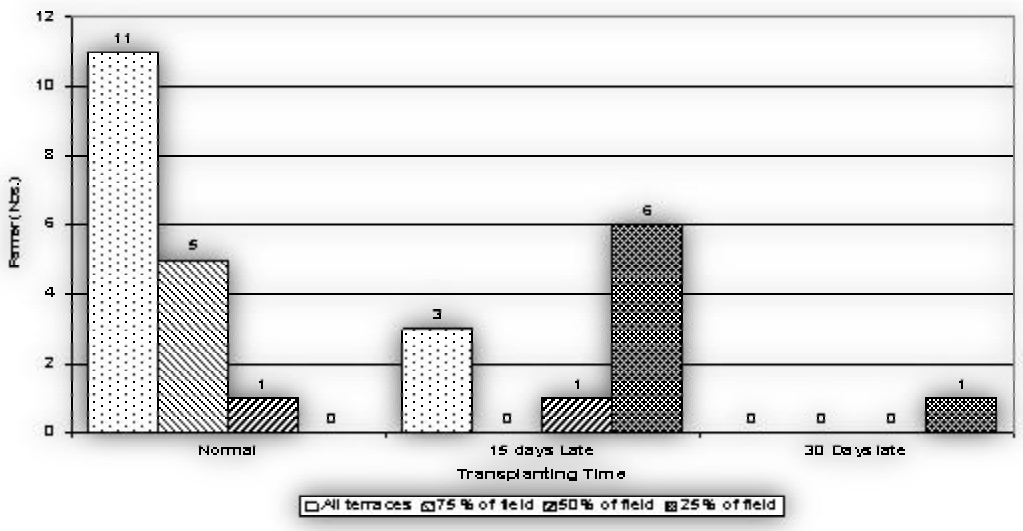


Figure 4: Transplanting time during 2005 season

43% of the surveyed farmers are early planters, 43% are mid season planters and 14% are late season planters. Among them, 57% managed to plant in the same time as usual, while 43% had to plant in different dates.

Some of the causes and its effects found during the monitoring are presented in Table 62.

Table 62: Causes and its effects

Causes	Effects
Low rainfall	• Drying of Seedlings • Delayed transplanting • Reduced vegetable production
Delayed Transplanting	• Delayed maturity • Delayed planting of other crops in rotation • Poor growth and tiller formation • Low yields and empty grain heads • Less cash income from sale of vegetable
Limited irrigation water	• Prolong transplanting time

	• Low yield • Less water in water turn and high labour need to protect water • More weed germination • More fallow lands • Channel maintenance • Prone to diseases • Few dried up after transplanting • Conflict in irrigation water sharing • Had to pump water from main river below • Empty grains and yield reduction
Low rice yield	• Not enough rice for whole year • Need to buy from market • Less household income • Increase in market price for rice • Had to burrow or buy from market • Increase debt to meet food demand
Low discharge from watershed	• Delayed transplanting • Low yield • Effect crop rotation • Effect paddy cultivation in lower communities • More land will be left fallow • Conflict likely to arise due to competition for limited water • No water for human and animals • Decrease income since they cannot cultivate vegetables

5.1.6 Watershed Management Committee By-laws

From the 7 members who had participated in drafting of by-laws, 5 of them initiated some discussion on the Management by-laws with the community members. All the drafting committee members interviewed felt that every community members will accept the by-laws as it is.

Among the non-drafting members interviewed, 76% reported to have heard about the drafting of by-laws and 69% of them were confident that the bylaws will work. While 31% pointed that management committee will work if there is no public contribution in any form, by-laws are implemented properly, and community members cooperate and agree to implement collective actions.14% who did not hear about the by-laws because they did not expect such committee will come as it was first of its kind and there is no experience.

When non-drafting committee were asked for their view on aspects they thought was important to be included in the management committee by-laws, many thought water sharing issue, NRM, forest conservation, and responsibility of committee should be included. They also indicated that aspects like conflict resolution and traditional water

sharing system needs to be elaborated in the by-laws (Table 63). The entire respondent supported the need for management committee and by-laws agreed upon by the community members.

Table 63: Issues to be included and emphasized in the by-laws

Include	Emphasize
Exclude Water Sharing	As age old practice exist
Include Water Sharing	Traditional sharing system, Sharing between Dompola and Limbukha,
Responsibility of Committee	Conflict resolution
NRM and Forest preservation	
Collective actions	
Drinking water	Equitable access
No idea	

57% of the non-participating farmers knew about the upcoming management committee. There main concern was to increase the numbers participants (43%) in the meetings where by-laws will be discussed and prior information (10%) should be given to all community members

In relation to the irrigation water availability, all 7 respondent confirmed less irrigation water in the current season. 71% of respondents considered that less irrigation water will affect rice yield. Less water results to poor growth since the land are sandy and will have lesser yield. More water with constant water in the field especially in red varieties which are long duration and requires early transplanting and with delayed rainfall, irrigation was not possible so yield will be bit lower

Less water will result to poor growth and less yield. The earlier transplanted fields have once dried up and the yield come down but cannot say unless the paddy are threshed. Especially in red variety which is long duration and transplanted earlier, with less rainfall the crop stand are not so good compared to previous year, The plant height are shorter for the red variety this year and hope yield will also reduce, In field with inadequate irrigation the plant stands are not so good and also there is lot of weed pressure, Last year although there was adequate rainfall yet the yield was very low, this year the crop looks better but cannot say about the yield until it is thrashed, Although there was less rainfall yet yield seems better this year.

5.1.7 Launching of Watershed Management Committee

The outcome of the April 2005 RPG discussions with regards to the need, advantages and disadvantages of establishing watershed institution - The Watershed Management Group, Constitution and By-laws were presented to plenary secession. The result of secrets ballot ranking indicated that collective mode of RPG ranked the highest. This indicated that the majority of the participants are in favoured working together towards common vision of the watershed development through establishment of watershed level institution.

Following the workshop, the work plan which sets the process of developing the bylaws was developed by the village Tshogpas. The schedule is aimed at completing the task of formulation the bylaws by November 2005, which will be presented in the plenary for consensus and formalization.

The bylaws were formulated by the members nominated in each community in consultation with the general public and researchers facilitated in finalization and conducting routine monitoring (as detailed in above section).

Picture 36: Watershed management committee members

The Watershed Management Committee was formally launched on 7th December 2005 (Picture 36) with finalized by-laws and constitution in place (refer By-laws for Lingmutey Chhu Watershed Management for details).

5.1.8 Support services to the Watershed Management Committee

The watershed management committee was successfully established as a local independent institution with the objectives to:

- Improve water management techniques in on-farm and off-farm to increase water productivity by 25% in the watershed,
- Enhance awareness and capacity of the people on NRM strategies and involve them in collective actions,
- Consolidate and source resources (internal and external) for development of the watershed,
- Foster the development of local watershed restoration and protection programs in accordance with appropriate management strategies and techniques,
- Provide a forum for sharing of information and experiences on scientific, administrative, legal, and financial aspects of watershed management,
- Encourage the development of local, state, and national programs, policies and legislation promoting watershed management, and
- Encourage the cooperation and interaction of organizations, agencies, units of government, and individuals concerned with watershed improvement and protection.

Since the management committee was in the initial phase of establishment, support services were deem required to enhance their capacity to function as independent institution in long run. Research centre provided technical support in the following areas:

Project proposal development
The watershed management committee has come up with few planned activities and to support these activities a project proposal was developed for fund support through Small Grant Program (SGP) under Global Environmental Fund (GEF) of UNDP. The proposal is for the period of three years and it was focus on improving irrigation system, water use efficiency, conservation of watershed resources by improving forest cover and building capacity of the watershed farmers.

Implementation of collective action
In order to make the watershed management committee functional, the committee had planned to undertake three collective actions viz. i) Plant trees in the sub-catchment areas within the locality of individual communities. Plantations will be done on critical catchment areas of water sources, ii) Construct small scale rainwater collection ponds in the village chatchments and iii) Rejuvenate irrigation water source and renovate canal in Lumpa, under Omteykha Chewog.

Research Centre supported in implementing the above activities by providing required materials and organizing community mobilization to under take the works

5.1.9 Case Study Writing

A training program on Analytical Skills and Case Study Writing was organized by Participatory Forest Management Project and Community-Based Natural Resources Management Program between March to June 2006. The objectives of the training program were:

- To enhance participant's capacity to collect data, analyze and write pertinent case studies on selected themes;
- To strengthen participant's capacity in developing well structured and logically argued cases
- To document and disseminate lessons and experiences from Community-based natural resources management in Bhutan.

The training program was broken into three activities:

Activity 1 focused on bringing the selected CBNRM participants together to clarify their selected case study topics, analyze their 'main message' and consider data collected procedures during the month of March 2006;
Activity 2 focused on collection of field data and further refining the case study objectives within March to June 2006; and

Activity 3 focused on writing of a pertinent, well packaged and well structured and logically presented case studies.

The outcome of the case study writing training program was a well structured and presented case study on "Equity and Traditional Water Sharing Systems in Lingmutey Chhu Watershed" (refer case study report).

5.2 Integrated Plant Nutrient Systems (IPNS)

IPNS research was continued with the aim to bringing together research, extension and the farmers to improve farmers' soil fertility management systems through an integrated plant nutrient systems approach. The general objectives were to study farmers' soil nutrient management practices, improve upon them and to develop appropriate and affordable technologies that will improve the productivity of the land without depleting the soil resources.

5.2.1 Effect of different rates of NPK on improved and local rice varieties

Yields of both local and improved rice varieties are known to be low in Tsirang Dzongkhag. Application of inorganic fertilizers in crops is rare and the use of FYM is very limited, done mostly through tethering. Therefore, to see if there is any improvement in the yields of both the local and the improved rice varieties with inorganic fertilizers, trials were implemented in four geogs viz. Kekorthang, Goseling, Tshokona and Mendelgang. The main objective of the trial was to compare farmer practice and recommended practice in terms of rice yield, soil and plant nutrient status. Trials were conducted with four farmers who did not use inorganic fertilizers at all. There were eight treatments, four lower rates for local rice varieties and four higher rates for the improved rice variety as shown below.

Table 64: Effect of inorganic fertilizers on yields of local and improved varieties

Treatment	Choti and Atay, local varieties.	Bajo Maap II, improved variety.
T1 Control	0:0:0 NPK kg ha^{-1}	Control 0:0:0 NPK kg ha^{-1}
T2	30:30:20 NPK kg ha^{-1}	40:30:20 NPK kg ha^{-1}
T3	60:30:50 NPK kg ha^{-1}	70:30:50 NPK kg ha^{-1}
T4	90:30:80 NPK kg ha^{-1}	100:30:80 NPK kg ha^{-1}

Nitrogen and potassium were applied in two splits, one at transplanting and the other after five weeks. Fertilizer materials used were suphala, urea, MoP and SSP.

Crop cuts were done on 14 test farmers' fields. Within each treatment plot, three sub crop cuts each within $6m^2$ were carried out. A total of 12 crop cuts were done on each test farmer's field. The result is presented in Figure 8. The effect of treatments on straw and grain yields was not significant. However, the straw yields showed increasing trend with increasing NPK application. The grain yields were between 1.03 t/ac and 1.11 t/ac and the straw yields ranged between 4.43 t/ac and 6.22 t/ac.

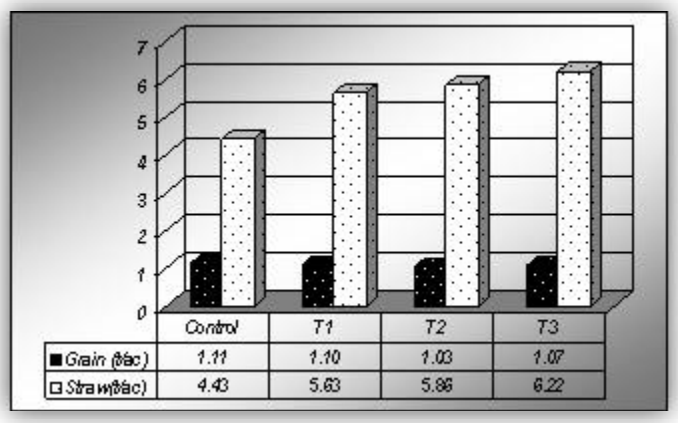


Figure 5: Rice yield as affected by different treatments

Figure 5 shows the yield comparison among the four geogs. Straw and grain yields were significantly different among the four geogs (p=0.006, p=0.007). Goseling had the highest grain yield of 1.3 t/ac and the lowest straw yield of 3.9 t/ac. The grain yield was lowest in Tshokona with 0.84 t/ac and the straw yield was highest in Mendelgang with 6.9 t/ac.

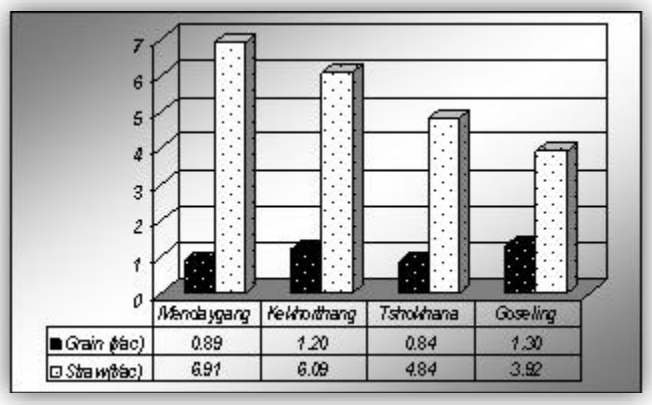


Figure 6: Rice grain and straw yield in four geogs **(Grain s.e. = 0.37, cv% = 34 and straw s.e. = 2.2, cv% = 39)**

Figure 7 shows the yield of the two rice varieties which are significantly different (grain p = 0.02 and straw p = 0.005). Bajo Maap II had higher grain yield of 1.3 t/ac and lower straw yield of 3.9 t/ac while the local variety had lower grain yield of 1.02 t/ac and higher straw yield of 6 t/ac.

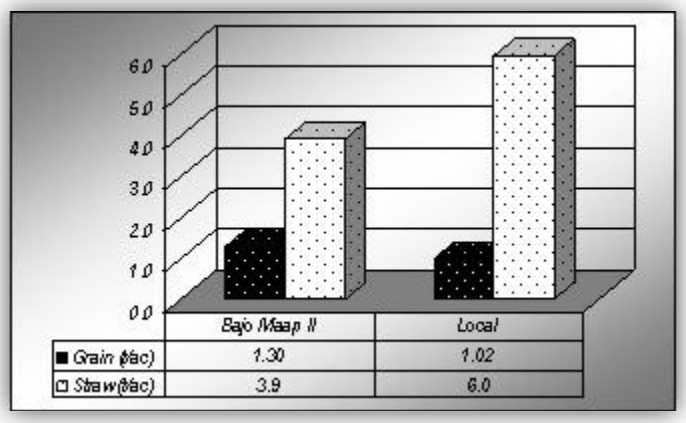


Figure 7: Rice and straw yield of local and improved varieties **(Grain s.e. = 0.38, cv% = 36 and straw s.e. = 2.13 and cv% = 38.4)**

Pre and post trial soil nutrient status

About 73% of the samples had low pH, between 5 and 5.5, about 86% of the samples had very low to low available K (< 40 and > 40 and < 99 respectively), about 43% of the samples had very low to low available P (< 5 and > 5 and < 14.9) and all the samples had very low CEC and C percentage.

After trial soil sample analysis results showed that there have been slight changes in the soil nutrient status, in that, about 93% of the samples had medium pH ranging between 5.5 and 6.5, both available K and P had decreased while the CEC and the carbon percentage had improved slightly, although still low. Therefore, the overall soil fertility was low before and after the trial. The treatments did not have any significant effect on the soil nutrient status.

Mineral content in grain and straw

The effect of different treatments on the nutrient contents and removal was not significant for both the varieties; however, within the varieties they were significantly different. Mineral contents were higher in Bajo Maap II and therefore, it removed greater amount of nutrient from the soil. Calcium and potassium contents were greater in straw while the contents of nitrogen and phosphate were greater in grains of both the rice varieties.

Although the soil nutrient status was significantly different in different geogs, the overall soil fertility status was low in all the four geogs. The effect of different treatments on the soil nutrient status was not significant, indicating either the NPK rates used were not high enough to bring about any changes or there has been nutrient losses through leaching and/or run off. Soil pH was within the low to medium range. Available P and K, organic matter and CEC were low both before and after the trial. The effect of different treatments on the rice yield was not significant; however, yields of the two varieties in different geogs were significantly different. Bajo Maap II grown in Goseling had the highest grain yield of

1.3 t/ac and the lowest straw yield of 3.9 t/ac. The effect of treatment on mineral content and removal was not significant for both varieties; however, within varieties and geogs, they were significantly different. Bajo Maap II grown in Goseling had higher nutrient contents in the plant tissue and removed more nutrients from the soil as compared to the local variety grown in other three geogs. Calcium and potassium were removed mainly through straw while the nitrogen and phosphate were removed mainly through grains.

As indicated by the soil analysis results, there was no significant effect of the treatments on the soil nutrient status; therefore, the NPK rates should be increased. The trial site soils are coarse textured sandy loam soils with low organic matter content, CEC and BS% with high chances of nutrient losses through leaching and run off. In such places, split application of fertilizers should be practiced and improve the use of FYM and crop residue to increase the soil organic matter.

5.2.2 Assessment of soil fertility status in potato fields at Phobjikha

During a weeklong retreat among the senior MoA officials in Phobjikha valley in May 2004, Mr Ugyen, Agriculture Extension Agent (EA) of Phobjikha reported declining trend in potato yields in valley over. To establish better understanding of the issue, one day field trip was organized in the valley to discuss with the EA on possible factors influencing declining yield and to plan possible research activities to address the problem.

The average potato yield in the valley during 1990s was reported to be 8 t/ac [20 t/ha]. However as per the Extension Agent and farmers' observation, over the years, the potato yield had been decreasing and the average yield at present in the valley is said to be 6.5 t ac^{-1} [16.25 t ha^{-1}]. According to the EA, in few pocket areas, the yield-declining problem was very severe that farmers hardly recover the potato seeds they plant. The major causal problems as suspected by the EA were (i) sequential monoculture crop rotation (potato – turnip - potato), (ii) imbalance use of soil fertility management inputs (mostly only chemical fertilizers), and (iii) wild animal damage (wild boar).

Farmers have been practicing potato seed replacement as advised by the EA. However, as the seed replacement was taking place within the valley, it did not bring about any improvement in the yield. In addition to this, EA also encouraged farmers to reduce use of chemical fertilizers and increase the application of FYM so as to balance the nutrient inputs.

In September 2004, a total of 78 soil samples were collected from randomly selected fields in order to see if soil fertility is the cause of declining potato yield in the Valley. Soil samples were analysed for pH, organic carbon, total N, available P, available K, exchangeable cations. Along with the soil sample collection, Focus Group Interviews (FGI) were done in randomly selected villages, mainly to find out the trends in potato yields, use of inputs such as chemical fertilizers and FYM, and farmers' opinion on the yield declining factors, strategies they have adopted and possible future solutions. Issues raised during the FGI were similar in most village; they are potato yield declining is a problem, use of chemical fertilizer has increased over the years, and use of FYM

remained the same in most villages but in few pocket areas it has decreased due to reduced in livestock number.

Soil analysis results and discussions

Soil analysis result indicate that soil pH as acidic. About 66% of the soils have very low (<5) to low pH range (>5 and <5.5) while only about 33% of the samples had pH within the medium range of >5.5 and <6.5. Potato is tolerant to wide pH range but grow best on moderately acidic soils. The optimum pH for potatoes is between 5.0 and 6.0 and therefore in this regard the pH of most samples could be considered suitable for growing potatoes. However, in soils with pH less than 5, the availability of some of the nutrients such as phosphorous, calcium and magnesium would be low while that of others such as iron, aluminium and manganese would be high resulting in the deficiency and toxicity of various nutrients, poor growth, low biological activity and reduced yield levels.

Figure 9 shows the cation exchange capacity of the soil. About 82% of the samples had medium CEC (>15 and <25 meq. $100g^{-1}$). The CEC is used to assess the fertility potential of a soil and therefore, the moderate CEC of the soils indicates moderately fertile soil.

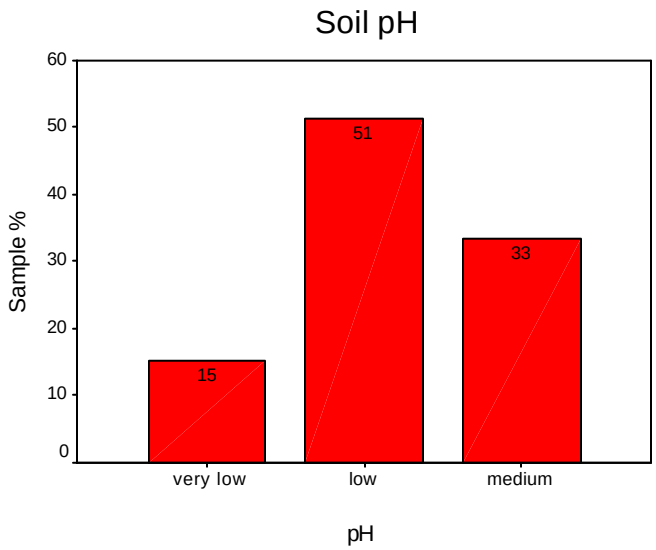


Figure 8: Soil pH of potato fields in Phobjikha

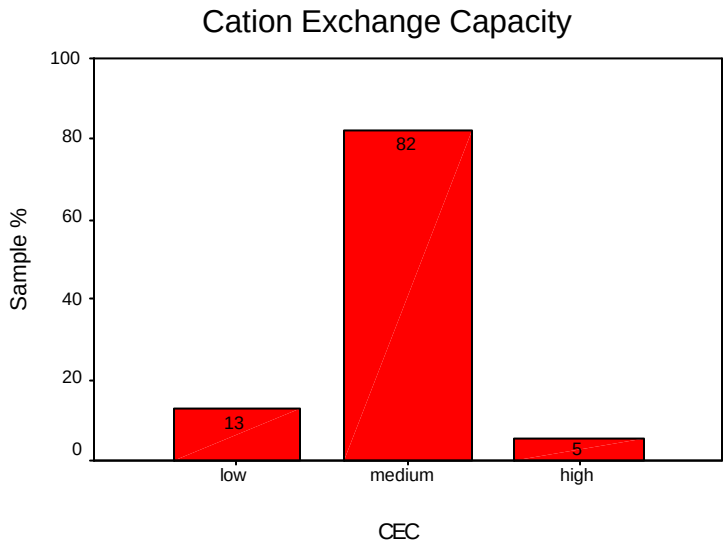


Figure 9: Cation Exchange Capacity of potato fields in Phobjikha

Available Phosphorus [P] shown in Figure 10 ranged from very low to high, however, about 66% of the samples had medium (>15 and <29.9 mg kg^{-1}) to high (>30 mg kg^{-1}) available phosphate. High available P status could be due to the regular application of P containing fertilizers and therefore may have resulted in soil P build up. Other factors that could contribute to high P would be the shallow root system of potato plants not being able to utilize the less available P forms easily and the immobilization of P fertilizers in the soils with low pH. According to literature, potato responses better to P in acidic hill soils compared to black clay soils. However in Phobjikha, the main source of P is through SSP and the recovery of P from SSP by potato is hardly 10-15%. This shows that much of applied P remains in the soil. Also most of the P applied as SSP to acidic soils is converted to unsolubilized form.

Figure 11 showing the available Potassium [K] indicates the K status to be moderate (>100 and <199) for about 64% of the samples and low (>40 and <99) for about 23% of the samples. Potatoes require high K supply as it plays an important role in photosynthesis and starch production by the potato crop.

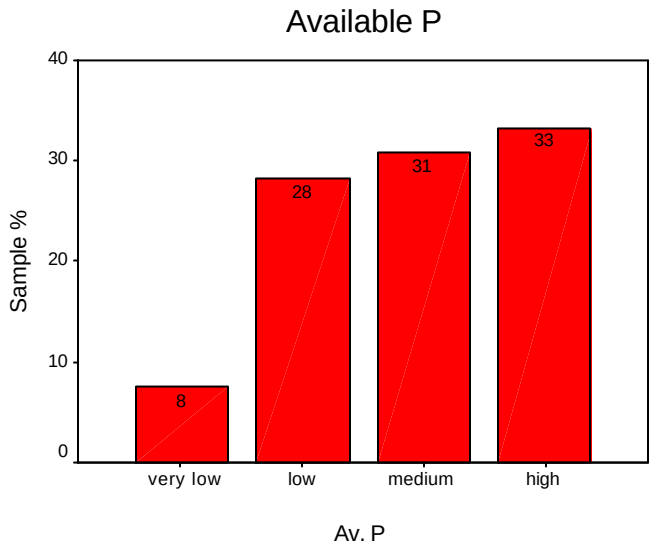


Figure 10: Available P in soil of Phobjikha

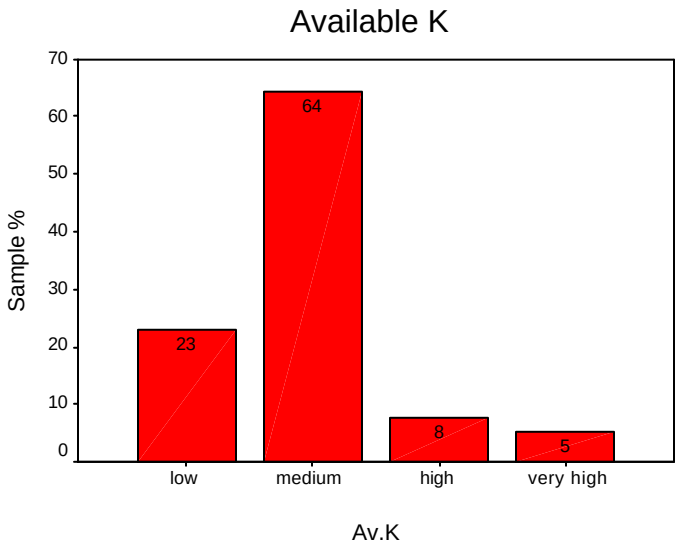


Figure 11: Available K in soils of Phobjikha

Soil organic matter content was high (>5%) in about 95% of the soil samples collected while only 5% of the samples had medium organic matter status (Figure 12**Figure 10**). This either indicates regular application of FYM in huge quantities or slow decomposition rate of organic matters with low temperature and in low pH soils with reduced microbial activity.

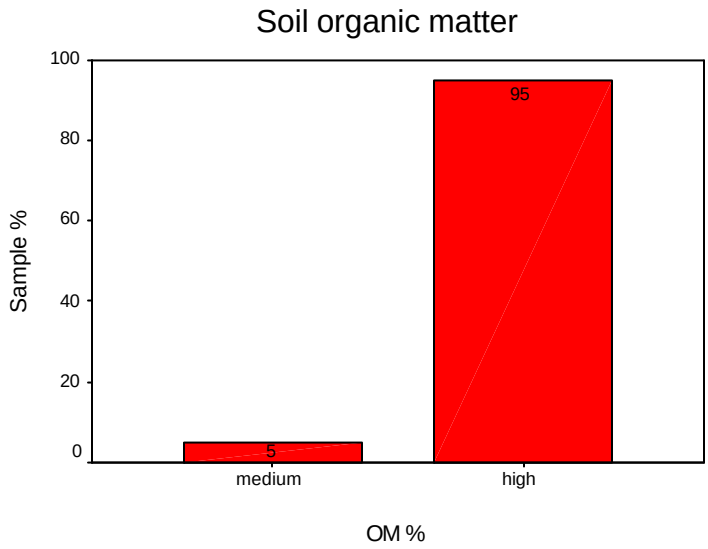


Figure 12: Organic Matter content in soils of Phobjikha

Conclusion and Recommendation

Overall, all the sampled fields have moderately fertile soil. However, potato may not respond to Phosphorus fertilizer application as much as to Potassium fertilizer, because about 66% of the sampled fields had medium (>15 and <29.9 mg kg^{-1}) to high (>30 mg kg^{-1}) available phosphate. This could have been resulted from the regular application of P containing fertilizers, which have contributed towards soil P build up. Therefore, P fertilizer application may be left out in soils with medium to high available P for few years. On the other hand, Potassium fertilizer needs to be applied regularly as most of the sampled fields have available K content between low to medium despite its high requirement by potato crop. Organic matter content is high; therefore, application amount may be reduced for some years. In addition it is recommended that soil sample analysis should be done periodically.

5.2.3 On-farm Potassium response trial on Potato

Soil samples were collected and analyzed annually from few randomly selected potato fields in Limbukha. The general aim was to see if repeated cultivation of potato after rice in the same field has any negative impact on soil fertility. Crop cuts were taken both for rice and potato annually and results indicated that yields of both potato and rice were lower in the fields with very low-to-low available K content. Soil analysis results showed that the available potassium is within the very low-to-low range in most of the sampled fields. This probably indicates either an insufficient application of mineral K, small soil K reserves or high K fixation capacity of the soils. The removal of K through rice straw is higher than through grains and in Limbuklha straw is used as winter fodder and is not incorporated back into the soil, thus K is removed permanently from the soil. In addition, both potato and rice require K in large quantity compared to other nutrients. Thus it is not

known if low available K content is limiting potato yield in Limbukha. Therefore, this trial was implemented using different rates of K with fixed rate of N and P. The focus of this trial was to see if K is the limiting factor for low potato yields in some fields in Limbukha.

The trial was conducted with one farmer whose field had very low available K content. The trial had four treatments as follows. The trial was conducted in RCBD with three replications, in plot size of 6m x 6m with spacing of normal farmer practice.

T_1 - 100:80:30 kg NPK ha^{-1} (Recommended rate)
T_2 - 100:80:60 kg NPK ha^{-1}
T_3 - 100:80:90 kg NPK ha^{-1}
T_4 - Control (Farmer practice 0:0:0 NPK kg ha^{-1})

Nitrogen was applied in two splits, one at the time of potato sowing and the other after weeding at about nine weeks later.

ANOVA was used to detect treatment differences using Genstat 5 Release 3.2. Results are presented in **Table 65**. There were no significant (p = 0.20) differences between the treatments used.

Table 65: Effect of different levels of K on potato yield

Treatments	Mean Yield (t/ha)
Control (0:0:0 NPK kg $ha^{-1)}$	17.0
T_1 – 100:80:30 kg NPK ha^{-1}	16.6
T_2 – 100:80:60 kg NPK ha^{-1}	18.8
T_3 – 100:80:90 kg NPK ha^{-1}	23.0
S.E.D	3.18
L.S.D	7.79
CV%	20.5

The possible reasons for non-significant effect of different treatments could be due to the damage caused by reindeer during potato shoot development. In all the replications many plots were heavily grazed during vegetative development. This must have hampered the good tuber development. Weeds heavily infested some treatment plots while others were free of weeds and potato performances in heavily infested plots were very weak with stunted growth. Therefore, nothing can be concluded from this trial at this stage and it is recommended that this trial be continued.

5.3 Water Management Research

The Water Management Research started as Water Management Research Project (WMRP) in the beginning of 8th Five Year Plan. WMRP was originated from the need felt within the Ministry of Agriculture for an integrated sustained national research effort to study the relations between water management practices, soil water and crop production. The project came to end in 2000 and water management research was institutionalized as part of regular research program in RNR RC Bajo. The national mandate of WMR Programme is to conduct and coordinate water management research for enhancing and sustaining the rural livelihood.

The water management research activities implemented by the sector are as follows:
Water Harvesting Work in Tshokorthang under Nahi (Completed)

- Lingmutey Chu Watershed Activities
- Lingmutey Chu Watershed Management Group Formation (completed)
- Study on water resources for Lumpa irrigation scheme (completed)
- Construction of Rainwater seepage ponds (On-going)
- Plantation (ongoing)
- Design, preparation of estimate and construction of Pig house (completed)
- Irrigation support to Samthang/Adang (Completed)
- Participatory Research & Development (Completed)
- 2nd Phase Renovation of RNR Sub-centre Tsirang (Completed)
- Construction of Drying floor/ Tennis court (Completed)
- Construction of Class Three Staff Quarter (Completed)
- Participatory Research and Development training
- NIP Review Workshop in Thimphu
- CBNRM Planning Workshop in Bumthang

5.3.1 Water harvesting activities at Tshokorthang

Tshokorthang is a small Chiwog under Nahi in Wangdue Dzongkhag. The village is composed of 11 households. It is situated at an altitude ranging from 2000 to 2400m. The village is located on the east-facing slope. Lower part of the village has flat area with a small depression in the centre. As per the villagers this flat area was a lake in the past and hence the village is called Tshokorthang. Out of 11 households in the village seven are located in the main village near Shawakha Lhakhang. Other two houses are located near Khujurla Lhakhang about a kilometre away towards north from the main village. Jana, Pangsho, and Langjikha Lhakhangs are located at the upper ridges of the village.

Dry land farming is the main occupation in the village. Maize is the main season crop followed by wheat in winter. Only one household has an acre of wetland at the lower part of the village. Farmers have reported that pest problem is the main constraint in growing vegetables.

During the Agriculture Minister's visit to the village in 2005, farmers have expressed water scarcity as the main problem in the village. RNR RC Bajo along with Dzongkhag

Agriculture sector was given the task to address this issue. A very preliminary discussion on the issue was done in August 2005 and proposal was developed for getting the fund support. The proposal had identified capacity development for the Tshokorthang Community for natural resources management for enhancing water productivity as one of the crucial processes in addressing the water scarcity problem in the village.

Lack of water adequate water source near the village has created water scarcity problem. On the other hand community was not in position to make capital investment for bringing water from far sources. In general people do not have adequate experience in vegetable production.

Water Resources

Kinleylum-chu the nearest source which was used to be only water source for drinking for the village in the past, presently it is used for paddy cultivation by one household. As this source is located at the lower part of the village it is not accessible to most of the households. In addition this source becomes smaller in winter. But this source can be harvested to benefit the lower part of the village. The second nearest source is called Tshechey-chu which is the present drinking water source. This source was tapped for drinking water for the Lhakhang and the main village about eight years ago. At present all the flow at the source is not tapped due to the smaller GI pipe of 15mm (½ inch), which is used for conveying water across a rock face near the source. The total length of GI pipe used is about 40m. Rest of the conveyance line is HDPV pipe of 50mm (2inch) diameter. The third source is called Taksachu, which is 1 km further away from the Tshechy-chu. The flow at this source is bigger compared to other two. Villagers reported that if this source were tapped fully it would be sufficient for cultivating paddy in the village. Oreymo Chu source which is the present drinking water source for Khujurla village. Two households are benefited from the pipeline of khujurla Lhakhang provided by Lam Jamtsho, the owner of Khujula Lhakhang till now. At present the flow is very small the size of pipe is 15mm (½ inch), which is insufficient for them to use for drinking and irrigation at their vegetable garden.

Rationale and Objective

The rationale was to use the local skills and understanding as a starting point to formulate a sustainable resources management system using participatory learning approaches. This process is expected to help the community to make rational decision with regards to the sustainable management of the local resources. The specific objectives of the water harvesting activity were:

- To enhance water yield in the village by protecting the water source catchment
- To the address the water shortage problem by harvesting existing sources and rainwater
- To develop efficient water management system (delivery and storage system)
- To utilized the water for irrigating winter vegetable crops for to enhance the off season production

Methodology

As per the preliminary proposal the farmers training workshop was conducted on December 22 and 23, 2005. A total of eleven farmers, Extension Agents and Gup

participated in the training. WMR Sector of RNR RC Bajo and DAO of Wangdue Dzongkhag facilitated the training workshop. Khujurla Lam provided the training venue in the Khujurla Lhakhang. The day started with the opening remark from DAO of Wangdue Dzongkhag. DAO highlighted the general purpose of the training and what will be the expected out come of the two days. The researcher presented the overall program for the two days training workshop, specific objective and the immediate expected outcome.

Local Understanding

Before starting the main training, farmers were asked how much water is required by a person in one day. The average domestic water requirements as per the participants are 45.45 litres per day. However, this water requirement does not include the water required to produce food that a person eats per day which amounts to about more than 99% of the daily domestic water requirement. Therefore net water requirement is estimate to be 5000 litres per person per day. This exercise was done to get a picture of local perception on the water requirement. It was observed that most of them failed to consider the water required for producing food. All of them considered only domestic water requirement only.

Infiltration Rates

Farmers were asked to give their idea of the percentage of rainwater infiltration into soil and surface runoff during a rainfall in different type of vegetation cover. Table 66 gives the estimate made by individual farmers.

Table 66: Rainfall infiltration and surface runoff estimate made by individual farmers

Vegetation Cover Type		Participant				Remarks
		P1	P2	P3	P4	
Forest with undergrowth	Infiltration	100%	100%	100%		
	Runoff	0%	0%	0%		
Grassland	Infiltration	50%	60%	10%	90%	
	Runoff	50%	40%	90%	10%	
Exposed red soil	Infiltration	1%	10%	10%	40%	
	Runoff	99%	90%	90%	60%	
Forest burnt by the fire	Infiltration	50%	40%			
	Runoff	50%	60%			

Concept of Water Harvesting

Hydrologic cycle was used to explain the flow process of water in their village setting. Participants were asked to trace back the primary source of water that is coming out of a tap stand. Most of the participants explained that a spring source is the primary source of water and could not relate to the rainfall or snow as the primary source. Then another question was asked why the water sources become bigger during rainy season and small during the dry season. Then participants realized rainfall as the primary source. Then it was related to their idea of infiltration rate which was higher in the forested area and less in the exposed soils. Participants were asked to suggest where the rainwater which seeped into soil in forest covered area goes to.

Gradually, participants realized that the rainfall which seeped into soil during rainy season comes out as spring water during dry season. Participants comfortably explained

that the surface runoff goes to the river with short period of time causing flood and high discharge during rainy season. They also realized that the rainfall that has percolated deep into the underground benefit them during the dry season. Underground aquifer forms the biggest natural reservoir for storing water.

Resource Mapping

Resource mapping exercise was done to understand the change in resource status in the village. Participants were divided into two groups. One group composed mainly of elderly people were asked to draw the resource of village thirty years ago, while the other group were given the task of drawing the resource map depicting the present situation. The main purpose of this mapping was to assess the resource change, the result of the change (water scarcity problem at present), and use this understanding to look at the future situation of the resources if not managed at all. This resource mapping was also used in developing a common reference point for the natural resource situation in the village.

Problem Analysis

The primary aim of the resource mapping was to assess the change in the resources situation in the village over a thirty years period. Participants were asked to reason out, how and why did the resource condition changed over a time. Most reasoned out that the change was due to declining resources situation in the village due to the increasing population. One participant recalled how they used to burn the forest just to increase grass cover for grazing cattle in the past. In those areas the water resources dried up over the period of time. In the past the main village was near the Khujulla Lhakhang not at the present village. Most of them moved to present village due to the declining water sources.

The ruins of mani-chu-khor (water turned prayer wheel) located half a kilometre away from the Lopey Zachu water source (present drinking water source) is another indicator of declining water resources in the village. In the past Lopey-Zachu was big enough to run mani-chu-khor. The pond near the mani-chu-khor is over grown with trees. There is a pond (8 x 5 x 2 m^3) near this mani-chu-khor. According the villagers, the depression at the lower part of the village was once a Tshog (lake). The village derived its name from this lake – Tshokorthang. At present this lake does not exist. It generally indicates that the watershed in the village has degraded in terms of its ability to retain rainwater. Kinleylum Chu water sources which used to irrigate an acre of wetland up two years ago had become so small and transplanting could not be done since last year.

Elements of Water Scarcity Problems

At the end of the day, the workshop tried to reach conclusion as to why the village is experiencing water scarcity problem in the light of previous discussions during the day. As such participants expressed the following points with regard to increasing water scarcity problem in the village.

- Increased population size in the village has exerted pressure on the natural resources.
- Intensified and diversified (horticulture) cropping has increased demand for water thus creating water scarcity problem in the village.

Decline in water productivity

Some participants speculated that the amount of water declined due to decreasing rainfall or precipitations. As per the villagers moisture requirement of winter crops are met by snow or frost. Some participants believed that water scarcity problem in the village are due to decreased forest cover. This can be justified such that the present village was prime forest area in the past which formed the catchment area for the lake located at the lower part of the village.

Before the first day came to an end, participants were given an assignment to ask their family members the same questions-why the village is facing water scarcity problem. Next day participants reported the following points.

- Water scarcity is mainly due to the earthquakes which may have cracked the underlying impermeable layer.
- Farmers could not maintain the wooden flumes which used to convey water to the village from spring sources in the past
- Lack of leadership and proper management of water resources
- Degradation of natural forest
- Dying of traditional practices of conducting ceremonial offering to the local deities in the catchment areas. An elderly participant recalls the number of times they used to conduct ceremonies to the local deities by going to each and every water sources within and surrounding the village. The minimum frequency used to be once in a year for each source. But at present the village does not continue this tradition.

Action Plan for Soft System Development

The long term plan is to enhance the water productivity by adopting holistic approaches. This approach will encompass the development of local community level institutions for managing the resources like resources management by-laws and tshogpas. To facilitate these developments a number of workshops are tentatively scheduled within the first half of year 2006. In addition to these, some other necessary training needs are also identified as crucial processes for capacity development. This is true for the activities supported by this project SDC Helvatas (ending in December 2006), however the real natural resources management activities that will be initiated by the local level institute will span over many decades. This project support just aims to develop this local level institute only.

Short Term Strategy

The short term strategy is to address the immediate water scarcity problem by harvesting as many water sources as possible within the locality of the village thus increasing the water availability in the village. It was also focused on developing rainwater harvesting system at the individual household level as well. The rationale was to harvest all the possible spring sources for domestic consumption and use any excess water for small scale kitchen garden irrigation purpose. The additional irrigation water requirement will be supplemented by harvesting rainwater. The main idea was to store as much water as possible when it is available and use it during dry season.

Action Plan for Hard System Development

To realize the short term objective of addressing the water scarcity problem in the village, number of activities were identified. Table 67 gives the action plan for hard system development. For hard system development, the project will provide cement, pipes, other materials that are not available locally and payment for skilled labour like plumber etc. The project support will also include transportation charge of above materials up to the nearest point to the village. Community has agreed to provide construction material locally available like sand, stones and timber. Their contribution will also include labour, local transport and skilled masonry works.

Table 67: Action plan for hard system development

Activities	Time Frame		Responsibility
	Start	End	
Agreement on sharing of new water source		Jan-06, W2	EA, Gup, V-Tshogpa
Pipe alignment survey	Jan-06, W1	Jan-06, W2	RC Bajo, EA
Material collection for (sand, stone etc)	Jan-06, W1	Jan-06, W4	Tshogpa, Farmers
Purchase and transportation of cement, pipes	Dec-05, W4	Jan-06, W3	RC-Bajo, Farmers
Excavation work for pipeline, HH tanks, reservoir & tap stands	Jan-06, W3	Feb-06, W3	Tshogpa, EA, Public
Construction of reservoir, HH & intake tanks, tap stand and laying of pipes	Jan-06, W2	Feb-06, W4	RC Bajo, EA, Public
Construction of household ponds	Jan-06, W1	Feb-06, W4	Tshogpa, EA, Public

Note:-
V-Tshogpa : Village Tshopa existing as per the GYT Chathrim
Tshogpa : Tshogpa nominated for implementing water harvesting activity in nthe field. There are two of those, one from main village Mr. Tshering Wangchuk and from Khujurla Lhakhang area Mrs. Yeshey Pem
EA: Extension Agent (Agriculture)
RC Bajo: RNR RC Bajo,
Bold and underline works in the responsibility column represents lead responsibility
W1, W2, W3 & W4 : First Week, Second Week, Third Week and Fourth Week of a month

For the construction of household ponds only technical support will be provided by RC Bajo while all other construction will be done by individual households. It was agreed that every household will construct minimum of two ponds, but can construct additional as per their requirements and convenience.

Field Implementation Process

The RC Bajo provided all the technical support in terms of facilitating the planning and implementing the water harvesting activity in the village. The field work was planned to be complemented within four (December to March 2006) months period.

Planning: The resources management training was the starting point for the implementation process for the water harvesting activity. The training was used to analysis the local problem and developed strategies to over address it holistically. As such water harvesting activity was identified as one of the strategies to address the problem immediately. Hence two water sources: Tsechey Chu and Kinleylum Chu which were nearest to the village were identified for implementing harvesting activity. At the time during the start up of work the farmers again discussed that the source at Kinleylumchu was small and there are chances that the source may dry so they again made another agreement in front of their Gup. Following the agreement, a field survey for aligning the pipeline, location of common reservoir, household tanks and tap stands was done. Accordingly RNR RC Bajo prepared the technical estimate, source fund, provide technical support and facilitate the development of management plans.

Procurement and Transportation of Material: RNR RC Bajo secured the fund support of Nu.477000/- from SDC Helvatas Project. As per the estimate the materials that were not available locally was procured. The cost included the cost of pipe, cement, CGI sheet, nail, pipe work equipment, and transportation up to nearest road head- Khujurla. The local transportation was done by the community. More than 90% of the transportation was completed by March 2006, before the initiation of field work.

Field Work: The field work was started by January 2006. The field works were phased into two stages- the first and the second phase. The first phase includes the works that did not require skilled labour and can be done by the community themselves. These works includes clearing of bushes, collection of stones, trenching and earth excavation works. The second phased works was mainly cement construction work which required skilled masonry and plumbing works. As such RC Bajo provided the cost for the skilled labours to carry these works. The 2nd Phase was planned to be started by the middle of the 1st Phase. Both phases were planned to be completed within four months time.

Completion: Although the field work was planned for four months, it actually overshot by three months more. The work got delayed mainly because the community was not able to contribute the labour as planned. This happened because three people died within the initial two months in the village. As elsewhere villagers have to provide support to the households during times of distress. The new electricity line coming in the village made the people engaged with the house wiring, labour contributions for laying of electrical wires and carrying transformers. As a result the work got delayed and was able to complete by July 2006 only. As per the initial understanding the source selected was Kinleylum chu but at the later stage the community again decided to bring the water from Taksachu source which was quite far thereby took more time for completion.

Result and Discussion

The results and observation of water harvesting activity which was implemented in Tshokorthang Community are presented in this section. Although the actual completion of field works was delayed by three months. The villagers are more than happy that the water shortage problem is addressed.

Water Harvesting Infrastructure: The village has primary water harvesting infrastructure for harvesting water from two small sources and storing it for drinking and irrigation of vegetable crops. The village has two common reservoirs with effective capacity of 10,000 litres and individual household reservoir of with effective capacity of 1,152 litres per household. The total drinking quality storage capacity in the village is 34,000 litres. With a water demand of 50 litres per person per day, this storage is adequate to supply water for 300 people in the village for two months even the sources dry up completely during dry season. Although sources become smaller during winter, it never dries up. This implies there is some flow even during winter which can be used for cultivating off-season vegetable to enhance the household income. As per the action plan individual households agreed to develop rooftop and surrounding rainwater harvesting and storing system for irrigation purpose using water efficient irrigation technologies.

Process Observations: In the first week of the field work there was 100% labour contribution form every household and work progressed as planned. All households contributed one labour each while some days even more than one labour. Two people passed away due to some illness from the village. Funerals were conducted in Wangdue Dzong and at least a person from each household had to attend the funeral as part of the local traditions. The following couple of days no one would turn up for work. Within the next twenty days only half of the people turned up for the work; the rest were engaged in the death rituals. This happened for two times in the village one two months time thus hampering the progress of the work. The new electricity coming up in the village also made the people busy thus hampered our work in between.

Village Meeting- During Night: The village headman conducted most of the village meeting during the night. This was done to enable all the villagers to be able to attend the meeting who are busy during day time working in the field, guarding crops, herding cattle and other attending to other important chores. Chiwog Tshogpa proposed that conducting meeting during night is ideal in terms of achieving 100% participation as all the participants are villagers. But this is always not possible if there are participants from outside the community.

Cost and Contribution: The physical estimated cost of the water harvesting activity was Nu. 477000/-. The details breakdown of the cost is presented in the table below. Although the physical contribution by community is 61% of the total cost, and this percentage is much higher if the social and opportunity costs are all included. The above mentioned total cost does not include the technical and administrative cost covered by RNR RC Bajo.

Table 68: Total cost of water harvesting infrastructure development at Tshokorthang

Name Work	Quantity	Cost (Nu)			Remarks
		Comty.	SDC	Total	
Intake tank	2 No	7,486	9,934	17,420	
Common Reservoir (10,051 litres)	1 No	20,972	15,534	36,506	3.2x3.2x2.1 m^3
House tank (13 Nos x 1152lit = 14976.00 litres)	13 No	118,162	115,149	2,33311	1.2x1.2x1.0 m^3
Tap stand	3 No	5,977	6,056	12,033	
Pipeline	4700 m	109,730	179,673	289,403	
Total	271,416 (45%)		367,204 (61%)	606,620	

Conclusion

Although the actual completion of field works was delayed by three months. The villagers are more than happy that the water shortage problem is addressed in the village.

Leaving and working with the community was more rewarding in terms of understanding the real situation at the practical level. It gives us an opportunity to appreciate the constraints encounter by our fallow villager in their day to day life.

One is not sure weather a development activity may or may not bring benefit to the village, or even if it brings weather will it sustain or not, but one is certain that he/she is left with two choices weather to guard his crop or attend a village meeting or woola. It was observed that whenever there are not participants from out side village, villager meetings are conducted during nights.

In a farm labour shortage scenario, the policy of inculcating ownership for development projects although appears as a very approach needs to be reconsidered in the specific local situations. It is crucial for us to understand what decentralization and participation mean to a household when one has to guard crop and other has to look after the cattle. There are households even with one person.

5.3.2 Watershed Management Committee

The last watershed level RPG identified the need to have watershed level institution to ensure integrity of the natural resource system that supports the livelihood of the people. This institution can ensure the efficient utilization of the resources giving due consideration to the younger generation. The participants of the workshop agreed that the watershed institution will be fully functional by January 2006.

The three days of RPGs and discussions had helped to enhance the capacity of the participants to understanding and analysis the problems and issues and were able to explore the options of addressing the problems. Participants were in a position to vision a

common goal for the watershed development. The participants have reached unanimous agreement for establishing Watershed Management committee which is a strategy for realizing the common goal. In general third day saw more agreement and support towards the formulation of Watershed Management Committee.

The outcome of the discussions with regards to the need, advantages and disadvantages of establishing watershed institution- The Watershed Management Group, Constitution and By-laws were presented to plenary secession. The result of secrets ballot ranking indicated that collective mode of RPG ranked the highest. This indicated that the majority of the participants are in favoured working together towards common vision of the watershed development through establishment of watershed level institution. The name of this organization shall be the Lingmuteychu Lueng Zimchong Tshogpa (Lingmuteychu Watershed Management Committee), hereinafter designated as the Tshogpa and abbreviated LLZT.

Objectives of Watershed Management committee

The specific objectives of the *Lingmuteychu Watershed Management* Tshogpas are to:

- Improve water management techniques in on-farm and off-farm to increase water productivity by 25% in the watershed,
- Enhance awareness and capacity of the people on NRM strategies and involve them in collective actions,
- Consolidate and source resources (internal and external) for development of the watershed,
- Foster the development of local watershed restoration and protection programs in accordance with appropriate management strategies and techniques,
- Provide a forum for sharing of information and experiences on scientific, administrative, legal, and financial aspects of watershed management,
- Encourage the development of local, state, and national programs, policies and legislation promoting watershed management, and
- Encourage the cooperation and interaction of organizations, agencies, units of government, and individuals concerned with watershed improvement and protection.

Boundary

Boundary defines the limits of a resource and/or the individuals who can use the resource and closes it to the outsiders.

- All the residents of 7 villages (Limbukha, Dompola, Nabchee, Omteykha, Matalungchu, Wangjokha, and Thangu) are considered as the immediate beneficiaries of the Management Tshogpa.
- The watershed is bounded by a ridgeline running down from Antakarchu range at 3040m in north, Dothogewa in the west, Punatshangchu in the south, and Bzhomaney in the east.
- At the downstream of the watershed, the west limit extends to the ridge (GPS reading of E89.88988°, N27.51724°, at an altitude of 1217m) between Thangu and Samthang, and the east limit being the ridge above Bajo Lhakhang (GPS reading of E89.89872°, N27.50142° at an altitude of 1304m).

- The watershed is located on the left bank of the Punatshang Chu occupying an area of 34 km^2.
- All the tributaries and distributaries originating from the 11 km long Limti Chu stream is also included within the management Tshogpa.

Membership

- The membership of the Tshogpa shall consist of and be open to all individuals, institutions, corporations, and organizations whose interests are consistent with the objectives of the Thsogpa. (*Voluntary for HHs of 7 villages -Limbukha, Dompola, Nabchee, Omteykha, Matalungchu, Wangjokha, and Thangu*)
- Only the registered households of above 7 villages will be considered as voting members.
- Each member will have to deposit registration fee (to be decided) and annually the membership fee to the Tshogpa.
- The annual membership dues for each of the membership categories shall be evaluated on an annual basis by the management Tshogpa.
- The membership year of the Tshogpa shall start from 1 July and end on June 31 of the following year. Annual membership dues are to be paid with June and are not refundable. Dues are payable to the LLZT for deposit by the Treasurer into the LLZT account.
- A member shall uphold and be guided by the Vision and Mission enshrined in the By-laws.
- A member's sex, creed, religion, wealth category and ethnic background shall not be considered for membership.

Management plans

Under the supervision of the Geog RNR staff, the Tshogpa shall develop watershed management plans in accordance with the existing Acts (e.g. Chapter II Article 5 and Article 6 of Forest and Nature Conservation Act of Bhutan, 1995; Cooperatives Act 2002, Land Act 1979, etc.). The Management Plan can include:-

- Catchment protection
- Community forestry
- Riparian zone management
- Rehabilitation of irrigation schemes
- Reforestation of degraded areas
- Gully stabilization
- Forest protection
- Environmental management
- Cooperatives
- Eco-tourism
- Multi-stage check dams
- Land management campaign

Monitoring and evaluation

- Member representing each community of the watershed will monitor the day to day progress of the activities.

- Chairperson through the Tshogpa shall ensure proportionate participation of the members in the management actions, monitor and evaluate the impacts of every action.
- The Geog RNR staff who will regularly report the progress to their respective sector in the Dzongkhag and subsequently to the Departments in Thimphu shall also serve as the monitoring.
- An external agency (e.g RNRRC, Projects) can be requested to conduct impact evaluation after a stipulated life of the Management Tshogpa.
- Coinciding with the Geog auditing by RAA, the LLZT can also be audited simultaneously.

Penalties for Violation of By-laws

- Any members acting in contradiction to the objectives and agreed actions of the Tshogpa shall be subject to penal sanctions.
- Any individual or institutions committing any unlawful acts by definition of various Acts and Laws of the Kingdom shall be tried in court of law.
- Violation of By-laws by any office bearers shall be subject to penal liabilities as per existing laws of the Kingdom.

Institutional linkages

In view of the extent of a watershed, which can spread beyond one geog and even sometimes Dzongkhags, a dynamic institutional linkage would be desirable to permit integrated approach to watershed development.

Table 69: Institutional linkage

Institution	Status	Relevance	Linkages
Dzongkhag Administration	Direct controlling agency	Control of actions in geog	Administrative, Financial, Judicial and Technical requirements
Dzongkhag Yargay Tshogchhung (DYT)	Highest decision making body at Dzongkhag level	Forum to prioritize Dzongkhag development plans	All GYTs in a Dzongkhag converge to DYT
Geog Yargay Tshogchhung (GYT)	Decision making body at Geog level	Manages the Geog Development plan	Some members of the GYT are members of the Tshogpa
Geog RNR (Agriculture, Forest and Livestock) Extension office	Govt. Office in geog	Custodian of Forest and Facilitator for RNR development in geog	Technical support, initially secretarial support. (Link to DoF, DoA, DoL, MoA)
RNR Research Centre in Bajo	Regional Research Centre	Facilitator (since 1997)	Technical support (Back stopping)

5.3.3 Field Activities in the Watershed

Revival of Lumpa Irrigation System
During the RPG workshops the participant with the enhanced understanding of watershed NRM dynamics decided that the watershed management is crucial for all generations of people. Therefore participants agreed to implement few field activities initially that will contribute to the better management of the watershed. Restoration of irrigation canal at Lumpa was also one of the main activities pointed out by the community.

It was decided to rehabilitate 7 acres of abandoned wet land at Lumpa by making water available through workshop, discussions and presentations on effect of deforestation resulting to decline in water volume. Farmers realised and raised concern about the abandoned wetland at Lumpa, opposite to Omteykha which was earlier under cultivation but over time, due to scarcity of water which did not reach the fields, had led farmers to leave the land fallow. The participants assured that the abandoned wetland will be rehabilitated through collective action which will be led by the village head (Gup).

RC Bajo provided all the technical support in terms of facilitating the planning and implementing for restoration of irrigation canal in the Lumpa village. The field work was planned to be completed within two (May to June 2006) months period.

Planning: An informal meeting was conducted in the farmers' field to initiate the restoration works for canal. A field survey for detail measurement of irrigation canal and location of source were done. Accordingly RC Bajo prepared the technical estimate, sourced fund, provided technical support and facilitated the activities.
Procurement and Transportation of Material: RC Bajo secured the fund support of Nu.100000/- from Ecol-Commod Project. As per the estimate, the materials that were not available locally were procured. The cost included the cost of cement, and transportation up to nearest road head- Omteykha. The local transportation was done by the community.

Field Work: WMR Sector was responsible to supervise the mason work. The field work was started by May 2006. The works that did not require skilled labour was done by the community themselves. The cement construction works required skilled labourers the cost of which was provided by RC Bajo.

Completion: Although the field work was planned for four weeks, it actually overshot by one-two weeks more. The work got delayed mainly because the community was not able to contribute the labour as planned. This happened because one people died within the initial start of work in the village. As practised elsewhere villager has to provide support to the households in times of distress. Moreover there are only five households and one member representing as *woola* was not sufficient at the site. As a result the work got delayed by two weeks and completed by June 20 2006 only.

Conclusion
The farmers are really happy to have their irrigation canal restored. They said that they will soon start the cultivation on their idly kept wet land as the irrigation problem is solved.

The other activities like construction rainwater seepage ponds and spring source development and plantation of trees on the Critical Areas in the watershed are under progress and will be completed in the next fiscal year.

5.3.4 Other Regional Activities

In addition to the planned water management activities, the sector was also engaged in the cross-sectoral activities of the centre. The sector also rendered technical support to the client Dzongkhags. The major inter-disciplinary activities undertaken by the centre are Athang Gewog Diagnostics Survey and Development of Organic Farm in Punakha.

Athang Diagnostic Survey
Athang Diagnostic Survey was conducted in last week of April 2005 following the Agriculture Minister's visit to the Gewog. Athang is one of the remotest Gewog in Wangdue Dzongkhag. Owing to its remoteness, the development activities of the government hardly reached the Gewog. As a result the people living in the Gewog are relatively poor compared to others.

The aim of the diagnostic survey was to understand the problems and issues of the Gewog to formulate a strategy for the development activities to improve the living standard of the people. The main findings of the study were the people generally were poor with limited landholdings living in scattered settlements, poor access to market (no farm road), poor access to extension & development support and poor access to health and education services.
During the diagnostic survey it was also found that the Samthang village also has irrigation water supply problems. They have an irrigation canal but due to the instability of the soil the conveyance is to too low. The water gets lost due to seepage and landslides. To overcome the problem WMR Sector had the commitment to prepare the estimates of the HDPE pipes to be used on the critical areas. RC Bajo provided 23 numbers of HDPE pipes along with the sockets. WMR sector assisted in the supervision during laying those pipes at the critical areas. SDC Helvatas project covered the cost of the pipes.

Participatory Research & Development Project
Research Assistants of WMR and Field Crops sectors participated in the regional capacity development for participatory research and development project training in Thailand. At the end of the training-field research-mentoring scheme, participants would be able to:

- Discuss the conceptual and methodological characteristics of PR&D in the context of agriculture and natural resource management.
- Field-test and adapt the existing pool of PR&D knowledge and practices in participants' own work settings.

- Assess how PR&D can contribute to program agenda of participating organizations, and to identify effective strategies for PR&D application and capacity development.

The field research was conducted in the four Irrigation schemes in Wangdue and Punakha Dzongkhags. The research was made and presented in the summative workshop which was held in Nepal in October 2005.

Civil Engineering Works

As RC Bajo does not have a separate maintenance unit, WMR Sector is also mandated to take up the civil engineering works within the research capacity. As such we have to devote significant amount of time and effort for civil engineering and other maintenance works of the centre. At the same time the sector have to cater similar need and support to Regional Agricultural Machinery Centre (RAMC) and Druk Seed Cooperation (DSC) located in Wangdue. The engineering works includes the design, drawing, preparation of estimate, contract tendering, implementation, site inspection, bill verifications, certification and reporting. Total of four engineering works was implemented by the sector are completed. The following table gives the list of activities with the status and cost of the activities implemented during the financial year.

Table 70: Activities by status and cost implemented during the fiscal year

Activities	Cost (Nu)	Remark
Construction Drying floor/ Tennis court	5,39,000.00	Completed
Renovation of RNR Sub-centre Tsirang (2nd phase)	11,90,000.00	Completed
Construction of Class Three Staff Quarter	22,69,000.00	On-going
Construction of Machinery shade house at RAMC, Bajo	3,35,000.00	
All the routine maintenance work for RC Bajo	3,000.00	Completed
Supply of 225mm dia 4 kg pressure HDPE pipes to samthang		Completed
Total Cost (Nu.)		

Capacity Development

List of workshops, conference and field visit attended/partivipated fully or partially by WMR staff as givenven below:

- CBNRM – Next Phase Design Workshop: The sector participated in CBNRM – Next Phase Design Workshop held in Hotel Olathang, Paro from August 02 to 06, 2005.
- Climate Change Workshop: The sector participated in the workshop on Inception of Climate Change & Potential Impacts on rice production in Mountain Lodge in Bumthang from September, 2005. The sector presented a discussion paper on the Water requirement & water use characteristic of rice under different production systems. The workshop was supported by NCCSAP Project Agriculture Study Component
- Writeshop: The sector participated in the writeshop in consolidating seven years of experiences in Lingmuteychu Watershed from June 06 to 11 2005, in Damchen Resort in Punakha and from June 13 to 18 2006 at RNR RC Bajo.

- PR&D - Capacity Development for Participatory Research and Development. The sector Research assistant took Part in the Introductory training in Bangkok RECOFTC (Feb 28th – 11th March 2005, Field Research in Bhutan (7 months) and Summative Workshop in Nepal (1st October-6th 2005).

5.4 Agricultural Economics

5.4.1 Economics of Rice Production in the West-Central Region

Rice is the most important crop in Punakha, Wangdue, Tsirang and Sarpang in terms of area, production, and employment and as a staple food crop. With about 38% of the rice area, it accounts for about 44% of national rice production.

Rice production in Bhutan is labour intensive: some 83 labour-days per acre may be used to grow this crop (*Swinkels et al, 2000*). In Bhutan, farmers are engaged in rice production related activities, all year round. Such activities start from leaf litter collection and nursery bed preparation in winter, to crop harvesting and threshing in autumn-winter. That is why some people argue that rice may not be a profitable crop for Bhutan. However, limited recent field data are available to substantiate this.

It therefore seemed important to conduct a study to update our understanding of the costs and returns involved in growing rice. Such an understanding would also help to assess the economic impact of any possible new technologies for growing these crops. It would also contribute to debate on e.g. the rice self-sufficiency policy.

The objectives of this study are to:

- quantify inputs such as labour and material inputs for growing rice;
- determine costs of production of rice;
- determine the profitability of rice growing, by assessing its returns to land and labour and comparing these with available alternatives;
- test and further develop a method for assessing costs and returns of crops in Bhutan.

Methodology

The study was conducted with a total of 120 farmers from selected geogs of Punakha, Wangdue, Tsirang and Sarpang Dzongkhags. Of the 120 farmers 25 were from Punakha, 32 from Wangdue, 36 from Tsirang and 35 from Sarpang. Care was taken to select households proportionately to the total number households in the Dzongkhag. This was done to help ensure a fair representation of the households from each of the Dzongkhags.

Table 71: Number of households selected for the study

Dzongkhag	Geog	Number of hh interviewed
Punakha	Shengana	14
	Dzomi	11
Wangdue	Kazhi	13
	Gase Tsho Gom	8

	Rubisa	11
Tsirang	Mendregang	19
	Tsholingkhar	17
Sarpang	Gelephu	19
	Chuzagang	16
Total		120

Data collection and analysis

For this study, all data were collected through farmers' recall using interviews with individual farmers. Farmers were asked about their actual labour and other inputs, as well as outputs from their fields in 2003. Rice price data were the prevailing market rates. The opportunity costs of household and exchange labour are unknown. In the analysis, we estimated this to be 75% of the hired labour costs. In the crop budgets, all labour was valued at this rate. Crop guarding labour was regarded as 'light work' and was therefore counted in the analysis for only one third, that is, one day of crop guarding labour is one third of a 'normal' labour day. Data were entered in a data entry form in MS EXCEL, which consisted of several worksheets linked together. The analysis usually combined the data from all individual rice fields of one farmer into one crop budget for each farmer. Subsequently, averages and standard deviations of the most important crop budget parameters were then calculated.

Results

Costs

The total production costs (Nu/acre) of rice of the four Dzongkhags were as follow: Punakha – Nu 22,448 per acre; Wangdue - Nu.20, 675 per acre; Tsirang – Nu. 6,330 per acre and Sarpang – Nu. 4,928 per acre. This shows that the production cost in Punakha and Wangdue were much higher than Tsirang and Sarpang. The reasons for the variations in production cost will be explained in the subsequent paragraphs.

Cost comprise of material inputs, ploughing and threshing, and labour inputs. Proportion of total rice production costs presented in Table 71 shows that the use of inputs in rice production is very low in Tsirang and Sarpang compared to Punakha and Wangdue.

Table 72: Cost components in rice production

Dzongkhag	Production cost (Nu/acre)		
	Material inputs	Ploughing	Labour inputs
Punakha	3853	2735	15860
Wangdue	4020	2167	14488
Tsirang	825	1275	4231
Sarpang	679	1054	3194

Material Inputs

Material inputs used by farmers for rice production were seeds, fertilizer, farm yard manure and herbicide. Use of fertilizer and herbicide were quite minimal in Tsirang and Sarpang. In comparison Punkha farmers use more fertilizer for rice production. This was evident by the cost incurred on fertilizer by Punakha farmers. Farmers in Punakha and Wangdue also spent Nu. 231 to 249/acre on herbicide while Tsirang and Sarpang farmers on the average use less fertilizer and herbicide. Moreover, use of FYM in rice fields in Tsirang and Sarpang was also found to be quite low. Apart from practicing tethering, farmers do not use any fertilizer in their rice fields. However, low use of herbicide could be explained by the fact that weed is not much of a problem in these Dzongkhags.

Table 73: Material inputs used for rice production

Dzongkhag	Variable Inputs (Nu/acre)			
	Seeds	Fertilizer	Herbicide	FYM
Punakha	776	127	231	2719
Wangdue	825	51	249	2895
Tsirang	547	12	3	263
Sarpang	399	25	53	203

Ploughing and threshing

Ploughing and threshing constitute another important cost in rice production. Land preparation is mostly done using oxen ploughs, although use of power tiller is most prevalent in Punakha and Wangdue. Similarly, pedal thresher is mostly used in threshing. Table 73 shows the cost incurred by farmers for ploughing and threshing.

Table 74: Ploughing and threshing costs

Dzongkhag	Variable Inputs (Nu/acre)		
	Pedal thresher	Power tiller	Oxen-plough
Punakha	133	543	2033
Wangdue	153	94	2018
Tsirang	0	0	1275
Sarpang	0	91	963

Labour Inputs

The average labour input for rice and their corresponding costs are presented in Table 74. Labour use per acre was high in Punakha and Wangdue districts. The main reason for this was the crop guarding labour for approximately 3 months in these districts. Even when counted as one-third of total labour days, crop guarding still consisted of 24% of the total labour input. Another was due to labour required in FYM transport and spreading in the rice fields. In the southern Dzongkhags crop guarding and FYM application was either very low or none at all.

Table 75: Labour inputs and their costs.

Dzongkhag	Labour input (Person-days/acre)	Labour cost (Nu./acre)
Punakha	132	15860
Wangdue	152	14488
Tsirang	85	4231
Sarpang	67	3194

Figure 13 and 14 shows the proportion of labour inputs in rice production in the study areas. In Punakha and Wangdue, crop guarding, weeding and land preparation were the most labour intensive activities while in Tsirang and Sarpang land preparation, planting and harvesting were the activities that required higher labour-days. Crop guarding in Punakha and Wangdue alone takes about 35 labour-days per acre in Wangdue and Punakha.

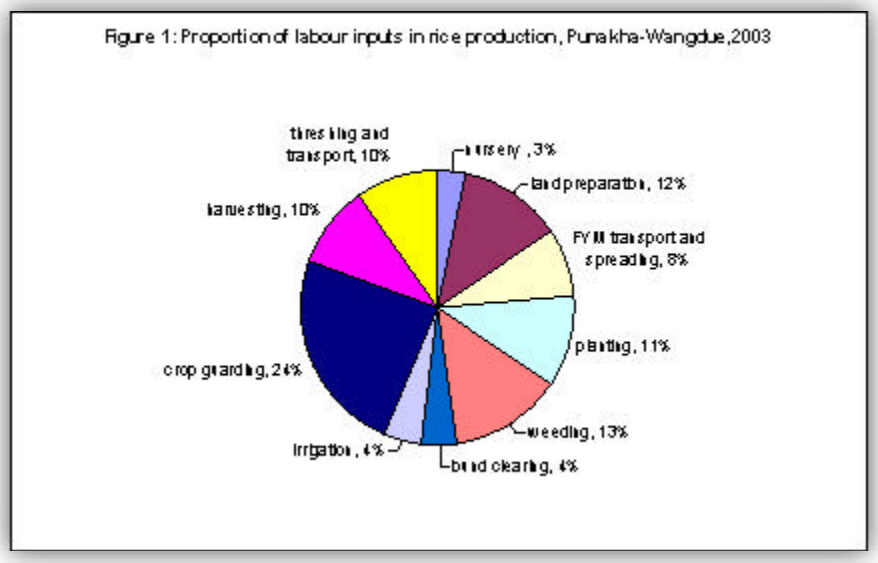


Figure 13: Proportion of labour inputs for rice in Punakha-Wangdue

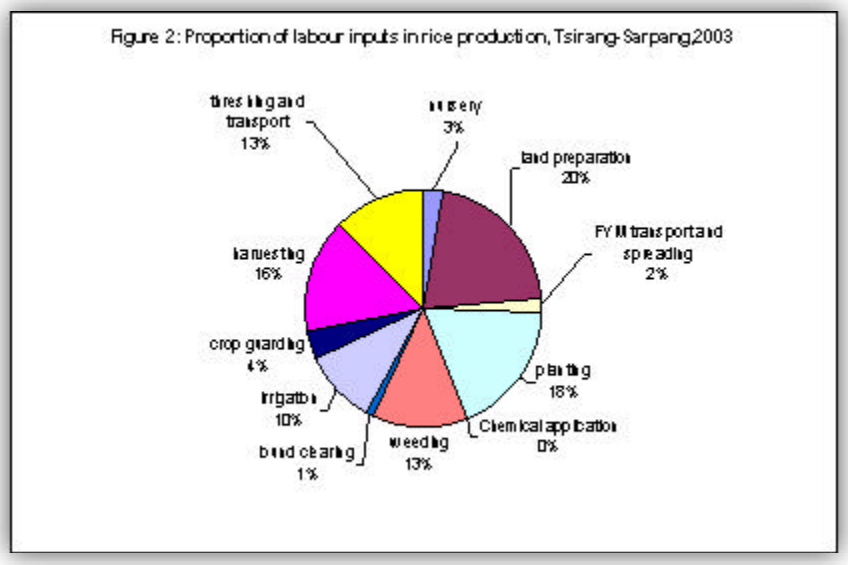


Figure 14: Proportion of labour inputs for rice in Tsirang and Sarpang

Of all labour, men provide most of the labour in rice production in Tsirang and Sarpang ie. 56% of the total labour, while in Wangdue and Punakha, labour contribution by gender was almost equal (i.e men provides 49% of the total labour).

Rice Yields, Production Costs and Returns

Average paddy yield and their standard deviations are presented in Table 75. These yield data were from different rice varieties. Yields were found to be very low in Tsirang and Sarpang – almost half of Punakha and Wangdue. Low use of inputs such as fertilizer, improved seed varieties and water for irrigation were the main causes for this low yield.

Table 76: Average paddy yield, 2003

Dzongkhag	Average Paddy yield (kg/acre)	Standard deviation
Punakha	2052	409
Wangdue	1760	564
Tsirang	906	243
Sarpang	1157	187

The average cost of production of milled rice is presented in Table 76. It can be seen that rice production cost is the lowest in Sarpang followed by Tsirang. There was not much variation in the cost of production among the farmers. The 95% confidence interval of the cost of production was found to be Nu. 1.09 per kg for Punakha, Nu. 1.7 per kg for Wangdue, Nu. 1.6 per kg for Tsirang and Nu. 0.47 per kg for Sarpang. This means that there is 95% probability that the cost of rice production could be plus or minus by those amount from the average production cost.

Table 77: Rice production costs

Dzongkhag	Total production cost (Nu/acre)	Yield (kg/acre)	Production costs (Nu/kg)
Punakha	22399	2052	11.19
Wangdue	21817	1760	13.18
Tsirang	6333	906	7.79
Sarpang	4933	1157	4.30

Analysis to returns to land and returns to labour are useful parameters. Both are relevant for farmers in the area because both arable land and labour are scarce factors. Returns to labour and land are shown in Table 77. Returns to land and labour in all Dzongkhags were lower than their opportunity costs indicating that it is not economically attractive for farmers to grow rice.

Table 78: Returns to labour and land

Dzongkhag	Returns to labour(Nu/day)	Returns to land (Nu/acre)
Punakha	49 (standard dev. = 60)	3751 (standard dev. = 6,579)
Wangdue	43 (standard dev. = 88)	1743 (standard dev. = 11,355)
Tsirang	-6 (standard dev. = 37)	5052 (standard dev. = 2,825)
Sarpang	45 (standard dev. = 37)	9254 (standard dev. = 2,390)

Conclusions

Rice production is indeed labour intensive. Labour comprises of about 70 percent of the total production costs. The results from this study shows that on average 142 labour days per acre is used to grow the crop in Punakha and Wangdue with 49% of the labour use accounted for crop guarding, weeding and land preparation. Crop guarding alone accounts for 24% of the total labour days. Labour days per acre was much lower in Tsirang and Sarpang as compared to Punakha and Wangdue (75 days per acre). Labour intensive activities in Tsirang and Sarpang were land preparation, planting and harvesting.

Recommendations

- Farm mechanization (planting, harvesting and mechanical threshers) would greatly reduce the high labour costs. Unlike tractors and power tillers, these farm machines could be used despite unfavourable terrains.
- Wildlife damage to crops not only reduces production but also increases cost of production. Therefore, a solution to this problem must be found at all costs.
- Yield level must be improved especially in Tsirang and Sarpang. Increase in use of improved inputs, like fertilizer and high yielding varieties can greatly increase the production.

5.4.2 Goen Shari Diagnostic Survey

Gewog Profile

Goen Shari gewog is located south of Gasa Dzongkhag. It comprise of five chiwogs with an altitude range of 1400 – 4000m above sea level. There are 82 households in the gewog with an approximate population of 600. The climate of Goen Shari is sub-tropical which has usually cold winters and warm and humid summers. The annual rainfall ranges from 500mm to 1500mm. The minimum and maximum temperature ranges from 4 degree Celsius to 30 degree Celsius.

About 90 % of the land is under forest cover. Broad leaf forest is 70% and conifer forest is 20%. Cultivable land is about 5% and the rest are scrub and natural pasture. Of the total cultivable land, wetland comprise of about 264 acres and 59 acres of dry land. Cereal crops grown in the gewog are paddy, wheat, maize, mustard and buckwheat. Vegetables like potato, radish, beans, spinach, cabbage, turnip and onions are also grown. Potential crops (horticultural) crops are walnut, pear, peach and apricot.

Punakha-Tashithang road runs through the gewog. However, most of the villages are located more than two hours walking distance from the road head. The gewog has one community school, one outreach clinic, one agriculture centre and one livestock centre.

Objectives

- To understand the current local situation (practices, problems and opportunities)
- And to gather information needed for the design of interventions

Research Methodology

RRA tools and techniques were used for field level data collection. Because of the important role of discussion between individuals involved in implementing RRA and the need for several perspectives, RRA was carried out by a multi-disciplinary team having some familiarity with all aspects of the local farming system. Interview techniques, seasonal calendar, ranking, village and resource mapping are some of the tools that were used. Prior to the survey, the sectors concerned were consulted to identify areas of interest for data collection.

Seycheykha Village

Secheykha, also called Sechena has 11 households and is located at an altitude of 2080 masl. Five households claimed to be food self-sufficient while rest had to depend on imported rice during the deficit period. Food deficit months are from June-August.

Table 79: Average land and livestock per households in Sechekha

Village	Family Members	Land holding (Ac)		pig (no)	poultry (no)	cattle (no)	horse (no)
		wetland	dryland				
Sechekha	7.75	2.34	1.12	0.5	3.5	8.7	0.3

Findings

The farmers were formed into three groups and were given the task to draw resource maps of three consecutive decades i.e. past 10 years, present and future, 10 years from the present. The group division was governed by age. That was senior farmers were asked to map the past resources while the mid aged farmers were asked to map the present situation and the younger ones to draw the future resource map. The findings of the groups were presented to the plenary comprising of all the groups and the researchers.

Table 80: Resource map of Sechekha village

Agriculture

	Future	Present	Past
1	Accessibility: • Farm Road	• No road	• No road
2	Improved rice varieties	Improved • Chumroo Local rice varieties • Bunaap, wangdakarm, goenbja	Only local rice varieties
3	Improved wheat varieties Improved mustard varieties	Local varieties Local mustard varieties • Peka naam	Only local wheat varieties Only local mustard varieties
4	Improved fruit plants • Japanese pear (Drelee), soft shell walnut, peach, Mandarin, apple, pear, persimmon	Local fruit plants • Peach, pear	Only local fruit varieties
5	Improved vegetable production • chilli, potato, cabbage, radish, Sag and Mushroom	Improved (introduced) • bringal, carrot, asparagus Local vegetable Local vegetable • chilli, potato, cabbage, radish, coriander, spring onion, garlic	No improved vegetable production, only local vegetable
6	Irrigation channel Management • Churagu lum channel, Rhotsa lum channel	Existing Channels • Churagulum channel, Rhotsa lum channel	Existing Channels • Churagu lum channel, Rhotsa lum channel
7	Farm Machineries • Rice hauler, pedal thresher, powertiller	• Rice hauler, pedal thresher	No farm machineries

Livestock

	Future	Present	Past
1	Breeding bull (Brown Swiss)	Artificial Insemination	Local bulls
2	Half linger	Pigs: local and Improved	Local pigs
3	Poultry	Local poultry and Improved	Local poultry
4	Feed and Fodder • Winter oat, ficus	• Winter oat, ficus	Natural fodder and grasses
5	Artificial Insemination (AI)		

Forestry

	Future	Present	Past
1	Assistance in community forestry establishment	Natural forest	Natural forest
2	Assistance in improving the stands in the Sokshing areas	Sokshing available for all households	Sokshing available for all households
Non Agricultural			
1	Rural Electrification	No electricity	No electricity

Need assessment of Seychekha village and the priorities made by the farmers by bean ranking was done. Since the needs may different for women and men they were given 100 numbers of beans for both ladies and gents to put in their prioritized needs.

Table 81: Need assessment and priorities of Sechekha village

Village needs	Ranking by Male	Ranking by Female	Total	Priority
Farm road	29	24	53	1
Improved vegetable varieties	7	11	18	3
Cereals	8	10	18	3
Fruit plants varieties	4	10	14	5
Artificial Insemination	2	13	15	4
Electrification	19	21	40	2

Major Constraints

- Absence of motorable road in the village
- No electricity in the village for lighting, cooking etc
- Chilli blight disease

Opportunities

- In agriculture, there is potential for farm mechanization. Since the wetlands are flat they conducive for machines to carry out various operations.
- Supply of more fruit crops saplings in horticulture

Recommendations

Since the farmers have been facing Chilli blight disease and no remedial measures found, it is recommended that IPM sector of RNRRC Bajo and Agriculture sector of Punakha Dzongkhag lay out trials to find out the solution.

Dochukha Village

Dochukha is situated on a gentle slope above road leading to Gasa and it takes roughly two hours walk from the road. The village has 15 scattered households. The altitude ranges from 1800 m to 1900 masl.

Rice is their main staple food as well as cash crop. The minimum wetland holding was 0.75 acres and maximum of 10 acres per farmer. Farmers cultivate rice and maize as summer crops followed by wheat, buckwheat and mustard in small scale in winter. Barter system is prevalent in the village. They exchange rice with yak meat, butter and cheese. They also grow chilli and tree tomato but they hardly grow other vegetable. The farmers mainly depend on livestock. The village has a total of 110 cattle and 51 poultry. They sell eggs, butter and cheese in Punakha market and sometimes bring down to the road side and sell the products.

Forest coverage is good and they get sufficient timber, firewood, leaf litter and more importantly they get ample of ferns and mushroom in summer thus they collect them and sell it for cash income.

Table 82: Average land and livestock per households in Dochukha

Village	Family members	Land holding (Ac)		pig (no)	poultry (no)	cattle (no)	horse (no)
		wetland	dryland				
Dochukha	7.7	3.57	0.07	0.31	2.75	7.25	0.44

Constraints

- Lack of farm road hampers farmers to market their surplus produce
- Crop and Livestock predation by wild animals
- Insufficient volume of irrigation water especially during transplanting.
- Farm labour shortage problem especially during peak cropping seasons thus forcing some farmers to leave their land fallow.
- Shortage of fodder during especially in winter.

Non RNR

- The village doesn't have electricity.
- Lack of road makes it difficult for the farmers to market their farm produce. The road leading from Punakha to Goen Dhamji does not benefit. Vehicles plying on this road are mostly private cars and taxis on some days due to which most of the time farmers have to go on foot which takes half the day to reach the market.

Opportunities

- The village has a proposal for a farm road. If the road is constructed, use of farm machinery like power tiller would save labour and increase work efficiency.
- With some assistance from the government, the farmers could maintain their irrigation channel well. This would help in increasing their rice production. .
- Improvement of livestock breeds like Jursey, mithun, Brown swiss, piggery and poultry could enhance production.
- Introduction of fruit crop like pear, guava, passion fruit, litchi etc .

Gumgang Village

Gumgang is situated on the other side of the Mochu River at an altitude of 2150m. The village is widely spread on the gentle slope facing northwest. On its three sides there is broad leaf forest and on the other side lies Yobu village. Out of twelve households four households were reported to be food deficit. These farmers buy rice from Punakha FCB in the deficit period of one to two months. Eight households reported to have food surplus which they sell to *Layap* and in Punakha market.

Major constraints

- Lack of irrigation water for winter crops
- No access to improve seeds
- Labour shortages during the peak seasons
- Crop damage by wild animals (wild boar and deer).
- Farm machines and labour saving tools are not accessible
- Lack of awareness and training
- Shortage of land for improved pasture development activities
- Shortage of manpower to look after the day grazing animals
- Livestock attack by wild animals.
- Lack of electricity.

Opportunities

- Farm Mechanization: Since the farm road is coming up there are opportunities for mechanization and introduction of labour saving tools.
- Increase in Production: Since the present yields are low, the production can be increased through promotion of improved varieties and management practices.
- Winter fodder (oats): There is good potential to grow winter fodder like oats in rotation to rice. Besides oats, the community can also go for tuber crops like Swede, turnip and radish etc which can supplement winter feed.
- Gumgang will be greatly benefited by the farm road. Problem of transporting farm produce to the markets will be solved to a great extent.

Recommendations

- Improvement in productivity of rice with introduction of new seed of Khangma Maap and other high altitude improved varieties and crop management practices.
- Improved varieties of wheat and mustard with early planting

- Introduction of improved farm machinery (power tiller and other labour saving tools)
- It is strongly recommended that the Dzongkhag Livestock Sector could continue further support the community, such as in cross breeding program.

The group also emphasise that Dzongkhag livestock sector could continue the Urea treatment of paddy straw which is an existing technology in extension for the last decades. Because farmers have only rice straw as the fodder resources during the winter, they could be trained in the methods of preparation of Urea treatment, preservation and feeding management.

Yobu Village

Yobu village is located about two hours walk from the nearest motorable road point. It is situated on the other side of the Mochu River at an altitude of 2050m in the middle of the village. At present there are nineteen households in the Yobu village. The village is surrounded by forest on three sides mainly broad leaves and the other side lays the Gumgang village. The road to lunana and hot spring passes through this village and had the opportunities to sell their product in the village itself. During the winter the Lunaps come to their village and purchased rice from them. Sometime the Lunaps bring goods from Lunana and exchange rice. It is the main rice-supplying village for Lunana people. During the lean season the farmers also transport good to Lunana with horses.

Farmers' vision

The farmers visions matches with their development opportunities. The farmers who have dry land want to make use of it by cultivating potato and establishing orchard. The access to farm road has raised the interest of potato cultivation. The market facility within the village itself has contributed to continued increased production of rice crop.

Table 83: Farmers' vision: Sechekha village

Vision	Remarks
Potato cultivation	Dryland left unused at present
	Problem of overgrown tree restrictions
Increase rice production	
Take up horticultural crop	Apple
Raise more improved Livestock	Diary Farm
Establish private nursery	Forestry

The main sources of income to the farmers were from sale of Rice, Pony charges and remittance. Besides they also receive income from sale of eggs, fern, butter and cheese. For rice farmers they had the market in the village itself and they save the transportation charges. They sell rice to the people of Lunana in cash and sometime in exchange for other goods. The other products like eggs, butter, cheese etc. were sold to the people travelling to hot spring. They receive the remittance from their family who are working, mainly in the monk body.

Table 84: Sources of Income for Sechekha farmers

Source of Income	Average Household (Nu/year)
Remittance*	42,000
Rice	2900
Pony charges	1400
NTFP	750
Eggs, butter and cheese	700
Eggs	400
Vegetables	100

**Remittance is mostly from monk body.*

The number of household members working permanently in the farm ranges from 1 – 4. During the peak seasons especially during rice transplanting they find it difficult to manage. Farmers use exchange labour. The village has 9 rice mills and 3 pedal threshers.

Vision

The village called Yoebu is very excited to receive the power tiller road to their village. The road construction is already in full operation and reached almost half way to their village. On arrival of farm road, some farmers are interested in establishing a community Dairy farm. Besides, they are also anxious about getting electricity in their village.

Major constraints

- Irrigation problem especially during transplanting.
- Non-availability of power tiller in the village
- Lack of electricity
- Farmers explained the problem of crop damage by wild animals (boar, reindeer, bear, monkey and leopard). They also face other pest and diseases of rice. Chili wilt is a big problem.
- Lack of access to improved seed and seedlings as the village is located far away from the Dzongkhag.
- Labour shortage
- Rigid rules and regulation of the forest is also one of their problems.
- Natural calamities like hail storm, drought are also the main constraints of the village.

Recommendation

- Improvement in productivity of rice with introduction of new variety such as Khangma Maap and other high altitude improved varieties and crop management practices.
- Introduction of improve farm machinery (power tiller and other labour saving tools)
- Replacing of wooden channel (around 30 m) with pipes.

Opportunities

- Mechanization: Since the road is coming up there is an opportunity for mechanization and introduction of labour saving tools.
- Increase Production: Since the present rice yields are low, the production can be increased through promotion of improved varieties and management practices.
- High potential to grow the winter fodder like oats in rotation to rice. Besides the community can also go for growing tuber crops like Swede, turnip and radish etc in which can supplement winter feed. The community like Yoebu will be also benefited by the farm road which is shortly connecting their village to Punakha-Gasa road.

Recommendations

- It is strongly recommended that the Dzongkhag Livestock Sector could consider supporting the community in establishing a community Dairy farm.
- As rice straw is the only fodder resources during the winter farmers needed to be demonstrated in the method of preparation of Urea treatment, preservation and feeding management. The advantages of Urea treatment were supposed to include higher palability and intake, better N intake and reduction of liverfluke infestations.

Shangosa

Shangosa is located about one and half hours walk from the Punakha – Damji nearest road point. It is situated on the other side of the Mochu River at an altitude of 1500 - 2000m. The Shangosa village consists of twenty-five households. The village is surrounded by forest mainly broad leaves and forest resources are easily available. The agricultural land is little bit flat on the lower part of the village and sloppy on upper part of the village. Rice based cropping system is common practice in the village. The village is not access to farm road and electricity. The electricity remains the farmers' top priority from the labour saving prospects. The nearest school is Kapataksa community school, which is two hours walk from the village. For schooling the students have to travel in morning and back in the evening.

Table 85: Major constraints and Ranking expressed by farmer

Problems	Ranking (1=most imp, 5=least imp)
Electricity	1
Farm Road	2
Improved cattle breed	3
Improved varieties seed	3
Wild animals	4
Lack of farm Machinery	5

Most of the household faced labour shortage problem. They depend on hired labour from the neighbours especially for rice transplanting, weeding, harvesting, FYM carrying, fire wood collection, construction work etc. The wage rate in the village depends on the type

of work. Hiring rate was Nu. 70-80/day and Nu 150 with three meals with three meals construction work.

The main sources of income for the farmers were from sale of rice, and remittance. Besides they also receive income from sale of fern, mushroom, butter and cheese. The farmers usually sell their product at Punakha and Thimphu. They receive the remittance from their family who are mainly working in the monk body. 70% of the households have achieved food self sufficiency. The remaining 30% are food deficit farmers due to less land to cultivate. They purchase food from retailers and work in other farm for the food grains. The deficit months are from June to September.

Table 86: Income from different sources

Source of income	Ave hh income (Nu/year)
Rice	2040
Remittance	1650
Butter and cheese	1075
NTFP	165

Vision

The Shengosa village is eagerly looking forward having electricity connection to their village. The power line runs through their Geog to Gasa Dzongkhag. Some of the people in Shengosa also looking for better cattle breed to be purchased either in full cost or possibility to get at subsidized cost. They also enquired about the sources and procedures on buying these improved breed.

Opportunities

Mechanization: The land area is relatively flat so there is opportunity for mechanization and use of labour saving tools.

Increase Production*:* Use of improved varieties of rice, wheat and maize and better management practices could be promoted for higher production and improving food security.

Recommendation

- Improvement in productivity of rice with introduction of new seed of khangma Maap and other high altitude improved varieties and crop management practices.
- Introduction of improved farm machinery and other labour saving tool.
- The Dzongkhag Livestock Sector support the community to procure the high yielding cattle breed and make awareness of the breeding program.

5.5 Integrated Pest Management (IPM)

Some of the major activities for the Plant Protection sector implemented in 2005 were the on-going and routine activities which include community based fruit fly campaign in Tsirang and on-station *Shochum* weeding campaign. Other activities include weed control awareness campaigns for Parthenium, evaluation of rice blast through trap nurseries, rice blast monitoring and surveillance in the west-central rice growing areas and attending to *ad hoc* requests from client Dzongkhags on plant protection related field problems.

5.5.1 Community Based Fruit Fly Managment

The study to confirm that recommended citrus fruit drop collection every 10 days (NPPC, 2001) would lower potential fruit fly population in the subsequent years was established in Batasey, Tsirang at the end of 2003. The assumption is that collection and proper disposal of dropped fruit in September-October each year would minimise the fruit fly population level over the years and hence the reduction in fruit drop. The objective was to reconfirm that the recommendation of collecting dropped fruit every 10 days would accrue to decrease in fruit drop in succeeding years and motivate the farmers to implement the fruit-drop collection campaign as a long term fruit fly control strategy combined with proper management practices.

The study site Batasay (1400m approx.) under Kikhorthang geog, Tsirang is separated from other citrus growing villages. Hence it was considered an ideal study site for fruit drop collection campaign. Citrus is the main cash crop for the farmers of the village.

Interim data (**Figure 15)** indicate that the collection of the dropped fruit during September-October each year reduce the fruit fly population as shown by the increase in fruit yield.

Table 87: Mandarin yield trend as affected by fruit drop collection campaign

Name[11]	No. of mandarin plants	Yield (No.) 2003	Yield (No.) 2004	Yield (No.) 2005	Remarks
Muktinath Khatiwada	35	29600	38800	35000	1
Omnath Acharya	480	58000	75000	130000	2
Tulsiram Acharya					3
Ganeshyam Acharya					4
Gopilal Acharya	50	1500	5500	9000	5
Dilliram Acharya	25	1700	7500	14000	

[11] Farmers corresponding to serial number 2, 3 and 4 share the same mandarin orchard.

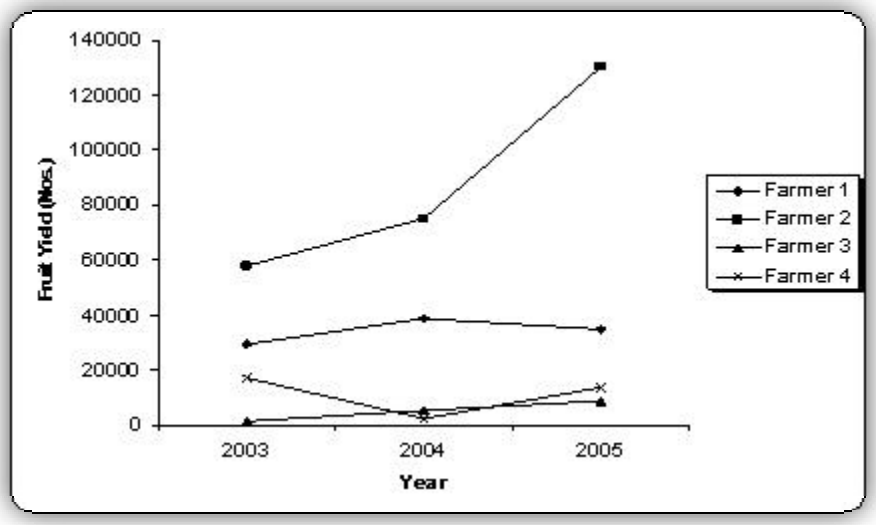


Figure 15: Over-the-years mandarin yield trend as affected by fruit drop collection campaign

Figure 15 presents the effect of fruit drop collection campaign on fruit fly population from 2003-2005 in Batasay village in Tsirang. By and large, there is a significant increase in fruit yield in all the mandarin orchards. The highest recorded increase in fruit yield was in 2005 for farmer 4 which saw a 460% increase. However the same farmer experienced 85.29% reduction in fruit yield in 2004. Plausible reason could be that the farmer did not collect and dispose the fruits in 2003 as recommended (every 10 days) further implying that the maggots had exited the fruits and entered the soil by the time the fruits were disposed off. The lowest recorded fruit yield (31.08%) was in farmer 2 in 2004. except for the same farmer experiencing a reduction of approximately 10% in fruit yield in 2005. Otherwise other farmers in the village have seen a significant fruit yield increase in 2005 as shown above.

Feedbacks from these farmers indicate that the fruit drop has reduced each year over the years which translate into higher cash income for them. Researchers and extension personnel have been able to convince the farmers that the causal organism of the late fruit drop is the Chinese fruit fly via demonstration of “fruit dissection” exposing the maggots that are potential fruit flies for the next fruiting season. As such the farmers have expressed their interests to continue practising the fruit drop collection in their community each cropping season.

To quantify the effect of the fruit drop collection campaign more concretely, the need to acquire data on different fruit grades (Meel, Keel, etc.) for the market has been stressed. Beginning 2005 harvest season, the extension agent (EA) for the geog has been instructed to collect fruit grade information for each of the farmer. It must be highlighted here that the farmers do not take the fruits to the market for sale; as practised elsewhere contractors come to the farmers and negotiate the price for the fruits while the fruits are

still on the trees. Therefore the cash income for the farmers from the contractors may not be one of the perfect yardsticks to measure the indirect effect of the fruit drop collection campaign.

The trial will continue for next 2 years while interim report will continued to be published in the centre's annual report. A report for the study will be published after the completion of the trial.

5.5.2 Shochum Weeding Campaigns

Shochum weeding campaigns initiated by this centre in 2000 has formally been taken up as a regular activity by the client Dzongkhags of west-central region after the Honourable Minister of Agriculture, Lyonpo Sangay Ngedup took the lead in a day long *Shochum* campaigns in Wangdue and Punakha in 2004. Since then the research centre has withdrawn from the weeding campaigns in the Dzongkhags and have continued to support the clienteles via technical services.

However the research centre continues to advocate *Shochum* weeding campaigns in the research rice fields. Each year staff and elementary support personnel (ESP) come together to participate in the weeding exercise which was started in 2005. The primary objective of the on-station *Shochum* campaign is to demonstrate that intensive hand weeding at critical periods will suppress the weed over time. Concurrently the campaign brings together the staff and ESP strengthening the camaraderie among the staff.

Quantitative data include weed sampling of fresh weed weights and rice yield from the weeded rice fields. Weed samples are taken for two hand weeding 2 and 4 weeks after transplanting. At the moment, the data collected is not enough to show the effects of hand weeding; more data need to be recorded to show the trend of hand weeding on the weed population. At least 2-3 more years' of data have to be in place to demonstrate the effects of weeding on *Shochum* reduction.

A pictorial glimpse of on-station *Shochum* weeding exercise is given Picture 37.

Picture 37: Researchers and farm labourers participating in the on-station *Shochum* weeding campaign

RESEARCH COMMUNICATION

5.6 Research Communication Sector

The Research Communication sectors 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, organising study visits in the centre, field days, annual workshops and online information sharing. The sector also coordinates the maintenance of technology parks in the extension centres for demonstrating the successful technologies. Besides, it is also a focal sector for imparting training and backstopping the farmers group formation in the region.

5.6.1 Technology Packaging

The centre published 7600 copies of various research technologies as packaged by different sector in the form of extension leaflets.

- Rice cultivation in Lowland
- Mustard cultivation
- Rice seedlings production practices
- Wheat cultivation in wet land
- Maize trash line
- Apricot cultivation
- Walnut Grafting
- Horti. Released technologies
- Bamboo Propagation
- Pangtse Shing propagation and management
- Fig tree propagation and management
- Tsenden propagation and management
- Tsakusha propagation and management
- Tsampaka metog propagation and management

These materials were distributed to all EAs of the region, relevant institutions of Ministry of Agriculture and farmers who attended 8th RNR Expo at Zhemgang. Apart from these some 200 nos. of technology packages were printed, laminated and distributed during the RNR Expo 2005.

The published materials were also updated in the digital compendium and will be hosted in the MoA website soon.

5.6.2 Model RNR Extension Centre Development

The four RNR Extension Centres are well in place however without difficulties, fund being the major constraint. Seedlings of fruit plants have been supplied to Phobjikha centre to replace the grazed seedlings.
Visits have been made to the RNR model centres to back them up with technical problems if there are any. However more than the technical problem they are presently facing financial problem as budgeting has not yet been systemised and incorporated in

the Dzonkhag budget. Hence labour payment, fencing, irrigation water supply are some of the difficulties mentioned during our visit.

It has been made clear that RC Bajo will not be in a position to to support them financially and would however support them in technical matters.

Vegetable seed, MS lebel, watering can, fruit plant saplings and fodder saplings have been provided to Dagapela ,Mendrelgang and Phobjikha RNR centres.

5.6.3 Technology Adoption Study

In order to bridge the gap better between farmers and research and extension and research it was felt necessary to study the adoption of technologies by farmers, which were released by the research.

A survey has been already conducted within the region and the data is under process. The report will be available very soon, sometime in January 2007.

5.6.4 Farmers Group Formation

Dompola saving group has eighteen members and is growing strong.They have a saving of about Nu.100000.00 which they loan out to the members and collect interest. Interest rates are charged higher when they loan out to other farmers.The group is also involved in mushroom cultivation, which they are still continuing.

The Dagapela Shindrel Tshokpa consisting of 22 members is two years old.The group has been formally recognized by the Dzongkhag. Apart from producing orange pulp the group will export orange to Bangladesh. For this purpose the group is being supported by FCB.

One group of farmers in Salamjee has been organised and is known as the Salamjee Phashing Zinchong Tshokpa. Their main objective of the group is to collectively manage their land which has high risk of erosion and land slide. By-laws of the group is already in place and they have started land management activities right after the training imparted by a multi-disciplinary team from RC, Bajo. Another small farmers saving group has been formed in Adang geog.

This centre was also involved in the group formation process of the Daga Shindrel Tshokpa which is now recognised by the Dzongkhag and even supported by the FCB, Phuntsholing. The vision, mission and by laws development has been supported by RC Bajo as well.

5.6.5 Research Extension Linkage

The sector has organized the annual research meeting for the second time in the west-central region. The meeting was conducted in Dzongkhag to discuss and prioritize problems which are reported to ARWP for appraisal and accordingly incorporated in the

Research-Extension Collaborative work plan. This meeting initiated by RNR RC for first one or two years would be more sustainable if Dzongkags would organise themselves and mainstreaming in their annual work plan. In earlier pre-regional meetings we have already indicated to leave upon the Dzongkhags to organise themselves in long run for future sustainability of this important event.

5.6.6 Annual Review and Planning Workshop

The sector has organized the annual research meeting for the second time in the west-central region. The meeting was conducted in Dzongkhag to discuss and prioritize problems which are reported to ARWP for appraisal and accordingly incorporated in the Research-Extension Collaborative work plan. This meeting initiated by RNR RC for first one or two years would be more sustainable if Dzongkags would organise themselves and mainstreaming in their annual work plan. In earlier pre-regional meetings we have already indicated to leave upon the Dzongkhags to organise themselves in long run for future sustainability of this important event.

5.6.7 Support and Coordination to the Visitors of the Centre

Through out the year round visitors from the Dzongkhag, Schools, NRTI, Farmers group visit this centre to familarise themselves with the research system. Logistic and other arrangements have to be made as most of the visitors come from far away distance. This year as well more than 15 such groups have been entertained.

5.6.8 Support to Organic Farm

Technical support is being continued to the Gupjithang Farm in its progress towards going organic. This is the second year of support and the farm is producing local red and white paddy, mung bean, ground nut, maize and soya. A trial on safflower also has been successfully conducted to see the possibility of safflower production in Gupjithang. In order to enhance soil fertility Dhaincha seeds have been provided to the farmers. Some of the crop has been already incorporated in the soil while about half acre has been kept for seed.

The farmer is aiming towards keeping about 40 heads of cattle and 200 birds in the coming year and for that the cattle and poultry shed is under construction.

Some fruit plants have been supplied from this centre which includes litchi, guava, persimmon and passion fruit. Few other ornamental plants have also been provided which are doing well.

The major problem faced by the farmer is labour shortage and lack of permanent workers.

6 TRAINING AND WORKSHOPS

Date	Name	Purpose
26Feb-11 March 2005	Zangmo & Meena D Dhungyel	Participatory Research and Development. Bangkok, Thailand.
7-11 Feb 2005	Sangay Duba & Doley Tshering	Training in Natural Resource Mgt., India.
12-25 March 2005	Mahesh Ghimiray	To attend meeting on BUCAP, Thailand.
14-18 March 2005	Tayan Raj Gurung & Aita Kumar Bhujel	E-collective learning processes in companion modeling for natural resource management and the environment, Thailand.
14th March -1st April 2005	Dawa Zangpo	Basic modern Administration Mgt Training at RIM, Thimphu.
17 -21 August 2005	P.P. Nepal	Training on mushroom production, RC – Jakar, Bumthang.
1- 6th October	Meena & Zangmo	Summative Workshop on participatory Research and Development in South East Asia. Kathamandu, Nepal.
16 – 22 October	Sangay Duba	Food Safety Program, ICIMOD, Nepal.
9 Oct 04 -7 Sept 2005	Sangay Wangdi	12 month MSc training on Tropical Agriculture Development (Crop Protection) at the University of Reading, United Kingdom.
26 – 30 Sept 2005	Dawa Lhakpa Sherpa, Yeshey, Lungki & Lhab Gyem.	GPS Training organized by DSLR, MoA, Thimphu.
3 – 7 Oct 2005	Tayan Rai Gurung	Companion modeling for water management, Thailand.
11 – 14 July 2005	Yog Rai	In-Country Training on Pests & Pathogens, RC – Jakar, Bumthang.
16 – 22 Oct 2005	Rinzin Dorji	In-Country training on forest regeneration ecology and Silvi -culture system, RC – Jakar, Bumthang.
13 – 14 Dec 2005	Aita Kumar Bhujel	Workshop on understanding CBNRM in South Asia Organized by CISED, Bangalore, India.
18 – 24 Nov 2005	Mahesh Ghimiray	5th International Rice Genetics Symposium, Philippines
26 Dec 05 -24 Jan 06	Namgay Lhamo	Training on Dzongkha Computer, RIM, Thimphu.
14 Feb -2o Feb	Neelam Pradhan	Plant Breeders Meeting, Bohol, Philippines.

16Jan – 20Jan	Lhab Gyem	Training on farmer field school, Phuentsholing.
23 – 27 Jan 06	`Aita Kumar Bhujel & Jigme Norbu	Use of Companion Modeling for NRM, Lobeysa.
6 – 9 March 06	Yeshey & Aita Kumar Bhujel	Analytical Skills & Case Study Writing for Community Based Forest & Natural Resource Management.
7 – 16 Dec 05	Dawa L. Sherpa	Study tour to North Indian states on Livestock & fodder research, North India.
15 – 25 Feb 2006	Sangay Duba, Purna Bdr Gurung, Doley Tshering & Robin	CBNRM Study Tour to Nepal.
17th April – 19th May	Choki Wangmo	Training on information Technology for information Management. New Delhi, India.
20 – 30th April	Kinzang Dorji	Workshop and Seminar on Application of GIS on Rangeland Management, Paro.
15 – 23rd June 06	Dawa Dukpa	Certificate training Programme on Organic & Biodynamic Agriculture, India.

7 VISITORS TO THE CENTRE

Date	Address & Name	Purpose
2/3/05	IDRC Board of Governors (12 members), Members from different countries	Official visit for project familiarization
8/4/05	Mr. Suphat Chitranukroh, Thai Ambassador to Bhutan, Bangkok, Thailand	Official visit to learn about agri research
8/4/05	Dr. Matsushima Ken, Asstt Professor, Shinshu University (Japan)	Study of citrus greening disease
19/4/05	Dr. Guy Trebul and Francios, CIRAD project	To monitor project activities
4/5/05	Mr Saroj Nepal Dr. Antonie de Wit Mr. Tikaram Gurung Ms.Elisabeth Ruegg, Local and international consultants	Part of the EU Mission to formulate project for MoA.
4-18/5/05	Mr. Ajit Menon and K.J.Joy, CISED, Bangalore, India	To undertake a study of Limbukha watershed
29/9/05	Dr. Arun Kumar, ICAR, India	Oil seed consultant to revive oil seed research
4 -8/10/05	Dr. Diwakar Sharma & R.B Katwal, NARC, Nepal	Exchange of maize scientists visit.
2-12 /10 /05	Ms. Emily Deomano and Dr. G McLaren, IRRI, Philippines	To conduct training on Statistics.
12/10/05	Professor Masao Yakoo, JICA, Japan	Visit of rice research
12/1/06	SAP teachers from NRTI, NRTI, Lobyesa	Familiarisation visit
18/2/06	Dr. O.P. Dubey ,ICAR, New Delhi Dr. N.I. Nashaat, Harpenden, UK Dr. Arvind Kumar, Bharatpur, India	To explore possibility of collaborative project on Rapeseed Mustard.
22/3/06	29 BAFRA Inspectors led by Joint Director, MoA, BAFRA & NPPC, Thimphu	To visit horticulture and other research activities.
3/4/06	Dr. Nigel Mohamed, Regional Coordinator UNEP	Official visit.
19/4/06	25 NRTI trainees and lecturer, NRTI, Lobyesa	To see feed and fodder activities at RC-Bajo.
16/5/06	Trainees of Taba Forestry Institute, Taba, Thimphu	Field visit of Forest Guard to see Research activities
24/5/06	Mr. Leslie Baxter Ms. Sindra Hardy Ms. Kuhu Chaterjee Ms. Delia Dray, Australia Centre for International Agriculture research (ACIAR)	Formulation of Citrus development project.
27/5/06	27 Bachelor of Science students & 1 lecturer, Sherubtse Colleg,e Kanglung	To learn about Agricultural Research activities

20/6/06	JICA Coordinator, Thimphu Office	To decide on approval of senior JICA volunteer for field crop sector
25/6/06	Samjana Shrestha, Consultant, IRRI, Philippines	Maize adoption and impact assessment consultancy
30/9/05	40 farmers, Adhang geog, Wangdue	To attend field day at RC Bajo
16/3/06	12 Farmers and 2 EAs, Phutenchu geog, Tsirang	To see and learn about research activities
18/4/06	12 farmer and 3 EAs, Gasa Dzongkhag	To see various research activities
30/4/06	18 farmers, 3 EAs, Lungni Geog , Paro	To see feed and fodder activities at RC-Bajo
6-7/5/06	30 farmers and 3 forester EAs, Dorokha and Sipsu	To see community and social forestry activities.
10/5/06	28 farmers 2 EAs, Haa Dzongkhag	To see research activities
7/6/06	25 farmers & 1 EA, Chukha Dzongkhag	To visit research activities.
13/6/06	39 Farmers & 2 Forester EAs, Tashigang Dzongkhag	Study tour on Social and Community forestry activities
21/6/06	25 farmers and 2 EAs, Tsirang (Mindrelgang, Patale and Tsirangtoe geog)	Study tour to the centre

8 FINANCIAL PROGRESS

Expenditure Statement for the Financial Year 2005-2006

Royal Government of Bhutan Contribution

Sl No	OBC	Particular	Amount m Nu.
1	1.01	Pay & Allowances	6.167
2	2.01	Other Personal Emoluments	1.223
3	4.01	Fuel Allowance	0.059
4	11.01	Travel-In country	2.345
5	12.01	Utilities-Telephone,Fax,Internet,E-Mail	0.131
6	12.02	Utilities-Telegram, Postage	0.030
7	12.03	Utilities-Electricity,Water,Sewerage	0.053
8	14.01	S&M-Office Supplies, Printing, Publication	0.140
9	14.03	S&M- Fertilizer, Chemical, Manures, Innocuments	0.040
10	14.04	S&M-Seeds & Seedlings	0.014
11	14.06	S&M-Uniform, Extension Kits	0.125
12	15.01	Maint of Property-Building	0.025
13	15.02	Maint of prop-Vehicle	0.550
14	15.05	Maint of prop-Equipment	0.150
15	15.06	Maint of prop-Plantation	0.048
16	15.07	Maint of prop-Computers	0.024
14	17.03	Op Expenses-Transportation	0.022
18	17.04	Op Expenses-Energy/Propulsion	0.009
19	24.03	Contribution-provident Fund	0.321
20	25.01	Retirement benefits	0.066
21	51.01	Const of Staff quarter	1.029
		Total	**12.570**

Helvetas/Swiss Development Contribution

Sl No	OBC	Particular	Amount m Nu
1	11.02	Travel- Outside Bhutan	0.028
2	12.01	Utilities-Telephone,Fax,Internet,E-Mail	0.050
3	14.01	S&M-Office Supplies, Printing, Publication	0.257
4	14.03	S&M-Fertilizer, Chemical, Manures, Innocuments	0.044
5	14.04	S&M-Seeds & Seedlings	0.020
6	14.07	S&M-Text Books, Library books	0.007
7	14.08	S&M-Others	0.113
8	15.01	Renovation of RNR Sub Centre at Tsirang	1.210
9	15.05	Maint of prop-Equipment	0.013
10	15.07	Maint of prop-Computers	0.056
11	15.08	Maint of prop-Others	0.050

12	17.01	Op Expenses-Advertisement	0.015
13	45.02	Training-Others	0.210
14	51.04	Exp on structure- Irrigation channel	0.426
15	51.08	Exp on structure- others	0.540
16	52.05	Plant & Equip-Agriculture Machinery	0.621
17	54.02	Office Equipment	0.300
18	55.01	Professional Services	0.670
		Total:	**4.630**

IDRC/CBNRM Contribution

1	11.01	Travel-In country	0.065
2	11.02	Travel-outside Bhutan	0.034
3	13.02	Rental of Property-Vehicle	0.102
4	14.01	S&M-Office Supplies, Printing, Publication	0.075
5	14.07	S&M-Text books, Library, Stationeries	0.090
6	14.08	S&M-Others	1.272
7	17.07	Op.Expenses-Others	0.597
8	45.01	Training-HRD	0.603
9	45.02	Training – Others	0.938
10	54.03	Computer & Peripherals	0.781
		Total	**4.560**

CIRAD/Ecole-Commod Contribution

1	12.01	Utilities- Telephone, Fax	0.012
2	13.02	Rental of property-Vehicle	0.071
3	14.01	S&M-Office Supplies, Printing, Publication	0.008
4	45.02	Training – Others	0.379
5	51.04	Exp. On structure-Irrigation channel	0.101
6	54.03	Computer & Peripherals	0.187
7	54.01	Furniture	0.020
		Total	**0.780**
		G/Total	**22.540**

Capital Works during the financial year 2005-2006

1. Construction of Staff quarter Nu 1.029m (RGoB Contribution)
2. Renovation of RNR-Sub Centre, Tsirang Nu 1.210m (SDC/Helvetas Cont)
3. Samthang irrigation channel under Adhang geog & water harvesting activity at Nahi Nu 0.426m (SDC/Helvetas Cont)

4. Construction of Threshing cum drying Nu 0.540m (SDC/Helvetas Cont)
5. Restoration of Lungpa irrigation channel Nu 0.101m (Ecole-Commod Cont)

9 METEOROLOGICAL INFORMATION

Monthly rainfall and temperatures, RC Bajo, Wangdue, 2005

Months	Rainfall (mm)	Temperature (°C)	
		Maximum	Minimum
January	13.7	8.8	2.5
February	8	15.6	1.7
March	9.8	16.6	7.1
April	17.9	18.5	9.1
May	17.2	21.9	13.6
June	28	22.8	19.1
July	13.3	22.4	19.7
August	25.7	23.6	20.5
September	18.9	21.7	17.7
October	25.8	20.4	11
November	0.9	14.3	5.6
December	0	10.9	2.1