RENEWABLE NATURAL RESOURCES RESEARCH CENTRE
BAJOTHANG, WANGDUEPHODRANG

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ABOUT THIS REPORT

This is the 20th 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.

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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 ha 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
AEPO	Assistant Extension Program Officer
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
EPO	Extension Program Officer
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

Field Crops Research program aims at increasing and sustaining the productivity of cereals (Rice, Wheat, Maize and minor cereals), oilseeds (rapeseed-mustard) and grain legumes (Soybean, Groundnut and Mungbean) through identification, adaptation and developing appropriate and affordable technologies. Researches are being done in both on-station and on-farm in collaboration with concerned extension staffs and co-operative farmers.

The variety selection criteria for Rice are the yield potential, medium height of 100-120 cm, medium maturity of 130-150 days and resistance to prevailing pests and diseases. In 2004, AET consisted of 20 entries including the checks. From the entries YOU MI 18 yielded the highest with 7.77 t/ha. Zakha, the local check yielded the lowest with 5.8 t/ha. IET consisted of 24 test lines including the checks. Statistical analysis of grain yield showed that NR 10353 was the highest yielder with 7.53 t/ha followed by NR 10291 with 7.35 t/ha. The other promising lines were also selected for further evaluation. 56 entries from the Observation nursery of IRRI-INGER program were evaluated and selected in addition to bulk selection from 14 crosses.

The On-farm trial had 3 mid altitude rice varieties laid out in different mid altitude regions. B2983B-SR-85-3-2-4 yielded the highest with 5.54 t/ha followed by SPR 87036-7-1-1-2 with 5.52 t/ha and GUOJING 4 with 5.09 t/ha. They will be further evaluated.

Wheat trial consisted of observation trial of 207 Nepal Advanced Lines (NAL) to assess its performance under Bhutanese agro-ecological conditions in terms of yield, disease resistance and other agronomic traits. Amongst the lines ANNAPURNA-1 yielded the highest with 5.5t/ha. Out of 8 varieties of BARI wheat, Kanchana was the highest yielder with 2.5 t/ha.

Mustard Observation trial consisted of four BARI lines in addition to three released varieties as checks. Amongst the BARI test lines, BARI-11 yielded the highest with 0.57 t/ha.

HORTICULTURE

The horticulture research in RNRRC-Bajo is involved in identifying appropriate technology and information to improve quality and yield of vegetables, nut crops, low chilled temperate fruits and subtropical fruits. Horticulture research focuses on broadening the genetic base of priority horticultural crops through introduction, diversification and selection from local diversity; improved crop production and post-harvest technologies; improved seeds and plant propagation techniques. Beside sector emphasize on reaching out improved crops varieties and crop production technologies through on-farm demonstration and research outreach programme where researcher work directly with the farmers in a selected communities. Main approach of information dissemination is through publication, trainings of farmers and dissemination of information by agriculture extension

system. On-station and on-farm-client-oriented participatory horticultural research are the approaches being adopted by the center.

The achievement highlights of horticulture research programme of this centre in 2004-2005 are as follows:

1. Under the variety improvement of fruits and vegetables, the centre had identified one pomegranate, 2 guava, three mango and two local beans promising cultivars for release for general cultivation. Nationally coordinated walnut and chestnut variety evaluation trials were established in all the regions.
2. Through research outreach programme, location specific assorted fruit crops (746 plants) on a trial basis were promoted in all villages in the Adhang geog for homestead fruit crops production (detail distribution list in Annexure 1) with an objective to evaluate their performance and commercialization of few performing species in future.
3. We have supported five RNR technology park development, one in each Dzongkhag of West Central region with improved and superior vegetable seeds, peach, pear, walnut, apricot, guava, Bajo apple, almond, temperate apple and chestnut varieties where appropriate. (Damji, Phobjikha, Chubu, Dagapela and Mendelgang)
4. Participatory evaluation of fruits and vegetable are on-going with 11 demonstration orchards established in the region.
5. Vegetable breeder seeds of 22 cultivars that were released from the centre is being maintained.
6. Mother plants of all fruits cultivars released from this centre are being maintained.
7. New additional horticulture technologies: Booklet published and distributed to all the regional extension agents
8. Supported and technical recommendations were provided to the client Dzongkhags of this region and to the policy maker of MOA on solving the farming production problems.

LIVESTOCK

The livestock research program started in 1995. Since then, livestock program remained focused mainly on feed and fodder owing to the critical problem of feed shortages especially in winter. The research program gained progress in initiating fodder researches as a demand driven program in solving farmers' immediate problem of fodder shortages. The introduction of some popular winter fodder species like Oat and winter legumes were tried to over-come this problem to some extent. Apparently due to winter fodder shortages limited livestock production. The situation is cumulating with the increasing livestock population that remained uncontrollable due to religious sentiments attached to culling and killings.

Efforts will be continued to have better understanding of the system. The scarcity of fodder for cattle especially during winter will be researched further. The sector had focused and given major emphasis on feed and fodder research in trying to mitigate these problems. Most of the activities have focused in fodder production.

Over the years, the livestock research has expanded to cover-up activities under the sub-program breeding, socio-economy and marketing. In breeding and management efforts were put in documenting information on local pig genetic resources, yak herd monitoring and apiculture practices. Documentation of livestock products, processing and marketing aspects were also covered. More than 70% of the activities related to both feed and fodder and breeding and management have been implemented and monitored jointly with extension gearing towards solving some of the field problems and farmers' need in general.

During the year, there were 11 activities of which 1 was new and 10 ongoing. These activities were both regional and nationally coordinated. From these activities, 6 were on-station and 5 were on-farm collaborative trials. Out of these, 8 activities were on feed and fodder and 3 were under breeding and management. During the year, 3 activities were reported as completed and 8 activities are ongoing for further evaluation and assessment.

FORESTRY

This year saw the community forestry activities in the Lingmutey Chu watershed culminating into the preparation of a draft management plan by the local people with support from the centre and the Dzongkhag Forestry sector of Punakha. The initiative to develop a simple local watershed forest management plan was continued. Forest resource assessment, forest demand assessment and function mapping activities were completed. The sector is now in the process of developing the management plan based on information generated by these activities.

On-station activities continued to focus on multiplication, propagation and evaluation of multi-purpose tree species (MPTS) and some new accessions were added. An arboretum was also initiated that would include many MPTS found in the region. Extension leaflets describing the propagation and management techniques have been developed and are ready for circulation.

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. The broadleaf forest dynamics research was approved by the Ministry of Agriculture and the framework document for adopting Rimchu forest management unit (FMU) as a research forest was developed. BG-SRDP, Lobeysa committed a small fund to support activities. The final plot layout will be carried out in December 2005. Research topics such as regeneration dynamics, permanent sample plot study, grazing ecology are implemented in close collaboration with RNRRC Yusipang, BG-SRDP, Lobeysa, the Wangdue Divisional Office and the NRTI, Lobeysa. A forest fire study has also been initiated in collaboration with the Social Forestry Division. This study would study the efficacy of traditional forest fire management strategies such as prescribed burning, fire lines etc and also select sites to include for impact assessment of forest fires on the forest ecology.

SYSTEM RESOURCE MANAGEMENT

Community Based Natural Resources Management (CBNRM)

During 2004-05 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 focussed 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 (Machapuchray 3) was tried for its yield and farmers' acceptance potential at Limbukha together with farmers and farmers preferred the variety and have promoted in larger scale. Due to traditional water sharing system 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. The effect of treatments on mineral content and

removal was not significant for both the varieties; however, within varieties and geogs they 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. This could be due to regular application of Phosphate containing fertilizers. Thus potato may not respond to Phosphorus fertilizer application as much as to Potassium fertilizer. The other indication from the results is Potassium fertilizer needs to be applied regularly with a reduced amount of FYM application.

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 have 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. 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 the removal of K from the soil is permanent. In addition, potato also requires K in large quantity compared to other nutrients. 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

Agriculture Economics research team supports other sectors by way of assisting them in conduct of socio-economic studies. The sector conducted five activities during 2004-2005 in collaboration with other sectors.

A simple economic analysis was done to determine the cost of producing mungbean in Drugyelgang. Using the cost analysis, it was found that growing mungbean is profitable. With the prevailing market price of Nu. 40/kg, it costs Nu. 14.41 to produce a kg of mungbean. Economics study on intensive hand weeding of *Shochum* done in Lingmuteychu revealed that with marginal rate of return (MRR) of 20% it is not economically attractive. However, it has to be considered in view of the incremental benefits that would accrue from a *Shochum* free land in the long run. The report on impact study of maize will be released by end of 2005.

Integrated Pest Management (IPM)

As in the previous years, the mandate of the IPM sector has not changed brought about by the restructuring of Council of Research and Extension (CORE) to Council for RNR Research of Bhutan (CoRRB). Although linkage with National Plant Protection Centre (NPPC) has ceased in terms of research needs and technical support, the 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. Research for 2004-2005 concentrated on *Shochum* Control Campaign, on-farm chilli blight disease management through sequential sowing, and rice blast evaluation through trap nurseries. Long term trials such as cardamom disease on-farm observation study and community based citrus fruit fly management are ongoing. *Parthenium* weed control campaign is implemented during critical stages of the weed through June through October each year.

Mr. Sangay Wangdi, Research Officer 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).

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 for 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)

In 2004, AET consisted of 20 test entries including local and standard check varieties. The objective of this trial was to identify suitable varieties with high yield potential, medium height, optimum maturity and resistance to prevailing pest and diseases for mid-altitude rice valleys.

The trial was laid out in a randomized complete block design with three replications. Seedlings were transplanted in 10 sqm plots at a spacing of 20 x 20 cm. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha with half the N as top dress at panicle initiation (PI). To control the weed, Butachlor 5G was applied at the rate of 1.5 kg a.i./ha. Hand weeding was done whenever necessary. Irrigation was given as and when required. Grain yield was estimated from a harvest area of 5.04 sqm and grain moisture content was standardized at 14%.

Analysis of grain yield showed that the highest yielders were Bajo Kaap 2 (8.41± 0.49 t/ha), YOU MI18 (7.77 ± 0.49 t/ha) and WAB 340-B-B-10-112 (7.32 ± 0.49 t/ha). Several other crossbred lines produced yields higher or comparable to standard check IR 64. Local check Zakha yielded low with 5.80 ± 0.49 t/ha (Table 1). Occurrence of insect pests and diseases were negligible during the test season and hence no inter-varietal rating was done. The best performers from this trial will be evaluated in the farmers' fields in the ensuing season. Highest straw yield was observed in BR1543-9-2-1 (11.64 ± 0.82 t/ha) whereas its grain yield was low (5.35 ± 0.49 t/ha). YOU MI 18 gave appreciably high straw yield (10.05 ± 0.82 t/ha) while the grain yield was also significantly higher than local Zakha and comparable to standard check IR 64.

Table 1: Agronomic traits of entries in AET, 2004

Variety	50% flower-ing	Tiller No.	Plant height (cm)	Straw yield (t/ha)	Grain Yield (t/ha)
RHS 351-19CX-7CX-2CX	125	14	93	9.19	7.29
SPR87032-2-1-1-4	124	11	103	9.39	6.68
NR 10291	115	12	101	10.65	7.19
YOU MI 18	122	10	106	10.05	7.77
IR17146-97-1-2-1-3	112	11	90	7.47	6.33
CH 5	124	11	114	6.61	7.22
BW348-1	126	11	104	9.46	6.25
NR 10276	113	15	119	9.26	6.66
BR1711-7-2-4-2	115	13	107	7.87	5.92
RHS 33025-CX-3CX-024	126	13	97	9.59	6.81
CH6	126	10	104	11.05	6.47
WAB 340-B-B-10-112	115	14	120	8.27	7.32
BR1543-9-2-1	126	10	105	11.64	5.35
IR 64683-87-2-2-3-3	113	13	93	8.66	7.00

CNAX 4506-3-2-2-1-B	117	12	89	10.38	6.68
ZHONGYO 5 (AET)	116	9	100	9.33	6.39
Bajo Kaap 2	122	12	89	10.18	8.41
Bajo Maap 2	111	14	97	7.47	5.68
IR 64	115	15	89	8.73	7.07
Zakha	115	15	118	10.18	5.80
CV (%)	0.1	3.4	0.4	6.2	4.20
S.E.D.	0.89	1.41	3	0.824	0.49
L.S.D	1.81	2.86	7	1.668	1.01

1.1.2 Initial Evaluation Trial (IET)

IET consisted mainly of entries from introductions and breeding lines intended for identification of promising materials in terms of grain and straw yields, maturity, height and resistance/tolerance to biotic and abiotic stresses. The trial consisted of 24 test lines which were advanced from the observation trial of the previous season.

The trial was laid out in a randomized complete block design with three replications. Seedlings were transplanted in 10 sqm plots. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha, with half the N top-dressed at PI. Butachlor 5G was applied at the rate of 1.5 kg a.i/ha to control weeds. Hand weeding and irrigation were done whenever necessary. Grain yield was obtained from a harvest area of 5.04 sqm. ANOVA was used to analyze the data and the results are presented in Table 2.

Analysis of variance showed that all test varieties were low yielder than the check Bajo Kaap 2. However, several lines yielded higher or comparable to check IR 64. Amongst the test lines high yielders are NR 10353 (7.53 ± 1.57 t/ha)), NR 10291 (7.35 ± 1.57 t/ha), MK 9-87 (7.34 ± 1.57 t/ha), Khumal 6 (7.17± 1.57 t/ha) with yields equivalent to the standard check IR64. Straw yield ranged from 6.02 to 13.49 t/ha. Days to 50% flowering ranged from 105-130 days. No significant damage due to insects and diseases occurred precluding a differential rating among the entries. The elite selection from this trial will be further evaluated in the following season.

Table 2: Performance of entries in IET, 2004

Variety	50% flowering	Tiller no.	Pl ht (cm)	Straw yield (t/ha)	Grain Yield (t/ha)
Bajo Kaap 2	124	15	93	9.19	7.89
NR 10353	126	13	103	12.30	7.53
NR 10291	122	15	99	12.37	7.35
MK 9-87	126	14	99	11.11	7.34
Khumal 6	115	16	126	12.24	7.17
IR 64	115	17	90	10.05	6.94
NR 10276	113	17	128	12.56	6.80
BR4656-1-2-3-2	123	14	103	12.70	6.78
CT 9737-5-2-1-2-4P-M	115	13	89	11.44	6.63

Bajo Maap 2	110	17	105	7.87	6.59
C 74	126	14	104	13.49	6.59
IRGA 318-11-6-9-2-A3	113	15	93	8.14	6.57
TOX3211-14-1-2-1-2	124	11	97	11.77	6.54
P 4	124	11	100	8.86	6.53
BR4726-2B-6-1-2-J4	113	15	106	12.24	6.48
Himali	116	12	87	6.55	6.35
8344	124	14	106	12.90	6.33
IR71604-4-4-3-7-2-2-3-3	114	15	90	11.11	6.20
242	113	13	99	7.61	6.13
ITA306	126	13	86	10.32	6.11
CT 6163-8-9	116	12	92	8.00	6.01
Khumal 4	124	15	131	8.07	5.92
NR 10375	113	14	87	6.41	4.83
Local Zakha	114	17	123	6.02	4.45
S.E.D.	0.70	1.54	5.20	1.44	0.78
L.S.D.	1.42	3.10	3.78	2.90	1.57
CV%	0.1	13.5	7.608	8.50	14.4

1.1.3 Observation Nursery

The Observation Nursery consisted of test lines selected from the IRRI-INGER nursery of the previous season. A total of 56 entries were evaluated in single plots of 10 sqm for yield, maturity period, adaptability, pest resistance and plant height. Seedlings were transplanted at 20 x 20 cm in late June. Inorganic fertilizers were applied at the rate of 70: 40: 20 NPK kg/ha. Butachlor was applied at the rate of 1.5 kg a.i./ha to control weeds.

The observed yield ranged from 3.55- 9.38 t/ha (Table 3). The yields of most of the entries were higher than the local check variety Zakha. The plant height ranged from 74-120 cm and tiller numbers ranged from 6 to 22 per hill. No notable insect pests and diseases were observed in the trial. The selected entries will be further evaluated in replicated yield trials.

Table 3: Agronomic traits of entries in observation nursery

Variety	P.Ht (cm)	Tiller (nos.)	Yield (t/ha)
PR 234163-34	83	22	7.14
BM 9820	91	6	6.85
C 2732-10-2-1-1-1	83	18	7.55
IR 69003-47-3-3-2-3-2-3	80	17	5.75
TO*3255-82-1-3-2	74	20	4.51
RP 1125-1562-2-2-3	77	15	6.1
IR 72102-3-221-2-2-3-3	78	22	6.52
FR * 92 F3B-14F4BF5	96	14	6.46
TO *3118-12-1-3-1	74	12	5.09

Q1 GUIZHAN	83	16	6.45
TO * 981-10-3-2	85	14	7.37
IR 73008-138-2-2-2	90	16	7.79
PSB RC 74	92	11	8.03
UPR 1561-6-3	84	15	8.58
CT 6163-8-9-5-2-M-84-M	91	13	6.99
DIANSHAO 3	95	17	7.75
IR 72891-73-3-3-1	80	20	6.12
CT 9868-3-2-2-3-3P-M	86	14	5.78
BR 5538-12-1-2	115	13	3.55
IR 72904-195-1-3-2	91	15	6.90
IR 74052-72-1-3	92	13	6.04
LTH-M4-14	92	13	6.65
CAN 8023	89	13	7.97
TO * 3553-36-2-2-2	80	12	7.5
ITA 304	88	11	8.19
TO * 3107-39-1-2-1	86	11	7.04
Shanyon 559	94	9	6.55
N 30	92	8	7.06
P8	86	9	5.88
IR 73435-29-3-3-1	74	17	5.12
JEQUITIBA	83	14	6.26
IR 74052-165-3-2	86	12	7.59
SPR 85013-5-2	93	14	6.61
OM 1271	97	19	7.88
M1-6148 UL	86	18	7.59
CAN 8487 {CNA8487}	87	14	9.38
BURDAGOL	88	15	7.83
IR 73013	83	16	6.3
CT9506-44-2-1-2-M-1-3P-M-1	85	13	6.13
GUI-4-XUAN	96	10	6.92
M1-6-120 UL	89	13	4.98
TO * 3118-6-E2-3-2	82	15	4.72
BA GUIZHAN	90	12	6.52
IR72895-17-2-3-2	86	12	6.85
C 4249-1-2-2-1-2	89	18	6.37
IR 74052-297-2-1	90	13	6.66
IR 71780-1-1-3-2	83	14	5.26
IR 72176-140-1-2-2-3	92	13	7.06
IR 73933-8-2-2-3	94	9	6.84
IR 73974-143-6-2-2	93	12	6.26
IR 72981-92-1-1-2-2	86	12	7.00
IR 72164-405-5-1-1	88	12	6.40
IR 73935-51-1-3-1	94	12	6.58
IR 74295-22-2-2-2-3	97	14	8.31
IR75282-10-3-3-2	88	14	7.40
IR 73907-53-3-2-2	91	20	8.46
Bajo Maap 2	93	13	8.71
Bajo Kaap 2	99	18	6.65
IR 64	92	13	6.11
Zakha	120	21	4.84

1.1.4 Selection from crossbred populations

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

A total of 14 F2 populations were raised in single large plots and subjected to selection at the station in 2004 using bulk selection method. Seeds of each population 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

1.1.5 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. These varieties were Bajo Kaap 1 and 2, Bajo Maap 1 and 2, IR 64, IR 20913, Khangma Maap, Khumal 2, Yusi Ray Maap and Kaap, BR 153 and Milyang 54.

1.1.6 Seed Maintenance and production of released varieties

A total of 1675 number of samples (Table 4) 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 (Table 5) were produced for supply of Breeders' Seed to DSC and further multiplication and use.

Table 4: Nucleus seed produced in 2004

Sl No.	Variety	No. of samples
1.	IR 20913	152
2.	Barket	75
3.	Bajo Maap 1	200
4.	IR 64	200
5.	No 11	150
6.	Bajo Maap 2	200
7.	Bajo Kaap 1	150
8.	Bajo Kaap 2	200
9.	B 298 B-SR-85-3-2-4	148
10.	Guojing 4	100
11.	SPR 87036-7-1-1-2	100

Table 5: Pre-basic and Basic seed produced (Kg) in 2004

Variety	Pre-Basic	Basic	Total	Remarks
No 11	-	70	70	
K. B	-	150	150	
IR 64	75	475	550	
Bajo Maap 1	98	300	398	
Bajo Kaap 2	97	350	447	
Bajo Kaap 1	79	580	659	
Bajo Maap 2	54	160	214	
IR 20913	-	175	175	
Mama	-	40	40	
SPR 87036-7-1-1-2	-	145	145	onfarm
Guojing 4	-	156	156	onfarm
Barket	-	140	140	
B 298 B-SR-85-3-2-4	-	174	174	onfarm
Khangma Maap	-	50	50	
Machapurcharey 3	-	60	60	
Total	403	3025	3428	

1.1.7 On-farm Trials of Mid-altitude Rice varieties

Three promising mid-altitude rice varieties (GUOJING 4, SPR 87036-7-1-1-2 and B2983B-SR-85-3-2-4) were identified after rigorous testing at the station. These varieties were then further evaluated under farmers' management practices to critically analyze the yield performances and to study their adaptation in different sites.

Four different sites - Nisho and Phangyul in Wangduephodrang, and Kabji and Toewang in Punakha were selected for the trial in consultation with the Dzongkhag staff. In each geog, two farmers were selected to conduct a set of trial. 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 and advice from the extension staff and researchers.

Crop cuts from an area of 6 m^2 were taken during the harvest of the crop to measure the grain yield. The results of trials in different sites are presented in Table 6. Mean yield of the test varieties across locations was higher than the local checks. B2983B-SR-85-3-2-4 yielded the highest, with a mean yield of 5.54 t/ha across all sites. This was a difference of 1.11 t/ha from the local variety. However, all test varieties yielded lower at Phangyul when compared to locals but the differences were not significantly high. The lines will be evaluated in the ensuing season to further ascertain their performance.

Table 6: Yield (t/ha) performance of test entries across locations

Variety	Sites				
	Nisho	Toewang	Phangyul	Kabji	Mean
GUOGING 4	5.94	6.08	3.11	5.25	5.09
B2983B-SR-85-3-2-4	5.53	6.06	4.55	6.00	5.54
SPR 87036-7-1-1-2	4.91	7.39	4.33	5.45	5.52
Local	4.60	4.28	4.77	4.07	4.43

1.1.8 BUCAP Activities in the West Central Region

The activities under the Biodiversity Use and Conservation Asia Pacific Project (BUCAP) have been ongoing at Thangu, Thedtsho and Guenshari. In 2004, the main activities included rice farmers' field school at Thangu, Thedtso and Guenshari and maize seeds selection training at Tsirang.

Participatory Varietal Selection at Thangu

In 2003 three promising lines were identified by FFS from a total of nine lines to further assessment. The objectives were to facilitate farmers' access to improved varieties/genetic materials, broaden genetic base of the crops in the locality and to promote participatory varietal selection.

Seeds of GUOJING 4, SPR 87036-7-1-1-2 and IR 64683-87-2-2-3-3 were sown on 25th May 2004. Transplanting was done on 9th July 2004 in single large terrace. FYM was applied @ 1500 kg/ha. Butachlor was applied @ 1.5 kg a.i./ha to control weeds. Farmers carried out all operations of land preparation to transplanting with the assistance of the extension agent.

Crop sampling was conducted prior to harvesting during the field day to assess yield performance of the test lines. Amongst the three varieties, IR 64683-2-2-3-3 yielded highest with an average yield of 8.13 t/ha of rough rice. Guoging 4 yielded 7.0 t/ha and SPR 87036-7-1-1-2 gave 7.25 t/ha. Farmers collectively selected the highest yielding variety to be further evaluated in the ensuing season in larger scale.

Yield assessment of selected local varieties

Three local varieties, viz., Nabja, Apa Dogo and Dawa Yangkum that have been seed selected since 2001 by FFS were transplanted in the farmer's field on 4 June 2004 to assess the improvement of varieties subjected to seed selection techniques in previous seasons and to promote conservation of landraces through improved productivity of the same. The aim was also to further purify the landraces from mixtures and off-types over the years.

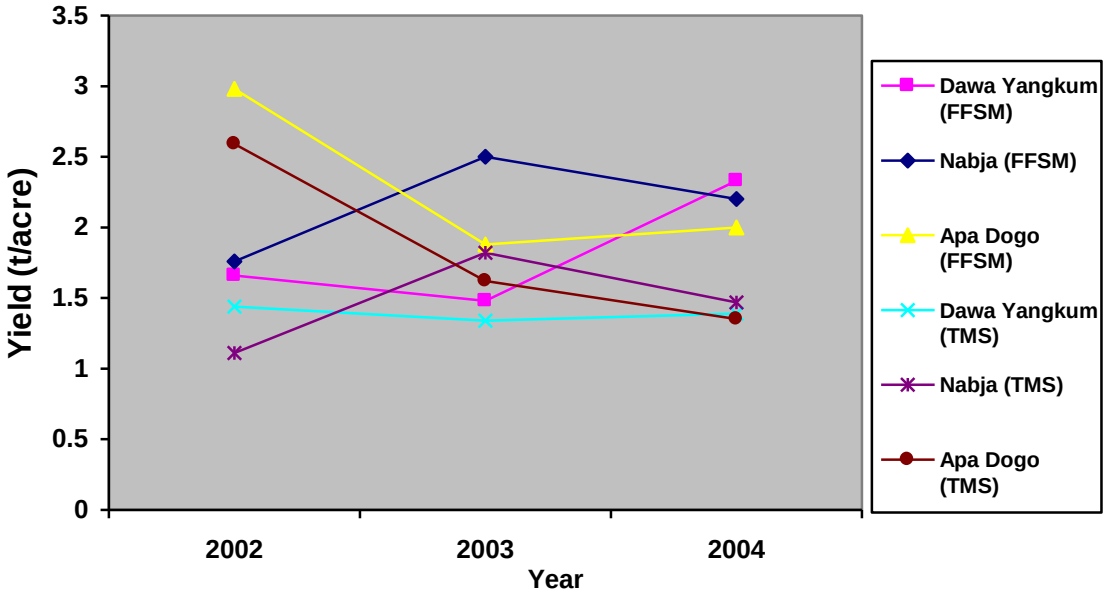
Management was carried out by farmers as per their existing cultivation practices. Field day was conducted during the crop harvest wherein crop cut samples were taken to assess the yield performance. The result of crop cut samples of seed selection plots for three varieties are presented in Table 7. There is a significant difference in grain yield of same varieties between two different methods of seed selection.

Table 7: Yield performance of Seed selection plot 2004, Thangu, Thedtso

Varieties	Traditional method (t/acre)	FFS technique (t/acre)	Difference (t/acre)
Nabja	1.39	2.33	0.94
Apa Dogo	1.47	2.20	0.73
Dawa Yangkum	1.35	2.00	0.65

Figure 1 shows the yield trend of three varieties over the years through different techniques, and it is apparent that the techniques adopted by FFS for rice seed selection yields higher than selected through traditional method. A significant improvement in yield is noticed over the years in Dawa Yangkum whereas in other two varieties improvement in yield is not very much.

Figure 1: Yield local varieties using different method of seed selection



Note: *FFSM- Farmers' Field School method of seed selection*
TMS- *Traditional Method of seed selection*

Participatory Varietal Selection at Nob Sechekha, Guenshari

As in Thangu, seven varieties were selected by FFS in Guenshari. These varieties were Phulaychu, Bunap Kaap, Khangma Maap, Yusi Ray Kaap, Yusi Ray Maap, PP2-38-4 and Machapuchrey-3. Phulaychu and Bunap Kaap were included in the study as the local check.

During harvest time, a field day was conducted and crop cut samples were taken to determine the performance of the test lines. Phenotypic acceptability test were also to understand the preferences of farmers to a particular variety. Amongst the test lines (Table 8), Yusiray Maap yielded the highest (7.65 t/ha) and was accepted by the FFS to be further evaluated next season. Besides, two other varieties, Machapucharey 3 and PP-2-38-4 were also selected to be further evaluated in the ensuing season.

Table 8: Yield performance of the PVS plot 2004 at Guenshari

Variety	Yield ($kg/6m^2$)	Yield (t/ha)
Bunap Naap	4.5	7.15
Machapucharey 3	4.1	6.68
Phulaychu	5.2	8.25
Khangma Maap	3.4	5.53
Yusiray Maap	4.7	7.65
Yusiray Kaap	3.3	5.38
PP-2-38-4	3.8	6.18

Yield assessment of two local seed selected varieties

In 2003, two high altitude traditional varieties, Phulaychu and Bunap Kaap, were seed selected with an aim to improve their yield. Therefore, seeds of the same varieties obtained from the seed selection plot of 2003 were planted in farmers' field this year. The FFS conducted the crop cut during the harvest time to assess the performance of the local varieties. Yield comparison between FFS selected seed and farmer's seed was carried out to assess the improvement of yield due to selection method employed by FFS.

The results presented in Table 9 showed a slight increase in yield in the two varieties. However, further purification study will be pursued for greater yield improvement.

Table 9: Yield (t/ha) from seed selection plots, Guenshari

Variety	FFS selected seed	Farmers' seed	Difference (t/ha)
Phulaychu	6.83	6.50	0.33
Bunap Naap	6.18	6.0	0.18

Maize seed selection training in Tsirang

Maize ranks highest both in acreage and production in the country. However, declining seed quality has been emerging as a serious bottleneck in sustaining yield. During the 6th National Field Crops Workshop in 2004, maize seed selection training to agriculture extension and farmers was planned as an immediate action to redress the issue of seed degeneration.

In the west central region, the training was conducted at Tsirang Dzongkhag. RC Bajo facilitated the training whereas RC Wengkhar arranged the technical expert for the training. With financial support from NBC, Serbithang, 10 agriculture extension agents were trained on maize seed selection. The training included both theoretical guidelines on maize seed selection and practical demonstration in the field.

As a follow up to this training, Extension Agents were required to impart their skills in maize seed selection to farmers in their respective geog for which the financial support was also extended through the BUCAP project. A total of 127 farmers from 6 different geogs were imparted with the skills of selecting pure and better seed by the Extension Agents of their respective geogs.

Study tour to Vietnam

The BUCAP project organized a study tour to Vietnam from 18th June to 27th June 2004. The tour was mainly aimed to exchange learning experiences from the partner country, Vietnam, where similar kind of activities have been carried out by the project in Bhutan. The program consisted of visit to the farmers study plot, exchange of experiences and ideas among the farmers of two countries, cultural exhibits, farmers' seed fair and the workshop with officials of Plant Protection Department and the farmers of Vietnam. The team consisted of 19 members, which included farmers, extensionist, researcher, and officials from the Central Programs. From the West-Central region one researcher, Mr. Neelam Pradhan, and two farmers, Mr. Tshering Dhendup and Ms. Chador Bida, participated in the study tour.

1.2 Maize Research

1.2.1 Sweet Corn Adaptation Study

In 2003, a sweet corn variety was introduced and evaluated on-station at RC Bajo, which performed well. The variety introduced from Philippines is noted for its sweetness and can be consumed when fresh/green, which could be a better alternative variety than locals for table purposes. In 2004, the trial was carried out in all the four research centres with an objective to introduce and critically evaluate the adaptability of sweet corn variety in the test regions based on criteria such as yield performance and resistance to pest and diseases.

The trial was laid out in single large plots and a spacing of 75 x 50 cm was maintained between the plants. Two to three seedlings were planted per hill.

Fertilizers were applied at a 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 when ever necessary to suppress weed growth.
The results from RC Bajo and RC Wengkhar are presented in Table 10. No significant damage due to insects and diseases occurred in the test variety at both the sites. After harvesting and recording the data, green cobs were distributed to staff for testing. Many reported that consumption at green stage after boiling is better than the local in sweetness. However, the sweetness is lost when cobs are matured. Some reported that the endosperm is harder than local corn.

Table 10: Agronomic traits of Sweet corn, 2004

Site	Plant height (cm)	Cob length (cm)	No of ears	Yield of green cobs (t/ha)
RC Bajo	215	23.6	1	8.54
RC Wengkhar	232	21.5	1	12.61

1.2.2 Pop-corn Adaptation Study

The aim of this activity was to introduce and critically evaluate the adaptability of sweet corn variety in the test region based on criteria such as yield performance and resistance to pest and diseases. The trial was laid out in single large plots and a spacing of 75 x 50 cm was maintained between the plants. Two to three seedlings were planted per hill. Fertilizers were applied at a 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 when ever necessary to suppress weed growth.

The average plant height was 169 cm, with 3 cobs per plant. The fresh cob yield was 4.17 t/ha and the grain yield 3.33 t/ha. The crop was free of any noticeable pest and disease during the growth period at the Bajo station. However, the crop was severely damaged by blight during the tasseling stage at RC Wengkhar and hence there was no cob formation. At RC Jakar and RC Yusipang, there was a vigorous vegetative growth but failed to produce matured grains, which could be due to long growing period of the variety. The variety will be further evaluated to ascertain its performance.

1.3 Wheat Research

1.3.1 Observation Trial of Nepal Advanced Lines (NAL)

The trial consisted of 207 varieties and 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 a row of 2 m

length while spacing of 30 cm was maintained between varieties. 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. Frequent hand weedings were done depending on the weed pressure.

Amongst the lines, ANNAPURNA-1 (check) yielded the highest with 5.5 t/ha followed by BL3185 with yield of 5.3 t/ha. BL3140 and CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/3/VEE≠7/BOW/4/PASTOR-10Y-OM-5KBYOKBY-OM also gave an appreciable yield of 5.16 t/ha each (Table 11). The lines will be further evaluated in the ensuing season.

Table 11: Agronomic traits of Nepal Advanced Lines

Lines	50% Flw days	Maturity days	Plant ht cm	Yield t/ha
BL3071	102	149	89	3.49
BL3072	102	149	88	3.33
BL3079	96	141	91	2.9
BL3082	98	138	85	2.9
BL3083	96	150	81	2.3
BL3088	98	153	82	3.2
BL3090	102	153	78	2.16
BL3093	102	140	73.	3.33
BL3099	102	148	74	2.66
BL3100	103	148	72	3.2
BL3102	102	155	73	2.9
BL3103	102	153	80	3.9
BL3108	102	148	67	3.33
BL3111	102	153	81	3.33
BL3112	93	141	96	3.83
BL3115	96	140	106	3.9
BL3116	96	140	84	4.33
BL3118	93	140	108	4.99
BL3121	96	140	111	4.49
BHIRKUTI(Check)	98	148	73	4.16
BL3122	102	148	77	2.49
BL3124	102	148	78	3.66
BL3125	98	155	96	3.3
BL3126	96	141	100	3.9
BL3128	98	148	89	3.3
BL3131	93	138	82	3.49
BL3134	93	138	87	3.33
BL3135	102	153	98	4.3
BL3136	93	138	63	3.16
BL3138	93	138	68	4.9
BL3140	96	141	103	5.16
BL3141	105	155	93	3.49
BL3143	96	138	72	3.66
BL3144	96	138	91	4.66
BL3150	93	138	98	3.33
BL3152	93	138	82	4.16
BL3153	96	141	80	4.83
BL3154	93	140	89	3.9

BL3156	93	140	87	4.49
BL1887 (Check)	102	155	82	2.83
BL3158	103	138	71	4.16
BL3160	102	138	69	3.66
BL3162	98	138	74	3.16
BL3163	98	140	89	2.99
BL3166	103	148	71	2.33
BL3167	103	147	68	2.33
BL3168	98	148	87	2.9
BL3169	98	148	82	4.6
BL3174	96	141	85	4.3
BL3177	96	148	98	3.9
BL3178	98	153	98	4.16
BL3179	98	148	80	3.9
BL3182	96	155	95	4.6
BL3183	105	148	105	4.6
BL3185	105	148	103	5.3
BL3188	98	142	86	3.49
BL3189	96	141	93	4.9
BL3190	96	140	96	3.6
BL3192	96	140	86	4.3
BL1473 (Check)	93	147	90	3.8
BL3193	105	155	56	1.6
BL3196	98	148	88	2.3
BL3200	98	147	81	2.49
BL3201	98	148	78	2.9
BL3204	96	148	100	3.3
BL3205	103	153	86	2.9
BL3206	98	148	90	3.3
BL3209	98	153	103	3.8
BL3211	98	148	96	4.49
BL3213	96	148	86	3.66
BL3215	93	147	90	2.49
BL3216	93	138	90	4.16
BL3218	98	141	97	4.3
BL3219	96	141	90	2.8
BL3220	96	148	91	3.3
BL3221	93	138	95	3.49
BL3223	93	140	102	3.6
BL3230	98	148	83	2.8
BL3233	98	147	94	3.6
NEPAL297(Check)	93	140	80	3.9
BL3241	93	138	84	3.49
BL3243	96	141	85	4.16
BL3244	93	140	86	3.3
BL3246	98	141	86	4.6
BL3247	96	142	87	1.9
BL3249	96	141	78	3.9
BL3250	98	141	83	4.16
BL3258	98	140	101	3.49
BL3260	93	138	95	3.3
BL3261	93	138	82	2.8

BL3262	93	138	85	2.8
BL3263	93	141	80	2.6
PBW65/2*PASTOR-CGSS97Y00036M-099TOPB-067Y-OO9M-OO9Y-OO9B-16Y-OB	98	141	89	3.83
PBW65/2*PASTOR-19Y-OB	96	141	79	4.49
PBW65/2*PASTOR-20Y-OB	98	141	81	3.83
PBW65/2*PASTOR-25Y-OB	98	141	77	3.83
HUW234+LR34*2//PRL/VEE=10	93	141	76	3.9
HUW234+LR34/PRINIA	93	141	75	3.16
IA0216	102	148	86	2.83
ANNAPURNA-1(Check)	102	1471	77	3.16
QUP8002-00	98	141	70	2.6
PBW299	102	148	69	3.3
PARWAZ-94	96	148	78	2.49
SW895124*2/FASAN	93	148	71	2.9
W462/VEE/KOEL/3/PEG//MRL/BUC	93	141	77	2.9
ALTAR84/AESQUARROSA(219)//3*ESDA – CMSS92YO1875M-16Y-010M-010Y-4KBY-5M-OY-2KBY-OKBY-OM	98	148	82	2.8
ALTAR84/AESQUARROSA(219)//3*ESDA- 5KBY-1M-OY-18KBY-OKBY-OM	102	148	79	2.49
ALTAR84/AESQUARROSA(219)//3*ESDA-5KBY-3M-OY-3KBY-OKBY-OM	98	153	77	2.8
PASTOR/3/VEE≠5//DOVE/BUC	102	148	73	3.16
CEP14/CMH81.137//2*THB/3/BOW/PRL//BUC	102	148	80	3.49
CHOIX/STAR/3/HE1/3*CNO79//2*SERI	102	153	89	3.9
KAUZ//SERI/CEP80120	102	147	69	2.9
SW89.2089/KAUZ	102	148	60	3.8
CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/3/VEE≠7/BOW/4/PASTOR-CMSS93BO1854T-O4OY-8Y-O1OM-O1OY-010M-7Y-OM-5KBY-OKBY-OM	98	148	77	3.8
CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/3/VEE≠7/BOW/4/PASTOR-8Y-OM-5KBY-OKBY-OM	98	141	74	2.6
CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/3/VEE≠7/BOW/4/PASTOR-10Y-OM-5KBY-OKBY-OM	96	140	79	5.16
COQ/F41.70//CNDR/4/NAR59/3/FN/K58//N/5/PHO/6/2*KAUZ/7/GALVEZ/WEAVER	102	138	77	3.9
PBW343*2/KUKUN	98	141	77	4.8
INQALAB91*2/KUKUN	99	153	85	4.49

BHRIKUTI(Check)	102	155	80	3.16
INQALAB91*2/TUKURU-CGSS99B00015F-099Y-099M-099Y-099M-29Y-OB	98	153	80	2.3
INQALAB91*2/TUKURU-36Y-OB	98	153	86	4.49
INQALAB91*2/TUKURU-49Y-OB	102	155	84	2.9
OPATA/RAYON//KAUZ-CMBW90Y3180-0T0PM-3Y-010M-010M-010Y-6M-015Y-0Y-4KBY-0KBY-OM	98	148	78	3.16
OPATA/RAYON//KAUZ-10M-015Y-0Y-3KBY-0KBY-OM	98	147	71	3.16
W462//VEE/KOEL/3/PEG//MRL/BUC	96	141	81	2.6
CHOIX/STAR/3/HE1/3*CNO79//2*SERI	102	155	79	3.49
PBW65/2*SERI.1B	102	147	76	3.66
PRL/2*PASTOR	102	148	66	3.9
HUW234+LR34*2/PASTOR	98	153	72	3.66
BL2922	102	153	83	4.16
BL2932	96	155	82	4.3
BL2935	98	148	87	4.3
BL2936	102	155	73	3.6
BL2982	105	148	106	3.8
BL3001	98	141	89	2.3
BL3002	96	138	98	3.9
BL3004	96	138	96	3.6
BL3020	102	148	92	2.9
BL1887 (Check)	102	153	85	3.16
BL3021	102	153	73	2.3
BL3023	98	148	80	2.9
BL3025	96	141	82	4.3
BL3054	96	153	86	4.16
BL3063	93	141	92	4.16
BL3065	96	141	87	3.9
BL2748	96	141	91	3.8
BL2774	93	141	83	4.49
NAC/VEE//CATBIRD-BD(DIN)850S-ODI-ODI-ODI-1D1-(1-10)DI-RC1DI	96	148	83	4.16
NAC/VEE//CATBIRD- RC8DI	96	141	81	2.49
NAC/VEE//CATBIRD-10D1-(1-10)DI-RC1DI	98	141	79	4.16
ND/VG9144//KAL/BB/3/YACO/4/CHTL/5/BAW824(RL6043/4*NAC)	93	138	73	4.8
BAW897*2/CATBIRD-BD(DIN)104098B-ODI-HRDI-RC5DI	98	148	79	4.8
BAW897*2/CATBIRD- RC8DI	102	153	78	2.6
NAC/VEE//CATBIRD-BD(DIN)85097S-ODI-OBD-HRDI-RC3DI	98	140	80	3.6
NAC/VEE//CATBIRD- RC6DI	96	138	83	3.8
BAW378//BB/TOB//CNO67/3/HUAC/4/TIRESEL/3/BB/PL//SX/5/ICTAL-123	96	138	81	4.8

ICTAL 123/3/RAWAL87//VEE/HD2285-BJO9586-OJO-3JE-OJE-HRDI-RC2DI	98	147	80	3.3
ICTAL 123/3/RAWAL87//VEE/HD2285-RC3DI	98	155	83	2.16
BL1473 (Check)	96	155	86	3.3
ICTAL 123/3/RAWAL87//VEE/HD2285-RC5DI	98	148	88	4.9
BAW966	98	148	84	4.3
BL2890	103	153	79	3.6
BL2892	98	148	80	2.8
BL2906	98	148	90	2.6
BL2920	103	155	66	2.8
BL2927	102	147	94	3.6
BL2935	102	147	83	3.8
BL2979	103	155	100	1.9
BL2980	103	153	98	3.49
BL2981	103	153	89	2.6
BL2995	102	153	101	3.8
BL3010	102	153	88	4.16
BL3018	103	153	107	2.9
BL3037	102	148	111	3.3
BL3046	103	148	96	2.3
BL3064	96	147	94	3.49
BL2807	93	141	99	4.6
M758064/2*6TA876//EMS-6TA876/3/6TB219/6TA876/4/RONDO/2*ERIZO-11/5/ONA-2*2/NIMIR-4	96	153	108	4.4
NEPAL 297 (Check)	96	148	83	3.3
PASTOR/3/MUNIA//CHEN/ALTAR84/5/CNDO/R143/ENTE/MEXI-2/3/AEGILOPS SQUARROSA	98	148	74	4.8
BABAX*2/PRL	96	153	86	3.8
KAMBARA 1- CGSS95B00016F-099Y-099B-099Y-099B-25Y-OB-OSY	102	148	97	4.6
AJAIA12/F3LOCAL(SELETHIO.135.85) //PLATA-13	102	153	70	2.6
KAMBARA 1-020Y-OB-OSY	102	148	87	3.49
MILAN/AMSEL	102	147	69	2.16
BOW/URES//KEA/3/SITE	103	155	84	2.6
MILAN/MUNIA	102	155	86	2.49
JUN//MAYA/MON/3/PGO/4/MILAN	102	148	79	2.16
MILAN//PSN/BOW-	102	148	72	2.16
MILAN//PSN/BOW-1PZ-OY	98	148	73	2.3
PAT24/ALD//DOVE/BUC/5/GOV/AZ//MUS/3/DODO/4/BOW	102	153	80	2.6
MILAN/AMSEL//CBRD	103	147	75	2.6
TNMU/MILAN//MILAN/SHA7	103	153	86	2.49
WK 1444	103	153	99	4.16
WK 1334	102	147	84	3.8

WK 1308	102	147	91	3.6
CMH 843379/CMH78578/MILAN	102	153	79	3.16
WEAVER/4/NAC/TH.AC//3PVN/3/MIRLO/BUC	102	148	75	2.9
ANNAPURNA-1 (Check)	102	147	82	5.5
PASTOR/KAUZ	102	153	77	2.8
CNDO/R143//ENTE/MEX12/3/AEGILOPS SQUARROSA (TAUS)/4/WEAVER/5/2*KAUZ	102	153	67	3.8
CMH82A.1294/2*KAUZ//MUNIA/CHTO/3/MILAN-CMSS94YYO2299T-030Y-0300M-0100Y-0100M-4Y-8M-0Y-16Y-OB	102	153	76	2.49
CMH82A.1294/2*KAUZ//MUNIA/CHTO/3/MILAN-41Y-OB	102	153	82	3.8
FALKE*2/BISU/3/CHEN/AESQUA(TAUS)//BCN	102	153	79	3.6
MILAN/KAUZ//PRINIA	96	141	83	4.4
OPATA/RAYON//KAUZ/3/TOBA97	102	148	78	2.6

1.3.2 International Disease Trap Nursery (IDTN)

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 110 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 the weed. The results of the trials are presented in Table 12.

Table 12 : Observations of IDTN Trial

Genotype	Observed date/leaf yellow rust scoring	Observed date/leaf	Observed date/leaf	Observed date/leaf yellow rust scoring
	25/3/05	1/4/2005	18/4/05	27/4/05
THATCHER	1% leaf rust	1% leaf rust	30% leaf rust	90% leaf rust
TC*6/CNTENARIO(RL6003)	-	-	35% leaf rust	90% leaf rust
TC*6/WEBSTER(RL6016)	-	-	10% leaf rust	35% leaf rust
TC*6/CARINA(RL6019)	-	5% leaf rust	20% leaf rust	95% leaf rust
TC*6/LOROS(RL6047)	-	2-3% leaf rust	50% leaf rust	85% leaf rust
TC*6/DEMOCRAT(RL6002)	3% leaf rust	5% leaf rust	55% leaf rust	85% leaf rust
TC*6/ANIVERSARIO(RL6007)	7% leaf rust	10% leaf rust	60% leaf rust	70% leaf rust
BAGE/8*TC(RL6042)	2% leaf	8% leaf	70% leaf	85% leaf

	rust	rust	rust	rust
TRANSFER/6*TC(RL6010)	-	5% leaf rust	50% leaf rust	85% leaf rust
TC*6/EXCHANGE(RL6004)	20% leaf rust	85% leaf rust	90% leaf rust	90% leaf rust
HUSSAR(W976)	50% leaf rust	90% leaf rust	95% leaf rust	100% leaf rust
B19EXCHANGE/6*TC(RL6011)	-	15% leaf rust	30% leaf rust	75% leaf rust
MANITOU	-	15% leaf rust	30% leaf rust	85% leaf rust
SLKIRK/6*TC(RL6013)	-	10% leaf rust	60% leaf rust	85% leaf rust
TC*6/MARIAESCOBAR(RL6006)	-	-	55% leaf rust	80% leaf rust
TC*6/KENYA1483(RL6052)	-	2-3% leaf rust	70% leaf rust	80% leaf rust
TC*6/EXCHANGE(RL6005)	-	50% leaf rust	90% leaf rust	95% leaf rust
KLEIN LUCERO/6*TC(RL6008)	50% leaf rust	70% leaf rust	90 leaf rust	100% leaf rust
TC*7/AFRICA43(RL6009)	30% leaf rust	60% leaf rust	80% leaf rust	95% leaf rust
TC*7/TR(RL6040)	-	75% leaf rust	85% leaf rust	95% leaf rust
THEW(W203)	-	5% leaf rust	10% leaf rust	Leaves dried
TC*6/RL5406(RL6043)	-	5% leaf rust	30% leaf rust	70% leaf rust
TC*6/RL5404(RL6044)	30% leaf rust	50% leaf rust	80% leaf rust	90% leaf rust
LEE310/6*TC(RL6012)	25% leaf rust	30% leaf rust	80% leaf rust	90% leaf rust
TC*6/AGENT(RL6064)	55% leaf rust	80% leaf rust	95% leaf rust	95% leaf rust
TC*?/TRANSEC	55% leaf rust	80% leaf rust	95% leaf rust	95% leaf rust
TC*6/ST-1-25(RL6078)	-	-	-	1% leaf rust
GATCHER(W3201)	-	15% leaf rust	50% leaf rust	Leaves dried
CS2D-2M	-	-	25% leaf rust	30% leaf rust
TC*6/CS7AG≠11(RL6080)	1% leaf rust	2% leaf rust	25% leaf rust	25% leaf rust
TC*6/TERENZ10(RL6049)	-	2% leaf rust	50% leaf rust	75% leaf rust
TCLR32(RL5497)	-	5% leaf rust	60% leaf rust	85% leaf rust
TC*6/P158548(RL6057)	-	5% leaf rust	65% leaf rust	90% leaf rust
TC*6/P158548(RL6058)	-	-	15% leaf	25% leaf

			rust	rust
RL5711	-	-	5% leaf rust	5% leaf rust
E84018(NEP/AE.SPELTOIDES2-9-W//5*NEPT-3-3*MITU)	-	-	50% leaf rust	90% leaf rust
TC*6/VPM(RL6081)	-	3% leaf rust	50% leaf rust	80% leaf rust
TC*6//CARINA(RL6051)	-	5% leaf rust	50% leaf rust	85% leaf rust
WL711	5% Leaf rust	10% leaf rust	65% leaf rust	Leaves dried
GAZA(W277)(DURUM)	-	-	15% leaf rust	Leaves dried
ALTAR84(DURUM)	-	-	5% leaf rust	Leaves dried
NDLINE (DURUM)	-	-	5% leaf rust	Leaves dried
IUMILLO (DURUM)	-	-	5% leaf rust	5% leaf rust
LOCAL RED (DURUM)	60% leaf rust	90% leaf rust	100% leaf rust	Leaves dried
SONORA 64	-	60% leaf rust	Leaves dried	Leaves dried
YECORA 70	-	80% leaf rust	Leaves dried	Leaves dried
INIA 66	-	3-5% leaf rust	Leaves dried	Leaves dried
NOROESTE	-	3-5% leaf rust	Leaves dried	Leaves dried
OPATA 85	-	-	Leaves dried	Leaves dried
JUPATECO 73S	-	70% leaf rust	Leaves dried	Leaves dried
JUPATECO 73R	-	-	Leaves dried	Leaves dried
ANAHUAC 75	-	3-5% leaf rust	Leaves dried	Leaves dried
GENARO 81	-	-	Leaves dried	Leaves dried
SERI 82	-	-	Leaves dried	Leaves dried
SUPER SERI ≠2	-	1% leaf rust	Leaves dried	Leaves dried
BABAX≠1	-	10% leaf rust	Leaves dried	Leaves dried
BABAX≠2	-	-	Leaves dried	Leaves dried
SUPER KAUZ	-	-	Leaves dried	Leaves dried
TONICHI 81	-	-	Leaves dried	Leaves dried
PARULA	-	-	Leaves	Leaves

			dried	dried
PAVON 76	-	3% leaf rust	50% leaf rust	Leaves dried
PASTOR	-	-	5% leaf rust	Leaves dried
ATTILA	-	-	3-5% leaf rust	Leaves dried
AMADINA	-	-	3-5% leaf rust	Leaves dried
BUCK BUCK	-	-	-	Leaves dried
CHAPIO	-	-	-	Leaves dried
TUKURU	-	-	-	Leaves dried
KUKUNA	-	-	5% leaf rust	Leaves dried
KAKATSI	-	-	-	Leaves dried
MOROCCO	80% leaf rust	100% leaf rust	Leaves dried	Leaves dried
YR1/6*AVOCET(CX93.51.3.3)	-	5% yellow rust	90% yellow rust	Leaves dried
YR5/6*AVOCET(CX86.6.1.20)	-	5% yellow rust	10% yellow rust	Leaves dried
YR6/6*AVOCET(CX94.2.2.25)	65% yellow rust	90% yellow rust	100% yellow rust	Leaves dried
YR7/6*AVOCET(CX93.21.3.1)	65% yellow rust	90% yellow rust	100% yellow rust	Leaves dried
YR8/6*AVOCET(CX86.18.1.8)	-	-	80% yellow rust	90% Yellow rust
YR9/6*AVOCET(CX93.24.1.22)	-	-	80% yellow rust	Leaves dried
YR10/6*AVOCET(CX93.53.3.1)	-	-	5% yellow rust	Leaves dried
YR15/6*AVOCET(CX89.1.1.27)	-	-	-	Leaves dried
YR17/4*AVOCET(CX94.8.1.25)	-	85% yellow rust	100% yellow rust	Leaves dried
YR18/3*AVOCET(CX94.10.1.7)	-	20% yellow rust	85% yellow rust	Leaves dried
YR24/3*AVOCET(CX96.1.3.12)	-	2-4% yellow rust	50% yellow rust	Leaves dried
YR26/3*AVOCET(CX96.17.1)	-	-	35% yellow rust	Leaves dried
YRSP/6*AVOCET(CX94.14.1.15)	-	-	30% yellow rust	Leaves dried
YR27/3*AVOCET(CX94.19.1.1)	-	3-5% yellow rust	80% yellow rust	Leaves dried
AVOCET+YRA	-	75% yellow rust	95% yellow rust	Leaves dried

AVOCET+YRA	50% yellow rust	80% yellow rust	100% yellow rust	Leaves dried
Cartens Vgene in Avocet	-	-	55% yellow rust	Leaves dried
Tatara	-	-	5% yellow rust	Leaves dried
BL2217	55% yellow rust	80% yellow rust	100% yellow rust	Leaves dried
Milan/Sha 7	-	20% yellow rust	90% yellow rust	Leaves dried
PBW 343	-	-	5% yellow rust	Leaves dried
PBW 373	-	-	-	Leaves dried
RAJ 3765	-	-	-	Leaves dried
HP 1633	70% yellow rust	95% yellow rust	100% yellow rust	Leaves dried
HD 2204	-	2-5% yellow rust	80% yellow rust	Leaves dried
WL 1562	-	-	15% yellow rust	Leaves dried
Annapurna -1	-	-	-	Leaves dried
Pasang Lamu	-	-	10% yellow rust	Leaves dried
BL 1473	-	-	Leaves dried	Leaves dried
RR21	30% yellow rust	50% yellow rust	90% yellow rust	Leaves dried
BHIRIKUTI.	-	-	-	Leaves dried
BL1813	-	10% yellow rust	95% yellow rust	Leaves dried
BL1887	-	3-5% yellow rust	10% yellow rust	Leaves dried
MH 97	-	-	-	Leaves dried
INQUILAB	-	-	30% yellow rust	Leaves dried
BAKHTAWAR	-	-	-	Leaves dried
KOHISTAN 97	-	8-10% yellow rust	95% yellow rust	Leaves dried
PUNJAB 85	-	10% yellow rust	65% yellow rust	Leaves dried
KANCHAN	40% yellow rust	70% yellow rust	100% yellow rust	Leaves dried
GAURAB	-	5% yellow rust	45% 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 sqm (2m x 2m). 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 13.

Table 13: Observations of Rust Trap Nursery

Genotype	28/3/05 Rust scoring	6/4/05 Rust Scoring	18/4/05 Rust Scoring
Annapurna1	10%	10%	10-15%
WL 1562	10%	60-70%	80%
HD 2204	5%	40-50%	50%
PBW 343	-	-	5%
HD 2687	-	1-3%	5%
HD 2189	10%	70-80%	90%
HD 2133	80%	90-100%	100%
Pak 81	-	5-10%	30%
Punjab 85	20%	20-25%	25%
Chakwal	30%	30%	45%
Faisalabad 85	35%	35%	40%
Inquilabad	30%	40-45%	45%
Faisalabad 83	5%	40%	70%
Rawal 87	-	10%	25%
Kohsar	-	10%	20%
Bakhtawar	10%	5-10%	20%
Raj 3765	-	10%	10%
Gaurab	-	10%	15%
PBW 373	-	-	10%
Morocco	90%	90%	100%

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 introduce promising materials and to assess the performance under our environment. The trial was laid out in a single observation plot of 15 sqm (5m x 3m). 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.

Amongst the varieties, Kanchan yielded the highest with 2.5 t/ha (Table 14) followed by Gourav with a yield of 2.04 t/ha and Sourav with 1.5t/ha.

Table 14: Agronomic traits of BARI Wheat

Variety	50% FLW		Maturity		Plant height	Yield
	Date	days	Date	days	cm	t/ha
Shatabdi	5/3/05	107	4/5/05	167	76	1.46
Protiba	14/3/05	116	24/4/05	157	75	1.20
Sourav	5/3/05	107	28/4/05	161	73	1.50
Gourav	16/3/05	118	28/4/05	161	74	2.00
Kanchan	21/3/05	123	4/5/05	167	76	2.50
Bajoka 1	16/3/05	118	28/4/05	161	79	0.50
Bajoka 2	5/3/05	107	21/4/05	154	93	1.80
Sonalika	16/3/05	118	28/4/05	161	72	1.20

1.3.5 Seed production and maintenance of released lines

A total of 315 kgs of seed of three released varieties of wheat were produced and maintained at research centre for supplying breeder's seed to Druk Seed Corporation and further research use (Table 15).

Table 15: Wheat seed production in 2004-2005

Sl.No	Variety	Quantity (Kg)
1	Bajoka-1	68
2	Bajoka-2	90
3	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/evaluate the performance of the lines from BARI under Bhutanese agro-ecological conditions in terms of yield, maturity days, flowering time and pests and disease incidence. The trial was laid out in a single observation plot of 15 sqm. The trial consisted of seven varieties including three released varieties as the standard checks. Frequent hand weedings were done to prevent the crop from weed dominance. Amongst the introduced BARI lines BARI-11 yielded the highest with 0.57 t/ha (Table 16) followed by Sonalika Sarisha with 0.44 t/ha.

Table 16: Agronomic traits of BARI lines

Variety	50% flowering		Maturity		Pests & Diseases incidence	Yield (t/ha)
	Date	Days	Date	Days		
BARI-11	24/1/05	76	7/4/05	148	Powdery mildew & beetle	0.57
BARI-6	17/1/05	69	4/4/05	145		0.36
BARI-9	17/1/05	69	21/4/05	162		0.37
Sonalika sarisha	24/1/05	76	5/4/05	146	Beetle attack	0.44
Bajo peka-1	17/1/05	69	27/3/05	138	White rust	0.65
Bajo peka-2	17/1/05	69	27/3/05	138	White rust	0.44
M-27	17/1/05	69	23/3/05	134	Powdery mildew & bettle	0.24

1.4.2 Selection of lines from the mass selected mustard

The main objective of this trial was to evaluate the performance of varieties subjected to mass selection. The trial was laid out in a single observation plot in a plot size of 15 sqm. 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, named as Bajo selection 1 to 24, were made from the field.

1.4.3 Economic Analysis of Nature Farming

[This is an abstract of the analysis/report done by Ms Iris Glanzmann, a student from the Swiss College of Agriculture, as part of her field work from April to October 2005 at RC Bajo]

Since 1995 an area of 4247 sqm has been managed without any synthetic inputs at RC Bajo. Crop residues are recycled after composting with EM (Effective Micro-organisms) yielding so called Bokashi-compost. In addition, considerable amounts of farmyard manure are purchased from outside and added to the system each year. Crops grown include rice in summer and wheat or mustard seed in winter, while maize is grown under dryland conditions. In 2005 three trials on organic farming were initiated by the trainee and the area was expanded. Contamination with synthetic inputs through water can't be fully avoided, given that the water comes from the irrigation system in the valley above. The area has been managed as a long term trial, basically assessing yield levels.

The task of the trainee was to critically review the technical and economic aspects of growing crops in organic rice-based systems and make context-related and relevant suggestions for changes in the management for the subsequent years. The main question is: What should be the future of the

natural farming area at the centre and how can it be best used to contribute to organic issue? It seemed important to conduct an economic study facilitating first notion of costs and returns resulting of growing rice organically. It was agreed on analyzing the nature farming long term trial on station and comparing it to conventional rice production at RC Bajo and at Lingmuteychhu watershed. The objectives of the economic analysis were to:

- Quantify production costs and conduct a cost-benefit analysis of the organic rice grown in the natural farming area.
- Identify and compare labour inputs of an organic and a conventional system on station and put it side by side to labour time used at farm level.
- Estimate minimum price difference to be obtained for a profitable organic rice production and conduct a sensitivity analysis by assuming relevant parameters of organic rice production at farm level
- Summarize findings between an organic and the present farmer's rice growing technique. Specify implications and bottlenecks if it comes to an organic production.

The aim was to obtain a first notion of net returns, overall production costs and detailed labour investment of the organic long term rice trial. Rough data of production costs in the nature farming area were available from 2004. Records from all production inputs were taken during the growing season 2005 until August. The final calculation was done with data from 2004 to August 2005. Initially the production costs and labour data from 2004 were compared to those from 2005 in order to track inconsistencies and make records comprehensive. The mean production costs of both years were determined and defined in an "adjusted" version of a cost-benefit analysis. Bearing in mind that the production technique in the past years had not changed it seemed reasonable to use the average yield of the past three years for a final adjusted calculation of net returns.

The most important parameters such as labour input, composition of production costs as well as the yields are presented and compared to other studies (on-station and on-farm) in order to point out differences and features in an organically managed rice system.

Comparison to farmer's practice: RC Bajo conducted a detailed economic study on rice production in the near Lingmuteychhu Watershed in 1998. This study was taken as a base reference for comparison to the farmer's practice. Prices for material inputs had to be adapted to present rates. Slight modifications were made to allow a sound comparison. The conventional on-station production is thought to be representative for an intensive rice production area such as the Punakha-Wangdue valley. Main features of the three rice cultivation systems used for the economic study are found in Table 17.

Table 17: Main features of the three rice cultivation environments used for the economic study of organic rice production

Economic study	*Rice production in the natural farming area at RC Bajo*	*Conventional rice production at RC Bajo*	*Rice production in the Lingmuteychu Watershed*
Year of evaluation	2004 – 2005 (analysis of costs), 2002 – 2004 (average yield)	2000 - 2002	1998
Area or number of hh	4247m^2	512m^2	12 hh, 53 rice fields
Aim of study	Facilitate first notion of indications such as labour input, price difference and baseline for improvement suggestion	Comparison of net returns in rice and potato cultivation	Detailed economic study of rice production in the LW
Inputs used	Compost, FYM	Herbicide, Urea, Suphala, SSP, Potash	75% of all hh used synthetic fertilizer and herbicide
Land preparation	Mechanically (powertiller)	Mechanically (powertiller)	Oxen plow and powertiller
Used term	Organic	Conventional	Farmer's practice
Altitude zone and intensity of rice production	Medium altitude, fertile valley, medium intensity	Medium altitude, fertile valley, high intensity	High altitude, low to medium intensity

Results and Discussion

The results provide preliminary indications of the important issues (labour time, production costs, and price) and point at aspects to be improved in future. Rice yields from the long-term trial show a noticeable gradation over time. The reason for these peculiar yield fluctuations lies in the modification of fertilization rates on the one hand (Table 18). The high yields in the first year are explained with the previous crop rotation: green manure *Sesbania acculeata* was cultivated for three years. The change of personnel managing the trial in 2001 may have an effect as well, especially related to field activities done at the right time. Yields of on average 6 t/ha are feasible with the corresponding cultivation management but show a big fluctuation.

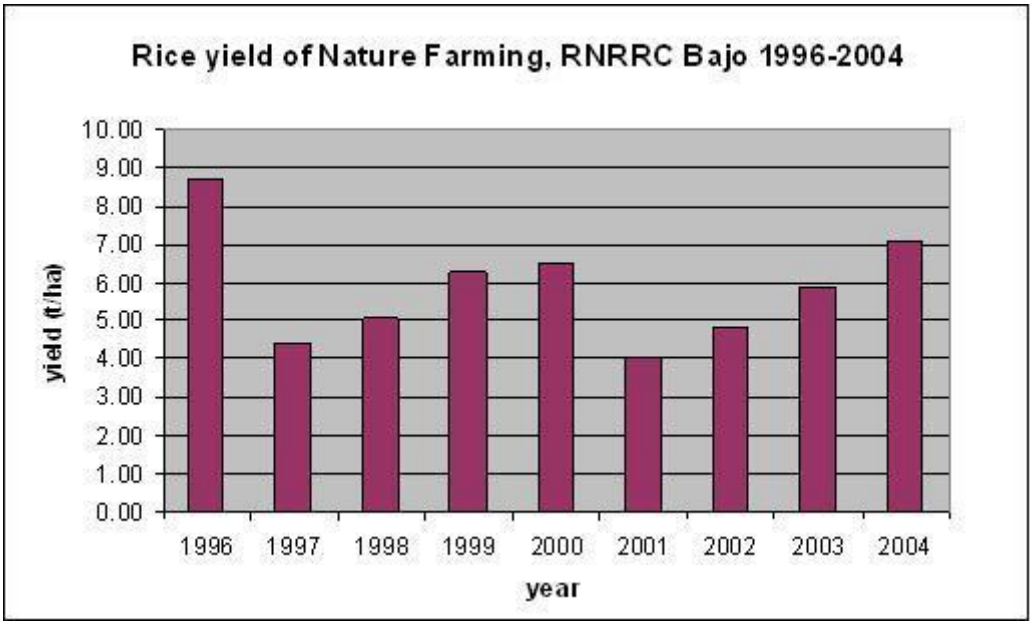


Figure 2 Rice yield of IR-64 in nature farming trial, RNRRC Bajo 1996 - 2004

Table 18: Rice fertilization rates Natural Farming 2001 - 2004, RC Bajo

	2001	2002	2003	2004
FYM t/ha	2.5	8	8	6
Compost t/ha	0	8	8	6

Looking at the conventional production, the average yield (for IR-64) with use of herbicide, urea and FYM is on average 7.5 t/ha at the research centre and at around 6 t/ha at farm level in the Wangdue-Punakha valley.

Cost-benefit analysis

The figures are indicated per hectare. The assessed area measures 4257m^2 (what corresponds to field sizes at farm level) and is extrapolated to a per hectare calculation. Indications for labour input for one hectare could possibly lie above the linear extrapolation if the work is done manually (longer work breaks). This was however not taken into account.

Table 19 Cost benefit analysis of organic rice production, RC Bajo 2005

Organic rice at RC Bajo			
Economic Indicators (Nu.[1])	**2'004 ha**	**2'005 ha**	**adjusted ha**
Paddy yield kg	**7'100**	-	**6'000**
Milled rice yield (paddy *0.6)	4'260		3'600
Price/kg milled rice	18.9	18.9	18.9
Gross Return milled rice	**80'512**	-	**68'040**
Labour-days	**268**	**262**	**265**
Labour costs/day	100	100	100
Total labour costs	**26'838**	**26'192**	**26'515**
Material inputs (machinery costs)	6'637	7'608	7'123
Other Material (seeds, ingredients for compost, FYM)	4'884	4'884	4'884
Total production costs	**38'358**	**38'684**	**38'521**
Production costs (Nu/kg)	5.4	-	6.4
Total Net Returns (gross return - production cost)	**42'153**	-	**29'519**

[1] *Exchange rate: 43 Ngultrum (Nu.) = 1$*

Calculations with milled rice provide a better base for comparison to other studies. The conversion factor for milled rice is estimated at 0.6 (Shreshta 2004). The farm gate price for milled white rice (IR-64) is defined at Nu 18.4 (price in 2004). Table 19 llustrates that the total production costs are constant over both years. Since the production technique and the production inputs have not changed significantly in the past 3 years the average yield of 6 t/ha was considered representative for the final "adjusted" cost-benefit calculation. The latter will be used for all calculations in this report.

The wages for hired labour are rated at Ngultrum 100 per day, one labour-day consisting of eight hours. Machinery costs such as costs for power-tiller and tractor are valued at 1200 Ngultrum per day (operator included). All land preparation and harvest was done mechanically. The overall working time was found to be 107 labour-days (LD) per acre or 265 LDs per hectare.

Comparing labour input among different rice cultivation management practices at the station and at farm level, the organic rice production is highest with 265 days per hectare with a mean yield of 6 t/ha (2001 – 2004).

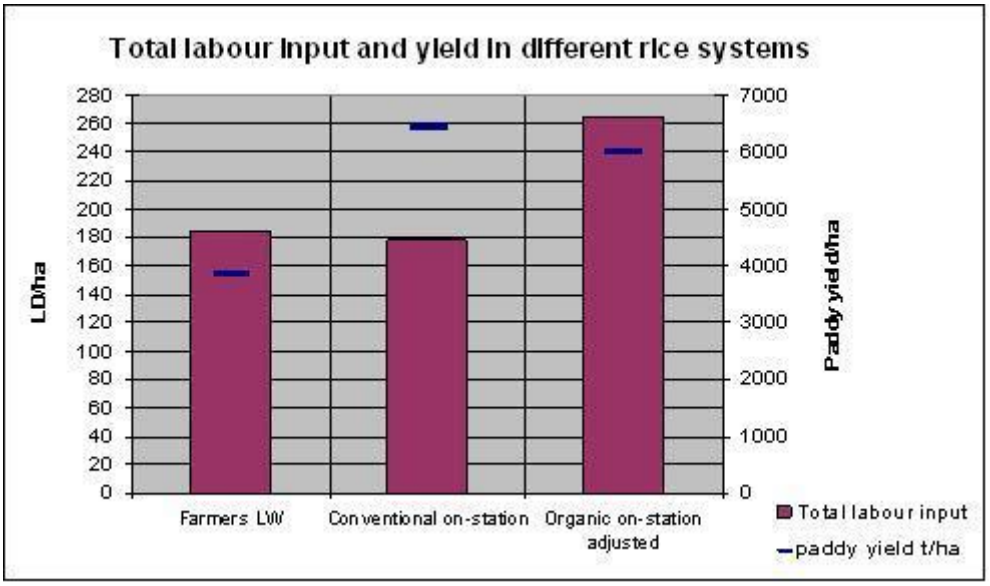


Figure 3 Total labour investment and yield under different cultivation managements at the station and at farm level, RC Bajo 2005

In contrast, Lingmuteychu watershed used 185 labour days per hectare for an average production of 3.8 t/ha (Wangdi and Swinkels 1998). For the conventional rice production of 6.4 t/ha at the research station using synthetic fertilizers and herbicide, an average of 178 LD per hectare was recorded (Figure 3).

Figure 4 provides a closer insight into the composition of different field activities and specifies time used for it. The most striking difference in an organically managed system is characterized by the high labour input for weeding and compost preparation. This is explained by the labour-intensive weeding of grass. Grass in rice fields is a serious problem when the water level can't be maintained continuously, what is often the case in the fields.

The difference of weeding time in organic and conventional is 24 LD at the station level. Compared to farm level, the organic version needs 31 LD more.

Other labour inputs for field work are comparable. Harvest in the farmer's field is done manually in contrast to the mechanical harvest on station. Irrigation differs depending on the given irrigation system and water supply. Application time for FYM and compost greatly depends on walking distances. Special crop protection measures in the farmer's field such as crop guarding and fencing are not listed.

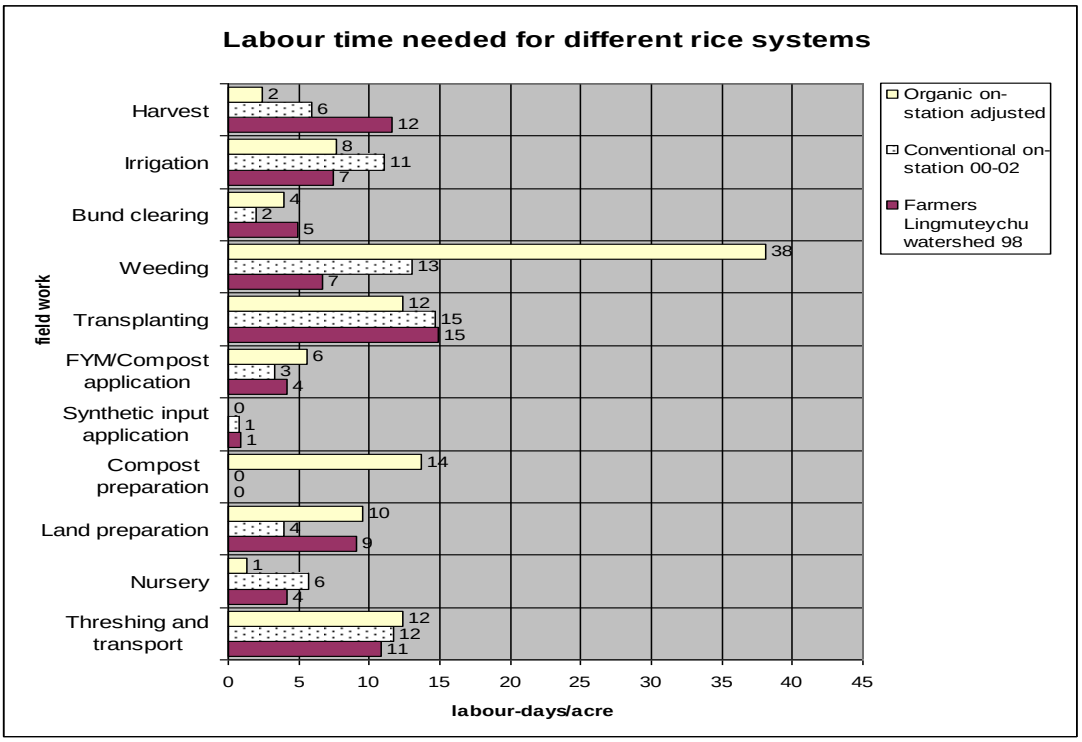


Figure 4: Comparison of labour input for different rice managements, RC Bajo 2005

Production costs

Shifting to an organic farming system is often said to be profitable due to reduced inputs of agrochemicals. In similar rice production areas like Lingmuteychu Watershed this won't be the case after all. Looking at the proportion of production costs in Figure 5 makes clear that costs for synthetic inputs used by farmers in the Lingmuteychhu Watershed only count 2% of total production costs. That is because agro-chemicals are cheap and farmers use only small amounts.

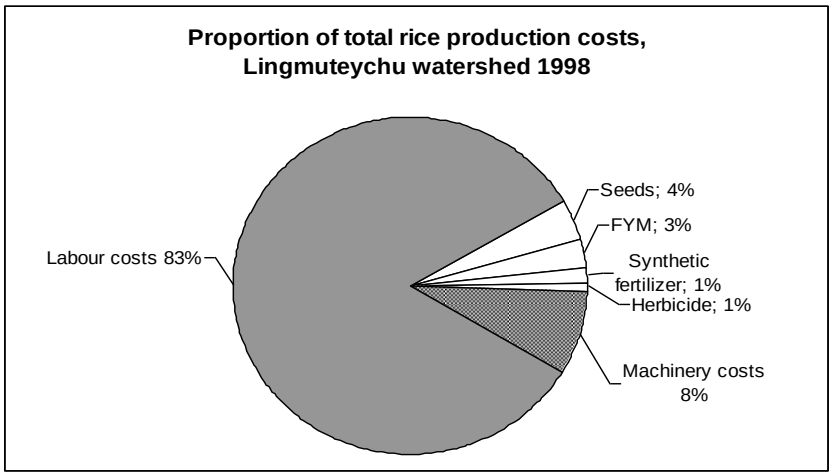


Figure 5: Proportion of rice production costs in LW 1998

In the Lingmuteychhu Watershed on average 60 kg of Urea and 11 kg of the herbicide Butachlor is applied to rice. But already small quantities of herbicides significantly reduce the labour time for weeding. Converting to an organic system in the Watershed would thus mean: More labour for weeding, collection of organic material (leaf litter) and for FYM application and production (time for rearing cattle) and in most of the cases no significant decrease of costs for material inputs. As a result, higher prices need to compensate possible yield reductions and higher labour investments. The higher price however will only be guaranteed through recognition of the organic production system by certification.

In the more intensive rice cultivation at the station the costs for synthetic inputs are found to be 18% of the total production. The organic production can't compete with this system through renunciation of synthetic inputs - because costs for these substances are low (5 Nu/kg of urea and 23 Nu/kg of Butachlor) and yields are higher.

Sensitivity analysis and price estimation for organic rice

Table 20 estimates the required price difference for a competitive organic rice production, either related to the same net returns or the same returns to labour.

Table 20: Price estimation for organic rice (medium altitude zone), Bajo 2005

Price estimation for organic rice per ha	Organic rice on station adjusted	Conv. rice on-station 2000-2002	Variant1a (same net returns):	Variant1b (same net returns to labour):
Rice variety	IR64	IR64	IR64	IR64
Total produced paddy (rough rice)	6'000	6'433	6'000	6'000
Total produced milled rice (kg/ha)	3'600	3860	3'600	3'600
Average price milled rice (Nu/kg)	18.9	18.9	22.1 (+17%)	24.9 (+ 31%)

TOTAL GROSS RETURNS (Nu/ha)	68'040	72'948	79'397	89'629
Machinery costs (Nu/ha)	7123	8538	12'006	12'006
Material costs[4] (Nu/ha)	4848	5758		
Total (labour-days/ha)	265	178	265	265
Total labour costs (Nu.100/labour-day)	26'515	17'775	26'515	26'515
-Total production costs (Nu./ha)	38'521	32'072	38'521	38'521
Total NET RETURNS	29'519	40'876	40'877	51'108
Opportunity costs of land	20'000	20'000	20'000	20'000
NET RETURNS to LABOUR (Nu./day)	136	217	179	217
Production cost (Nu./kg) FYM / compost Ø Fertilization rate(Urea) Ø Herbicide	10.7 6 - 8t/ha	8.3 96kg/ha 38kg/ha	10.7 6 - 8t/ha	10.7 6 - 8t/ha

The net returns to labour for organic rice production is 136 Nu per day. Although this is still above the prevailing wage rate of 100 Nu/day, the organic rice farmer would earn 81 Nu/day less than the conventional rice grower with the same price. Hence, net return to labour is a crucial parameter, especially since labour is a limiting factor for the farmers.

Variant 1a in Table 20 shows that a price increase of 17% would be required to cover the same net returns as in a conventional system. However the net returns to labour would still be lower than in the conventional system. To achieve the same daily net returns to labour a price difference of at least 31% is needed, as calculated in Variant1b.

The sensitivity analysis in Table 21 estimates the minimum price for organic rice needed to compete with that of Lingmuteychhu Watershed. The average mixed price for red local rice was Nu 21.8 what still corresponds to the present prices. 75% of the households use chemical fertilizer and herbicide, which only constitutes 2% of the total production costs or approximately Nu 500 per ha. Costs for machinery (land preparation) are low because most of the households use oxen instead of powertiller.

Table 21: Price sensitivity analysis for organic rice, RC Bajo 2005

	Rice cultivation LW 1998	Variant2:
Rice variety	Local red rice	Improved red rice
Total produced paddy (rough rice)	3'847	3'200
Total produced milled rice (kg/ha)	2'308	1'920
Average price milled rice (Nu/kg)	21.8	28.3 +30%

[4] Material costs include: Seeds, synthetic fertilizer, FYM, compost, herbicide

TOTAL GROSS RETURNS (Nu/ha)	50'322	54'325
Material & machinery costs (Nu/ha)	4'334	3'900
Total (labour-days/ha)	185	216
Total labour costs (Nu.100/labour-day)	18'450	21'600
-Total production costs (Nu./ha)	22'784	25'500
Total NET RETURNS	27'538	28'825
Opportunity costs of land	20'000	20'000
Net returns to all labour (Nu./day)	141	141
Production cost (Nu./kg)	9.9	13.3
FYM kg/ha; 0.5Nu/ha	5000	7750
Urea kg/ha ; 5Nu/kg	60	
Herbicide kg/ha; 23Nu/kg	11	

Variant2 draws a possible situation: Assuming slightly lower yields that originate from higher weed pressure and total lower fertilization rates with only FYM. A higher fertilization rate is questionable since fodder and time for livestock rearing is limited and leaf litter collection cannot be intensified. The average use of FYM to rice is 7750 kg/ha (RNRRC Bajo and NSSC Semthoka 2001). The material costs are reduced with approximately 400 Nu without using synthetic inputs but more FYM. Presuming that the additional labour time needed for weeding is 31 LD (see Figure 4) a price increase of 29% is required to reach at least the same net returns to labour as before.

Any economic analysis done at the research station possesses a designed character differing in many aspects from reality (steady availability of laborers, guaranteed irrigation, optimized inputs, mechanization). The results should be considered as preliminary, bearing in mind that the existing cultivation practice needs adjustment. The huge amount of compost produced for example is not compatible to the farmer's practice and not compulsory in OA. The suggested reduction of compost production reduces total labour input by 14 LD but this would certainly influence rice yields. In order to gain more relevant data, future economic analysis needs to be done at farm level.

It is assumed that the price for organic rice should at least make up the same net returns or net returns to labour as prior to the conversion to make OF interesting. The required price difference consequently depends greatly on the previous production intensity and conditions. For farming systems that use less synthetic inputs the step to organic farming may be smaller. But it should be taken into account that the step to more labour-days can be a big one.

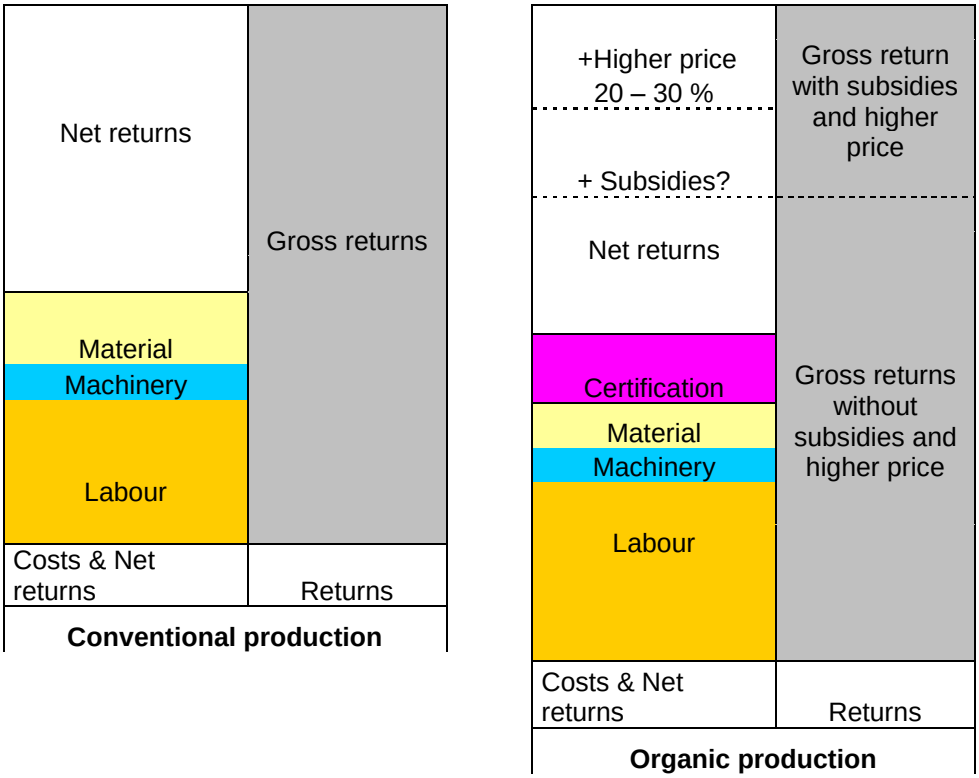


Figure 6: Cost-benefit comparison between Organic and Conventional farming

Figure 6 summarizes the differences of price composition in an organic and conventional system. The costs that can be economized not using chemicals are of minor importance. Higher labour costs, possible lower yields and costs for certification need to be compensated through higher prices. To achieve a profitable level of net returns, subsidies could compensate one part of the higher costs. Subsidies for organic farms are thought to be a reward for an environmental friendly and nature conserving agriculture and at the same time a compensation for yield losses.

Prior to conversion, markets need to be explored and guaranteed. In the present case, organic rice production is not profitable without a higher price of 17 to 31% (certification costs not included) largely related to higher labor costs for weeding and only slight cost reduction for synthetic inputs. When farmers use herbicide and fertilizers, particularly in small quantities, organic rice production cannot compete with the conventional production in terms of labour and yield.

In conclusion, the analyzed organic system differs through more laborious weeding with additional 31 LDs (compared to the conventional version at the research centre). But rearing cattle for sufficient FYM production would result indirectly to higher expenditures on time and costs. The production of large amounts of compost is not compulsory and isn't realistic to that extent as done at RC Bajo.

On average some 180 – 237 LD per hectare are needed to grow rice in Bhutan (Dorji et al 1990). One may ask if farms which used synthetic inputs already before are able to cope with an additional work load of 31 LDs for weeding. Even if the critical minimum price which would cover all expenses and would make a farm viable was guaranteed, would the manpower be physically available? Farmers may not always be able to allocate work force right in time and withdraw it from other farm activities. Where is the critical limit for additional work load and in which time of the season? The answer will very much vary among the farms as the span of labour-days already reveals. Norbu and Floyd (1999) state that 48% of the hh in the Lingmuteychu Watershed report a decline in household labour availability in the last 10 to 15 years. Research should therefore lay all emphasis on developing labour saving cultivation methods that guarantee reasonable yields for marketable and valuable crops.

After all, the benefit of organic farming lies not only within a higher price or better net returns. How we value the returns in form of a healthy working environment, a nature conserving and sustainable farming system is also important. Although these long term benefits may be difficult to explain to a farmer who struggles to make a living, they are the real profit of organic farming and should be valued.

HORTICULTURE RESEARCH

2 HORTICULTURE RESEARCH

2.1 Subtropical Fruits and Low Chilled Temperate Fruits and Nuts

2.1.1 Pomegranate Variety evaluation trial

The pomegranate variety evaluation trial was established in 1994. The objective of the trial was to evaluate the promising varieties for mid altitude dry sub tropical zone. Five Cultivars of pomegranate (Beedana, P575, Amer shurin, Chawa and khandari) with three plants each were planted in the trial orchard with a spacing of 6m x 6m row to row and plant to plant. The trees were trained as modified center leader system. The plants were irrigated during the dry period coinciding the time of flowering and fruit setting period. Weeding, basin preparation, mulching and application of fertilizer were done as recommended.

Out of five cultivars, the vegetative growth was good in all the varieties except for P575 cultivar. Beedana was identified as the earliest cultivar maturing by the first week of August and other three cultivars at the end of August. No major pest was observed other than bird damage on early cultivar Beedana. Chawla was susceptible to fruit rot and spliting. The plants started fruiting after 3 years from transplanting but only one to two fruits per tree till fifth year of transplanting. Table 22 gives tree characteristics of the cultivars, Table 23 and Table 24 the yield and quality of fruit.

Table 22: Morphological characteristics of five pomegranate cultivars

Cultivars	Tree appearance	Bloom time	Leafing	Harvest time
Beedana	Semi vigorous	Late March to late April	March	1st week of Aug.
P5 75	Semi vigorous	Early to mid April	March	2nd week of Aug.
Amar shurin	Semi-vigorous	Early to mid April	March	3rd week of Aug.
Chuwla	Semi- vigorous	Early to mid April	March	3rd week ofAug.
Khandari	Semi-dwarf	Early to mid April	March	3rd week of Aug.

Table 23: Fruit characteristics and quality aspect of five pomegranate cultivars

Cultivars	Shape	Diameter (cm)	Length (cm)	Fruit skin color	Fruit flesh color	TSS (%)	Fruit taste
Beedana	Round	7.5	6.9	Pink	Light red	13	Sour
P575	Pear	8.4	9.4	brown	Red	13.1	sweet
Amer Shurin	Round	8.8	8.4	brown	Light pink	12	sweet
Chawla	Round	7.9	8.4	brown	Light pink	14.1	sweet
Khandari	round	7.9	5.9	brown	Light red	16	sweet

Table 24: Average yield (kg/tree) trend of five pomegranate cultivars

Cultivars	Year						
	2000	2001	2002	2003	2004	2005	Average
Beedana	11.5	24.3	17.5	29	23.8	11.4	19.58
P575	2	8.2	2	0	0	1	2.20
Amar shurin	18.8	20	22	5.6	43	6.2	19.26
Chawla	21.5	30.6	23	18	38	17.4	24.75
Khandari	3	23.5	11.5	14	26.7	14.5	15.53

All the cultivars have round shape fruits except P575, whose fruit is pear shaped. Beedana has beautiful pink skin colour fruit while all other cultivars are brown. There is a significant difference in TSS content of fruit juice, with Khandari the highest and Amar Shurin the lowest. There is also difference in taste of the fruits. Beedana is sour while all others have sweet taste. The variation in fruit flesh colour is from red to light pink. Alternate bearing habit was observed for all the cultivars. P575 did not perform well under Bajo condition and produced significantly low yield among all the five cultivars. Considering all the fruit charactersistics, yield performance and pests tolerance, Khandari cultivar seem to be promising. It may be recommended for release for general cultivation since there isn't any pomegranate cultivar released formally yet. On-station pomegranate variety evaluation will be terminated and the cultivars will be maintained in the scion wood collection block as mandated.

2.1.2 Guava variety evaluation trial

The guava variety trial was established in 1995. The varieties evaluated were Pink Flesh, Thai Giant, Allahabad Safeda and local variety. The main objective of the trial was to assess the variety suitable for the mid-altitude growing environments. The four varieties with three plants in each replication were planted with spacing of 6m x 6m plant to plant and row to row. The trees were trained into open center system. The basin preparation, mulching, weeding and plant protection were done as appropriate. FYM was applied in winter and varying dose of fertilizer as appropriate with age of the tree was applied in May-June and top dressed in September-October. Irrigation was done in dry period mainly in winter, spring and early summer prior to monsoon. The parameters of evaluation included time of crop maturity, quality, yield and pests and diseases.

The plant started fruiting after two years from planting. The plant started flowering in the month of May and the fruit matured in October. The growth of all the plants was good. There were no major pests and diseases observed during the trial period except bird damage and canker disease. However, Thai giant and Allahabad Safeda were quite susceptible to fruit rot. Table 25, Table 26 and Table 27 provides morphological characteristics, fruit quality aspects and the yield recorded as of 2004.

Table 25: Morphological characteristics of four Guava cultivars

Cultivars	Tree growth	Bloom time	Harvest time
Pink flesh	Semi vigorous	May	Mid Sept to Oct.
Thai giant	Semi vigorous	May	October
Allahabad Safeda	Dwarf	May	October
Local	Semi vigorous	May	October

Table 26: Fruit characteristics and quality aspect of four guava cultivars

Cultivars	Fruit shape	Diamet-er (cm)	Length (cm)	Skin color	Flesh color	taste	TSS
Pink flesh	round	6.6	6.4	Light yellow	Light pink	sweet	11.6
Thai giant	round	7.5	7.0	Green & rough	Whitish green	sweet	-
Allahabad Safeda	round	7.0	6.0	White & smooth	Yellow	sweet	10.26
Local	round	6.63	6.86	cream	White	sweet	12

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

Cultivar	1999	2000	2001	2002	2003	2004	Average
Pink flesh	5.18	8.23	10.5	15.4	34.25	14.45	14.66
Thai giant	5.22	0	8.9	39.30	6.2	42.3	20.38
Allahabad Safeda	2.7	7.1	5.8	4.18	3.4	8.45	6.33
Local	4.75	9.93	11.3	10.13	15.58	14.22	13.18

There were significant differences in the yield of cultivars - Allahabad Safeda produced significantly lower yield compared to other cultivars. Thai giant has hard, green and rough skin, less juice content and quality of fruit is poor. Pink Flesh and local cultivar have consistently produced better yield, higher TSS value, quality fruits and consumers preferred them. Local cultivar has creamy light yellow skin and white flesh colour and fruit is aromatic. This variety trial will be terminated from this year. Pink flesh and local cultivars are recommended for release for general cultivation.

2.1.3 Mango variety evaluation trial

The mango variety trial was established in 1995 with an objective to identify and evaluate the best variety for mid altitudes. The varieties were Chausa, Himsagar, Langra, Gulabkhas, Amarpali and Deshari. Single plots with three plants for each treatment. The spacing of 8 m x 8m was kept between plant to plant and row to row. The young plants were protected from frost by having a thatched roof made of paddy straw in the winter. Trees were trained to centre leader system and pruning, particularly removal of dead and diseased twigs, was done when needed. Basin preparation was done twice, once in spring and in Autumn after the crop harvest, followed by fertilizer application and mulching immediately.

Perfomance parameters like vegetative growth, precocity, cropping habit, yield and pests and diseases incidence were recorded and are presented in Table 28, Table 29 and Table 30. Two cultivars Chausa and Gulabkhas did not survive under Bajo conditions. The growth of all other cultivars was good. No insect pests and diseases were observed till last year but from this year fruit fly infestation in all the cultivars was observed.

Table 28: Morphological characteristics of four 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 29: 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, pointed tip	10.9	8.1	Yellow	Green & smooth	sweet	20

Table 30: Average yield (kg/tree) trend of four mango cultivars

Cultivar	2000	2001	2002	2003	2004	2005
Himsagar	7.9	6.6	11.3	0	12.3	3.5
Deshari	4.5	9.43	2.5	10.1	15.8	4.3
Amarpalli	7.25	3.1	10.8	0	24.3	25.7
Langra	0	6.52	1.6	13.8	6.3	1.6

Desheri and Himsagar were harvested in mid August and observed as the earliest maturing cultivars followed by Langra under Bajo condition. The late variety Amarpalli was harvested in second week of September and also it was the sweetest variety compared to all other cultivars. Amarpalli is a dwarf cultivar and recommended for high density planting. The fruit coloration of all varieties is poor under Bajo condition, remaining 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, thereby limiting 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. Dashehari as early, Langra as mid and Amarpalli as late cultivars are recommended to release. On-station mango variety trial will be terminated and promising mango cultivars will be maintained in the scion wood block in the Centre.

2.1.4 Cardamom Variety evaluation

The cardamom variety evaluation trial was established in 2000 as an on-farm trial at Tsokana geog in Tsirang. The varieties tested are Bharlanghe, Dzongu golsey, Ramsey and Swaney. The objective of the trial was to find out the suitability, productivity, and pest and disease tolerance of different cultivars across various agro-climatic regions of Bhutan. The trial is also conducted to develop a first hand data base on cardamom husbandry under Bhutanese condition and to develop recommendation based on long term observation.

The trial design is laid out in randomized completed block design with 3 replications (25 plants per replication) with four cultivars. The plot size of each treatment is 36 m^2. Plant spacing of 1.5m x 1.5m plant to plant and row to row and 3m gap was maintained between the borders of each treatment.

The growth of all the four varieties was good and free from pests and diseases. However, plant density is less, as many did not survive after transplanting. All the four varieties took about 3 years from transplanting to fruiting. Harvesting was completed but drying and processing was not completed at the time of reporting. Details will be reported in the next annual report.

2.1.5 Maintenance of fruits mother plant or scion bank

The mother plants or scion bank of newly released Bajo apple, Bajokham-1 and 2 (peach), Bajokhamchu-1 (apricot), Bajolea-1 (pear), Bearss (lime), Bajo apple, Perlette, Muscat of Alexandria (grapes), Drake, Texas, Dhebar Bhadan and Kagzi for general cultivation are being maintained at the Centre as mandated. A total of 28 citrus cultivars are also being maintained as germplasm collection and as sources of scion wood.

2.1.6 Evaluation of top-working as alternative method for walnut orchard development

Walnut orchard development gained momentum with the commencement of 8th five year plan as one of the priority commodities for horticulture development in the country. The walnut orchards being developed from seeds have resulted to a huge variation in the orchard yield and nut quality. These seeds probably were imported from European countries and America. The grafting techniques have been studied and successfully demonstrated for use by Druk Seed Corporation and private nursery growers but there are no mother plants established in the country to be used as sources of scion wood. In eastern and central Bhutan, private nursery operators promoted by the Ministry of Agriculture are producing and supplying soft-shell walnut seedlings. But we need to discourage the supplying of seedlings to the growers to avoid undesirable inherent characteristics of seedling plants (> 50% of soft shell seedling walnut produces hard shell walnut) and to derive the benefit of uniformity, precocity and trueness to type of the grafted plants.

Top-working is termed as a process when comparatively older rootstocks are grafted or budded at the higher level (1m above the ground) in the production field. 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. This method appears to be appropriate for us.

Materials and methods

Local hard-shell walnut seedlings were transplanted in the production field at Naji in Punakha and Sha Komathang in Wangdue. A large number of wild walnut trees (*J. regia*) in farmers' fields were also top-worked with improved cultivar (Franquette). Two to 10 years old seedlings were top-worked in March and April when the plants are growing actively between 1300 to 2300 masl. The dormant scion wood (cv. Franquette) was cut from parent tree in advance, waxed and stored in the refrigerator at 4^{o}C after proper packing. The local hard-shell walnut (*J.regia*) seedlings were top-worked when they are 3 to 5 years old. Bark grafting was used as a technique either for top-working or frame-working. Frame-working or grafting of

branches is done for top-working of grown up trees. Three to five branches with wide angles and the projection in all the directions are retained for this purpose and other branches are removed. After bark grafting, the open wounds were covered by 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 sunburn. The suckers or water shoot from stock were removed as and when they appeared. Staking of successful top-worked plants was done to avoid breakage by strong wind. The plastic covering the graft unions was removed once the union formation was complete.

Results and discussion

The frame working resulted in 92% graft take while top-working particularly older trees resulted in graft take of 70-80% in altitudes of 1300 to 2300m. Fruiting commenced after two years of operation in altitude of 1300-1800m and in 3 years above 1900m for 3-4 years old seedling trees. If younger stocks (< 3 years) are top-worked it takes 3 years to fruit after operation.

Sap bleeding is a problem in walnut top-working especially when it is done in early spring. This can be avoided by heading back the stock before two weeks of actual operation. Frame-working or grafting of branches is desirable over top-working in grown-up trees, for quicker healing of wounds, higher graft take, earlier production and higher yields. The thick plastic wrapping encourages callus formation and hastens tissue union and wound healing process. To protect from sunburn, the stem portion needs white washing and no shoot other than the scion should be allowed to grow on the plant. An added advantage of top-working is that the scions make rapid growth and commence bearing earlier than transplanted trees. Staking with small poles is effective in preventing breakage of topworked graft union by strong wind.

Top-working is best practiced for seedling stock of below three years old where wound healing is easier and higher percentage of graft take is obtained. Frame-working can be safely practiced for seedling stocks of above three years old in between the altitudes of 1300 to 2300m. However, if older walnut trees are top-worked, wound healing process is slow and the economic production period of the top-worked walnut needs to be assessed.

2.1.7 Pear and persimmon seed germination trial

The trial was conducted to investigate the effect of time of sowing and chilling treatment in local pear and persimmon seeds germination for percentage and seedling survival rate under mid-altitude dry subtropical areas. This is done for the purpose of raising rootstock of above crops. The treatments consisted of:

- October sowing of each crop seeds without artificial chilling treatment.
- January sowing with each crop seeds and 1.5 months chilling treatment of seeds at 4^{o}C.
- March sowing with 3 months chilling treatment at 4^{o}C.

A total of 100 seeds each of pear and persimmon were sown in germination trays in mid of October 2003, January and March 2004. All the seeds were sown in the same

sized germination trays, potting mixture and under the 75% partial shed house. Both pear and persimmon were potted in polybags a few weeks after germination and were allowed to grow in the same environment for about 2 months. After that pear was planted in the open field nursery to allow plants to grow freely.The germination was observed at weekly intervals and the last count of germination was done 2 months after March sowing. Number of germinated plants in all treatments was counted in July 2005.

Results and discussion

For pear, there was no germination of seed sown in January, only 2% germination for October sowing and about 80% germination when sown in March. There was about 40% germination for March sown persimmon seeds and 10% germination for other two treatments. This clearly showed that pear required 3 months chilling treatment at 4^0C prior to sowing. Nursery in mid altitudes needs to be done under partial shed as the temperature is too hot in spring under Bajo condition. Pears and persimmon are temperate crops and mild climatic conditions are ideal for their growing. Irrigation management is critical for pear and persimmon nursery, soil moisture content has to be at field capacity once they are sown. Interrupted wetting and drying is injurious to germinating seeds and hampers germination. Pear seedlings growth in the open field nursery planted from shed house is not very good but the survival is about 90%. Pear and persimmon nursery trial needs to be continued to understand problems in the mid altitudes zones.

2.1.8 Nursery management and plant propagation

The planting materials of various fruit crops are produced in the centre for meeting the requirement of on-farm testing and promotion of released fruit cultivars through research outreach program in focus villages. The propagation techniques successfully tested and planting materials produced are in Table 31.

Table 31: Grafting technique and number of planting materials produced

Crop	Grafting Technique	No. of planting materials produced	Remarks
Sub-tropical apple	Whip	100	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	500	
Peach	Whip	100	
Apricot	Whip	227	
Walnut	Whip	244	
Pecan roostocks and grafts	Whip	1400	
pear	whip	65	
mango	Cleft	140	
Grapes	cuttings	80	
Pomegranate	Cutting	110	
Guava	seedlings	1200	
Passion fruit	seedlings	2500	
Citrus rootstock	Different Rootstock	1200	All these rootstock will be used for propagating the promising
Walnut rootstock		1500	

Avocado rootstock		50	cultivars that are to be used for establishing on-farm demonstration orchard/outreach programme.
Apple rootstock		60	
Peach rootstock		200	
Apricot rootstock		100	
Pear rootstock		300	
Persimmon	Rootstock	50	
Mango	Rootstock	150	

2.1.9 On-farm Evaluation of Fruit and Nuts Crops

Evaluation of station-proven planting materials in farmer's fields has been a pre-requisite before recommending the materials for general cultivation. The objective of on-farm testing is to identify superior genotypes that perform best under farmers' management capability. Testing suitability of materials under major agro-ecologies is another aim.

Horticultural crops especially fruits are important cash crop in the region. Among fruits, citrus and cardamom are priority cash crops in the region. Citrus is the most important sub-tropical fruit covering an area of about 1036 hectares (LUPP, 1995). The citrus industry, however, is based on few species grown under modest levels of inputs. The most popular mandarin grown in Bhutan is *Citrus reticulata*. Going by the sources of already introduced materials, it is believed that in general citrus grown in the country has a narrow genetic base. Therefore, it implies that the citrus industry is vulnerable to pest outbreaks as has happened elsewhere.

RNRRC Bajo has been introducing popular crops and their varieties from outside with the objective of diversifying the cultivation of fruit, nuts and spices. Some of these materials are ready to be tested in on-farm under wider agro-climatic conditions and management levels. Unlike cereal and vegetable crops, however, tree crops are perennial and have longer juvenile phase. Further, in tree fruits many of plant growth aspects and performance parameters cannot be determined at the station level since it would take longer time and at the same time the suitability of materials generated may be limited by conditions prevailing at the station. Placing these materials early on under on-farm would not only gain time but would result in identification of materials appropriate to different agro-ecologies. However, once the new materials are planted in the field, observation, monitoring, and management of crops needs to be continued until fruiting.

Two on-farm approaches to test horticultural materials are foreseen. One approach is to distribute the materials directly to farmers and monitor while the other method is to identify permanent test sites representing various agro-ecologies. In the former approach, monitoring would be extremely difficult besides subjecting trees under variable management levels. The latter approach of identifying permanent sites is preferred as it will not encounter any of above problems but may require some initial investment at the sites. It is worth making the initial investment since the site will be available for testing for a minimum of 10 years during which several species would have been evaluated. Considering these advantages it was considered that

permanent sites would be required for on-farm testing of fruit species. The main objectives are:

- Multi-location evaluation of new fruits and nuts cultivars and identify superior genotypes that perform best under existing farmers' management
- The test site in the longer run will serve as a demonstration plot for showcasing of new fruits and nuts cultivars and their management practices

Materials and Method

The permanent test sites and farmer co-operators were identified and proposed by Dzongkhags and RNRC-Bajo representing the spectrum of agro-ecologies found in the region. The proposed sites were physically verified based on the selection criteria developed for the same and written agreements were signed with the co-operators. Ten permanent test sites (two sites in each Dzongkhag) were identified. Since the co-operator had to bear risks of testing new materials, fencing and planting materials and supplementary inorganic fertilizers were provided free of cost as incentives. The calendar of operations was discussed and agreed to be implemented jointly by the farmers and extension staff as advised by researchers. Field implementation, monitoring, data collection and reporting of the trial in the Dzongkhag are to be done by the extension agent in the geog. Researchers have to ensure supply of inputs, backstop extension and co-operator farmers in care, management, monitoring and data collection of the trial. Researchers also have to write up performance reports across locations and conduct farmer's field days in collaboration with respective Dzongkhags. Two trial orchards of assorted fruits crops in all five Dzongkhags of west-central region have been established.

Preliminary results and discussions

It is too early for a full report since planting in all the sites could not be completed until 2004 due to non-availability of planting materials. However citrus, Bajo apple, peach, pomegranates and chestnut were planted in most sites as early as 2001. These crops planted earlier have started bearing fruits from a few sites.

Bajo apple has fruited in Omtekha, Rubesa, Kabji and Dagapela and its performance is good. Farmers could harvest 5–10kg of fruit per tree and marketed locally without any difficulty @ of Nu. 70 per kg. Farmers in these sites want to expand cultivation of Bajo apple compared to other fruit crops. However, large scale promotion might entail market problems since it has a very short shelf life (less than a week) and not very suitable for export purposes. Its performance is very good in the altitude range of 1250m to 1500m; it performs poorly above or below this range.


Pic 1

Chestnut (Pic 1) fruited in Omtekha and Rubessa trial sites, but many unfilled nuts were observed which may due to poor pollination since only one cultivar was planted. There are plans to frame-work some of branches with other varieties and also plant additional varieties that were introduced recently. Pomegranates started fruiting in Rubesa trial site

only and farmers find it very easy to market in the local market.

Lime and orange (Valencia) also fruited in Rubesa and Kabji trial sites. Rubesa farmers find it difficult to market them in Wangdue while Kabji farmers could sell in Thimphu market easily. Lime has a huge market in India, as it is a part of every Indian meal. Though Valencia is sweet and internationally popular, local consumers are not used to it since it is difficulty to peel. It might take some time before South Asian markets accept it as that of local mandarin. Valencia fruits hold on to the tree for a long time and farmers could harvest in March which is off-season for citrus.

Peach variety Bajokham-1 fruited in Yamina, Kabji, Salambi, Omtekha and Dagapela demo-orchards. The highest yield record of 44.5 kg per tree was from Yamina. All collaborating farmers except a few from Yamina feel that peach cultivars are better than the local cultivars and found no difficulty in marketing them. Yamina farmer had harvested about 44.5 kg of fruits per tree but could not sell because of distance from the market. The fruit ripening and time of harvest of both improved and local peach coincided at the same time in higher elevation like Yamina (1900m) where farmers prefer local Loshukham variety to improved ones. Therefore from this multi-location trial it may be concluded that the market acceptance of Bajokham-1 and 2 is high in the low and mid altitudes as the fruit appears first in the market and fetches premium price but this is not the case at higher elevation of 1900m and above. First peach harvest from the trial site in Salambi also had some difficulty in selling fruits in local market as people were suspicious of its quality since it appeared very early in the market. Consumers in Tsirang thought those peaches were dropped fruits of local varieties.

Preliminary results of date palm trial (Pic 2) showed good vegetative growth at Pinsa, Baychu and Bhur farm and very poor growth at Bajo Research Centre indicating that date palm will not perform well under Bajo and alike climatic conditions (1300m). The vegetative growth indicates that date palm can do well in areas of 900m and below with mild winters. However, it is too early to make any conlusions at this stage.

Pic 2

2.1.10 Translating research into communication materials

Some of the publications and recommendation submitted or produced by the sector are as follows:

- Additional New Technologies in Horticulture: Booklets on newly released fruit and vegetable cultivars, production management technologies published and circulated to the Dzongkhags in the region.
- Leaflets on walnut propagation under ambient condition published and circulated at national level.
- Effect of time of grafting on walnut graft success under different altitudes ranges, paper published in Acta Horticulturae, 5th International walnut Sympoium, Proceedings. International Society for Horticulture Science (ISHS), November 9th to 13th, 2004.

- Participated in writing the book "Facilitating change: experiences of Lingmutey Chu watershed" which is under publication by RNRRC-Bajo.

2.2 Vegetables

2.2.1 Watermelon variety trial

Watermelon is a vegetable when green and a refreshing fruit at the ripe stage. It is a warm season crop and its growth is poor in cold weather. Watermelons have a good market and are popular among consumers. Indian watermelons appear only in spring season. However, demands in the markets are high in summer season. It is possible to grow watermelon in lower elevation of our country and harvest in summer season. Thirteen hybrid watermelon varieties from Thai, Royal foundation project and Marcapolo Seed Company were evaluated for their yield, fruit quality and resistance to pest and disease in 2004. The same trial was continued in 2005 with nine hybrid varieties, as the seeds of other varieties were not in sufficient amount.

The experiment was conducted from April to August 2005 in RNRRC Bajo. A randomised complete block design (RCBD) with three replications was used. The plot size was $10m^2$ with one bed per plot. Watermelon seeds were sown on April 13, 2005 in poly pots containing a mixture of FYM, sand and soil at 4 : 1: 2 . Seedlings were transplanted in the field on May 18, 2005 with one row in a plot and five plants per row. The spacing used was 2 m from plant to plant. Fertilizer was applied at the rate of 45: 35: 25 kg per ha and with 1 kg FYM per pit. Pit size was 25 cm wide and 25 cm depth. Weeding and irrigation was done as and when necessary. Harvesting was done in August 3, 2005 for all varieties. Yield and fruit charatistristics (Table 32) of watermelon varieties were analysed using ANOVA in Genstat.

Table 32: Yield and fruit characteristics of watermelon varieties

Treatment	Yield (t /ha)	TSS (%)	F. length (cm)	F. width (cm)	Av. f. wt (kg)	Fruit skin colour	Fruit flesh colour
Sugar baby	10.77	14.00	15.83	15.83	2.133	Dark green	Red
Yad phate	11.77	17.20	15.37	14.73	1.567	Dark green stripe	Red
New jintara	13.03	17.67	19.67	19.67	1.900	Light green stripe	Red
Jinda manee	18.10	16.40	19.33	19.33	2.133	Green stripe	L. Red
New red delicious	12.47	13.00	14.50	14.50	2.000	Light green stripe	Red
Shawing 175	13.67	16.73	17.50	17.50	1.967	Green stripe	Red
Jumbo jintara	20.67	14.73	18.33	18.33	2.867	Dark green stripe	Red
Flower dragon	13.63	12.33	19.00	19.00	2.500	light green stripe	Red
Fine light	18.17	13.67	26.00	26.00	2.100	Light green stripe	Red
Ten bow	24.10	12.67	17.67	17.67	2.700	Light green stripe	D. Red
F. prob	0.001	0.001	0.096	0.282	0.033		
L SD	4.8	2.249	6.703	4.242	0.70		
CV%	9.5	1.9	5.4	2.2	6.8		

The crop was attacked by pumpkin beetle at the seedling and early growth stage, but its population was not so high. It was controlled by spraying and dusting Malathion. At fruiting stage the crop suffered fruit rot due to continued heavy rain.

Statistical analysis showed there was significant difference in yield of the watermelon varieties. Ten Bow yielded significantly higher (P= 0.001) than all others varieties except Jumbo Jintara and local check Sugar Baby yielded the lowest. The fruit sizes of most of varieties are medium to large, average fruit weight ranged from 1.567 kg to 2.867kg. Jumbo Jintara produced significantly heavier weight fruit (P = 0.05) than all entries, except Flower Dragon, Fine Light and Ten Bow. The fruit quality of all the exotic varieties was good. Yatphat and New Jintara were sweetest. The local check recorded significantly lower total soluble solute contents. All the varieties did perform well under Bajo conditions. The fruits of all these cultivars were evaluated for taste by farmers and government officials of different agencies. Feedbacks received were positive but these varieties are hybrids and seed production is an issue. The hybrid cultivars yielded significantly high and have better taste and consumer preference than the only commercially available local variety sugar baby. Therefore, varieties like Yat Phate, New Jintara, Fine Light and Ten Bow are recommended, if MoA decides on promotion of hybrid melons.

2.2.2 Brinjal varietal 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. At present local variety (Paro local) and Pusa Purple Long (improved variety) are being widely grown in Bhutan. Many consumers prefer Paro local than PP Long. However, Paro local has poor adaptability, poor resistance to pest and diseases compared to PP Long. Since there is limited choice of varieties, two open pollinated varieties from BARI, Bangladesh and two hybrid varieties from Sungro Seed Ltd, India were tested for yield and resistance to pest and diseases. The trial was established in late summer. The same trial was continued in 2004 and was established in early spring summer season to see their performance during that time of the year. This change of establishment time was done because the problems associated with the cultivation of brinjal are different in the wet season from those in the dry season.

The seed was sown in March and transplanted after one month. Transplanting was done at the spacing of 50 cm x 50 cm in the plot size of 1 m wide and 5m long with three replications. All necessary cultural practices were carried out as appropriate and recommended fertilizer dose for brinjal was used. New varieties were BARI- 1, BARI-4, HYB-PPL-79, F1-HYB-PK-123 and Pusa Purpal Long as local check. Observations were made on fruit type, total fresh yield and incidence of fruit borer. The data were analysed using GENSTAT and the mean yield, fruit character and incidence of borer are given in Table 33.

Table 33: Mean yield, fruit character and borer incidence of brinjal varieties.

Cultivars	Yield (t/ ha)	Fruit colour	Fruit shape	Flesh colour	Incidence of fruit borer
PPL	28.93	Dark purple	Slender	Greenish white	Mild
BARI-1	17.00	Purple	Tip blunt	White	Mild

BARI-4	24.40	Dark purple	Oblong	Greenish white	Mild
HYB-PPL-79	30.73	Dark purple	Slender	Greenish white	Mild
F1-HYB-PK-123	33.67	Dark purple	Oblong	Greenish white	Mild
F probability	0.001				
LSD	3.418				
CV%	0.5				

F1 HYB-PK-123 produced significantly higher yield (P = 0.001) than any other entries but its fruit size was too big for the market. HYB-PPL-123 had similar fruit type to Pusa purple long. BARI-1 yielded lowest among all entries but its fruit size is smaller and appropriate for the market. BARI-1 and 4 showed tolerance to frost compared to PP Long. Taking into consideration all quality aspects of brinjal cultivars, BARI-1 & 4 seem promising. Therefore, it is planned to observe their performance and market acceptability by evaluating in multi-location on-farm trials in next cropping season under farmer management conditions.

2.2.3 Tomato Variety Trial

Tomato is one of the most important vegetable crops cultivated all over the world and it is a popularly grown in the early spring and summer in the mid altitude regions in the country. Many varieties have been developed for high yield, quality and resistance to biotic and abiotic stress. Attempts are also being made to select varieties highly adaptable to a particular location. In this regard, it is important to exchange and evaluate varieties developed in different countries to identify the most promising variety suited to our conditions and preferred by our consummers. For these reasons, eight tomato varieties from AVRDC were evaluated for their performance under Bajo condition.

The seeds were sown in the nursery on 20th May and made ready for transplanting in July. An RCB design was used with three replications. Each plot contained at least 20 plants. The plant to plant and row to row distance was maintained at 60 cm and 50 cm respectively and planted in beds of about 1 m wide and 6m long. Varieties tested were BSS 99, CLN 495 Bc F2 265-9-0, CL 143-0-10-3-0-1-10, CL 5915-93-D4-1-0-6-1, CL 1131-0-0-13-0-6, CLN 65-349-D5-2-0 and Roma (local check). Fertilizers were applied @ 25:50:40kg /ha with 40t/ha FYM. Three hand weedings were done. The detailed yield data, other horticultural traits and incidence of major pests and diseases were recorded. The data were analysed using Genstat (one-way analysis of variance with blocking) and the mean yield and their horticultural characteristics are given in Table 34.

Table 34: Average yield and other characteristic of tomato varieties

Treatment	Fruit length (cm)	Fruit width (cm)	Fruit per cluster (no)	TSS (%)	Fruit wall thickness (cm)	Fruit weight (g)	Yield (t/ha)
BSS 99	3.7667	3.867	5.967	3.633	0.700	40.73	24.40
CLN 495 Bc F2 265-9-0	4.1333	3.633	6.300	3.300	0.600	34.57	9.60
CL 143-0-10-3-0-1-10	4.5000	4.200	5.967	3.200	0.600	38.47	15.33
CL 5915-93-D4-1-0-6-1	3.7667	5.300	5.000	4.200	0.633	71.20	17.00

CL 1131-0-0-13-0-6	3.6667	3.833	5.333	3.633	0.600	40.73	19.33
CLN 65-349-D5-2-0	4.2000	4.300	5.700	4.100	0.600	46.17	23.00
Roma	5.7667	4.467	5.433	4.067	0.833	67.23	20.00
F Probability	0.001	0.001	0.02	0.001	0.06	0.001	0.001
LSD	0.06	0.26	0.714	0.303	0.163	1.266	4.829
CV	3.2	2.7	4.5	2.2	4.6	1.5	14.1

Released and popularly grown cultivar-Roma and new cultivars BSS 99 and CLN 65-349-D5-2-0 yielded significantly higher (P = 0.001) than any other newly introduced tomato varieties from AVRDC Thailand. BSS99 has medium size fruit and round shape while CLN 65-349-D5-2-0 is bigger in fruit size. These two varieties seem to be promising and seed production of these varieties will be done so that they can be tested under farmers' management practices. Consumer's preference will be evaluated against the currently available cultivar Roma.

2.2.4 Cucumber variety evaluation trial

Cucumber is a popular summer vegetable grown all over Bhutan. The main cucumber growing areas in the region are Thinlaygang and Nobgang. Almost all of their harvests are sold in the Wangdue, Punakha and Thimphu weekend markets. Main varieties grown by the farmers are the local long green type (Shabi genchu) and Thinlaygang Local, which has a smooth dark green skin (also called Dhomi genchu). These varieties come to harvest at almost the same time and therefore flood the market at the same time. The objective of this trial was to assess the new varieties for suitability to stagger the harvest season and for yield and other characteristics. The centre received three new cucumber varieties from HRH Prince Namgyel Wangchuk through the Ministry of Agriculture for testing.

The seeds were sown in pots filled with a mixture of compost and soil, on 13 April 2005. Transplanting was done on 10 May 2001.The trial was laid out in RCB design with three replications and there were 5 plants per replication. A popular local variety from Thinlaygang was included as the check. Well rotten farmyard manure was applied at the time of land preparation. Hills were then filled with a handful of suphala and mixed before transplanting. Top dressing with nitrogen was done during fruit setting. Hoeing and other cultural practices were done manually. The mean yield and other fruit characteristics are given in Table 35.

Table 35 :Mean yield, fruit characteristics of cucumber varieties.

Cultivars	Yield (t/ha)	Fruit weight (kg)	Fruit length (cm)	Fruit breadth (cm)	Incidence of powdery mildew
Norgoan	6.7	0.6	15	25	mild
Bavipal	11.2	1.2	29.5	5	severe
Rampali	19.5	1.1	16	4.5	mild
Thinley gang local	20.1	1.3	30	10	resistant
LSD	12.30				
CV%	21				

There was no significant difference in the yield of different cucumber varieties. However, the taste of the introduced varieties is poor and not preferred by the consumers. Variety Norgoan was the earliest to flower and fruit. It matures about two weeks before the local variety. The fruit size was small, short, and very green and tender. The fruits turned dark brownish and round when matured with about three deep ridges. The fruit was sour and very juicy. Rampali is late maturing. It matures about thirteen days after the local variety. The fruits are juicy with higher water content. It was observed to have more seeds and less flesh. Bavipal has long dark green fruits and looks similar to the local Dhomi genchu. It matures later than the local variety but earlier than Rampal. It was observed to be highly susceptible to powdery mildew in the early growth stage.

Thinlaygang local is the most popular variety grown by the farmers in the area. The fruits are light green and very juicy. It is popular with consumers and it the preferred variety. The local variety was found to be more resistant to powdery mildew. The adaptability test was also done in Thinlaygang and Kabji, popular cucumber growing areas in the earlier years. Farmers' feed back was that all the new varieties had their own advantages. Norgoan was less preferred due to the shape and its characteristic of maturing "too soon". The trial is terminated from this year since no added advantage was observed over the local variety.

2.2.5 Effect of mulching on chilli yield and blight incidence

There is a high demand of green Bhutanese chili in the local market if it is produced early within the last week of April to second week of May. During this period the cost of green chilies goes as high as Nu. 100 to 150 /kg and it is one of the important cash crops for the farmers in the mid-altitudes. However, there are many difficulties to produce early chilli, the main one being low temperature. The planted seedling is either stunted or stagnant until the temperature rises. Therefore, there is a need to increase soil temperature for early chili production. The objective of this study was to evaluate the effect of different mulching methods to enhance early chilli production and chilli blight severity.

There were three treatments for this trial : black plastic sheet, paddy straw and control (no mulch). The straw mulch was applied as soon as the transplanting was over. The plastic sheet was spread on the bed prior to crop transplanting, hole at appropriate plant distance were made and chilli transplanted. The plot size was 10 sqm and in each plot there were two beds of 5m long and 1m wide with 20 plants in the each bed. The trial was laid out in RCB design with 4 replications. The chili nursery was established in mid December 2004 and the nursery covered with plastic sheet to hasten the germination and protect from frost and cold. The seedlings were potted at 2 to 3 leaf stage. The seedlings were dipped in 1% Ridomil® water solution prior to transplanting to avoid soil borne diseases. The crop was transplanted in mid February 2005. The crop were harvested in four pickings and yield, fruit quality aspect and incidence of blight disease were recorded. Table 36 presents the results of the trial.

Table 36: Mean yield, fruit characteristic and severity of blight diseases.

Treatment	Yield (t/ ha)	Fruit length (cm)	Fruit dia. (cm)	Fruit quality	Incidence of blight disease
Plastic mulch	4.4	7.9	2.5	poor	severe
Paddy straw mulch	5.6	7.4	2.6	good	Mild
Control	5.03	7.5	2.4	good	Mild
F probability	0.54	0.36	0.59		
LSD	2.5	0.83	0.64		
CV%	29.2	6.3	15		

Analysis of variance showed no significant difference in yield between the mulching treatments and also without mulching. There was no effect on earliness in crop growth and maturity among the treatments. However, there was a difference in the severity of blight infection among the treatments, plastic mulch increased chili blight infection. Plastic mulch might have created warmer soil temperature and higher soil moisture favoring the *Phytopthora capsici* multiplication instead of supporting the chilli plant growth. It may be concluded from these experiment that plastic mulch though helps in weed suppression is not appropriate for chilli production particularly in an area where there is a record of chilli blight disease.

2.2.6 Effect of chilli cultivation method on chilli blight incidence and yield

Chilli blight caused by *Phytophthora capsici* threatens cultivation of chilli in many parts of the country and severely affects production. The reasons for blight are mainly high planting density, improper drainage system, use of infected seedlings on traditional flat plots and lack of crop rotations. Farmers often do not adopt the raised bed method (1m wide 30 cm high and varing length of raised beds) of chilli cultivation recommended by researchers. Farmers practice of planting makes congenial micro-environment required for the fast development and multiplication of *Phytophthora* and resulting in severe chilli blight especially if the cultivation is during the monsoon. This experiment aimed to assess the efficacy of different chilli cultivation methods, including farmers' practice, some innovative methods like planting in ridges and mounds that controls plant density on the incidence of chilli blight and yield.

Treatments consisted of raised bed (recommendation), planting on ridges, mounds and flat beds (farmer's practice). Plant spacing was RR = 50 cm and PP = 30 cm in all cases. The plot size was 16 $m^{2.}$ Seeds were sown in shade house in mid April and potted in end of May. The crop was transplanted in mid June in the field. The trial was laid out in RCB design with three replications. Local cultivar Sha Ema was used. Suphala (15:15:15) @ 500g/plot was applied two weeks after transplanting. Other management was done as recommended for chilli production. Phenotypic data such as fruit length, fruit width, fresh ripe fruit yield and incidence and severity of chilli blight were recorded on a plot and replication basis.

Table 37: Mean yield, fruit characteristic and severity of blight diseases.

Treatment	Yield (t/ ha)	Fruit length (cm)	Fruit dia. (cm)	Fruit quality	Incidence of blight disease
Ridges	1.88	7.8	2.6	good	severe
Bed	2.65	7.4	2.5	good	Mild
Mound	0.75	7.3	2.7	good	severe
Farmer practice	0.66	7.6	2.4	good	severe
F probability	0.01				
LSD	0.99				
CV%	33.3				

One-way analysis of variance showed significant yield (P = 0.01) difference between the treatments (Table 37). Recommended raised bed and ridge planting methods produced significantly higher yield compared to mound planting and farmers' method but no significant difference was observed between the former two methods of planting. However, raised bed and mound methods of planting require slightly more labour hours than the recommended raised bed method of planting. It was found to be difficult to maintain the same plant density in mound methods compared to other methods, while preparing mounds it is difficult within the plant spacing of 50cm x 30cm. It is therefore, recommended to have 50cm x 50cm plant spacing for mound method of planting in future trial. The chilli blight infection was significantly lower in recommended raised bed method compared to other three planting methods but it is difficult to draw any conclusion from this trial since the preparation of ridges and mounds were not effective in the process of maintaining the same plant density. Therefore, same trial will be continued next year with plant density modification in mound methods of planting.

2.2.7 Maintenance of breeder seeds of released vegetable cultivars

RNRRCs are mandated to maintain the breeder seeds of the various crops released from their Centre. The horticulture section of RNRRC Bajo has started maintaining the breeder seeds of different vegetable cultivars. Most of the vegetable cultivars were released from RNRRC Bajo, but maintaining all cultivars of different vegetables is not possible in RNRRC Bajo due to specific climatic requirements. It also demands additional manpower. In all, 14 vegetable crops and 22 cultivars have been released from this Centre. The status of breeder seeds produced and supplied to DSC is given in Table 38. In many crops seed production failed due to breeder seed received from DSC being genetically mixed, poor seed viability and other technical reasons. None of the researchers are trained on breeder seeds production and maintenance.

Table 38: Vegetables breeder seed produced and maintained by RNRRC-Bajo

Sl No	Crop	Varieties	Quantity produced	Remarks
1	Brinjal	Pusa Purple long	250 g	Produced in 2004-05
2	Beans	Borlotto	6 kg	8 kgs handed over 11.2.2003
		Pusa Parvati	2kg	4 kgs handed over (2004 June)
		Top Crop	5kg	8 kgs handed over and produced in 2004-05
		Rajma	7kg	8 kgs handed over

3	Cabbage	Golden Acre	00	Unable to produce under Bajo condition
		Copenhegan Market	00	
4	Cauliflower	White Top	250g	Produced in 2004-05
		White Summer	00	No germination at all
5	Capsicum	California Wonder	10g	Seed production failed
6	Carrot	Early Nantes	10g	100 g handed over (2002)
7	Onion	Bajo Gop-I	100g	600 gms handed over in (2002/2003)
8	Sag	Phul Maya	200g	Under production
9	Spinach	All Green	3 kg	Seed production failed
10	Okra	Pusa Sawani	1kg	Var. Kranty supplied
11	Radish	Bajo Laphu-I	150g	600 gms handed over in (2002/2003) and produced in 2004
		Spring Tokinashi	10g	Under Seed production
12	Tomato	Bajolambenda-I	100g	200gms handed over in 2002/2003 and produced 1 kg 2004
		Cht-160	250 g	Produced in 2004-05
		Roma	100g	Produced in 2004-05
13	Jap. Green	Taisai	1kg	Produced in 2004-05
14	Watermelon	Sugar baby	300g	Produced in 2004-05
15	Brocolli	Dessico	3 kg	Produced in 2004-05

LIVESTOCK RESEARCH

3 LIVESTOCK RESEARCH

3.1 Feed and Fodder Research

3.1.1 Potential dry matter production trial

The primary 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 *Pennisetum purpureum*, *Paspalum dilatatum*, *Dactylis glomerata*, *Setaria sphecelata and Medicago sativa.* The trial was established at Bajo station during July 2002. It was replicated under irrigated and non-irrigated conditions.

The average fresh matter and dry matter yield and dry matter percentage are indicated in Table 39 and Table 40 below.

Table 39: Average Fresh Matter & DM yield (t/ha) from irrigated plots

Treatments	Fresh yield (t/ha)	Dry matter (t/ha)	Dry matter (%)
Napier	21	2.5	24
Setaria	15	3.1	20
Cockfoot	2	0.6	31
Paspalum	8.4	2.5	30
Lucerne	13	3.7	29

The findings revealed that the fresh biomass production of Napier was highest (20.7 t/ha) compared to other species from irrigated plots. Lucerne dry matter production was the highest (3.7 t/ha) out yielding *Napier* (2.5 t/ha).

Table 40. Mean fresh matter and dry matter yield (t/ha) from non-irrigated plots

Treatments	Fresh yield (t/ha)	Dry matter (t/ha)	Dry matter (%)
Napier	7.1	1.4	20
Cockfoot	0.8	0.2	19
Paspalum	3.4	0.9	25
Lucerne	5.3	1.2	23

From non-irrigated plots, *Napier* yielded the highest fresh biomass of (7.1 t/ha) as well the dry matter of (1.4t/ha) compared to other forage species. Napier out performed in terms of fresh matter and dry matter yields from both irrigated and non-irrigated plots during the year. Cocksfoot was the poorest of all treatments under both irrigated and non-irrigated conditions.

3.1.2 Napier propagation and distribution

The centre has maintained about half an acre of *Napier* as a propagation block. The main objective is to maintain and produce healthy Napier root slips for distribution to the farmers of the region for on-farm fodder production. It is proven as one of the most promising fodders having fast growth with high biomass. There is a great demand for slip for fodder production by the farmers. The centre is the only source of Napier root slips for distribution to farmers in the region. More than 50,000 root slips were distributed during the year to the farmers and dzongkhags of the region for

fodder production and soil stabilisation by land management campaigners. The block is maintained as a source of basic planting materials.

3.1.3 Evaluation of selected Lucerne varieties

The objectives of the trial were to evaluate production potential of Lucerne varieties over the seasons across Bhutanese environments and to look at their persistence over the years across the regions. The trial was established in July 2004 as an RCBD with 3 replicates. A total of 11 varieties are under test for fresh matter and dry matter production, including Kaituna, Venus, PL 55, Prime, Super 7, WL414, Aurora, SA 35076, SARBU 1, SARBU 2 and Eureka. The seeds were sown in rows with space of 20cm between rows, 50cm between plots and 1m between reps. Seed was sown @ 9gm/6m^2 plot size. SSP was applied @ 40gm/m^2 during establishment.

Initial observation showed that germination percentage and plant vigour from all the entries were recorded as good, and no pest and disease incidence observed so far. The average fresh matter and dry matter yield with dry matter percentage are indicated in Table 41.

Table 41: Cumulative fresh and dry weight (t/ha) and DM% from three cuttings

Trts	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
Av FM t/ha	2.2	3	3.3	2.8	2.7	3	2.2	2.7	2.8	3	2.9
Av DM t/ha	0.6	0.7	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Av DM %	26	24	26	26	25	25	25	24	24	23	24

The preliminary data from 8 successive cuttings at 42 days interval showed that treatment PL 55 (T3) yielded highest fresh matter on an average of 3.3 t/ha. Also the dry matter production of T3 and T2 (Venus) on an average produced the highest dry matter of 0.8 t/ha. The dry matter percentage of 26.3 % was the highest from T2.

3.1.4 Effect of management on performance of selected Lucerne varieties

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 Lucerne varieties over the season across regions and to quantify the seed production potential at selected sites. The trial was designed as a split plot with 3 replicates. The main plots were 12 m^2 with 6m^2 sub plots. The seed was sown in rows having space of 20cm between rows, 1.5 m between main plots and 2m between replicates. The seed rate was 9 gm/subplot. The SSP @ 40gm/m^2 was applied during establishment phase. There were two treatments such as cutting and irrigation intervals within the main plots as a management technique. The sub plots treatment consisted of Prime and Eureka varieties.

Initial observation showed that germination and plant vigour was good. There was no occurrence of pest and diseases, and the date of first flowering was noted during mid September. The measurements included plants per 1m^2, stems per plant, inflorescence per stem, pods per raceme, seeds per pod and seed yield per plot. The first recording after trial establishment in July 2003 was on 25 February 2004. The recordings all on average basis were as follows:

Table 42 Observation factors contributing to final seed yield

plants / m		7 no	per metre
stems / plant		23 no	per 10 plants
stems/m		129 no	per metre
inflorescence per stem		12 no	per 10 inflorescence
pods / raceme		5 no	per 10 raceme
seeds/pod		5 no	per 10 pods
seed yield in gm:	Eureka	5.7 g	per $6m^2$ plot
	Prime	9.3 g	per $6m^2$ plot

The seed production was successful under Bajo condition. The seed harvest in October 2004 yielded 9.5 kg/ha from Eureka and 15.5 kg/ha from Prime. Though seed production was low, however, it was a successful technical breakthrough in the history of Lucerne seed production in Bhutan. It seems that seed production in Bhutan is possible under Bajos' conditions.

The main problems in the seed production of Lucerne were continuous flowering, non-uniform fruit setting and maturity. From our experience so far, the harvesting of the seedpods were greatly hampered due to above stated problems. From last year's experience specific time to harvest Lucerne for seed collection is October. The seeds collected in summer were poor in quality. However, seeds collected in October were comparatively better in viability than that of seeds produced in summer. Therefore, seed collection is planned to be done only once in a year in October under Bajo conditions. To harvest quality seeds in October, one harvest of plants in July is a must. It allows renewed growth and healthy plants to bear better seeds. It also protects the plants from lodging and dying of plants due to stagnant water in summer. Additional technology or mechanism needs to be developed to make the seed production easy, viable and successful. It requires technical assistance for that.

3.1.5 Propagation of fodder species on contour terrace bunds

The objectives of this trial were to reinforce the terrace bunds through use of different fodder species and to evaluate fodder legume hedge species to control soil erosion under farmers' condition especially in the sloppy agriculture land. Two farmers of Nabchey village under Limbu geog had established in July 2001 species of *Napier, Guinea, Molasses, Setaria and Paspalum, Leucaena, Flemingia, Napier and Crotollaria* as hedge rows along the maize trashlines. These fodder species were propagated through seeds and slips through technical assistance from the Centre. It was observed that among the species *Leucaena, Flemingia, Napier and Setaria were* doing far better on bunds compared to other species. Perennial grasses and legumes are good bioengineering tools. These plant species were used on terrace bunds and erosion control through slips and direct seeding in Nabchey.

3.1.6 Fodder production on paddy bunds

Livestock production in Bhutan is concentrated in smallholder farms among the rural population. Just like in crops, technology in animal production has generally been designed for intensive system which is inappropriate and unaffordable. Technology is required for small-scale animal production that suits the need of small farmers. The greatest demand for forage is in the smallholder cropping sector, because of the

higher concentration of animals and the reduced availability of land for crop production. There is a need to develop production system that can produce food and at the same time forage crops. More on-farm feeding experiments are needed to evaluate the cop residues and forage crop produced from different cropping systems.

Forage research is undertaken in the region involving the use of improved perennial grasses and legumes both for cut and graze system. Shrubs and tree legumes are also incorporated as a high quality feed supplement, especially in winter along with other available feed resources. Several forage crops species are promising when intercropped with food crops under rice systems. In general, forage intercrops do not significantly reduce the yield of food crops. In addition to providing feed, the last harvest can be incorporated in the soil to provide organic fertiliser to the next crop. Some of the promising species under Bajo's conditions are *Desmanthus virgatus*, Lucerne, Crotolaria, Flemingia, Napier, Paspalum, Andropogon, Chloris, Guinea, Setaria, and Cenchrus.

The rice field levees or bunds comprise about 5-10% of the total land area in the wetland system. Such areas serve as the main source of feed especially during the winter where paddies are normally planted to rice. Native or indigenous species of grasses commonly grow which are generally of low quality. Replacing weeds in rice bunds by high yielding forage species that thrive from wet to dry condition will increase and improve forage quantity and quality. The aim of the trial was to describe and document fodder production techniques on paddy bunds and to select suitable species for propagation on paddy bunds.

The paddy bund tops were cleaned and removed of local weeds before the establishment of fodder crops. The bunds were 5-20 m long, 0.5 m wide at base and 0.3 m high with top with of 0.4m. The top surface of the bunds was dug to facilitate faster germination and emergence and also flattened to protect the seeds from being washed away. About 1-3 lines depending on the size of the bund were made for line sowing or transplanting. Planting in line facilitated easier weeding and cutting, ease fertiliser or manure application and digging at later stages. Sowing of seeds and transplantation of slips were synchronised with the rainy season. This helped in quicker emergence or faster recovery from transplantation shock for slips when the soil was still moist on the bunds. Use of fertiliser was very limited. Irrigation would be required if the plant showed the sign of wilting and drying. Till such time irrigation might not be necessary. The cutting or harvesting of the forage was not time bound. It could be cut and fed like any other local grasses. The legumes required time to attain first harvest, after that the harvest time was dependent on the seasonal growth and biomass. Cutting above 5-10 cm above ground was practised as blanket recommendation. The test and trial study lasted for five years under station conditions.

Pic 3: Paspalum on bund

The results are of on-station study involving 7 grasses and 4 legumes grown on rice bunds from 2000 to 2005. *Paspalum atratum* gave the yield of 241g DM/m/cut (that is equivalent to 1.37 t DM per year assuming 7% of the area is occupied by the bunds) and herbage yield of 9134g/m cut. The best among legumes was *Medicago sativa*. *Desmanthus* was not bad either. For quicker growth and ease of management Lucerne outdid other test legume species. Among the grasses, short height species like *Paspalum atratum* (Pic 3), *Setaria, Andropogon* were the best. These three species can be used almost interchangeably in terms of biomass, growth, vigour and density. However, *Paspalum atratum* showed better tillering vigour and faster regrowth. It out performed in terms of fresh biomass and dry matter yield under Bajo conditions. For the interested farmers who are beginners, it would be better to take just Lucerne (Pic 4) and Paspalum. This would make faster and higher fodder biomass. The nutrient requirements would also be balanced as Lucerne supplements protein requirement and Paspalum contributes other nutrients.

There was no comparative biomass yield data of these tested species propagated on paddy bunds. This was because there could be yield differences of same fodder species cultivated on different locations. It would be due to floor space of the bunds. Larger the bund higher the biomass from the crop cut results. Therefore, biomass data was not included in this study. The results were based mostly on growth and re-growth, tillering capacity, multicut attribute and tolerance to cutting.

Pic 4: Lucerne on bund

Since this trial was located on-station, wider farmer's opinions, impression and feedbacks were received. Most farmers from rice growing areas gave positive feedbacks and impressions. Reasons for such positive feedback were based on these aspects: suppresses weeds, reduce labour for weeding paddy bunds, reinforce the weak paddy bunds and provides fodder for their animals. The technology was designed to best suit the rice farmers. However, it can be adopted by the dry land farmers on the terrace bunds, fallow lands, field boundaries, and homestead areas. These fodder species are known to conserve soil from erosion, reinforce terrace bunds and gully stabilization. Besides propagating on bunds, these species could be established anywhere to meet forage needs. Some recommendations are:

- The forage species for bund should be of single species and not a mixture for ease of management
- All short height and non-trailing forage species perform well
- Species selection to be based on factors like climate, soil, rainfall, biomass, tolerance to cutting and grazing etc
- Number of cutting varies depending on management and other factors
- Do not select tall and shady species which might shade the main crop.

3.1.7 Local fodder trees/shrubs of Bhutan

In the context of increasing human population, decreasing land availability for forage crop production, increasing dependence of ruminants, tree fodder are increasingly seen as potential protein and energy supplements to increase productivity of ruminants. Local fodder tree/shrubs species have been a traditional supplement to straw based feed to ruminants in Bhutan. Till date, very little effort had been made to document and develop sound strategy and program for promotion and utilization of available indigenous tree/shrub species. Hence there is a need to immediately document some of the promising and potential local fodder trees/shrubs species commonly grown and utilized by the farmers across regions including their nutrient content. The main aims of this study were thus to:

- document detailed information on local fodder trees/shrubs species, their distribution pattern across different agro-ecological zones, tree description, its annual fodder production capacity across the country
- document their propagation/planting methods, attributes, management practices and their preferences across regions
- build information base for future research and development interventions on selected and promising fodder trees/shrubs species for their propagation as multipurpose tree species.

Only the major findings are reported here. The full report is available at the Centre as a separate technical publication.

Multipurpose and promising tree fodder species

The survey tried to capture those fodder trees which have multipurpose values. It was noted that there were numerous fodder trees planted by the farmers and used for various purposes not only as fodder but as timber, fuel wood, fruits, flowers and bark as pickle and pharmaceuticals to prepare homeopathic drugs to cure various diseases.

Annual fodder production potential and farmers' preferences

Farmers rate different fodder trees in the order of preferences as high, medium and low in the region. They have various reasons in rating them - highly palatable with high nutritive values, remaining evergreen throughout the season and high biomass yield were rated as high; species with low palatability, low nutritive values and deciduous were rated as medium; and fodder trees which are very fibrous, coarse, thorny, unpalatable having low nutritive value were rated as low and less preferred species. Farmers assign high nutritive value to those fodder trees which provide comparatively more milk when fed to dairy cattle. The annual fresh matter production, dry matter/tree and farmers' ratings are indicated in Table 43.

Table 43: Annual fodder production potential of tree fodder/ shrub species

Tree fodder/ shrubs species local name	Annual production of FM / tree (Kg)	Annual production of DM / tree (Kg)	Farmers rating of fodder trees
Baar	625	137	high
Badahar	1200	374	high
Bhatmase	25	8	high
Debre lahara	50	-	high
Dudhilo	50	17	high
Kabro	50	16	high
Katahar	1200	-	high
Khari	225	63	high
Khasray Khanew	25	8	high
Labar	50	18	high
Lute khanew	50	17	high
Nebara	100	30	high
Somi	50	-	high
Willow	50	-	high
Pipal	50	18	high
Chiuri	50	22	medium
Chuletro	75	17	medium
Gogun	75	17	medium
Jamuna	75	30	medium
Kaulo	50	15.3	medium
Khamari	50	12	medium
Khanyu	125	47	medium
Khirro	50	12	medium
Kimboo	50	13	medium
Koirala	75	27	medium
Kubinde	75	20.5	medium
Parari	75	17	medium
Taki	50	14	medium
Bohori	50	8	low
Dabdabe	100	34	low
Dumri	175	54	low
Faledo	50	19	low
Gayo	50	12.5	low
Ginderi	75	18	low
Gueylo	100	35	low
Kaijal	125	31	low
Khasre	25	6	low
Kutmiro	50	20.7	low
Malata	50	15	low
Phusro Khosray	25	-	low
Pipli	25	7	low
Sindure	50	19.9	low
Sisi/Khasru	50	20.4	low
Siyalfusre	175	63	low
Sokey/Musre Katus	50	22	low
Thomb/Phalant	50	21	low

Tree fodder availability and ruminant production system

The crucial period of fodder shortage mostly fall between November and March when there is no green forage in and around farmland as well for foraging in the

forest. Farmers commented that although they practice to some extent feeding crop byproducts and grow winter fodder like oat it was not adequate. The only option left with them was feeding the fodder trees to overcome the shortage particularly during extreme dry months. It was further revealed that farmers did not feed fodder trees indiscriminately to any livestock breed. The first preference was given to milking cows, young calves followed by draft bull and fed to other livestock categories when left in excess. Farmers strictly followed proper lopping and flushing timings of all the domesticated fodder trees so that each fodder get sufficient duration to regenerate and branch out copiously for the next lop. It was also indicative that most of the farmers in the region followed day grazing in their fellow land as well forage in the forest. Tethering and stall feeding practices were applied only to the crossbreed dairy cattle, cows in lactating stage and young calves.

Propagation and planting method

The study revealed that farmers have good knowledge on the propagation and planting of most of the domesticated fodder tree species. They commented that they had been collecting seeds/seedlings, stems/slips within and near by villages as well as from the forest and propagate them as fodder. Farmers also collect the seedlings and transplant them in their farm boundaries, marginal and unproductive land for fodder. However, farmers do not have sound technical knowledge on nursery raising and other management aspects.

Management practices

Farmers collect fodder trees most frequently from wild especially during their free time. From their farm land they follow sound management practices such as timely lopping and feeding on a regular interval to important livestock. Some farmers were observed taking much great care of tree fodder of wild origin with good loping methods and allowing sufficient time interval for trees to rejuvenate for the successive lopping. In general, the management practices of domesticated fodder trees were found sound.

Collection sites, right, frequency and its implications on fodder trees

Collection sites differ from villages to villages. The distance and time for collection too vary from 20 minutes to 2 hours depending on the access to forest and availability of fodder tree in abundance or scarcity. The frequency of collection was governed by number of factors such as category of livestock (milking and draft bull), total livestock holdings, availability of fodder within their farm land and manpower availability for collection from the wild. There is no set collection right/bylaws drawn amongst the farmers in the community for lop fodder tree collection from forests. It was noted that individual farmers had equal access and opportunity to lop and collect quantity of fodder trees any number of times from the wild.

Factor determining suitability of tree fodder/ shrubs species and points to consider while selecting them for mass propagation

Through the survey, the following points were noted for consideration while selecting trees fodder/ shrub species for mass propagation and multiplication for a successful future nursery development program in the villages:

- heavy to medium foliage fodder production capacity
- long longevity evergreen and early flushing
- tall tree, profuse branching, manageable to lop
- higher intake and feeding behaviour of animals when given tree fodder
- high voluntary intake of tree foliage under different environmental conditions
- better adaptation of trees fodder to varied agro- ecological zones
- ease of seedling establishment, rate of growth and regeneration capacity
- the growth pattern in relation to crops or pasture and their compatibility
- nutritive, mineral and chemical values of fodder and its change with harvesting, grazing or cultivation
- fast to medium growth habit
- farmer's opinions in selection and propagation in village nurseries
- Optimum time of seed collection, their storage and sowing season
- Easy nursery raising and management including seed treatment

Conclusion and recommendations

The most important issues for small farmers in developing countries are food, feed, fuel wood and timber. The order of their importance differs from region to region and village to village. The conclusion and recommendations in this report are indicative and are confined to findings of west-central region only.

- Foliage of fodder tree/shrubs form major component of ruminant diet as supplementation during critical time of dry seasons in a year, their role and contribution must be given due recognition and attention in future Feed and Fodder development programs.
- Planting multipurpose tree/shrubs in farm boundaries, gullies, marginal lands, road sides and terraces must be further promoted and encouraged.
- Most farmers do not possess adequate technical knowledge in nursery raising and management practices including propagation techniques. A complete package of practices should be developed and made available to extension staff and farmers.
- Farmers should also be encouraged to raise, plant and manage leguminous fodder shrubs and fodder trees lopped more than once a year such as *Ficus semicordata, Buddleja asistica, Leucaena.* These species are easy to manage and are compatible to plant in the field bunds of cultivated terraces as an option to overcome feed shortage.
- The farmers in the region do not have knowledge on collection rights, collection sites, frequency of collection from forest and their implications on fodder quality and quantity. In this line Departments/Ministry may come up with working guidelines and bye-laws incorporating all aspects for sustainable harvest and utilisation.

- Forestry officials at Dzongkhag and Geog level with the involvement of all stakeholders need to train and mobilise farmers/communities for promoting fodder resources. Formation of user groups and then gradually empowering communities to manage their fodder resources according to their requirement is a viable and long-lasting solution.

3.2 Breeding and Management Research

3.2.1 Goat farming practices

The goat was one of the first animals to be domesticated by humans about 9000 years ago. There are about 200 different breeds of goats producing a variety of products, including milk, meat, and fibre (mohair and cashmere). Worldwide, goat meat production is higher than meat production from cattle and hogs. Goat production can be a valuable part of a sustainable farm. Integration of livestock into the farm system can increase economic and environmental benefits and diversity, thereby making important contributions to the farms' sustainability. Goat may fit well into the biological and economic niches in a farm operation that otherwise go untapped. They can be incorporated into existing grazing operations with sheep and cattle. Goat can also be used for control of weeds and bush to help utilise a pasture's diversity, as long as they are not allowed to overgraze. Goats eat the forages, the goats' waste replaces some purchased fertilisers, and the life cycles of various crop and animal pests are interrupted.

The present goat population of Bhutan is about 14,988 (RNR Statistics, 2000). Till date not much importance and policy support is given to goat husbandry due to various reasons. Although research and development program pertaining to goat husbandry in Bhutan is non-existant, goats still play an important role in generating substantial income for poor households. Hence it was felt very timely and important to document the present goat husbandry practices in Bhutan including breed characterisation. The present study was aimed to encourage more people to recognise the crucial role that this animal could play in the farming systems in which many farmers are engaged. Specific aims were:

- to document information on exiting goat husbandry practices in Bhutan including their breed characterisation
- to give recognition and status on the crucial role played by this livestock to marginal farmers' household income generation, nutrition and their farming system
- to explore future areas of research and development interventions with sound policy and breeding program in place .

Major Findings

Population trend/status/origin of goat

Almost all the sample geogs surveyed indicated that overall goat population over the years had decreased. Farmers mostly rear local goat breed, which they usually procure within villages and their locality. The survey could not find any dates or records of the introduction of goat in Bhutan. Farmers have been rearing the local goat breed since many decades.

Feed and feeding

The survey tried to capture information on the management practices of goat across two regions. Most of the farmers follow stall-feeding practice with some exception to fallow grazing. Goats are mostly fed with *Artemesia* (Pati), *Eupatorium adenophorum* (kalizar), *Sida acuta* (Jhadru), local weeds, lopping of available tree fodder and crop byproducts. Among crop byproducts, mostly maize hulls are fed to adult goats and gruel to kids. Farmers commented that managing and feeding goat is easier compared to other livestock as they browse on almost all types of weeds. They further commented that goat does not require nutritious and palatable feed. In general goats survive on whatever feed is available at home with weeds as green roughage. Farmers seldom feed compound or concentrate feed for goats across region.

Breeding and reproduction

The survey also tried to explore areas like breeding and reproduction in goat and their production variables. It was clear from the survey that farmers did not keep proper records in most of the areas. However, some of the reproductive parameters like age at puberty, age at first kidding, kidding interval, kids per year, nature of kidding, life expectancy of doe, productivity of doe and total number of kidding per lifetime were documented and are summarised in Table 44 .

Table 44. Average breeding and reproduction/ production parameters

Breeding & reproduction variables	Average months
Age at puberty	7.1
Age at first kidding	12.5
Kidding interval	6.6
Kids per year	2.5
Life expectancy of Doe	16
Productive life of Doe	9.03
Total numbers of kidding/ lifetime	20.92

The nature of kidding in most of the cases was noted to be twin with little exception to single, triplets and rarely four in numbers. However, in most of the cases only one to two kids survived. The mating usually takes place between October - November and kidding during the months of March and April or early summer. However, there is no specific time of mating and kidding as reported through this survey. It was also noted that 6-40 kids can be expected in the lifetime of a female goat. Castration of male goat is quite common using local method for fattening across regions.

Importance of rearing goat

The study found that goat rearing was the easiest enterprise of all domesticated animals. Further it was clear that goat husbandry is an economically viable business to almost all goat rearing farmers in Bhutan. Farmers from across regions stated that they rear goats primarily for meat production and for manure to enrich their agriculture land. Some of the farmers rear goat for commercial purpose for an additional source of household income and sell meat at the local markets. Some of the farmers rear goat especially to offer to their local deities during special occasions. They make offering to their local dietiy once a year. Goats are rarely

reared in Bhutan for the purpose of milk production, as it is a quite common practice in other developing countries.

Market and marketing system

Farmers commented that they do not have any organized and established market for marketing live goat as well the chevon (goat meat). Farmers usually sell any excess meat after home consumption within their own community and villages. The price for a kilo of chevon varies a lot across the region and within villages. It was noted that chevon is widely sold within the villages @ Nu. 60-100/kg. Any excess chevon is mostly brought to towns and sold even at 150/kg. In some of the cases, the female goat meat is sold @ Nu. 100/ kg and meat from castrated males @ Nu. 120/ kg. A male adult goat by the time it is marketed fetches around Nu. 1500-3000 and female goat around Nu 600-1200. Castrated male and female with a pair of kid would fetch a cash income of Nu. 2000-4500 for the family. In general, marketing of meat or live animal is never seen as a problem and chevon is the most priced meat in the market today.

Phenotypic characterization

The phenotypic characterization of goat in general is summarized in Table 45**.** However in gist irrespective of sexes the coat colour noted were mostly black in colour with fewer white and brown with black dorsal lines. The horns were found mostly twisted and face bearded. The ears were dropping with fewer exceptions being horizontal.

Table 45: Physical observation & average body measurements of local goat breed

Parameters	Observation / measurements
Breed	All local
Age (year) / Sex	Various age groups; both m/f included
Physical observation	
Coat colour	Mostly black, white, brown with dark dorsal line
Horn	Mostly twisted
Wattle	-
Bearded	Mostly bearded
Long hair	Few long haired
Ear	Mostly dropping and few horizontal
Body measurements	
Body length (cm)	54.8
Heart girth (cm)	61.72
Wither height (cm)	51.85
Ear length (cm)	12.6

Constraints

Farmers did not express much constraint in goat rearing. They keep fewer numbers of goats up to four and mostly stall fed them with locally available fodder and weeds. Farmers commented that goat rearing in fact is the easiest compared to other livestock. Children are mostly employed for feeding and taking care of goat. However they commented that the main bottleneck in rearing more goats was the restriction

on the number from the Government/forest officials. They commented that the negative aspect of goat rearing was mainly because of their browsing of young saplings within their farmlands as well in the forest when let loose for free grazing. Since they had to stall fed them, they feel that there should not be any restriction on the number they can raise as they see a lot of potential in enhancing their economic status from goat farming.

Conclusions and recommendations

- The population of local goat in Bhutan is declining, which needs immediate attention from the conservation point of view.
- A review of the policy on goat raising may be necessary, with options for famers to rear any number of goats as long as they are stall-fed.
- Goat rearing is easy and convenient as they mostly feed on unwanted local weeds and convert the biomass into high quality and high priced meat. Policy support and encouragement in this area would be welcome.
- Encourage and explore feasibility of rearing milk goat breed to further diversify the production system and breed.
- Initiate study on economics of goat rearing in Bhutan and compare them with other livestock rearing enterprises.
- There is a need for sound breeding program and strong support in introducing hybrid Buck for cross breeding with local Doe to enhance productivity under varied agro-ecological conditions.

3.2.2 Status report on Yak Herd Monitoring

Yak herding is a part of Bhutanese high altitude alpine landscape. It will increasingly play a significant role in promoting both agro and eco-tourism in the country. However, pressures of socio economic changes are going to impact on the life of the herder society. Experiences from the neighbouring yak rearing countries (India, Nepal and Tibet) indicate that yak farming communities are gradually giving up their traditional practices and looking for alternative livelihood in downstream and urban settlements. Unless the yak farming enterprise is made profitable and attractive, it is highly unlikely (at least in the short term) that the young generation of herders would like to continue with the profession. This may impact negatively to the sustainability of the traditional yak farming system. As an initial attempt, a yak herd-monitoring scheme is being planned and a nationwide study initiated in the main yak rearing pockets of the country. The short-term objectives of the study are to quantify changes in the socio-economy of the herder communities over time, generate input for planning yak related research and development activities and to assess impact of development on the livelihood of herder society (rural-urban migration). The long-term objectives are to sensitize 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 beef producers' society, yak herders eco-tourism association, yak cheese (hard) processing, packaging and marketing group and to contribute to livelihood development methodology applicable in the high altitude mountain eco-systems.

Interim Findings

Herd information

Most of the yak herders interviewed did not have other categories of livestock. They were predominantly rearing yaks ranging from 12 to 40 numbers. Almost all the herd comprised of milking and dry yaks, breedable bulls, young bulls, heifers and calves. Only few herders had local cattle, horses (Yuta), and chicken in a small numbers. When questioned for reasons of not rearing other livestock, they said that it was their age-old practice of rearing yak which they are more accustomed with. Most of the female members were actively involved in the management of the yak including milking, product making, processing and marketing. All the yak herders interviewed owned their own yaks.

Yak herders did not have much knowledge in the areas of production and reproduction in yak. Therefore the team harvested very little information during this visit. The age at first calving in general was recorded at minimum of 3 years. The calving interval ranged from 18 months to 24 months. The average milk yield/ yak/day was noted to be 0.5 –1.5 liters. The average number of days in lactation was recorded as 365 days.

The entire yak herders interviewed did not have any newborn calves in their herd during the season. There was no practice of buying yaks from other areas for replacement stock or selling out from their herd. Among the bulls, only one superior bull was maintained for breeding purpose and the rest were castrated. These castrated bulls were easily manageable in the herd and were kept for carrying load during migration time as well as for meat production. Mostly meat was sold in the local market instead of live animal trading.

Migratory routes/sites and their resources

The yak herders were found commonly moving together with animals in a group ranging from 4 to 20 households for their summer and winter grazing sites. They have community tsamdro collectively for all the grazing herders. It was revealed from the study that they had specific sites identified for winter and summer grazing amongst the herders. The herding system was also found to be quite unique. One of the herder groups of Gangchukha village comprising of five members herded during winter at Zabaden, Lumkhemtey, Zilley, Tabuna, Choley, Nubchey, Gongchudoro and Pudoo. The summer grazing sites for these herders were at Sintha, Zakhentha, Bikchimo, Budee, Richey, Tampey, ZeeZee, Rithang and returning to the same route for their winter camping.

Some of the herders of Longtey village operated in a group of twenty members and they also had specific sites for their summer and winter camping. The quality of Tsamdro in general was graded from average to good. The tsamdro at higher elevation was better than at lower elevation. Although there were adequate grazing resources during summer, shortage of grazing resources was felt strongly during winter. The team noted some land that was leased out during early HLDP project time where yak herders have fenced them with local materials and used them for grazing their lactating, pregnant and calves during summer months. It was further

noted that there were about 800 heads in the Longtey area with 14 herds and 500 heads in Gangchukha with 9 herds surviving on these grazing sites at a time which had definitely caused grazing pressure and quality deterioration of the exiting tsamdro.

Grazing resources (Tsamdrog) and its management practices

The findings showed that the graze species comprise of two main species such as *Hiksey* or *Chaab* (local names for bamboo species) available at that altitude. This specie has dominated lower belt along the Pelela pass, upper Sephu valley in the Longtey/Longmey area and Jawading towards Phobjikha area of winter grazing sites. In the summer grazing areas only *Pangcha* (local grass species) was available. *Pangcha* is considered to be nutritious compared to *Chaab*.

It was also revealed through discussion with the herders that the community pasture in the alpine areas was dominated by the shrub species known as *Balu* and *Sulu.* Since the yaks did not graze on these species, it had spread at a faster rate and has started dominating the pasture species available for the yaks. They commented that the grazing pressure was found to be increasing with the disturbing effect of *Balu* and *Sulu* dominance. If this trend continues, they have the feeling that after few years time, there are chances that all the pasture species will get wiped off leaving nothing behind for the animals to graze. During discussion the herders expressed their concern for immediate need to control these shrubs by means of fire. They commented that if they are allowed to set fire, it would control the fast spreading of these local shrubs.

The study recommend that research, with the involvement geog extension staff and Dzongkhag Forestry Official, should carry out a study by visiting at the grazing sites and study actual rate, intensity and extent of spread of these shrubs, its implication on natural grass species regeneration and growth, extent of utilization of these shrubs for other purposes by the community and finally come up with appropriate remedial measures to manage the shrubs.

Breedable female population and breeding bull performance

From the survey it became apparent that the male to breedable female ratio was very low. In a group of 5 herds with a herd size of 300 heads the communities had maintained only 2 breeding bulls. The holding period of these breeding bulls within that herd was noted not less than 8 years. These practices of with holding the same breeding bull for a long period of time might have already resulted into inbreeding within the herd. The Extension staff of Sephu also commented that the inbreeding was quite apparent from the inferior quality progenies born in the herd. A few breeding bulls were supplied by the Department while rest were selected by the farmers from their herd itself. The breeding bull selected from the herd must have already caused greater threat of inbreeding. There were also instances of bringing breeding bulls from Dagala, Thimphu. There is a need to explore whether these bulls are genetically different from that of Sephu from the study carried out by Dr. Tashi Dorji, RNRRC Jakar on genetic characterization of yak in Bhutan.

The study recommend that for successful breeding schemes and quality progeny production, research in close collaboration with extension staff needs to intervene in selection and screening of bulls from a distant bloodline and supply quality bulls to to minimise inbreeding. Further, there is a need to explore the possibility of balancing and standardization of male to breedable female ratio in the herd.

Yaks mortality

The findings revealed that the yak mortality per herd was not less 20%. The mortality included both adults and young animals. The major causes of mortality were noted to be predation by wild animals like leopard and wolves. The death due to accidental falls from cliffs and diseases was also quite high. To a lesser extent, water and plant poisoning also contributed to yak mortality. The other factors that contributed to loss and mortality were theft and weakness in the herd. Weakness was caused mainly due to insufficient feed and inferior quality progenies born in the herd.

The herders said that that so far the Department of Forest did not pay them the compensation for the death caused by wild animal depredation. It was because the communities did not deliver the death report on snapshot basis. This happened due to the fact that herding sites were located far off even from the nearest forest office. Communities are finding difficult to synchronize the time of predation for communication to the forestry officials and for most of the time the predated animals could not be traced for evidence needed for legal claim for compensation. It is a difficult issue to handle and there are no readymade solutions. However, some workable solutions need to be worked out involving Dzongkhag Livestock and Forestry Officials. Further, a study on the the causal factors for yak poisoning from water and plants at the grazing sites requires to be done.

Carrying capacity and stocking rate of the community pasture

From the survey it became apparent that the carrying capacity of the community pasture is stretched in relation to yak population/herd grazing at the site for the pasture to renew and regenerate in the subsequent seasons. The carrying capacity of the pasture needs careful assessment. With such assessment, the stocking rate of each tshamdrog needs to be calculated. The stocking rate should correspond to the carrying capacity of each tshamdrog since the carrying capacity of Bhutanese unimproved alpine and sub-alpine pasture is 1.42 with a stocking rate of 0.64 LU / ha, according to Miller (1987) and Gibson (1991).

For derivation of correct figure, careful assessment of each grazing sites for botanical composition of grazed pasture species, regenerating capacity, grazing interval, growth of grazed pasture species, fresh biomass production and dry matter production including total digestible nutrient content need to be studied and analyzed.

Yak bull breeders association

Discussion was held very extensively with the communities on the formation of Yak Breeders Association at Sephu for the production, distribution and maintenance of quality breeding bulls. The communities have realized that such an association has a

long term benefit in addressing some of the issues related to inbreeding problem within their herd and exchange of quality yak breeding bulls with other regions. The study recommends that detailed modalities for the initiation of Yak Breeders Bulls Association be carried out.

It is also planned to map all *Tsamdrogs* and migratory routes of these herders in future follow up studies taking the assistance of GIS personnel from the Centre.

The herd monitoring is a long-term study and we need to consistently make efforts to visit the herders from time to time to address some of their concerns expressed in this report. At the same time effort should be made to address other bottlenecks that impede overall yak farming system and to make yak herding more self-sustaining, attractive and economically viable.

3.2.3 Hatchability study under farmers conditions

Village chicken production under the free-range and semi-intensive system is still the most popular and viable production system for rural households with little inputs. This system of production supplements the protein intake of the rural households as well as additional income when needs arise. Rearing poultry is a part of livestock farming in our condition. In a Buddhist community, poultry rearing is limited to egg production and consumption if they die of old age or natural death. However, in the southern districts poultry birds are kept both for meat and eggs and sold to generate cash. So far, most of the farmers in the distant corners do not have access to exotic pullets as limited by remoteness, diseases, poor adaptability, high mortality and lack of money to buy and transportation stresses. Owing to these reasons, most of the farmers keep few local birds in a traditional scavenging or semi-scavenging system with a provision of simple housing.

It has been observed that farmers do face problems in rearing exotic birds under their management conditions. They buy the exotic pullets of 8-12 weeks of age which have been brought up in the farm under intensive medication, care, feeding and housing system. These birds do not receive the same type of management on reaching the villages. Therefore, the farm-supplied birds experience a big change of housing and feed regimes and it takes time to get used to the new environment. The birds remain under stress due to these factors including transportation stress, which leads to high mortality of most farm-supplied birds. So in order to study the adaptability, survivability and productivity of exotic birds under farmers' conditions, hatching the exotic eggs by the local broody hen and raising it from day-old age to 65-72 weeks of age has been felt necessary. The immediate objectives of the study are to compare hatchability, adaptability and survivability of local vs. exotic chicks under scavenging/semi-scavenging system, and to assess production parameters of local and exotic chickens hatched by the local broody hens under farmers' conditions. The long-term objective is to produce exotic birds at village conditions and scale up rural poultry production.

Methodology

Prior to the start of the trial, the availability of local broody hens in villages was confirmed in easily accessible area for close monitoring. It was also confirmed when

those hens start would laying and get ready to brood. The local laying hens were provided with exotic fertile eggs for natural incubation. The owners were asked to select hens with previous history of good broodiness and mothering instinct. Each broody hen was given 10 eggs for incubation (number of eggs farmers normally allowed the hen to incubate). It was difficult to get broody hens readily available at a time in the villages. Two different season hatchings were tried to find out the effect of season on hatchability and survivability, one in summer and the other in winter. The season-based natural incubation yielded basic information on the hatchability, survivability, adaptability and production of the birds at different stages and at different altitudes.

The proper records of all individual brooding hens identified for the trial were maintained by the extension agents. The recordings covered date of incubation and hatching, number of chicks hatched and survived till the age of 18 weeks and to 72 weeks of age. Also comparative observation on the adaptability, natural instinct like that of local birds and diseases were also observed.

The trial sites were at Guma, Dzomi, Chubu and Taewang geogs under Punakha dzongkhag. The criteria for site selection included agro-climatically representative site, farmers willing and committed for the trial and places where population of local birds was high. The factors considered were exotic eggs, local broody hens, high, mid and low altitude, and size of hatch-size for natural incubation.

The assessment parameters covered both biophysical and socioeconomic conditions. These included hatchability, survivability, adaptability, diseases and parasites, number of clutches, point at lay, sale prices for eggs and live chickens, mortality, growth, egg production and feeds supply. Further, chick quality, farmers' preference and financial evaluation were also included. Post-trial follow up on survivability, adaptability at par with local birds were also assessed. The observation on the broodiness was cross checked. Additionally, New Castle Disease Vaccine as one of the trial treatments to observe the vaccine efficacy in summer follow up trial was carried out in collaboration RVEC, Serbithang.

Main Findings: Winter hatchability

The findings from the winter hatchability trial indicated 80% hatchability of both exotic and local eggs. The hatchability percentage was calculated from 29 local hens brooding exotic or local eggs and 10 broody hens brooding exotic or both exotic and local eggs. About 40% of the birds either did not brood or spoiled all eggs or were brooding at the time when this information was collected. Farmers showed keen interest in this activity although some commented that brooding is difficult especially in winter and that although hatching was successful the chicks tend not to survive in winter. This trial continued till the end of 2004. The findings could help in formulating guidelines to breeding farm in supplying the fertile eggs on pilot scheme to farmers for cross breeding programme and ultimately lower the cost of production in the central farms.

Summer hatchability

Pic 5 : Summer trial birds at laying stage

At the end of the winter trial period, the perception of the farmers as well as the extension agents was that summer hatching should also be carried out to compare the production performances similar to winter trial. A similar trial in summer was then conducted before making any conclusion and recommendation. For the summer, it was felt necessary to include New Castle Disease vaccine for birds in Dzomi and Guma geogs to control outbreak of this disease and to test drug efficacy. The birds (Pic 5) were vaccinated every four months and serum collected on every 21st day of vaccination. A total of four rounds of vaccination were completed and three rounds of serum collected and laboratory analysis completed in RVC, Serbithang.

Hatchability was 50%, which was lower than in the winter trial. The completed trial data revealed a survivability percentage of 30% only for the summer due to predation. However, no deaths were reported of diseases.

General findings

Diseases and parasites: There was hardly any case of death reported of diseases and parasitic infestation during the whole trial period. Few suspected cases appeared from Chubu where the birds not covered by vaccination.

Adaptation: The adaptability of the birds was better compared to 8 weeks old pullets brought directly from the central farms.

Growth: The growth of the exotic birds raised from day old chicks by natural incubation showed vigorous growth compared to the locals.

Egg production: The point of first lay was reported to be 6 months. The farmer co-operators reported more than six clutches of eggs laid by the exotic birds raised under farmers' conditions. Eggs ranging from 18-24 per clutch were laid by those exotic birds.

Feeds: The birds were fed twice a day. The feed composed of whole maize grains, grits, rice, broken rice, food, and kitchen wastes besides scavenging during the day.

Farmers' preference: Farmers who cooperated for this study were impressed by such initiatives taken by the research and extension for the first time. They expressed their happiness to receive exotic birds at their doors to allow their broody hens to incubate. Most of them were excited to see their hens hatching 100% eggs. They like to see exotic chicken in the flock local chickens. However, predation resulted in complete loss of hatched chicks.

Post trial performances: On visiting the farmer co-operators, it was not uncommon to hear that exotic birds produce an egg almost every day. Among those surviving, the hens were still active and laying vigorously. Farmers commented that after they got the chicks they never had to buy eggs from the shops. Instead they sell the surplus eggs on Sunday market and generate cash.

Drug efficacy

First round of Haemagglutination inhibition results: Of the total of 32 sera samples tested, 50% of the sera had protective titre against NCD. The number of birds without protective titre was 44%. Only 3% had low titre (2^2). Geometric Mean Titre (GMT), haemagglutination inhibition antibody of the sero-positive birds was $2^{3.7}$ indicative of protective titre against NCD.

Second round of Haemagglutination inhibition results: All vaccinated birds were in protected level of NCD except 2 birds.

Conclusions

The trial conducted in winter showed better performance compared to summer. This happened due to some logistical problem as the eggs were transported from long distance. Also, the eggs remained in the office of the DLO waiting for the farmers to come and collect the incubating eggs. On reaching the farmers, proper care was not taken to immediately let the hens incubate or sometime the hens would have completed their broodiness and were not willing to sit for incubation. Whatsoever, the trial was conducted successfully as planned, data generated and invaluable experience gained by both the farmers and the researchers. The study pinpointed certain managerial problems as the cause of mortality, low survivability, adaptability and productivity. The control of predation of birds would reduce mortality and survivability. There was an overwhelming interest from the farmers and extension agents in the study, perhaps indicating the significance of such studies in the rural setting.

Recommendations

- More intensive experimental trials and accurate assessment needs to be done to further authenticate the findings
- Farmers should be encouraged to go for natural incubation instead of supplying pullets of 8 weeks to avoid death resulting from transportation casualties, and change in food and living environments.
- Measures need to be taken to control predation (both during day and night) of chicks and even adult birds under local condition as this emerged as major cause of mortality resulting in drastic decline on survivability rate of village birds.
- Need to identify potential poultry production areas involving farmers to promote poultry farmers' associations and new entrepreneurs in poultry breeding and supply.

3.2.4 Demonstration of integrated rice-fish culture under Bajo research conditions

Introduction

Rice- fish culture consists of stocking of fish seed in rice field where rice is the principal crop and fish culture has to adapt to the conditions and requirement of the rice crop. The main advantages of this system are reported to be:

- Economic utilisation of land both for the production of rice and fish
- Diversified cultivation; the production in one crop can be compared with the production of other
- Animal protein, an important component of human diet, can be acquired by rice-fish culture system
- Rice production is increased by 10-15% (Pradhan, 1979) due to increased organic fertilization and reduced insect and pest pressure (Schuster et al 1955)
- Helps in eliminating some of the major weed that pose threat to rice farming
- Less labour and production costs are incurred in this system as extra labour cost is compensated by fish feeding in weed which otherwise require manual weeding.
- It is a beneficial opportunity to obtain better income for the farmers.

Some of the fish species commonly raised in rice system are Grass Carp (*Ctenopharyngondon idella*) and Common Carp (*Cyprinus carpio*). These fishes have the habitat of feeding extensively in phytoplankton, zooplankton and minute algae that are commonly available to them in the rice field. These fishes grow well in the rice-fish culture system. Research conducted by National Warm Water Fish Culture Centre, Geylegphu compared the yield differences and economics of growing rice as mono crop and with rice-fish culture system. Some of their results are quite interesting although research in other locations have not been conducted till date It is therefore felt imperative to carry out a similar kind of study in Wangdue to share our findings on this integrated approach and their comparative advantages with relevant stakeholders and the farmers.

Objectives

- To demonstrate integrated rice-fish production methods to the rice-based farmers**, t**o provide options for the farmers as an additional source of income and family nutrition through this integrated farming approach

- To understand the influence on rice yield as a mono crop and as rice-fish system

Materials and Methods

Materials

During the first year, about 800 Grass Carp and Common Carp fingerlings were procured from Geylegphu. In the second year, 400 numbers of Common and Grass Carp yearlings were introduced in the same plots. The rice field having an areas of 600m^2 were readied after consultation with the field crop colleagues where there was

perennial source of running water. One large terrace was used for this experiment. The other material required was the wire mess net to prevent the mixing of fingerlings from another compartment. Supplement feed consisting of maize grit, rice bran and oil cake were fed to fish. In addition to this, fresh manure application from time to time was done to maintain plankton's population and diversity.

Methods

Field trial setting

A 600m^2 rice terrace was divided into two compartments of equal size for Common Carp and Grass Carp. The plots were netted with wire mess to prevent mixing of fish from one compartment to other. In the first year, about 400 numbers each of Grass Carp and common Carp fingerlings were introduced. During the second year, about 200 Common and Grass Carp yearlings were released. Both the plots were transplanted rice of same variety. A minimum area of 600m^2 was maintained in both plots to allow fish growth. The fingerlings were stocked at the rate of 0.2 per square metre for Grass Carp and 0.1 for Common Carp as minor stocking in experimental field of circular trench when the fingerlings are of 10-12cm length and 9-12 gm weight. For the rectangular trench, the stocking rate is 0.6 per meter square and as the fingerlings grew the size was gradually increased to 2.5 m2 / fish. In the inlet and out lets, the wire mess was netted to prevent mixing of fishes and to regulate water level and maintain water temperature. A trench of 80cm wide and 80cm deep was made throughout the plot from two sides to maintain regular water flow and also to ease fish harvest. A minimum of 6-10cm deep water levels was maintained in the rice field at all time. The water temperature was maintained between 25-30^oC. The rice was transplanted at a distance of 15-20 cm plant to plant and a row distance of 20cm. Data on the growth rate; disease incidences, , supplement feeding and other production variables were collected. The fish was reared till the time of the rice maturity and harvested a week before rice harvest. The rice and fish yield from treatment plots and rice production from control plots were assessed and quantified. Direct cost benefit analyses were done to compare the outcome of the trial.

Agronomic practices of rice- fish culture

For rice production, basal dose @ of 150kg of SSP per acre was applied. In addition, it was top dressed with within 20-30 days of rice transplantation @ 60kg/ acre. After 15 days of paddy transplantation, the fingerlings were introduced. This gap was maintained to prevent damage of freshly transplanted rice by fish especially Grass Carp. The fish were harvested few days (3-5 days) before paddy harvest to dry the plot for the rice harvest.

Feeding arrangements

Grass Carp feeds on phytoplankton that are grown in the rice field and Common Carp being omnivorous and bottom foraging fish, mostly feed both on phytoplankton and to a lesser on zooplanktons. Manure / fertilise application was therefore applied in the field from time to time for maintaining sufficient growth of these planktons . Fish were also supplemented with 3 kg of feed per week consisting of maize grit, rice bran and oilcakes. About 2 kg fresh fodder leaves (Ficus, Napier, Alfalfa and White

clover) was also supplemented with the feed weekly. The water temperature to 15^{o} C and about knee high water level were regulated for faster growth of fish as well as the planktons. The unwanted aquatic weeds like *Monochoria vaginalis*, *Cyperus difformis*, *Schoenoplectus juncoides*, *Echinichloa crus-galli (Chris Parker, 1992, Weeds of Bhutan)* were removed manually to facilitate free movement of fish.

Results

Comparative Fish yield

It was observed that the growth rate of Common carp was found to be much faster and higher than the Grass carp. The Common carp weighed between 170 gm to 410 gm compared Grass Carp which weighed 30-80 gm in a period of three months. Further it was noted that their growth rate was optimal and overall survivability was found to be to be better than Grass carp.

Some degree of predation by aquatic birds was noticed which was beyond our capacity to control it. Some fingerlings were found to have escaped through the holes of the bunds made by insects and rodents especially during night time that ultimately contributed to over loss. However during the entire trial period no major mortality and diseases occurrences were observed.

The first trial was terminated on 20 October 2004 and the fishes were harvested one week prior to paddy harvest and weighed. In total Common carp yielded 11.2 kg compared to 3.5 kg from Grass carp.

During the second year of experiment, the yearlings were used instead of fingerlings. About 200 each of Common Carp and Grass Carp were released in the field. The fishes were harvested at 110 days of growth period in the rice field. On the day of harvest, 95 percent survival was recorded of Common Carp weighing 15 kg in total with an average weight of 79 gm each. Low survival rate of 30 percent from Grass Carp was recorded on the day of harvest. The average weight was 100 gm each weighing 3 Kg of total production from Grass carp as indicated in Table 46..

Table 46Fish species, quantity and yield of two years experiments

Fish species	Year 1		Year 2	
	N (number of observation)	Average weight	n	Average weight
Common Carp	6	170-410 gm*	190	79 gm
Grass Carp	6	30-80 gm*	60	100 gm

** weight in range; counting was not done at the time of harvest to derive the average weight*

Comparative Rice yield assessment

The paddy yield from treatment and control plots were assessed and quantified. It was observed that on an average, rice yield was higher from plot where Common Carp was introduced (8 t/ha) compared to Grass Carp plot (5.8 t/ha) as indicated in

Table 47. Rice production was also higher from Common Carp introduction plot (8 t/ha) compared to control plot without fish culture (5.8 t/ha).

Table 47 Rice yields of two-year experiments

Experiment plots	Average yield (T/Ha) Year 1	Average Yield (T/Ha) Year 2	Mean
Common Carp plot	7.5	8.3	8
Grass Carp Plot	5.0	6.6	5.8
Control plot	6.4	5.2	5.8

Looking at yield differences with and without treatments, the findings indicated that it is economical and advantageous in growing rice through introduction of Common Carp fish species than as mono crop under Bajo's conditions. Even through the paddy yield was much lower where Grass Carp was introduced. However, it had an additional advantage of fish harvest and *Sochum (Potamogeton distinctus)* weed being controlled to a large extent because of its feeding habitat. Though there was no yield differences in the plots of Grass Carp and the Control plot but still the plot with Grass Carp had higher economic return compared to the Control plot without fish. Also it had been indicative that the yield from the Grass plot was comparative to Control plot yield even beside the feeding habit of Grass Carp on rice plants.

Economics of rice-fish culture with rice as monoculture: a simple cost benefit analysis

The findings (in Table 48) revealed that the return from the rice-fish culture was higher compared to rice as monoculture. The rice-fish plot with Common carp yielded highest both in terms of paddy production and fish yield followed by Grass carp. The comparative finding is very apparent from Grass carp plot and Control plot paddy yield. Though the paddy yields were same but in terms of gross return, the Grass carp with rice appears better economically. There is greater assurance from fish harvest even during the time of crop failure due to natural calamities. Therefore, polyculture maximises production compared to monoculture.

Table 48 Simple economic analysis of rice-fish culture with rice as monocrop.

Treatment	Rough rice		Sale of rough rice	Fish		Sale of fish	Gross Income (Rice + Fish), Nu.
	Yield, Kg	Rate		yield (kg)	Rate		
Common Carp plot	237	12/Kg	2844	13	85/Kg	1105	3949
Grass Carp plot	174		2088	3.25		276	2364
Control Plot	174		2088	00		00	2088

Effective Shochum (Potamogeton distinctus **A. Benn.***) control by fish*

Common weed of rice known as *Shochum* infests paddy resulting in decline in rice yield in west and west-central region. This very weed is a type of *phytoplangtons* that Grass Carp nourishes. One of the aims of introducing fish in rice was to study the feeding habits of Grass Carp on this weed and in the trial plot where Grass Carp

species was introduced there *Shochum* was not seen indicating that Grass Carp species is a selective forager and eats *Sochum* available in the rice field.

Problems encountered

- The main problem encountered was the regulation of water level in the rice field. The water level had to be continuously monitored as the rodents and insects made holes through which the water sieved resulting into low water level in the rice field. The low level of water in the field also checked the moment of fish in the rice field.

- The other problem was the predation of fish mostly Grass Carp by the aquatic birds resulted into low Grass Carp yield at the end of the experiment.

- It was also observed that if the fish are introduced too early the Grass Carp were tempted to eat freshly transplanted rice plant. The problem was serious on introducing Grass Carp yearlings. This might be attributed to low rice yield at the end of the experiment.

- Size of fish harvested was small due to short growth period

- The present status of rice-fish culture is very unsatisfactory due to poor extension activities and the cultural system being new to the people.

Conclusion

Although economic analysis was not done, rice fish culture seems to be viable in in the rice growing areas with perennial irrigation system. Rice yield seems to increase with rice-fish culture especially with grass carp and control of weed is also possible and fish can be harvested from the same field for utilisation of the land. Therefore, such activities should be strengthened to accelerate the prospect of rice-fish culture system in future. However, this information could be validated further by conducting similar experiments at farmers' field to draw strong recommendations on this integrated farming approach at the wider scale. It is expected that this study would also help to some extent those interested to opt such polyculture production system to boost their production and income.

Future scope

There is a wide scope of rice-fish culture development in Bhutan especially in the rice-based system where rice cultivation is practiced through perennial irrigation source. The research and extension should promote and initiate its development involving farmers closely. More rice field should have irrigation facilities thereby rice-fish culture's scope will be increased. The demonstration of rice-fish culture at various parts and farmers field in the country needs to be promoted to understand its importance as it pays for the effort made with wider coverage.

FORESTRY RESEARCH

4 FORESTRY

Forestry research program continued placing great emphasis on social forestry research for this year too. Research activities were divided into broad sub-programs and projects[5] that include: social forestry, conifer forest management, broadleaf forest management, and forest protection. The following report will follow this categorisation.

4.1 Social Forestry

The social forestry sub-program consists of community forestry, agroforestry and watershed forest management and nursery management.

4.1.1 Community Nursery

Rehabilitation of degraded areas through community forest plantations and handing over of natural forest as community forests remain a priority activity for the forestry sector. The community forest plantations in the Lingmutey Chu watershed took off with the creation of the community forest nursery (CFN) followed by impressive planting of seedlings generated from this nursery on the degraded slopes of Omtekha and Matalumchu. A total of 29.04 ha of such land have been brought under community plantations from 1999 to 2002 (table 1 for details).

Various community meetings and discussions were facilitated by the forestry staff in collaboration with the Dzongkhag forestry sector. Farmers concerns were clarified, issues discussed and various options for the management of the community plantations were explored. A detailed management plan that covers management of the plantation, sharing of benefits and responsibities and wider issues have been prepared by the community members with technical inputs and facilitation from the implementing agencies. The plan has been forwarded to the Department of Forests for approval by the Dzongkhag Forestry sector of Punakha.

Table 49 Community plantations (from 1999-2002)

Year	Area (ha)	Location	Total seedlings (approx.)
97-98	8	Matalumchu and Omtekha	11000
98-99	8	do	10800
99-00	5.04		7700
00-01	4		4500
01-02	4		3600
TOTAL	**29.04**		**37600**

[5] Subprogram and projects as determined during the fourth national forestry research coordination workshop at Taba

4.1.2 Watershed Forest Management

It remains that only about 5 percent of the country's forest is managed under scientific prescriptions as forest management units. The rest of the forest areas remain *de facto* common forest with no proper management. The need for an alternative forest management strategy for extensive areas (such as those that are not within FMU or community forest) were discussed in various meetings of forestry professionals. RNRRC Bajo together with the BGSRDP, Lobeysa agreed to pilot a research activity to look at managing this kind of forest (outside FMU) areas. Lingmutey Chu watershed was selected for the purpose. The aim was to prepare a simple watershed forest management plan to help ensure the long-term sustainability of the forest resource use by the local people. A number of activities were planned and conducted by the forestry sector together with the BG-SRDP, Lobeysa and the local forest Beat Officer (BO). These include forest function mapping, division into blocks or compartments, forest product demand assessment and forest resources assessment.

Forest function mapping defines for all the forest areas within particular area ecological, environmental and social functions to allow a balance between the oftentimes conflicting management interest of the local forest users, nature conservation and environmental protection. Five categories of forest function were developed namely, soil conservation function (soil protection and soil conservation), water and watershed conservation (riparian reserve protection, local water supply, and watershed conservation), social function (local use only and religious site protection), nature conservation function (wildlife protection and wildlife conservation) and road buffer function. Classification criteria of dividing forest areas into different functions and the distribution of forest functions in the Lingmutey Chu watershed are given in table 2.

Forest functions have different impacts on forest management. Some protective functions prohibit the felling of trees at all, others impose restrictions only on the silvicultural system or to the use of minor forest products. Management restrictions for different forest zones have been prepared (reported elsewhere) which shall later serve as guiding principles for developing management prescriptions and silvicultural recommendations during the management plan formulation. Of the total 2493 ha of the watershed forest, 1107 ha have been classified as strictly protected zone and 177 ha as protected zone. The remaining 1319 ha can have forest management for local use implemented with some minor management restrictions.

Table 50 Classification of forest areas into functions

Forest functions	Classification criteria	Area			
		Symbol	Area (ha)	% of forest area	% of total area
Soil Protection	All areas above 30 degrees	SP	751.8	30	23
Soil Conservation	Steep, intersected, exposed sites and sites with high erosion risk	SC	1660.1	67	51
Total Soil Conservation			**2411.9**	**97**	**74**
Riparian Reserve Protection	Banks of rivers, areas subject to periodic inundation and flooding	WRR	265.3	11	8
Watershed Conservation	Upper catchment areas of water courses on steep, poorly drained	WSh	2493.4	100	77

	slopes				
Local Water Supply Protection	water resources for local water supply (50m around reservoirs)	WLS	129.1	5	-
Total Water Conservation			**2493.4**	**100**	**77**
Wildlife Protection	Breeding places and living habitats	NWP	472.9	19	15
Wildlife Conservation	Corridors along ridges and wildlife rich areas	NWC	713.6	29	22
Total Nature Conservation			**1186.5**	**48**	**36**
Local Use Only	All areas traditionally used by local people and indispensable	SocL	1318.6	53	40
Religious Sites Protection	Sites of lhakhags, geonpas, stupas and places of worship	SocRS	2.5	-	-
Total Social Function			**1321**	**53**	**40**
Road Buffer Function	135m buffer both uphill and downhill	**RB**	**171.6**	**7**	**5**

It was required then to divide the forest into compartments or blocks for the purpose for easier management. Specifically this aids: in determining the area of the block; for ease of identifying harvesting areas; deciding what silvicultural treatment may be necessary; and also assessing the potential of the forest in terms of capacity to supply various types of forest products mainly timber. Blocking also aids in monitoring the forest in terms of areas that are cut, destroyed by fire or other calamity etc. Watershed forest is variable and may cover a large area. A single description of the forest cannot be site-specific and a single management activity cannot be applied over the whole of the watershed forest. This was achieved by first drawing on base maps printed prior to the exercise various natural features and local boundaries and local names. These are then verified by walking into the forest with two or three local people. The local community representatives and the local forest officer (BO) were intensely involved in the exercise. Once areas were drawn on the base maps and GPS references of key features are taken in the field, these data are then fed into the GIS for accurate digitizing of the boundaries thus defined. The following details of the block are then computed and described for each block for later use: block name, block area, block description in terms of topography, presence of roads, streams etc., category according to function map (e.g. riparian protection, local use etc. – see 4.1.2.1)

Developing a forest management plan requires matching the demand for forest products of the various stakeholders with the production forecast and other potentials of that forest. A simple participatory demand assessment was carried out to achieve this purpose. PRA type exercises that elicited responses from community members on their demand forecast for about 10 years were done. Forest product demands of the local people were classified as: timber (cham, *drashing*[6], tsim etc); poles (for both fencing and other house building materials); and others (includes NWFPs, grazing requirements etc.). Each household predicted rough estimates, depending on their experience, what amount in each category they required. These were aggregated by the village to obtain the total demand for the village. The objective is to quantify forest product requirements of the local people from the

[6] Logs for sawing planks etc.

watershed forest. For a detailed description of the method, the reader is referred to "Community Forestry Manual for Bhutan, Part II[7]"

The final activity that remained was the resource assessment. This has the objective to provide in fast and simple way information for each forest block in a watershed on: forest type and condition; current use of the forest; management options and potential use for rural supply. A simple assessment method based on the principles such as: only information is collected which is actually required and used; assessment procedure must be simple, practical and easily understandable; inputs in terms of time, equipment and human resources should be kept to a minimum was developed and used. The method follows a point sampling approach along transect lines using a simple wedge prism linked with a fixed sample circle for the enumeration of regeneration and saplings. The assessment was done for the watershed as a "management unit" which is split into village areas and forest blocks. Assessment was only carried out in the areas predetermined as production forest by the function map. Field assessment with the aid of prior prepared block maps were conducted selected about 12-24 sample plots in each block depending on the size and variability. Quantified information on regeneration, volume of timber stock (basal area), occurrence of NTFP were collected. Description of the forest cover and site characteristics were also done. In every plot a tentative management prescription based on the site was also suggested. Data gathered have been analysed and the management plan preparation is underway.

4.1.3 Nursery Management

The sector maintains a multipurpose tree species nursery at the station with the objective to evaluate and develop appropriate propagation techniques for MPTS. The different tree saplings raised during the course of evaluation are planted in the centre's wasteland where agriculture production is not possible, for further screening. Table 51 show the list the species available in the nursery.

Table 51 List of species available in the MPTS nursery

SN	Species	Vernacular Name	Family
1	*Ficus religiosa*	Jangchu shing Dz.	Moraceae
2	*Ficus benghalensis*	Baar Lh.	
3	*Ficus roxburghii*	Baku shing Dz.	
4	*Ficus cunia*	Khaneu(Lh)	
5	*Morus australis*	Sanu Kimbu Lh.	
6	*Sapindus rarak*	Nakupaney shing Dz.	Sapindaceae
7	*Dodonaea angustifolia*	Dodonaea Co.	
8	*Phyllanthus emblica*	Omla shing Dz.	Euphorbiaceae
9	*Callistemon citrinus*	Red Bottle Brush Co.	Myrtaceae
10	*Syzygium cumini*	Nyasse shing Dz.	Sterculiaceae
11	*Rosa hybrida*	Hedge	Rosaceae
12	*Sterculia villosa*	Odhal(Lh) Phrang shing(Sh)	Sterculiaceae
13	*Terminalia bellirica*	Baru(Dz) Barra(Lh)	Combretaceae
14	*Prunus cerasoides*	Wild cherry(Eng)Paiyun(Lh)	Rosaceae
15	*Dendrocalamus spp*	Pakshi(Dz)	Gramineae
16	*Diploknema butyraceae*	Yeka(Dz) Churi(Lh)	Sapotaceae
17	*Tetradium fraxinifolium*	Khanakpa(Lh)	

[7] CF Manual for Bhutan Part II (Working Draft June 2003), Community Forestry Management Planning. Social Forestry Division, Department of Forest, MoA, Thimphu. Pp36-37.

18	*Quercus glauca*	Thorm shing(Dz) Phalat(Lh)	Fagaceae
19	*Quercus grifithii*	Sisishing(Dz) Khasru(Lh)	Fagaceae
20	*Benthamedia capitata*	Phetshu(Dz) Duckwood(Eng) Ramkatar(Lh)	Cornaceae
21	*Symplocos paniculata*	Pantchi(Dz)	Symplocaceae
22	*Bahunia purpurea*	Taki(Lh) Pegpeyposhing(Sh)	Leguminosae
23	*Acacia catechu*	Khair(Com)	Leguminosae
24	*Flamengia macrophylla*	Hedge(Exotic)	Leguminosae
25	*Cupressus corneyana*	Tshenden(Dz) Dhupi(Lh) Cypruss(Eng)	Cupressaceae
26	*Oroxylum indicum*	Tshampaka shing(Dz) Totola(Lh)	Bignoniaceae

Tree species propagated in the nursery was also planted in the centre waste land to serve as an arboretum to showcase species evaluated in the nursery and to also serve as germplasm for medicinal and economical important species in the region. A total of 31 species have been planted so far (Table 52).

Table 52 List of species in the arboretum

No	Botanical Name	Family	Vernacular Name
1	*Terminalia bellirica*	Combretaceae	Barru Dz.
2	*Terminalia chebula*	Combretaceae	Aru Dz.
3	*Ficus religiosa*	Moraceae	Jangchushing Dz.
4	*Ficus roxburghii*	Moraceae	Bakushing Dz.
5	*Morus australis*	Moraceae	Sanu Kimbu Lh.
6	*Morus macroura*	Moraceae	Tshendenshing Dz.
7	*Ficus benghalensis*	Moraceae	Bhar Lh.
8	*Prunus cerasoides*	Rosaceae	Wild cherry Eng.
9	*Doxynia indica*	Rosaceae	Tongshing Dz.
10	*Callistemon citrinus*	Myrtaceae	Red Bottle Brush Eng.
11	*Syzygium cumini*	Myrtaceae	Nyasseshing Dz.
13	*Jakaranda mimosifolia*	Bignoneaceae	-
14	*Oroxylum indicum*	Bignoneaceae	Tsampaka metog Dz.
15	*Diploknema butyraceae*	Sapotaceae	Yekashing Dz.
16	*Sapindus rarak*	Sapindaceae	Nakapanishing Dz.
17	*Dodonaea angustifolia*	Sapindaceae	
18	*Sloanea tomentosa*	Elaeocarpaceae	Thothrum Dz.
19	*Peseaa americana*	Lauraceae	Wild Avocado pear Eng.
20	*Phyllanthus emblica*	Euphorbeaceae	Omla Dz.
21	*Acacia catechu*	Leguminosae	Khair Lh.
22	*Albizia spp.*	Leguminosae	Siris Lh.
23	*Flemingia macrophylla*	Leguminosae	Batwase Lh.
24	*Spondias pinnata*	Anacardiaceae	Amaroo Lh.
25	*Melia azedarach*	Miliaceae	Bakaina Lh.
26	*Pupulus nigra*	Salicaceae	Popular Eng.
27	*Juglans regia*	Juglandaceae	Tashing Dz.
28	*Cupressus corneyana*	Cupressaceae	Tsenden shing
29	*Thuja spp.*	Cupressaceae	-
30	*Bambusa & Dendrocalamus spp*	Gramineae	Pashi Dz.
31	*Thysanolaena latifolia*	Gramineae	Tsakusha Dz.

4.2 Conifer Forest Management

4.2.1 Blue pine stand stability and thinning trial at Khotokha

The trial is located at Khotokha which situated between the Bjena and Rubisa geogs of Wangdue Phodrang Dzongkhag and ranges from an elevation of 2300m to 3785m. The dominant tree species in the FMU is blue pine (*Pinus wallichaina*, A. B. Jackson) with uses for timber, poles, firewood and leaf litter for farmyard manure. The trial was established with the objectives to: gain knowledge on the silvicultural

treatment of young blue pine stands; quantify the effect of thinning on the natural regeneration on former pasture land; improve stand stability by stand treatment (thinning); and improve timer quality of the stand (thinning and pruning). Bluepine regenerated here naturally and occupied the pasture land. Counting branch whorls put the stand age to about 22 to 24 years.

Three thinning treatments (T1: Control; no thinning at all; T2: Moderate thinning; about 25 % of the standing volume are to be removed; T3: Heavy thinning; about 30 to 35 % of the standing volume are to be removed) were applied in 2000. The criteria for assessment for each tree before the treatments were: tree number; tree species; diameter at breast height (dbh); tree height; social position; tree broken (no; <1/10, 1/10 – ¼ , ¼ - ½ , > ½ , tree completely dead); damages, pest and diseases (bark damage by deer, bark beetles, fungi, etc.); remarks (e.g. forest fires). As planned a second recording of height, diameter, volume and a subjective form assessment was carried out in 2003. The second thinning is due this year.

4.3 Broadleaf Forest Management

The acute lack of research into broadleaf forest management has been brought up and discussed in many of the past National Forest Research Coordination Workshops (NFRCW). Consequently RNRRC, Bajo together with the Bhutan-German Sustainable RNR Development Project (BG-SRDP), Lobyesa in collaboration with NRTI and RNRRC Yusipang has initiated various discussions in the Rimchu Forest Management Unit (FMU) culminating in a comprehensive report by a consultant, Dr. Armin Seydack, fielded by the BG-SRDP.

Rimchu Forest Management Unit under Punakha Dzongkhag has a gross total area of 212 hectares with gentle to moderately sloping topography. The forest type is sub-tropical cool broadleaf and the main species include *Michelia sp., Castonopsis sp., Quercus sp., Schima wallichii*. Logging has occurred since 1996 in accordance with a Working scheme prepared as an interim measure to meet the raw material requirements of the local population, urban centres of Punakha and Wangdue and the sawmill at Lobesa. These logged areas are characterized by profuse growth of *Macaranga sp.* with almost no other species regenerating.

A consultative meeting at Lobeysa among RNRRC Yusipang, Bajo, NRTI and BG-SRDP, Lobeysa discussed on the possibility of making Rimchu a broadleaf research forest and the establishment of permanent resource monitoring plots. Accordingly a framework for broadleaf forest research in Rimchu has been discussed and prepared by the forestry research coordinating centre, RNRRC Yusipang containing a comprehensive research plan on the dynamics of broadleaf forests in Rimchu. The proposal has been approved by the Ministry of Agriculture and initial financial support agreed by the BGSRPD. Preliminary selection of plots has been done. Permanent layout of plots and conduct of research activities that includes regeneration plots, grazing studies and growth and yield assessment will begin soon.

4.4 Forest Protection

4.4.1 Community perception of forest fires

Fire is a ubiquitous occurrence in forests and is by no means confined to one country or region. With the use of fire as a management tool in many of agricultural activities since man discovered and started making fire, the realization came that if left uncontrolled fires can spread over large areas causing considerable damage to forests, animals and people alike. Consequently, forests all over the world face the threat of fire constantly. Increasing concern with the conservation and wise use of forest resources has been paralleled with the organized efforts to mitigate the occurrence and damage of wild fires in the country. Often times local communities have been blamed for forest fires whether they started it or not. Forest officials have perceived local communities as part of the problem and not as part of the solution. However, the necessity to involve local communities in fire control and management with the recognition that communities do have a crucial role in fire management and control programmes is emerging in many countries. Local people are often in the best position to manage or prevent forest fires. A study was thus initiated to help understand the perceptions of the local people on forest fires.

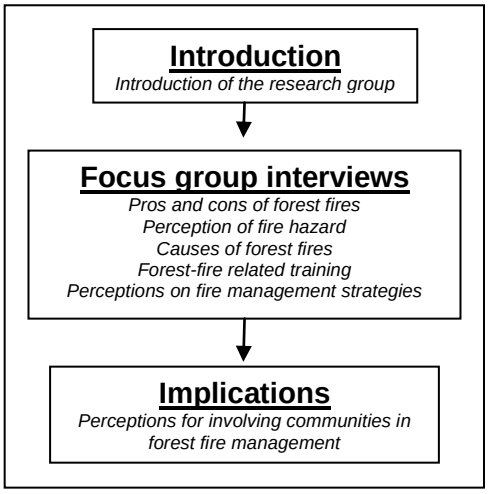


Figure 7 Conceptual frame of the research method

This study was conducted in few selected villages under the Punakha and Wangdue Dzongkhags. Many areas under these two dzongkhags, for instance, Kamichu, Shengana, Pinsa etc. are fire prone areas with reports of forest fires in 1990, 1995, 2000. Data collection was mainly done through focus group and key informant interviews. Focus group participants were selected randomly from the pool of the households in the study villages and key informants include the village tsogpas, risups and other elderly members of the village. The results[8] of the interviews were categorized into four broad themes: perceived pros and cons of forest fires; perception of fire hazard; causes of forest fires; reception of forest fire related training; and perception of forest fire management strategies. Points raised during the interviews are summarized in the above four themes. Attempts to support these summaries have been made by providing excerpts from the interviews with the participants wherever appropriate.

In contrast to the general perception that communities perceive forest fire as beneficial and are prime agents who start forest fires local people are in fact balanced in their view of the detrimental effects and benefits accruing from forest fire. Communities in all the three-study areas state that there is a high risk of forest fire in their locality during the dry season. Fire incidence however, they explained have reduced significantly compared to the past with the general awareness of the people about the harmful effects of forest fires and the strict protection afforded by

[8] Details of the results will be reported in the forthcoming RNR journal.

the Department of Forestry. Respondents in the three study areas divided forest fire causes into two namely intentional causes and unintentional causes. Intentional causes include deliberate setting of fire to forest for reasons as varied as to increase the area for grazing, to make more wild edibles such as ferns and asparagus which come up profusely after a fire or arson. Cause of forest fire by arson could result, explained the respondents, when a person(s) has a grievance against some forestry official or against the neighbouring village[9]. Escaped fires are recalled to be the major cause of forest fires. Interviews with the focus group members in all the villages considered mention fires escaping from controlled burning of dryland boundaries, wetland bunds or burning in the orchard as the main cause of forest fires. Local people have become more knowledgeable about the adverse effects of forest fires and have become more careful when carrying out controlled burning in their fields as a result of training conducted by the Dzongkhag forestry offices.

4.4.2 Ecological effects of fire in chirpine forests

The Social Forestry Division of the Department of Forestry Services, Ministry of Agriculture, Royal Government of Bhutan has initiated a study in spring 2004 to quantify the effects of different fire regimes on Chir Pine forest ecosystems and the growth of lemon grass in Eastern Bhutan. The present study represents the replication of this study in West-Central Bhutan, adopted to local conditions there. Increased understanding about the role of fires in fire adapted ecosystems lead to the use of fire inforest management in many countries worldwide. The policy of total fire exclusion in Bhutan might be detrimental to systems adapted to fire, just as elsewhere in the world. At the same time, the fire exclusion policy is very difficult to implement, since the local population in remote areas uses fire for vegetation management regardless of the legal situation. Allowing fires with certain restrictions might ease both aspects of the problem. Ravaging wildfires resulting from high fuel build-up would become a rare scenario due to regular fuel reduction using prescribed burning and the permission to use fire under certain circumstances would enable the local population to pursue traditional land use systems in a less dangerous and detrimental form. The results of the study should give a clear picture over the ecological impacts of fire with special reference to Chir Pine regeneration and ground vegetation growth. These results will serve as a supplement for policy decisions, whether to allow prescribed burning as a forest management tool in Chir Pine forests in Bhutan, and if yes, under what conditions.

The objectives of the current study 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.

Due to the high work load of two research sites considered to be unfeasible for RC Bajo due to low staff strength, only one site has been selected during a reconnaissance exercise conducted by SFD, RC Bajo and RC Jakar in November 2005 in Nahi Geog, Wangdue Dzongkhag. The following criteria were observed when selecting the site:

[9] Forestry officials very often hold responsible the neighbouring village for any incidence of forest fires

- Stand clearly dominated by Chir Pine
- Prescribed fire safety can be ensured – decision to be made by SFD
- Uniform topography
- Uniform stand and understory 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 all size 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 *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.

The factors seasonality, frequency and intensity of fires are the most important factors the effects of fire depend on. Due to the 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.

On each site, two plots treated with different fire intensities and one control plot of rectangular shape will be laid out in immediate vicinity of each other. The size of the treated and control plots will be 40 m x 40 m. Recordings will be done on a concentrical plot of 32 m x 32 m (approximately one quarter acre) in order to allow for 4 meters of buffer on each side. Treated plots will be subdivided into 64 subplots of 4 m x 4 m to allow a relatively fine-scale assessment of fire intensity and vegetation. The four corners of the plot will be marked using iron rods, while the remaining corners of subplots will be marked using wooded pegs. Fire breaks will be created around the plots based on the instructions of SFD to ensure prescribed burn safety. Protecting treated and control plots from wildfires is extremely important. General characteristics recorded for all plots will include:

- Slope in %
- Aspect
- Mesotopography (convex / concave / level / convex-concave)
- Altitude in meters above sea level
- Slope position and soil classification
- Soil moisture regime – see Table 50
- Soil nutrient regime – see Table 49
- Previous tree felling – recording of stump diameters
- Other anthropogenic impact: tracks, vicinity of pastures, grazing pressure
- Grazing pressure classes: low, medium, high

The trial is being jointly implemented by the forestry sector of the centre, the Wandgue Territorial Division and the Dzongkhag Forestry Office. RNRRC Bajo has the responsibility to coordinate and conduct the research and also prepare the research result in collaboration with CORET/RNRRC Jakar.

SYSTEMS RESOURCE MANAGEMENT

5 SYSTEMS RESOURCE MANAGEMENT

5.1 Community Based Natural Resources Management (CBNRM)

5.1.1 On-farm high altitude rice variety trial with MP-3

In collaboration with RNRRC Yusipang, trial on evaluation of high altitude rice variety Machapuchray 3 (MP-3) was done at Limbukha with one test farmer with the objectives to compare yield and farmers' preference with local variety under farmers' management.

1 kg of MP-3 was given to an interested farmer through participatory farmer selection, which was done jointly by geog extension agent and the researcher in consultation with community members. The nursery was sown on 26th March 2004 and transplanted in a single plot on 16th June 2004 and harvested on 13th October 2004.

Trial plot was managed in traditional way where FYM was applied at the rate of 60-80 baskets per langdo and top-dress with urea. Weedicide was applied to suppress the weeds with additional one hand weeding. Monitoring during different crop stages was done and data were recorded based on the protocol. At crop maturity and harvest, crop-cut data and farmers' feedback were collected and evaluated. The trial crop-cut results are presented in the table below:

Table 53. Performance of Machapuchray 3 in Limbukha

Variety	Blast score	# of hills per sq. m	Number of panicles	Plant height (m)	Yield (T/ac)
Machapuchray 3	3	20	13	1.2	**2.1**
Shengamaap (check)					**1.6**

Machapuchray 3 yielded 0.5 T/acre higher than Shengamaap. Farmers reported that MP-3 has better potential for promotion in Limbukha area for its uniformity in plant height, maturity and higher yield.

Although this variety is susceptible to grain shattering farmers like for its resistant to stunted growth which is common in Limbukha rice fields. Farmers have requested for more seed for promotion in 2005 this season. The paddy produced from last year test farmer's fields was all shared among Limbukha farmers as seed for coming seasons, beside additional seeds were also supplied from research center for further promotion. Commencing this season in Limbukha, many households have started growing MP-3 variety.

5.1.2 Monitoring of Rice transplanting date and its impact on rice yield

Monitoring the effect of transplanting date on rice yield in Dompla was initiated in 2003 with the objective to to see the variation in the yield against different transplanting date and to see the effect of double months on the crop yield, a simple procedure of crop yield assessment through crop-cut exercise from different fields that are transplanted in different water sharing schedule/turns was done.

The assessment was done by selecting farmers and field based on the different water turn and the transplanting dates. At the crop maturity and crop harvest joint assessment was done with participation from extension agent and farmers through crop cuts and collection of farmers' feedback on the assessment (Table 49).

Table 54. Selection of test farmers

Farmers	Water turn and date of transplant	Dates in Julian calendar		Yield (T/ac)	
		2004	2003	2004	2003
1st	10th day of 5th month	27th June	9th July	2.3	1.9
2nd	22nd day of 5th month	9th July	22nd July	1.3	
3rd	4th day of 6th month	21st July	2nd August	1.3	1.7

The result in Table 49 shows that the dates for transplanting in the year 2004 was earlier by 12 days compared to 2003, but the amount of rainfall was better in the 2003 as shown if Figure 7 which delayed transplanting resulting in yield reduction by 0.4 t/ac. As per farmers' feedback, increase in yield is also influenced by selection of field and plots as farmer usually select productive areas for transplanting during their earlier water turn and leave inferior land with sand deposits and less water holding capacity for delayed transplanting. It was also difficult to select test farmers and permanent test plot due to their traditional system of rotating water turns each year resulting in change of test farmers and site.

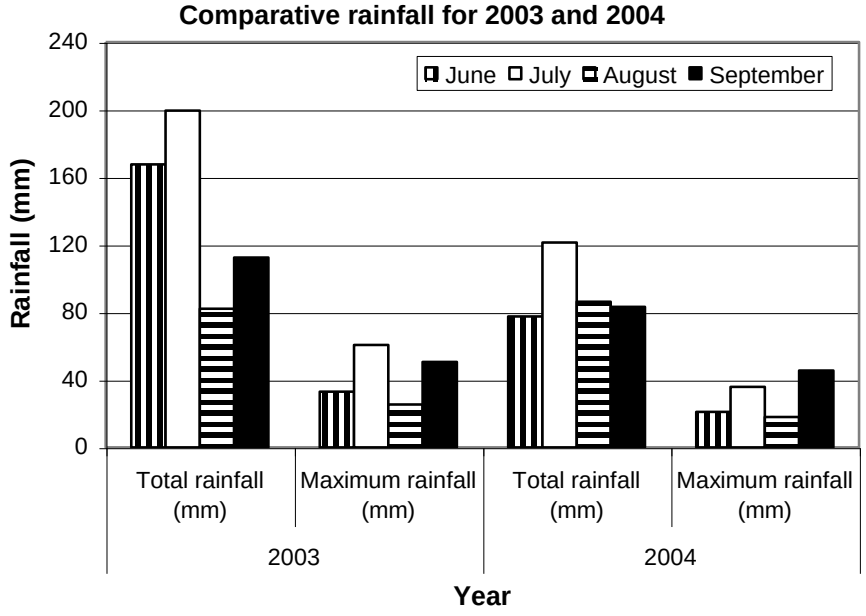


Figure 8. Rainfall (mm) in 2003 and 2004

5.1.3 Demonstration of Intermittent irrigation method for Paddy

This activity is also a continuation of 2003 activity to demonstrate farmers on efficient use of irrigation water for paddy cultivation. It was done to create awareness among farmers on the minimal use of irrigation water to produce optimum and stable yield

since irrigation water shortages during rice season is one of the major problems in Lingmuteychu watershed.

Intermittent irrigation is a controlled method of irrigation, where farmer maintains standing water in field for two weeks after transplanting, then the field is kept without irrigating until it starts cracking, after which they are irrigated again. In this process, some amount of water is saved during the crop season. The process is continued till the crops reaches maturity stage.

Demonstration was conducted with same farmers of previous year (1 farmer each from Dompola and Omteykha) based on their desire to continue collaboration. Monitoring during the intervals of irrigation was done followed by field days, crop-cut and farmers feed back at crop harvest. The result of crop-cut exercise is presented in Table 50.

Table 55. Influence of intermittent irrigation on rice yield (t/ac) in Lingmuteychu.

Farmers Name	Village	Variety	Intermittent irrigated		Normal irrigated	
			Yield (t/Ac)		Yield (t/Ac)	
			2003	2004	2003	2004
Kinley Dorji	Omteykha	Maap Phogom	1.34	1.28	1.50	1.70
Sangay Dorji	Dompola	Reda Machum	1.46	0.94	1.74	1.18
Average yield			1.40	1.11	1.62	1.44

The above result shows that there are no significant differences in the crop yield between the intermittent and normal irrigated fields. Cooperators expressed that control irrigation helped in reducing the *Shochum* pressure. However, controlled irrigation was reported to make thrashing difficult. One of the principle reason for lack of significant difference is due to the fact that traditional irrigation management system in Lingmuteychu watershed resembles intermittent irrigation due to the limited water and traditional water sharing system. However, there is always a tendency to flood the field whenever irrigation water is available in plenty.

5.1.4 On-farm observation trial on intensive hand weeding of *Shochum*

Intensive hand weeding of *Shochum* was done at Wangjokha and Omteykha. Three hand weedings was done at two weeks intervals after transplanting to see the decline of *Shochum* pressure over time and intensity of hand weeding. Weeding was done on the following dates as in table below:

Table 56. Schedule of *Shochum* hand weeding

Farmers Name	Transplanting date	1st weeding	2nd Weeding	3rd Weeding	Harvesting date
Gomchen	29/6/04	12/7/04	26/7/04	9/8/04	11/10/04
Kinley Dorji	23/6/04	14/7/04	28/7/04	11/8/04	30/10/04

Hand weeding of *Shochum* is done for last four years in the same fields. This crop season partial budgeting of the management practice was done to evaluate cost and benefit of intensive hand weeding and recommend for future actions. The details of

the study are reported in the Economics section of this report. The routine weeding was monitored and time and labour required were recorded, at the crop maturity crop-cut was done and farmers' feedback was collected. The results of the crop cut is presented in table 52.

Table 57. Effect of intensive handweeding on rice yield (t/ac)

Farmers Name	Village	**Variety**	**Yield (t/ac)**	
			Weeded field	**Normal weeding**
Sangchu	Wangokha	IR 64	2.8	2.1
Kinley Dorji	Omteykha	Maap phogom	2.2	1.9
	Average		**2.5**	**2.0**

Although there is definite yield advantage of ½ ton/ac from intensively weeded field the partial budgeting analysis do not favour intensive weeding. Economic analysis on the last four-year results indicate that marginal rate of returns (MRR) as 20%, implying that intensive hand weeding is not economically attractive.

Farmers perceived that intensive weeding of *Shochum* in a particular field has resulted in reduction of *Shochum* over time. Reduction of *Shochum* population has largely contributed to minimization of labour requirement by 50-70% for hand weeding compared to intial year.

The other advantages of this weeding over long term will be the incremental benefits, which will accrue from the eradication of *Shochum*. However, eradication has to be a collective action from farmers to do joint weeding and proper disposal of uprooted *Shochum* and hygienic irrigation water management at watershed level.

5.1.5 Private Fruit Plants Nursery Activities

Fruit trees nursery at Omteykha was established in 2002, with the objective to meet the demand of horticulture fruit seedlings of watershed farmers and also to cater fruit seedlings to the neighboring districts and to improve cash income of a farming household.

Technical support was continued from research centre to build the capacity of farmer in managing fruit nursery. Based on the constraint of the co-operator, irrigation facility was provided to improve the work efficiency. The center assisted in marketing of seedling (walnut-120, peach-40, and apricot-20) in Punakha and Wangdue dzongkhags through consultation with District Agriculture Officer.

In 2004 the nursery operator earned cash income from the sale of fruit seedlings amounting to Nu. 11,000. Meanwhile farmers in the watershed have benefited by easy access healthy seedlings produced within the locality which will ensure greater survival rate of the seedlings.

5.1.6 Adoption and development of focus village

Nabchey community in Lingmuteychu watershed is identified and adopted as a focus village to test research technology in a designated area to generate visible impact of

participatory action research and improve farmers' livelihood. Through this approach, activity will be prioritized and emphasized in line with the Ministry of Agriculture's concept of Production, Accessibility and Marketing (PAM).

One-day meeting was conducted between the community members and researchers from the center to review past activities and discuss on the priority opportunities for community development. The joint meeting resolved that farmers of Nabchey based on their interest and knowledge will focus on following activities:

- Soft shell walnut production
- Pig production for group marketing
- Potato cultivation in dry land for cash income

To support the above activities, center supplied 10 to 40 seedlings of walnut rootstocks per household. In total 440 walnut seedlings were planted at Nabchey. In 2004 as a follow up to the distribution of rootstock, field grafting was done with improved soft shell walnut scion.

Against the second activity improved breeding boars were supplied by Dzongkhag Livestock sector. To support the piggery development in Nabchey, RC, Bajo supported construction of recommended improved housing with an objective to study the effect of improved housing on production and performances of breeding boar.

Potato production program was fully supported by Dzongkhag Agriculture extension where the potato seeds were supplied on promotion. As potato suitably fits the existing maize based cropping system people are readily adopting potato as source of cash.

5.1.7 Saving groups

The savings group in Dompola is operating smoothly. All members are benefited from the small savings scheme by availing small loans to meet basic expenditure for children education and purchase of agriculture inputs.

Also the group venture on mushroom production as economic enterprise has started generating income from mushroom sale. In the first year, the group generated a sum of Nu. 6000 as income from mushroom production.

5.1.8 Role play Game (RPG)

Companion modeling through role-play game was conducted in Lingmuteychu watershed from 21st to 25th April 2005 involving representatives from all communities in Lingmuteychu watershed. Participatory workshop was organized with the objectives to enhance understanding of the stakeholder on resource use dynamics at watershed level and to facilitate formation of watershed management committee. This role-play game was a follow up to the RPG organized in 2003 between Limbukha and Dompola, which concluded the need for watershed level management committee.

The workshop concluded with positive attitude from the farmer participants on formation of management committee (detail report published) and the committee formation is in process by drafting the by-laws for the Management Committee. The watershed management committee is planned to be launched by end of 2005.

5.1.9 Community management of bull

The Nabchey community bull is managed by the bull keeper along with the community support. As a compensation for managing the breeding bull, community provides maintenance ration and Nu. 100/household to the bull keeper. The committee maintains the progeny born allowances collected from farmers outside Nabchey village. Through local initiatives, committee has started providing small credit to needy farmers within the community with small interest to let the collected amount grow, which they have planned to expend for purchasing new breeding bull. As of date the bull has serviced 40 cows, of which 26 progenies have born, and this has contributed to increased population of Mithun crossbred cattle in Nabchey.

5.1.10 Case study on CBNRM initiatives in Lingmuteychhu watershed

A case study was done in Lingmuteychhu watershed jointly by Indian research team and RC, Bajo as part of the IDRC supported activity to review and study in details the CBNRM type initiatives in the region. Selected farmers were interviewed and focus group discussions were done guided by a checklist on natural resources management, livelihood enhancement, and equity in resources sharing, technology adoption and impacts of research intervention in the watershed. The consolidated report is in the process of analysis and write up which will be published later.

A write shop was organized in June 2005 with an objective to consolidate and document the experiences and lessons learnt from Lingmuteychhu watershed since its inception in 1997. The report contained the details of the participatory watershed management activities, major achievement and impacts, lesson learnt and the recommendations and way forward based on the experiences. The report is in edition stage and will be published by end 2005.

5.2 Integrated Plant Nutrient Systems (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 Farmer Extension Fertilizer Utilization 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. The effect of treatments on mineral content and removal was not significant for both the varieties; however, within varieties and geogs they 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. This could be due to regular application of Phosphate containing fertilizers. Thus potato may not respond to Phosphorus fertilizer application as much as to Potassium fertilizer. The other indication from the results is Potassium fertilizer needs to be applied regularly with a reduced amount of FYM application.

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 have 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. 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 the removal of K from the soil is permanent. In addition, potato also requires K in large quantity compared to other nutrients. 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.

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.

	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 cut and discussions

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.

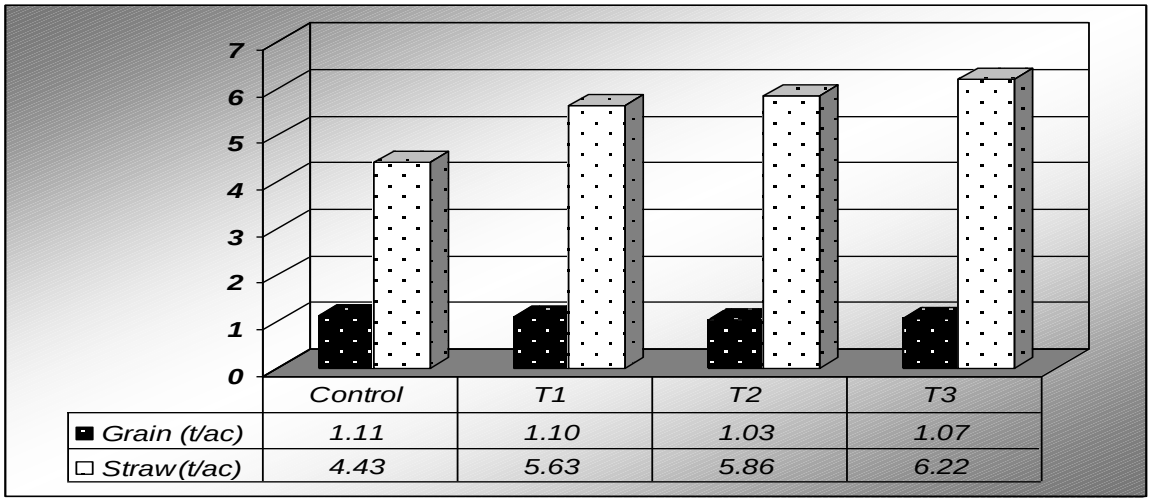


Figure 9. Rice yield as affected by different treatments

Figure 9 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.

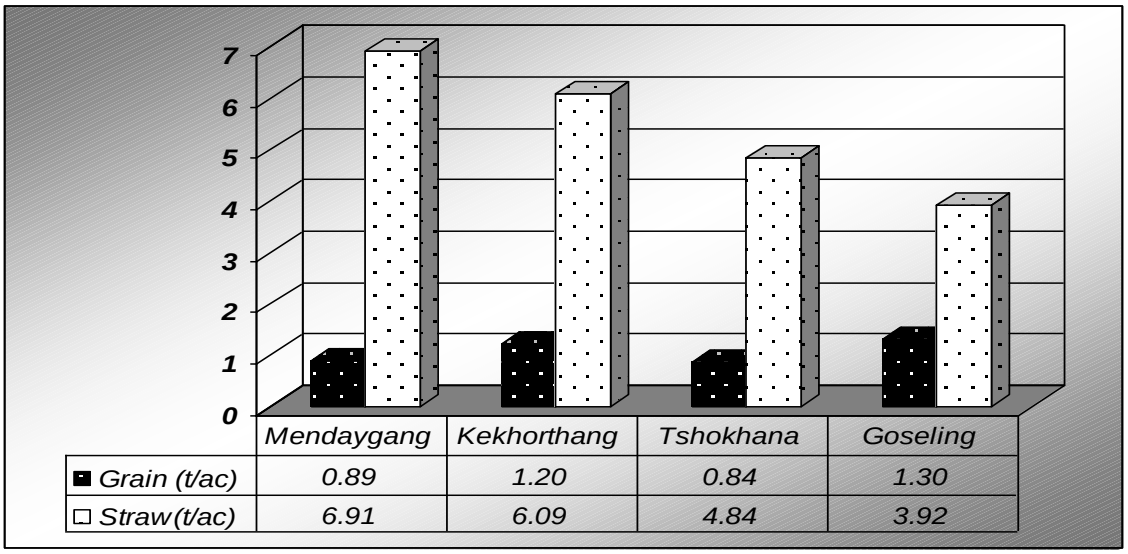


Figure 10. Rice grain and straw yield in four geogs (Grain s.e. = 0.37, cv% = 34 and straw s.e. = 2.2, cv% = 39)

Figure 10 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.

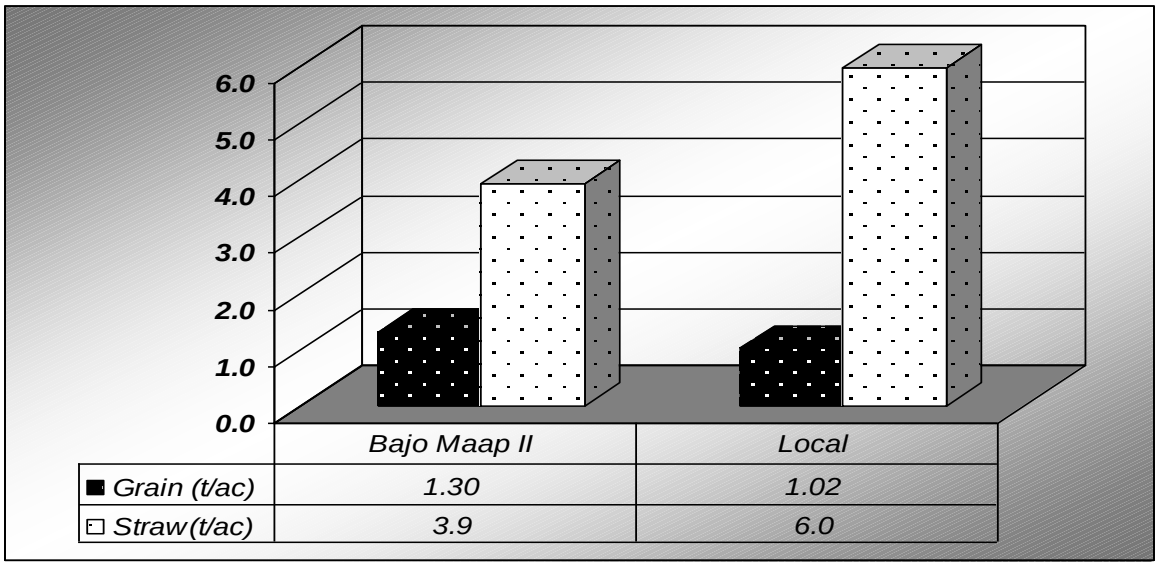


Figure 11. Rice and straw yield of local and improved varieties (Grain s.e. = 0.38, cv% = 36 and straw s.e. = 2.13 and cv% = 38.4)

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 a acidic (Figure 11). 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 12 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.

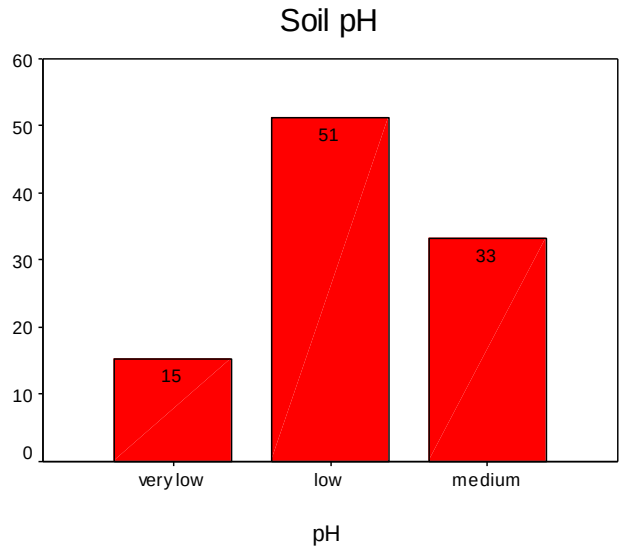


Figure 12. Soil pH of potato fields in Phobjikha

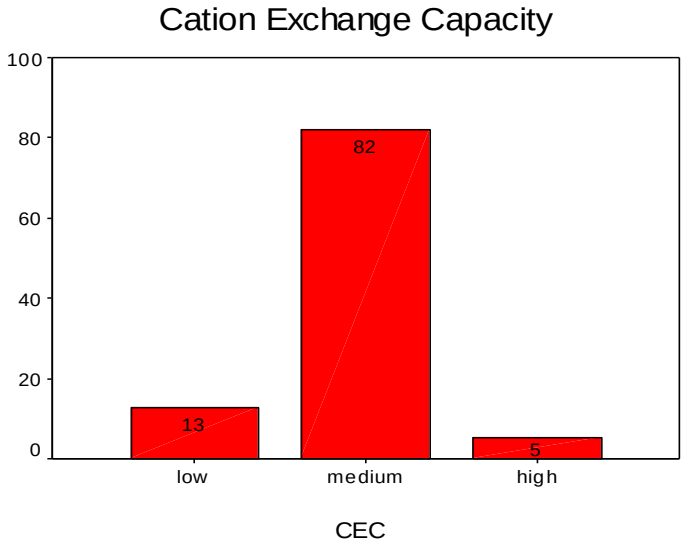


Figure 13. Cation Exchange Capacity of potato fields in Phobjikha

Available Phosphorus [P] shown in Figure 13 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 14 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.

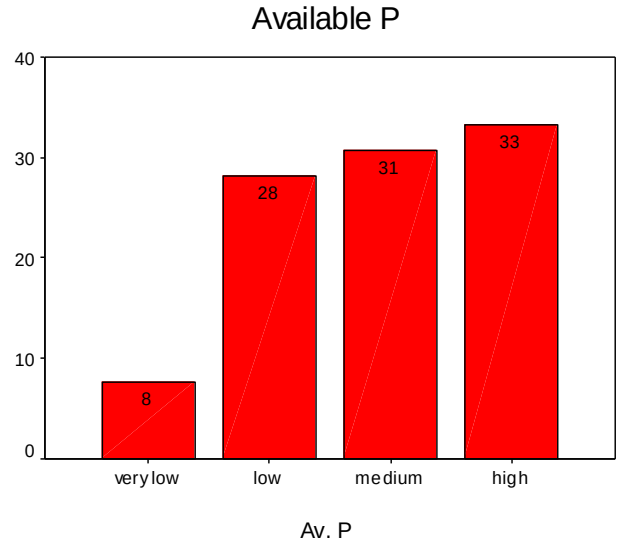


Figure 14. Available P in soil of Phobjikha

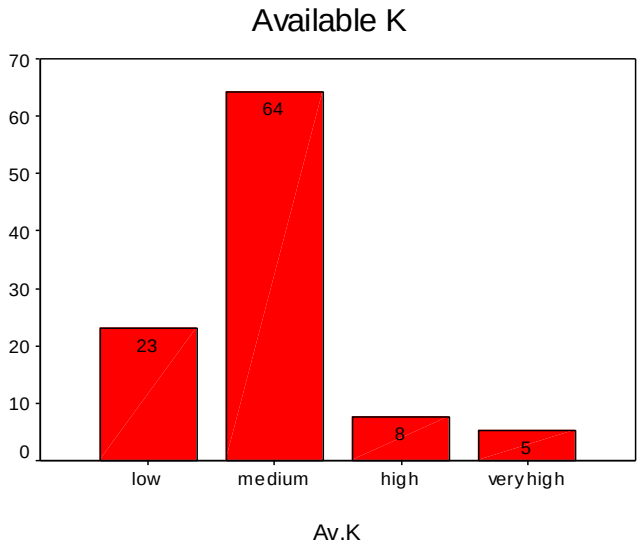


Figure 15. Available K in soils of Phobjikha

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 15). 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.

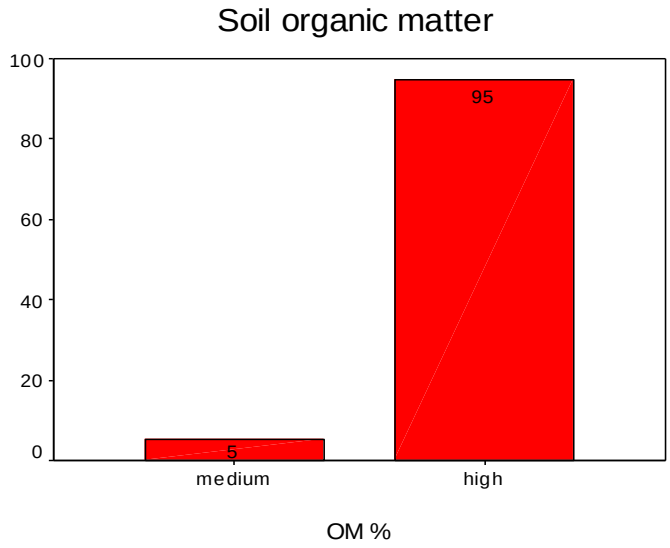


Figure 16. Organic Matter content in soils of Phobjikha

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 53. There were no significant (p = 0.20) differences between the treatments used.

Table 58. 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 main objectives of the WMR program were then to raise the productivity of existing rice-based irrigation schemes through improvements in water delivery. To increase rural incomes by diversifying the range of irrigated crops on wetland as well as on dry land. To rationalise the irrigation assistance program with a view to increase the role of water users and private sector to reduce recurrent government investments in irrigation schemes. To develop water resource management plan and policies for sustaining the resource base to ensure continued livelihood support to the rural community.

In Bhutan, general perception of the water resources is that “water is there in abundance so don’t have to do anything”. Amidst these perceptions a number of research activities like trials, surveys and case studies were conducted to understand the issues with regard to the efficient management of water resources for enhancing and sustaining the livelihood source. Fair understanding has been gained and documented which has formed the corner stone for inducing the formation of new polices (water policy, water act etc) and changing the perceptions on the water resource at least at the policy maker levels. Number of constraints and issues has been identified and put in the right perspective for better management of the resource.

A typical example of point (c), in Wang Watershed – Chhukha Hydropower is hitting lowest power generation every year because flow in the river is always decreasing. This is mainly because most of the rainfall goes as a surface runoff during the rainy season causing floods while only small percentage of rainfall is recharging the underground aquifer which maintains the flow during the dry season. This is happening because of decreasing forest cover as a result of human pressure on the resources.

Apart from little indigenous know-how, there is huge gap in terms of technical knowledge, how our water resource should be managed at national level. Therefore water management research has crucial role of generating adequate information with regards to water resources management to face the future challenges of increasing demand for water for feeding ever increasing population, minimize degradation of watersheds and minimize pollution of water bodies.

Water management research activities implemented can be broadly grouped under watershed, regional, and some civil engineering works. The overview of the activities is presented in the following:

Activities in Lingmutey Chu Watershed

- Resource Management Training for Nabchey Community (Completed)
- Water Harvesting Work in Nabchey (Completed)
- Watershed Level Role Playing Game (RPG) (Completed)
- Lingmutey Chu Watershed Management Group Formation (On-going)
- Study on water resources for Lumpa irrigation scheme (On-going)
- Construction of Rainwater seepage ponds (On-going)
- Plantation (On-going)
- Design, preparation of estimate and construction of Pig house. (On-going)

Regional Activities

- Citrus Irrigation Scheduling (Completed)
- Athang Diagnostic Survey (Completed)
- Participatory Research & Development (Ongoing)

RNR Engineering Activities

- Construction Rice Crossing House (Completed)
- Construction of Ram (Completed)
- RNR Lower Part Boundary Fencing Work (Completed)
- First renovation of RNR Sub-centre Tsirang (Completed)
- Renovation of roofing for RAMC Main Building (Completed)
- Construction of Class Three Staff Quarter (On-going)

5.3.1 Resource Management Training for Nabchey Community

Lingmutey Chu Watershed consists of seven chewogs with a total of 175 households. Rice based-cropping patterns dominate except for Nabchey where maize based cropping pattern is more dominant. Most households have small kitchen gardens. The produce is mostly consumed by the household while small surplus is sold in the local weekend markets in Punakha and Wangdue. Nabchey, is located on the left bank of Lingmuteychu. There are 20 households with a population of 300 people. The village has a steep terrain which does not favour wetland farming. As a result dryland maize based cropping pattern is dominant.

Water scarcity for both drinking and irrigation is the critical issue in Nabchey. Community expressed water scarcity as the main issue that community needs to address. The villagers recall that the drinking water source which was sufficient for human and livestock consumption throughout the season became insufficient by early 1980's. This source which used to be enough for all the households in the village is now sufficient for few households only. The rural water supply scheme established in the mid 70s became defunct because of the dwindling water source. Site visit by WMR team from RC Bajo confirmed that the catchment is under pressure from livestock grazing and other uses. Although there are few big trees within the catchment area there is hardly any undergrowth. Most of the rainfall is lost

as surface runoff with very little seepage that recharges the ground water which forms the source of spring water that comes out during dry season.

Training process described

A three-day resource (focused on water) management training workshop participated by 21 farmers (13 female) was conducted from August 24 to 26, 2004 in Nabchee. The major aim of the training was to facilitate community in understanding resource management concerns. Broadly it was designed with the objective to assess and provide a basis for formulation of resource management plan for the village and for developing a village level institution for addressing the NRM issues; and to build village level resources user association which will form the building blocks for watershed level management committee.

The training program was designed in such a way that people were able to make links between NRM concepts with the real NRM issues in the community. It also favoured an iterative learning process over the three days training program. Every day the program started at 0900 hrs and ended at 1700 hrs with one hour lunch break and two 15 minutes tea breaks. The following sections highlight the daily training program:-

The day started with the presentation of the objectives and an overview of the three days training program. The morning session was dedicated to exploring local concept of natural resources dynamics, how it can be managed to ensure that the resources continue to support their livelihood sustainably. The hydrological cycle was used as an example to demonstrate resource dynamics and links with other resource like forest, soil and the management practices.

Case studies of natural resource managements from other countries and water harvesting case study from Kengkhar, Mongar were also presented. The later part of the day was spent on relating these concepts and case studies to their own situation. To document the understanding of their resources and its dynamics the participants were divided into groups to come up with the resource map. To capture the resource dynamics over time one group was asked to work on the resource condition before 30 years when the Nabchey village has only one household while another group was engaged in resource mapping for the present time. Plenary presentation and discussion emphasised on changes in the resource condition over the years due to human activities. This aimed to help them visualize the future status of the resources if the resources are not managed properly.

Second day started with a recap of Day 01. The morning session was spent on analyzing the NR problem i.e., water scarcity problem in Nabchee. The participants were divided into two groups. Both groups were entrusted with same task. EAs and the NRTI Trainees facilitated the discussion. The group work was presented and discussed in plenary. The objective of this session was to help people

Box 1**: Group Work Guide Note for water scarcity problem analysis**

1. How was the problem in the past (historical trend of the problem)?
2. Why is it occurring?
3. How can it be solved?
4. What are the actions that are required to address the issue?
5. How can NR enhance the livelihood of the people?
6. How do you ensure that the resource based is sustainable?

analyze the problem and encouraged them to develop cause-effect understanding of the relationship in NR system and required interventions.

Field visits organized in the afternoon helped participants assess the resource situation in field and match with problem analysis. Field exercise on yield of few water sources were also conducted to help them visualize flow and its potential if managed properly.

Day three began with a review of some water resource management case studies in the light of the ideas and problem analysis done previously. The problem analysis exercise carried out the previous day was reviewed and verified in accordance with the observations made during field visit. This allowed an iterative learning process with participants given an opportunity to refine their outputs as their understanding through different exercises improved.

In afternoon, participants were involved in action planning in relation to NRM. Emphasis was given to action plans that are likely to happen in next few years. The participants were divided into two groups for this action planning exercise. Group one was composed of those households who needs immediate support in addressing their water scarcity problem and group two are the ones whose water scarcity problems are not so severe as compared to group one participants. Both groups had common activities like formation of resources user group, drawing up of NRM plan, development of household water harvesting system and vegetable cultivations that need to done as part of the action research by RC Bajo.

The training has increased the understanding of the participants on natural resources system and its dynamics. The participants expressed that they are now in a position to make relations between specific resource problems (water scarcity problems) with general problems (degradation of forest resources).

Text Box 2**: Guide questions for Action Planning**

- *Hard & soft system development*
- *Hard System/Infrastructure Development*
  a) Detail Surveying
  b) Material transport
  c) Field work
- *Soft System Development*
  a) Formulation of resource management plan
  b) Formation of institution
- *Enhancing the livelihood of the people*
  a) Vegetable production
  b) Irrigation of fruit trees

Resource Mapping & Problem Analysis

The resources maps produced by the group work were displayed and discussed on the changes over the thirty years. Table 59 summarizes these differences. This enabled participants to understand current resource situations, changes over time and the reasons for these changes thereby assisting participants to visualize resources condition in the future with and without adopting proper management strategies.

Table 59. Comparison of resource status in Nabchey

Parameters	Past (1970s)	Present (2004)	Remark
No. of household	1	20	Mostly retired
Forest cover	High	Decreased	army
Forest quality	Good	Declined	
Wetland	2 plots	2 plots Fallow	
Yield of spring sources	Good	Declined	

Exercise on water scarcity problem analysis helped participants to critically evaluate and consider the problem not just in isolation but in relation to other resources and consequence of human actions. Participants attributed water scarcity problem to decline in forest resources as a result of increasing pressure exacerbated through increasing population in the village. There was also an agreement that water scarcity problem may not be merely due to the increasing demand on water and that there was a need to have community resource management strategies to ensure that their resources continue to support their livelihood system. There was also an indication that a local institution to implement resource management plans needs to be developed in future.

During the field visit participants conducted the flow measurement at two household and two water sources. The results are shown in the following Table 55. Participants were asked to estimate the quantity (yields per day) of water at each source. Based on the water requirement for a person per day of 50 litres, participants were asked to estimate the number of people each water source can supply.

Table 60. Water flow measurements in different sources in Nabchey

Source	Date Measured	Flow (l/s)	Yield (l/Day)	Sufficient for*	Remark
Yanka-tsheri	28.2.01	0.15	12960	259	Proposed new source
Nabchee Chu, A	28.2.01	0.10	8640	173	Old existing Intake
Nabchee Chu , B	28.2.01	0.20	17280	346	Downstream
Uden	25.7.04	0.05	3910	78	Tap stand
Samdrugang source	25.7.04	0.56	48539	971	Nabchee Chu (downstream)
Aap Namgay	25.7.04	0.02	1452	29	Tap stand
Yanka-tsheri	25.7.04	0.18	15233	305	Proposed new source

* Based on the water requirement of a person per day of 50 litres

During the field trip participants visited 9 water sources of which seven were already being used by communities for drinking purposes. Yanka the current water source, one of the remaining two is being proposed by 8 households in Nabchey as their new source.

Most of the participants have not visited all water sources before. Few sources were developed recently with support from Dzongkhag and there are conflicts over these sources as the downstream flows are already being used by others either for drinking or irrigation purpose. Such issues have to be resolved through a local institution. It was noticed that newly developed water source intakes had properly constructed intake boxes which were termed “chu-yee-ka-sung-chop” or water source protection. The local understanding of source protection was only limited to protection of spring outlet only.

The final day of the training was kept aside for action planning for the future and focused on a balance of hard and soft system. Hard system includes the development of water harvesting system while the soft system refers to such aspects as formulation of resource management plans, development of local institution and development of a strategy to enhance their livelihood (Table 56).

Table 61. Components of hard and soft system development in Nabchey

A: Hard System	
• Community water harvesting system • Water source catchement protection (fencing) • Intake tank • Common reservior, • Water distribution networks	• Household water harvesting system • Household tanks • Tapstands • Rooftop rainwater harveting system • Household ponds • Drip irrigation system
B: Soft System	
• Community Resource Management Plan • Local institutions for NRM, marketing of fram products and any other community related activities	

Formulation of Resource Management Plan

By reflecting the status of NR in past, present and looking to the future participants felt the need to have resource management plans to ensure sustainability. The management plan would ensure that resource utilization is in balance with the regeneration capacity of the resource system and encompass a holistic approach to make sure that natural resources dynamics are not affected.

Agreement on Water Harvesting System

In view of unimodel rainfall pattern, more than 90% percent of the rainfall occur during July to September leaving rest of the year fairly dry. Under such rainfall conditions, areas at higher altitudes and along the ridges face water shortage problem during dry season. Local people refer to this as "*shallow catchments*". On the other hand degradation of catchment leads to similar water problems. These can be minimized by harvesting and storing the rainwater.

Water harvesting system is a means through which water resources can be managed to address water shortage problems. Some of the actions to sustain water sources are water harvesting infrastructures (intake tanks, common reservoir, household tanks & pond, distribution pipelines), and household rainwater harvesting system, resources management plans and the local institutions from the water harvesting system.

Role of Community

The community is the main stakeholder of the proposed water harvesting activity. This community based approach has the following characteristics:

Activities are community led, owned and to an extend community funded/supported. Researcher only help community to source external support when the local resources are not adequate to achieve the action. To support the hardware

component (road for marketing, water harvesting infrastructure for water resource management, irrigation infrastructure for crop production) there is equal need to support software components like (management plan, by-laws and institutions are important). The approach places high priority to capacity development of the local institutions to ensure sustainability. The activity thus is not a 'one time' intervention, but a process approach whereby peoples' capacity is enhanced. The approach is holistic, with decisions made based on the real dynamics on NR system within the community area.

In case of water harvesting activities, community identified the components which community will be able to contribute and also indicate the support required from other (Table 57).

Table 62. Community contribution in water harvesting activity

Components Activity	Contribution		
	Community	ESP	RC
Hard System Development			
Intake tanks (2 Nos)	70%	30%	
Common Reservoir	70%	30%	
Household Tanks	70%	30%	
Tap stand	70%	30%	
Household ponds	90%		10%
Pipelines	20%	80%	
Catchment protection	30%	50%	20%
Soft System Development			
Management Plan	50%	30%	20%
Local Institution Development	50%	30%	20%
Implementation of Mgt. Plans	90%		10%
Enhancing livelihood	40%	30%	30%
Monitoring & Evaluation	50%	10%	40%

Feedback and learnings from the training

The participant's feedback indicated high relevance of the training. Results of the feedback point out that majority of the participants found that the training is educative, relevant to their situation and useful for addressing the community's problem. The training also increased the trainer/facilitators understanding of the local situations, people's perceptions on the resources, number of conflicts over the drinking water sources within the community, local definition of water source protection, the degree of community cohesion etc. Such in-depth understanding is crucial for developing appropriate strategy to work with the community in addressing their NRM issues.

The training revealed that farmers with some facilitation are able to understand complex resource interactions and develop strategies to overcome their problems. This supports the universally accepted (but seldom implemented) fact that local development actions should emerge from communities and not by some development vanguards (however good the intentions maybe). There should be a heavy focus on not only decision making by farmers but also enabling them to carry out these decisions.

5.3.2 Water Harvesting in Nabchey

Nabchee is a small village under Limbu geog located on the left bank of Lingmuteychu a small tributary of Puna-tshang Chu. The village is one of the seven Chiwogs in the Lingmutey Chu Watershed. The village has 20 households with a population of 300 people. Except few pockets of paddy fields, maize-based dryland farming is dominant in the village mainly owing to the steep terrain. Except for one household, the people of this village are all from eastern part of the country. Most are retired army personnels. They were resettled in Nabchee in 1960s.

During the diagnostic study of the Lingmutey Chu Watershed (1997), Nabchey Community had expressed drinking water shortage as the main problem. The rural water supply scheme established in mid 1970s became defunct because of the dwindling water source. Site visit by WMR team from RC Bajo confirmed that the water catchment area is under pressure form livestock grazing and receding forest cover itself. Although there are few big trees within the catchment area there is hardly any undergrowth. Most of the rainfall is lost as surface runoff with very little seepage that recharges the ground water. Villagers recall that drinking water source which was sufficient for human and livestock consumption throughout the season became insufficient by early 1980's. One villager mentioned that the source was big enough to wash cloth in the past and now it is not sufficient for drinking even. An elderly villager commented that he has seen number of water sources drying up within his life time in the village.

The resources mapping and analysis during the resource management training has helped the people to better understand the resources dynamics in the village. They are able to see how the forests cover has reduced since the beginning of the settlement and how this has impacted the productivity of the water. Another villager argues that water sources have dried up due the earthquakes in the past. In general most villagers agree that reduction of forest cover has resulted in the low yield of water from the catchment. An elderly villager remarked that the present cultivated areas used to be forest in the past, hence it is possible that dwindling water resources is due to decreasing forest cover.

The rationale of the water harvesting activity was to build local capacity to holistically manage the resource base for water productivity through a cost sharing mechanism. This was done with intention of building the local ownership of the infrastructure and to build the capacity of the villagers to manage the system in future in terms of carrying out routine maintenance work. This water harvesting activity is focused more on the holistic system development. For instance holistic approach starts from (1) the management of the water source, (2) harvesting, conveyance, storing and sharing system development, and (3) building the capacity of the local community to enhance the understanding on the NRM.

The specific objectives of the water harvesting activity were:-

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

The RC Bajo provided all technical support in terms of facilitating planning and implementing the water harvesting activity in the village. The field work was planned to be completed within two (January to February 2005) months period. Yangkha-thseri and Nay-ta which were nearest to the village were selected for implementing water harvesting activity. Following the training workshop, a field survey for aligning the pipeline, location of common reservoir, household tanks and tap stands was done. Accordingly RNR RC Bajo prepared technical estimate, source fund, provided technical support and facilitated the development of management plans.

RNR RC Bajo secured fund support of Nu.234,293 from RNR ESP Project. The cost included the cost of pipe, cement, barbed wire, CGI sheet, nail, pipe work equipment, sand and transportation up to nearest road head. The local transportation was done by the community. More than 90% of the transportation was completed by December 2004, before the initiation of field work.

The field work was started by January 2005. The field works were phased into two stages. The first phase included the works that did not require skilled labour and can be done by the community themselves. These works included clearing of bushes, collection of stones and fencing post, trenching and earth excavation works. The second phase was mainly cement construction work which required skilled masonry and plumbing works. As such RC Bajo provided two skilled labours to carry these works. Construction of tank was completed by early April 2005

The village has a primary water harvesting infrastructure for harvesting water from two small sources and storing it for drinking and irrigating vegetable crops. The existing two sources which now benefits two households are also being managed by respective households. The village at present has a total of four small sources. It has one common reservoir with effective capacity of 10,000 litres in addition to individual household reservoir with effective capacity of 1,152 litres. The total drinking water storage capacity in the village is 18,000 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 if 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 vegetables 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 purposes using water efficient irrigation technologies.

In the first week of the field work there was 100% labour contribution from every household and work progressed as planned. The village leader maintained a register for labour contribution. All households contributed daily one labour each and some days even more than one labour.

The village headman conducted most of the village meeting during night. This was done to enable all the villagers to attend as they are busy during day time working in the field, guarding crops, herding cattle and attending to other important chores. Chiwog Tshogpa mentioned that conducting meeting during night is ideal in terms of getting 100% participation, and all the participants are villagers themselves. But this is always not possible if there are participants from outside.

Nabchey had also received the plan budget for revamping the defunct drinking water supply from Punakha Dzongkhag. However, RNR RC Bajo had already secured fund support from RNR ESP for the same purposes, the villagers had decided to give the

Dzongkhag budget support to neighbouring villages under Nabchee Chewog. The other work was completed about two months later. All the households in Nabchee Chiwog now have access to water for drinking and kitchen garden.

The physical estimated cost of the water harvesting activity was Nu. 418,642. The details breakdown of the cost is presented in the Table 58. Although the physical contribution by community is 44% of the total cost, this percentage will be much higher if social and opportunity costs are accounted for. The above costs do not include the technical and administrative cost covered by RNR RC Bajo.

Table 63. Total physical cost of the water harvesting infrastructure development in Nabchey.

Name Work	Quantity	Cost (Nu)			Remarks
		Community	ESP	Total	
Intake tank	2 No	6,492	10,928	17,420	
Common Reservoir (10,051 litres)	1 No	19,418	17,088	36,506	3.2x3.2x2.1 m3
House tank (7No x 1152lit = 8,064litres)	7 No	65,629	77,947	143,576	1.2x1.2x1.0 m3
Tap stand	8 No	14,323	17,765	32,088	
Pipeline	2630 m	53,785	101,405	155,190	
Intake protection (2 x 900m2 = 180m2)	2 No	24,701	9,161	33,862	
		184,348 (44%)	234,294 (56%)	418,642	

Although the actual completion of field works was delayed by one month, the villagers are more than happy that the water shortage problem is addressed in the village. Living 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 encountered by our fellow villagers in their day to day life.

In a farm labour shortage scenario, the policy of inculcating ownership for development projects although appears as a approach, it 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 look after cattle.

5.3.3 Watershed Level Role Play Game

This section highlights the four days of participatory workshop conducted in Tshochagsa in 2005. The workshop was aimed at enhancing the understanding the dynamics of NR at watershed scale by the local stakeholders, to forge a forum for addressing this complex cross-cutting NRM issues for developing better management strategies for the benefit of present and future generations. The workshop used Ecole-commod approach "Role Playing Game (RPG)" as a tool for understanding the socio-physical dynamics in the past, present and future. Based on these enhanced understanding by the people it was possible to develop strategies and action plans for addressing the NRM issues in the Lingmutey Chu Watershed.

The conflict on irrigation water is a perpetual concern in a 34Km^2 Lingmutey Chu watershed. The demand for water is increasing every day. The increase in demand was further aggravated by decline in water discharge and stream flow.

There also exists a case of up-stream and down-stream conflict in water demand. Irrigation water shortage during the rice transplanting season is the major constraint in the watershed. Past studies confirmed that seasonal water scarcity in the watershed is the consequence of a rigid traditional management practices. The water use efficiency is very low both at farm and system level. Water balance study indicated that the water resource in the watershed is adequate to meet the current demand if better management practice is adopted. However, strong traditional rights in the watershed prohibits introduction of any new management practice to be adopted specially in terms of sharing resources based on equity and efficiency. It also prevents any improvement of canal conveyance which is less than 50%.

In 2002, when the research to improve irrigation water sharing in Lingmutey Chu was conceived, Bhutanese researchers[10] attended training on Multi-Agent Systems and NRM in Chiang Mai University, Thailand. This training provided an opportunity for the Bhutanese researchers to identify Companion Modelling process as one of the tools for the NRM research. The companion modelling aptly suited the context in Lingmutey Chu as there was a clear need for joint learning to decide on future courses from the acquired knowledge. The companion modelling approach used in Lingmutey Chu is predominantly the Role Playing Game (PRG) played by community members of 7 villages over 4 days.

Companion modelling process in Lingmutey Chu began in May 2002 when first RPG was organized in Dompola. The first RPG was played by 6 players each from Limbukha and Dompola. The workshop revealed that sharing water by Limbukha in exchange to labour from Dompola was a potential strategy. All the players contemplated that the presence of Geog development members, Chusup (village irrigation guard) of all communities in the watershed, and District officials as observers of the process and the outcome will assure the relevance of the findings. It was also suggested that their presence will also make them aware of the issue and their role in the process.

Consequent to the above suggestions, a second RPG was organized in Tshochasa in December 2003. While the basic frame of the game was maintained, some features like labour component was included in the new game. Same 12 players attended the workshop and played RPG in presence of 12 observers[11].

[10] Tayan Raj Gurung and Thinlay Gyamtsho
[11] Gup, Mangmi, Clerk, 7 chusups, District Agriculture Officer, Planning Officer, PPD.

Some of the critical findings of the two RPGs are that: (i) RPG effectively facilitated self-motivating and non-confrontational interactions among the players; (ii) farmers knowledge and understanding of water sharing increased significantly between two RPGs; (iii) exchange protocols influenced water use and income more than the rainfall pattern and social networks; and (iv) collective mode of communication facilitated in better and frequent exchange of water.

The December 2003 RPG was remarkable in the intervention in Lingmutey Chu watershed. It can be considered as a step forward in the mediation process of developing efficient water sharing system. The two noteworthy proposals of the workshop were (i) Limbukha will release irrigation water 5 days earlier then on the 10th Day of the 5th month of Lunar Calender, and (ii) constitute a management committee at watershed level to promote and oversee the watershed management activities.

Year 2003 came to an end with high expectation of people being reasonable and sharing whatever they have. In May 2004, Dompola farmers approached to Limbukha people to discuss the change in water release date. To everyone's surprise, the Limbukha Tsogpa acknowledging that the issue was discussed and resolved, demanded the legally signed agreement following the resolution in December. As the news spread fast, RNRRC Bajo as a facilitating agency also made an effort to convince the Limbukha Tsogpa who stood firm in his claims. Thus the traditional system prevails and Limbukha farmers continue to exercise their traditional rights over water.

However, this denial was the principal lesson for the researchers and for the people themselves. If only we had made an effort to get signature of the members on their consensus, we would have made some progress.

Following to the recommendations of the 2003 RPGs, RNRRC planned for yet another RPG called "***7 villages Game***" in 2005. The game was intended for 7 villages[12] of Lingmutey Chu watershed. Each village was represented by 3 members. These 3 players per village were Village representative (Tshogpa), Chusup (Village water guard), and a farmer (active irrigator). They were selected based on the following requirements:-

- Person knowledgeable about the irrigation canal, water sharing systems and issues related to systems operations (Chusup),
- Person who is knowledgeable about the village in general, development needs and constraints, and has a decision making role in the village (Tshogpa), and
- Person who is an active farmer knowing about the issues related to irrigation water and rice cultivation (irrigator).

The specific objectives of the role play game are:-

- To facilitate exchanges among the 7 villages regarding NRM at the watershed level
- To enhance the understanding of the stakeholders and of the resource use dynamics at the watershed level

[12] Limbukha, Dompola, Nabchee, Omteykha, Matalunchu, Wangjokha, and Thangu.

- To accompany the creation of a Watershed Management Committee in Lingmutey Chu
- To define the next steps toward the establishment of a formal WMC before late 2005 and to plan several short-term priority actions in NRM

A generic game representing the watershed was used where 3 players each from 7 communities participated in the game. The process was facilitated by 7 group facilitators, 2 game facilitators, 4 observers and 1 overall coordinator was engaged during the game. The workshop lasted for 4 days, structured into first 2 days for RPG, day 3 for interview and discussion, and the preliminary results and workshop recommendations were presented to all the participants on 4th day. The workshop process can be summarized as follows.

The workshop started with general briefing, explaining the objectives of the workshop. The process of the game was also explained in detail. To provide a technical explanation on watershed from hydrological perspectives, an overview of the hydrological cycle and the concept of watershed were presented.

Three modes of communication (Individually-village wise, collective with flow of excess irrigation water, and collective decision on water sharing) were played.

Players were assigned to their respective villages, and explained of their roles as irrigators. 1 facilitator was attached to each group.

On day 1, five rounds of individual mode were played, where players were allowed to discuss and exchange water exclusively within their group.

In the afternoon of Day 1, 5 rounds of collective mode with flow of any surplus water were played.

The second collective mode was played on Day 2. During late afternoon of Day 2, the report drafting team (mangmi, clerk of Gup, some voluntary farmer representatives, District officers, Extension staff and researchers) brainstormed on the development of watershed level management committee,

On Day 3 the Tshogpa of 7 villages, gup, mangmi, dungyee, District officers, Extension staff and researchers were requested to report. Each community members present on Day 3 was interviewed on their views on the RPG and the process. Following the interview, the group deliberated on the Lingmutey Chu Watershed Management Committee.

The preliminary result of the RPG and recommendations of the group discussion were presented to the plenary on Day 4.

Water Used: While the water share per village varied with the weather type the use depended on the units used and sharing mechanism used in the game. The RPG result indicates that there is more influence of communication mode (M) on the water use than the rainfall pattern. Most players reported several times that the shortage of water is only related to rainfall pattern. The people have been sceptic on any suggestions made to improve the water situation. In the RPG, even when there is severe rainfall, collective communication mode only ensure equal water share among all villages. More rainfall did not provide more water for Dompola village which is always in shortage. Instead Dompola benefited more by collective management when rainfall was still wet.

Water Sharing: The individual mode of communication did not promote water sharing. Similarly during the dry season (lowest rainfall) there was no sharing reported. In the game, water sharing was recorded in collective and swapped collective in three rainfall pattern except in dry season. Maximum sharing was found when Rainfall was severe and in swapped-collective communication mode. This was expected as players in swapped roles had better opportunity to interact and bargain for the excess water. Considering the interactive communication in swapped mode, both bargaining power and exchanging process was facilitated.

Income: After every game the players were paid income gained by cropping their plots by using water share. In all three cases of communication modes, on an average Limbukha village generated 34% higher income than other villages. The highest income difference of >80% was observed between Limbukha and Dompola village in individual and collective mode. Interestingly income of Dompola in Swapped collective mode increased by 37% compared to other two communication mode. While there was no distinct influence of communication mode on income of Limbukha, Collective mode in Nabchee, Omteykha, Matalumchu, Wanjokha and Thangu helped to raise income by 8% to 14%. Overall, Collective mode of communication which promoted free exchange of goods and services, led to higher income in most villages.

On Day 4, prior to start of planned presentation of the workshop result, participants were asked to rank the best RPG mode that will help to address the NRM issues in the watershed through a secret ballot. The final presentation of the preliminary result was done by Mr. Gyembo Dorji, ALEO of Limbu Geog. The day started with presentation of the RPG results followed by the discussions results of previous days. It was followed by final drafting and adoption of the pledge by the participants to work towards achieving common vision for the watershed. The workshop ended in a high spirited mood with series of closing remarks by the Chairman of Limbu GYT, Dr. Guy Trébuil, DAO, DLO, Thinlay and finally by the facilitator of the workshop.

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 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.

Table 64. Action for next 7 months

Activities	How to implement	Who	Time frame		Location
			Start	End	
Appointment of village drafting committee representative	Concerned villages	Village Tshokpa	23/4/05	30/4/05	
Name list submission of drafting committee	Village Tshokpa	Limbu Gup and other 2 villages Tshokpa		30/4/05	
1st meeting to institute Lingmuteychu Watershed management Committee	Village committee representatives	RNRRC Bajo	13/5/05	13/5/05	Tshochasa
2nd Meeting	Village committee representatives	RNRRC Bajo	21/7/05	31/7/05	Tshochasa
Selection and nomination of Chairman and members	Village Tshokpas		Within 31/7/05		
Awareness on outputs of the workshop	All members	RNRRC Bajo	23/4/05	Within 1 month	RNRRC Bajo
Presentation of the final draft of the by-laws	Plenary (or workshop)	Drafting Committee	November 05		
Monitoring and Evaluation	Collective	RNRRC Bajo			

To ensure nothing is left to chance, the floor also adopted the pledge to work towards the common benefit not only for the present generation but also for many generations to come.

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s,leh,jMYs,ly,hGU,ry
,nIs,jY,hK_Y,'Ij,lku
d,j_Y,;Y,hUf,NIsh,C"
YYh,fs,hI'Y,jNyh,jI,
hK_Yf,gy,a´k,ayjh,C"

Pledge

We the people of seven villages within the Lingmuteychu watershed, collectively agree with loyalty and dedication to manage the natural resources and watershed for the present and the future benefits.

Box 1. Pledge to collectively manage the water.

Besides committee formation and drafting of constitution and byelaws, the workshop participants planned three collective actions as an out come of the workshop, which will be implemented immediately and these activities are:-

1. Planting of trees saplings at water sources: Understanding the dynamics and relations between forest and water, the participants felt that it is necessary to protect the spring water sources to improve ground water recharge and improve

volume of stream water. The participants unanimously agreed to plant tree saplings at water sources collectively but at individual village level.

2. Rehabilitating 7 acres of abandoned wetland 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 reached to the field had led farmers to left land fallow. The participants assured that the abandoned will be rehabilitated through collective action, which will be leaded by the village head (Gup).
3. Conservation of surface water run-off through check dams: An irrigation water shortage during rice transplanting was major issues for the farmers of Lingmuteychhu watershed. During workshop and also during individual interviews, it was revealed that irrigation water availability depends on the amount of rainfall. If there is good rainfall, good amount of water flows down the stream to the fields and then to river below. To check this surface water run-off during monsoon and to harvest this monsoon rain water, the participants agreed to make/construct small water reservoirs like ponds, check dams etc. in each villages for it will help in recharging the ground water and shall be used during water scarce season.

To better understand the process monitoring for next 6 months was agreed which will terminate with launching of the management committee. In November 05 which coincides 6 month after RPG, a workshop is planned to present the by-laws and launch the committee.

Role-playing game provided the opportunity for 7 villages to express their problems by using the game as a means to communicate. It also helped people to envision the future through different scenarios of communication modes and weather types. In general it enhanced the overall understanding of the people on the natural environment thereby enabling them to make rational decisions with regard to the NRM in future.

In view of the ever increasing conflict in natural resource use, there is an urgent need for an approach which can facilitate the process of participatory conflict resolution which can fortify the social capital to sustain the natural resources to perpetuity. This seems possible as RPG builds on collective learning and cross-fertilization of ideas to make collective decisions. As RPG promotes spontaneous actions (behaviour) of the players, there is no confrontation; rather very dynamic deliberations were observed which lead to collective decisions or co-creating the actions, thus promoting community mobilization.

The Ecole-Commod is a process oriented approach, which demands careful and continuous monitoring of actions and changes thereof. Therefore, to accurately validate the process of transformation from individualistic community to a collective process oriented community, continuous joint monitoring tools should be applied.

There is an explicit progression from the 2003 RPG when only 2 communities of Limbukha and Dompola considered localized actions for this widespread problem of irrigation water. Since RNR Research Centre, Bajo initiated its intervention in Lingmuteychu watershed in 1997, communities have gone through series of

discussions and workshops, and now in 2005 they have attended the stage to consolidate their concerns to institute watershed management committee. Such progression, although steady, needs to be recognized for relating it to mainstream programs like land management campaign and CBNRM.

5.3.4 Diagnostic Survey in Athang

As a follow up to Athang visit by H.E Minister of Agriculture, diagnostic survey was conducted in last week of April 2005 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. 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 survey was done in 7 villages of Athang by two groups consisting of six members each. Some of the tools used were resource mapping (past, present and future), group discussions, interviews and transit walks. At least one member from every household in the Gewog participated and expressed their views during the discussion in each village.

The study revealed that people are generally resource poor with limited landholdings, scattered settlements, poor access to market (no farm road), poor access to extension and development support. They also have poor access to health and education services. The study resulted in series of research, extension and infrastructural development activities of the geog. The complete report is published as an independent report.

5.3.5 Civil Engineering Works

Besides the mandated research works the sector also provide engineering services for RNR RC Bajo and RAMC. The engineering works includes the design, drawing, preparation of estimate, contract management, implementation, site inspection and reporting. Total of nine engineering works was implemented by the sector of which seven have been completed. From the remaining two, one is under implementing stage while the other one is yet to be implemented. As more than half of the sector's time was devoted in implementation of capital work it undermines the research output of the sector. Table 61 provides list of activities implemented during the financial year with their status and cost.

Table 65. Civil engineering activities undertaken by WMR Sector

Activities	Cost (Nu)	Remark
Construction Rice Crossing House	272,056.35	Completed
Construction of Ram	92,377.45	Completed
RNR Lower Part Boundary Fencing Work	785,598.14	Completed
Renovation of RNR Sub-centre Tsirang	901,834.00	Completed
Renovation of roofing for RAMC Main Building	335,000.00	Completed
Construction of Class Three Staff Quarter	2,536,296.00	On-going
All the routine maintenance work for RC Bajo	80,000.00	Completed
Design and estimation of Bore Pen for Nabchee	0	Completed
Preparation of estimate for renovation of Samthang Irrigation Canal	0	Completed
Total Cost (Nu.)	5,003,161.94	

5.4 Agricultural Economics

5.4.1 Cost of Mungbean Production at Drujaygang, Dagana

Mungbean is an important crop with regards to its high nutritional and market value. Despite its importance, very little locally produced mungbean is marketed. Its current market price is Nu 40 per kilogram. Locally there are yellow and black mugbean grown by farmers. Mungbean is cultivated in dryland as single crop or as intercropping in the mandarin orchards. In some areas it is also cultivated in paddy bunds.

In view of its importance, a simple economic analysis was done in Drujaygang, Dagana to determine cost of producing mungbean and profitability in farmer's field. 19 mungbean farmers (which represented 25% of mungbean farmers) were interviewed using structured questionnaire. Interview data was analyzed in MS-Excel spreadsheet.

Labour, material and draught power cost

Farmers mostly use household labour for mungbean production activities. Exchange labour for weeding and threshing. The opportunity cost of household labour and exchange labour was valued at 75 percent of hired labour cost which is calculated @ Nu.50 per day per person. The average labour cost per acre is found to be Nu 3725. This includes land preparation, sowing, weeding and earthing up, harvesting, crop guarding, threshing and drying. The only material input used is seed, which costs Nu 495 per acre. The seed usually kept by themselves. Other material inputs like FYM, urea, suphala etc were not used. Draught power cost per acre is calculated at Nu 1287. Labour was the main cost component. It comprised 68% of the total cost, followed by draught power (23%). Material inputs costs make only 9% of the total costs.

Analysis found that it costed Nu. 5507 to produce 1 acre of mungbean. Considering the average yield of mungbean as 383 kg/ac, it would cost Nu. 14.41 to produce a Kilogram of mungbean.

Most of the farmers interviewed sell their entire produce to wholesaler at farm only. The farm gate price of mungbean was Nu 20/kg, which means farmers getting a net profit of Nu 5.59/kg, which is Nu 2134 per acre.

Therefore it can be concluded that mungbean growing is a profitable venture for the farmers in Drujaygang. With the prevailing market price of Nu 40/kg, we can safely assume that mungbean is a profitable crop even after adding the marketing costs.

5.4.2 Partial Budgeting of intensive hand weeding of *Shochum*

Partial budgeting of intensive hand weeding of *Shochum* in rice field was done to compare costs and benefits of *Shochum* intensive hand weeding, and to map recommendations for adoption of the technique.

Two farmers were selected from mid altitude area for this study. Small plots selected and continued weeding for four years; data from these plots were used. Data (Table 62, 63, 64) collected through crop-cut and Socio-economic data (labour inputs, prices) are from on-going survey in the area. Some of the assumption used in the study are, Extra cost for threshing – Nu.1 per 10 kg; Extra cost for milling – Nu.6 per 10 kg; and Opportunity cost of labour as Nu 100/day.

Table 66. Rice yield (t/ha) over four years

Year	Intensive hand weeded	Farmers Normal practice
2001	5.78	4.15
2002	5.95	5.21
2003	6.21	5.10
2004	6.10	4.85
Average	6.01	4.83

Table 67. Difference in grain and straw yield (t/ha) over the years.

Year	Yield differences (T/ha)	Difference in straw weight (t/ha)
2001	1.63	1.15
2002	0.74	1.15
2003	1.11	1.15
2004	1.25	1.15
Average	1.18	1.15

Table 68. Extra costs, extra benefits and total net gain (Nu/ha)

Year	Total extra costs (a)	Total extra benefit (b)	Total net gain (a-b)
2001	16600	19560	2961
2002	11071	8880	-2191
2003	10602	13320	2718
2004	8456	15000	6544
Average	11682	14190	2508

Table 69. Discounting

Year	Disc. factor 7%	Disc.Total net gain (Nu/ha)	Disc. added Total Cost (Nu/ha)	Marginal rate of returns (%)
2001	0.935	2766.8	15513.6	18
2002	0.873	-1914.1	9670.2	-20
2003	0.816	2218.6	8654.5	26
2004	0.763	4992.7	6450.8	77
Net Present Value		8064.0	40289.0	20

The average annual added costs from intensive hand weeding in 4 years was Nu 11682/ha and the average annual gross benefits increased by Nu 14190/ha. The NPV of this technique is Nu 8064/ha with MRR of 20%. The MRR of 20% in intensive hand weeding of *Shochum* is not economically attractive but this has to be considered in view of the incremental benefits that would accrue from a *Shochum* free land. *Shochum* weeding can be economically profitable in the long run – although MRR in the short period (up to 4 years) is low.

Farmers perceive that collective action in weeding could lead to better results and decreased individual efforts. This study involves only two farmers. The study will be continued with larger numbers farmers in future.

5.4.3 Impact Assessment of Maize Research

Maize is the second staple crop after rice and is the main staple crop of the people of six eastern districts. Maize research was initiated as early as 1987 at RC Khangma. Since then a number of technologies have been released for general adoption by farmers. It is believed that as a result of adoption of some of these technologies, the household maize self-sufficiency level has increased and there is also some surplus production. However, in the absence of a well documented study it has been difficult to understand the status of real impact in the field.

This study aims to quantitatively measure the impacts of maize research interventions both at the household and farm level. Some of the measurement parameters are the spread of technologies, farmers' adoption rates, contribution of technologies to increases in food production and sufficiency level. The specific objectives of impact study are to study and document number of modern varieties released and extent of adoption, adoption of crop management practices, magnitude of yields gain and increase in value of production, increase in net income and household cash income of farmers, and achievement of self sufficiency and improved welfare.

The sample Dzongkhags and Gewogs for the survey were selected based on maize producing areas in Bhutan covering different AEZ. The survey team did random sampling of villages and households. The data were collected guided by structured questionnaires from 2 dongkhags in the low altitude, 4 dzongkhags in the medium altitude and 4 dzongkhags in the high altitude. The data collected was entered in spreadsheet developed in the MS Excel program.

Since the survey data is still in the process of analysis and documentation, the detailed nation-wide results will be reported later.

5.5 Integrated Pest Management (IPM)

5.5.1 On-Farm Chilli Blight Management Trial

Introduction

A chilli blight trial was planned during the Annual Review and Planning Workshop in January 2004 for Dagana Dzongkhag. The lead agency was Dagana Dzongkhag Agriculture sector while Plant Protection and Horticulture sectors collaborated through technical advisory services, monitoring and data collection. The objectives of the trial were:

1. to assess the optimum time of start and end of chilli planting,
2. to investigate the cause/s of chilli production constraints in Dagapela.

Methodology

Site Selection

Based on the research protocol, the site selection was done by the extension agent (EA), Mrs. Tshering Pem of Norbuzingkha geog under Dagana Dzongkhag and reassessed by the researchers during field visit. Mr. Asbir Waiba of the geog was jointly selected as the collaborator farmer as he had experience of chilli cultivation in the past years vis-à-vis had observed chilli blight-like symptoms on his chilli crops.

Due to practical field problems (land terrain), field area measuring 0.5 langdo as highlighted in the research protocol could not be found in the collaborator farmer's field. Instead a terrace measuring 115m by 2.5m was divided equally into two parts. One part was assigned to recommended management practices which include raised bed, proper drainage and timely chemical application and the other to same treatment without chemical application.

Seedlings

Potted Sha Ema disease free seedlings were raised at the research centre and transported to the trial site on 6 April 2004. The seedlings were transplanted the same evening. Other farmers of the geog were also involved during the land preparation and transplanting primarily to impart hands-on training on raised bed preparation and create awareness on integrated disease management of chilli blight through cultural, physical and chemical application.

Land Preparation and Transplanting

Twenty four beds of 2m length and 30cm high were prepared for the trials (1 and 2). Artemisia was used as mulch for the transplants and placement irrigation done right after transplanting.

Seed and Seedling Chemical Treatment

Chilli seeds were treated before sowing and the transplants dipped in Ridomil® at the recommended dosage of 2g/l water for 15 minutes. This was followed by foliage spray with the same chemical at 30 days interval based on the disease occurrence and intensity in the field.

However due to insufficient land and remoteness of the trial site especially in light of regular monitoring and data collection, the continuation of the trial was done in Tsendengang (1500m approximately) in Mr. Tshewang's field. The trials were shifted to the new site after consulting the EA and sector heads concerned.

Seedlings

Nurseries were raised in the collaborator farmer's field. The research centre provided disease-free seeds of Sha Ema. Sequential sowing of chilli seeds were down as shown in Table 70.

Table 70 Schedule of chilli seed sowing frequency

Date	Sowing Frequency
30 April 2004	Second
05 June 2004	Third
06 July 2004	Fourth

Trial Design

Two treatments, (a) recommended package of practices including raised bed, proper drainage and chemical (Ridomil®) application and (b) same treatment without chemical application to serve as control; for second planting, 20 raised beds of 10m by 1.3m were raised – 10 beds for each treatment. For the third and fourth planting 5 raised beds of 8m by 1.3m for each treatment were established. The recommended spacing by National Plant Protection Centre (NPPC) of 30cm X 30cm plant to plant and row to row was used for all the treatments.

Chemical Application

Fungicide (Ridomil®) application applied in trial 1 was used for the treatments in trials 2, 3 and 4 at the recommended doses as seed treatment, seedling dip and foliar application at 30-day interval based on blight symptoms.

Management Practices

Standard management practices were followed. As a standard practice, transplanting was done in the evening to reduce transplanting shock. Post transplanting, the beds were mulched with well decomposed compost and Artemisia. Irrigation was done for each transplant after transplanting. The farmer was advised to water the transplants until the plant recovered from transplanting shock.

Results and Discussion

Among the four trials spread over different locations in Norbuzingkha and Tsendengang, the first trial in Norbuzingkha fared better compared to the subsequent three trials during the 2004 chilli cropping season in Dagapela. This was evident from two harvests from the trial in Norbuzingkha while no harvest was possible from the other three trials as indicated in Table 71 and Table 72.

Table 71 Comparative activity information for trial 1

Activity	Trial 1	
	Treated	Non-Treated
Date of sowing	16/2/04	16/2/04
Date of transplanting	06/4/04	06/4/04
No. of transplants	180	180
Trial area	12 bedsX2mX1.3m	12 bedsX2mX1.3m
50% flowering	19.5	13.5
Scheduled spray	1st spray 07/05/04 2nd spray 05/06/04 3rd spray 07/07/04	Nil
No. of plants harvested	150	120
Plot yield	17.5kg	10kg
Blight incidence	1 plant (2nd harvest)	1 plant (fruiting) 3 plants (2nd harvest)
Cut worm damage	8 plants	4 plants
Average Plant height	65cm	75cm
Average plant width	65cm	65cm
Total proportion of damage by blight	2.22%	27.7%
Harvest date	1st harvest - 16/07/04 2nd harvest - 28/07/04	1st harvest - 16/07/04 2nd harvest - 28/07/04

Chilli blight incidence and severity were scored using the following scale for all the treatments.

0: Nil
1: Mild
2: Severe
3: Very severe

Treated plots recorded significantly higher yield (17.5kg/plot) than the non-treated plots (10kg/plot). Likewise blight incidence and percentage of damage due to the disease was higher in control plots; more than a quarter (27.7%) of the plants in non-treated plots was damaged due to blight. The results indicate that raised bed without

fungicide application showed no difference from the treated plots with raised beds in terms of overall yield.

Table 72 Comparative information on activity undertaken in trials 1, 2 and 3

Activity	Trial		
	2	3	4
Date of sowing	30/4/04	05/06/04	06/07/04
Date of transplanting	19/05/04	26/06/04	26/07/04
No. of transplants	800	250	250
Trial area	104m^2	50 m^2	50 m^2
50% flowering	6.8	0	0
Scheduled spray	1st spray 20/06/04 2nd spray 22/07/04 3rd spray 07/07/04	1st spray 25/07/04 2nd spray Nil 3rd spray 07/07/04	1st spray 27/09/04 2nd spray 05/06/04 3rd spray 07/07/04
No. of plants harvested	0	0	0
Plot yield	0	0	0
Blight incidence	2 foliage 3 flowering	2 foliage 3 flowering	2 seedling
Cut worm damage	Nil	Nil	Nil
Average Plant height	30cm	35cm	0
Average plant width	25cm	28cm	0
Plants at harvest	65 with few leaves	15 stem only	0
Weather	3 days mild rain	5 day mild rain	3 days heavy 2 days mild rain

Table 3 shows the information for trials 2, 3 and 4. As mentioned above no harvest was possible from the trials due to longer period of rainfall vis-à-vis high relative humidity recorded during the entire growing period. Blight incidence in the second and third sowings was observed in the foliage and flowering stages while the fourth sowing saw the disease right from the seedling stage.

Based on the information in table 3 and taking into account the regional rainfall regime, it can be deduced that harvesting of chilli is not possible from May to August planting in Dagapela region. Hence fifth and beyond planting cannot be continued due to lack of interest from co-operator farmers.

Conclusions

Based on the above information and discussions with the co-operator and local farmers the following conclusions are drawn.

1. Chilli cannot be cultivated post April in Dagapela region. The most suitable period for chilli cultivation in the region is early January/February for Bhutanese chilli and September-October for the Indian chilli. Further discussions with farmers revealed that chilli sown in January and February and transplanted in March-April

normally yields close to four harvests which fetches prices ranging from Nu. 80-120 locally and as far Thimphu. On the contrary, chilli sown in March/April and transplanted in May/June do not perform well due to excessive flower drop which coincides with rainy season and favours blight disease (both stem and aerial). Subsequently chilli sown in June/July and planted in August through September yields only one harvest with very low blight incidence.

2. Additionally soil type also contributes to chilli blight incidence such as clayey soil (middle area of Tsendengang geog) becoming hard during sunny period and muddy when rainy resulting to poor plant growth and vigour thereby becoming susceptible to diseases.

3. Feedbacks from participant farmers indicate that fungicide application during rainy on chilli crop do not reduce blight infection nor maintain plant stand in the field. However this perception needs further investigation as there is no data to support the chemical efficacy in controlling blight during rainy seasons.

4. A sequential chilli trial is proposed in the region during 2005 cropping season to assess and further reconfirm the best timing for chilli cultivation. This activity will de done collaboratively between Dzongkhag extension, horticulture and Plant Protection sectors of this centre.

5.5.2 *Shochum* Management Campaign

Like in the past, *Shochum* (*Potamogeton distinctus*), a noxious aquatic weed in rice was managed through intensive hand weeding campaign in the farmers' field. The campaign site in the watershed was implemented but the weeding site in Gaselo could not be continued due to lack of manpower on the part of the collaborator farmer.

Concurrently a large scale *Shochum* weeding campaign was organised by the research centre under the auspices of Honourable Minister of Agriculture, Lyonpo Sangay Ngedup. The weeding sites were at Kazhi, Wangdue Phodrang Dzongkhag and Tana, Punakha Dzongkhag. The objectives of the hand weeding campaign were:

- To provide momentum and popularity of timely and intensive had weeding to control *Shochum*.
- To create awareness on the importance of intensive hand weeding, provide publicity and education to farmers, extension personnel and general public on the need to contain *Shochum* for increased food production.
- To cross-share experiences and practices of hand weeding amongst farmers of different regions.
- To provide additional hands in weeding out *Shochum* for this rice season.
- To inculcate dignity of labour and agriculture amongst students.

- To celebrate locally the International Year of Rice in Bhutan.

The weeding campaign was conducted on 24 July 2004 at Kazhi and Tana villages on 25 July 2004. Weeding participants consisted of policy makers and officials from the Ministry of Agriculture led by His Honourable Lyonpo Sangay Ngedup, Dasho Dzongdag, researchers, agriculture staff, students and farmers. About 150-200 participants took part in the weeding campaigns completing about 5 acres of *Shochum* infested rice fields in each site. Experienced farmers on *Shochum* management from Paro were invited as resource persons during the campaign to share their experience on control and eradication of *Shochum* through intensive hand weeding. To boost awareness among farmers, posters on *Shochum* control and benefits of weeding in Dzongkha were distributed by the Honourable Minister. At the end of the weeding campaign, serrated sickles were distributed to the farmers by the minister.

His Excellency briefed the participating farmers that *Shochum* causes enormous yield loss to farmers affecting household food self-sufficiency and ultimately the national goal of food reliance. He highlighted that though chemical control is available it is not economically viable for the Bhutanese farmers due to exorbitant price. The day long weeding campaign at both the sites were organised by the centre with funding from RNR-ESP and GTZ.

The weeding campaign in general was a success due to the efforts of His Excellency the Agriculture Minister personally taking the time to lead and participate in the campaign. Closing the weeding campaign the Minister urged all farmers to make efforts to do intensive weeding to ultimately eradicate *Shochum* if possible like in Paro. Farmers at both sites agreed to take the effort to do timely weeding to manage and possibly eradicate the noxious weed in future. Concurrently the Extension Agents (EAs) in *Shochum* infested areas were urged to take the initiative to convince and lead the farmers in controlling *Shochum* through timely and intensive hand weeding.

5.5.3 On-Farm *Shochum* Weeding Trial

Introduction

As in the previous years, *Shochum* weeding campaign was continued at one site –in Wangdue (Wangjokha and Omteykha). The other site in Gaselo could not be implemented due to shortage of manpower of the collaborator farmer and the lack of interest on the part of the caretaker. Of the earlier three farmers in the Lingmuteychu watershed only two farmers participated in the weeding campaign. Chimmi Rinzin of Limbukha discontinued as he had participated for three years in the weeding campaign. Visual observation of reduced weed population and the reduction in rice yield due to intensive weeding reported in 2003-2004 annual report are indicative of the effects of weeding done over the years. The farmer has agreed to gradually apply the weeding technique in rest of his fields.

The recommended weeding regime of 2, 4 and 6 weeks after transplanting (WAT) was implemented. Butachlor was applied after transplanting at 12-14 kg/ac. Weeding date and rice yield during harvest were recorded for analysis.

Results and Discussion

Weed flushes at both the sites were few during first weeding and almost non-existent in the subsequent weeding - an indication of cumulative reduced weed pressure due to intensive hand weeding over the years. Average rice yield from the test fields were not significantly different from 2003 yields; yield from normal weeding ranged from 1.9-2.1 t/ac while 2.2-2.8 t/ac for hand weeded plots. Yield difference (0.8 t/ac) was higher for Gomchen compared to last year's yield difference of 0.36 t/ac. For Kinley Dorji, the yield difference was lower (0.30 t/ac) a 0.18 t/ac less than last year. Comparative difference in yield from the weeded and farmers' practice are given in Table 73.

Table 73 Comparative rice yield in intensively weeded and normal weeded fields

Farmer	Village	Variety	Yield (t/ac)		
			Hand Weeding	Normal weeding	Yield Difference
Gomchen	Wanjokha	IR 64	2.8	2.1	0.8
Kinley Dorji	Omteykha	Maap Phogom	2.2	1.9	0.3

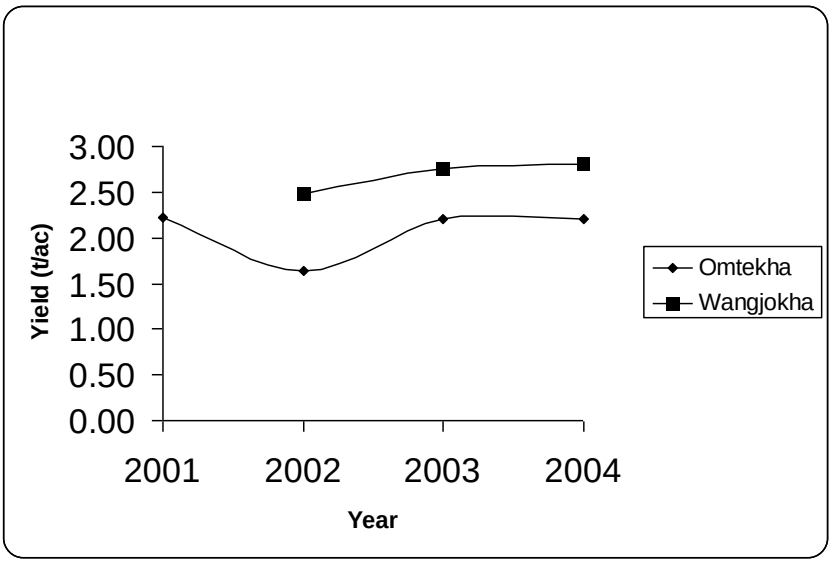


Figure 17 Rice yield trend as a result of intensive hand weeding in the Watershed

Figure 17 shows the rice yield trend as a result of intensive hand weeding over 3-4 years in the watershed. The yield in Omtekha has more or less remained stable (2.22 t/ac) during the period except in 2002 when the yield was just 1.64 t/ac. This, as indicated in earlier report, is due to delayed second weeding which was done 3 days after the scheduled weeding. However the yield has remained almost the same at 2.20 t/ac in 2004. The yield for Wangjokha increased from 2.48 t/ac in 2002 to

2.75 t/ac in 2003. The yield in 2004 is almost the same as in 2003 at 2.80 t/ac and therefore not significantly different.

Though yield benefits may not seem high, the weed pressure has significantly reduced over the weeding campaign period. Summarising the participant farmers' feed backs, some expressed that due to intensive hand weeding over 3-4 years only a few *Shochum* leaves are recorded during first weeding in the subsequent years of weeding. As a result the farmers feel that the subsequent (second and third) weeding is not necessary; this was the feedback from the earlier Limbukha collaborator farmer. The farmers through visual observations have seen that their rice fields are much clearer of the weed than some years ago. However their concerns of lack of manpower due to labour shortage still remain a constraint that hinders the primary objective of intensive hand weeding.

Conclusions

As proven in places like Paro, intensive hand weeding would prove successful only if it is done through a community approach and over a certain period of time – as long as 6 years to a decade from Paro experiences. Secondly manpower is a main constraint on a national level in villages and more particularly in rice growing Dzongkhags such as Paro, Thimphu, Punakha and Wangdue Phodrang where labour is in demand for transplanting and weeding.

Feedbacks from farmers reveal that they are aware of the benefits of intensive hand weeding if done timely and properly over a period of time. Cumulative rice yield data from Wangjokha and Omtekha indicate a 38% rice yield reduction can be accrued - a result of timely and intensive hand weeding. EAs in the respective sites are also aware of the benefits of the weeding regime. As such it is recommended that EAs take the lead and inculcate a sense of concern in controlling *Shochum* through the recommended weeding regime and thus increase rice production.

Further with the lead taken by the Honourable Minister of Agriculture, Lyonpo Sangay Ngedup in spearheading the weeding campaign in Wangdue and Punakha and further disseminating the message of *Shochum* control awareness through intensive hand weeding, it is felt that the extension colleagues are ready to shoulder the responsibility of continuing the weeding campaigns in the geogs concerned. The sector will stop leading the weeding campaigns in the above geogs. However technical backstopping and trainings will be provided on a priority and need basis.

5.5.4 Evaluation of leaf blast resistance of released and improved rice cultivars in different rice eco-zones

Introduction

Rice blast caused by the fungus *Pyricularia oryzae* was the primary cause of the "rice blast epidemic" in 1995; since then it has been a major production constraint of rice in the country. The disease occurs both at the high and low altitudes in different forms – at higher altitudes the disease is manifested in both leaf and nodes especially in the traditional varieties. Leaf blast is more common in the nurseries in the lowlands. NPPC (2002) reported that leaf and node blast symptoms were

recorded from Norin 11 variety in Paro; leaf blast was recorded in Khangma Maap but not as serious as in Norin 11. As we introduce modern high yielding varieties (HYVs) to increase rice production to meet the national goal of food sufficiency, it is imperative that we monitor blast disease occurrence in the released HYVs. An observation trial was designed with the following objectives.

- To monitor blast disease occurrence in improved released rice varieties in different ecological zones.
- To assess the reaction types in comparison to the international differential cultivars.

Materials and methods

Rice lines

IRBL = 24 cultivars with different complete resistance genes
Japanese Differentials = 13 cultivars with different complete resistance genes
Bhutanese Cultivars = 6 cultivars (*Zechum* and *Janam* included as susceptible check)

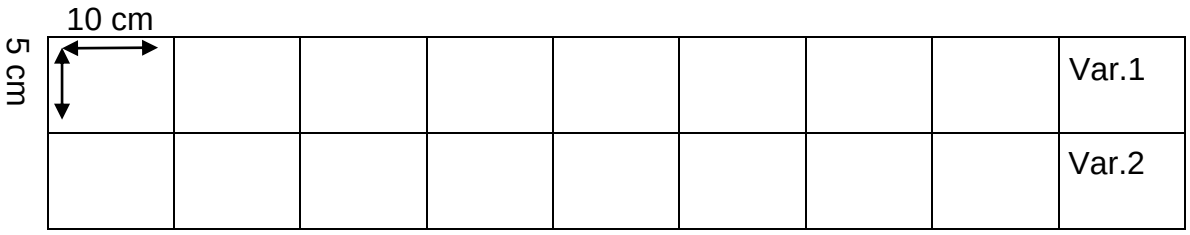
Trial Site

The site for the evaluation was selected in Rimchu, Punakha which is known to be a "hot spot" for rice blasts after the "blast epidemic" in 1995.

Trap nursery was established after the transplantation of farmers' field the site – mid July. Occurrence of blast after this period would guide the extension agent (EA) in taking preventive measures against outbreak of blast in the farmers' field. For research purpose, it would assist the researchers in assessing whether improved varieties in Bhutan are resistant to blast in different ecological zones.

Nursery Methods

In Rimchu, 2 X 2 m plot in rice field was selected. Land was prepared thoroughly removing all crop debris and soil clods. Farm yard manure (FYM) and urea were applied as recommended rate. 10-15 seeds of each variety were sown in line with 10 cm between varieties and 5 cm between seeds. Blast symptoms observations, if any, were made once the seedlings reached three-leaf stage. In all three observations were made; each observation was made and blast incidence recorded based on the following scale.



0 = No symptom

1-2 = Small necrotic brown spots on the leaves
3 = blast lesion but with white centre and brown colour. Lesions are smaller than typical susceptible blast lesions.

4-5 = typical spindle shape blast lesions with purple centre and velvety brown edge.

The results of the trials are given in table 4.

Table 74 Observations of rice trap nursery (2004)

Variety	Date: 3/8/2004 Blast Scoring	Date: 24/8/2004 Blast Scoring	Date: 10/9/2004 Blast Scoring	Remarks
BW-293	0	0	0	Stem borer (SB), brown spot (BS)
Barket	0	1	3	SB
Milyang	0	0	0	
IR293	0	0	1	
Khumal	0	0	0	SB
Chumro	0	0	0	SB, BS
Bajo Kaap 2	0	0	0	SB
Bajo Maap 2	0	0	0	
Bajo Maap 1	0	0	0	
No. 11	0	0	0	SB
BR153	0	1	0	SB
Bajo Kaap 1	0	0	0	BS
Yusi Kaap	0	0	1	BS
Yusi Maap	0	0	0	No germination
IR64	0	1	0	

0 = No symptom

1-2 = Small necrotic brown spots on the leaves
3 = blast lesion but with white centre and brown colour. Lesions are smaller than typical susceptible blast lesions.

4-5 = typical spindle shape blast lesions with purple centre and velvety brown edge.

The IRBL and Japanese cultivars could not be included in the study due to lack of seeds. The trap nursery included only the local available varieties and varieties available in the centre. Over all the blast symptoms were not recorded from the nursery. Small necrotic brown spots on the leaves were recorded initially on Barket, IR293, BR153, Milyang, Yusi Kaap and IR64 but recovered during subsequent observations. However Barket recorded significant symptoms of blast on third observation.

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 300 copies each of eight research technologies as packaged by different sector in the form of extension leaflets.

- lFC-001: Rice double cropping in dry subtropical zones (Sept, 2004)
- lFC-002: Pre-rice green manuring (Sept, 2004)
- lFC-003: Mustard Cultivation in wetland system (Sept, 2004)
- lFC-004: Wheat cultivation in wet land production system
- lFC-005: Recommended rice seedling production practices
- lFC-006: Rice Ratooning
- IFC-001: Recommended practices for direct seeding of rice (April, 2005)
- lHO-002: Pointer for successful walnut grafting (Oct, 2004)

These materials were distributed to all EAs of the region, relevant institutions of Ministry of Agriculture and farmers who attended 7th RNR Expo at Kanglung. In view of the additional demand for nation-wide additional 400 copies of IFC-004, IFC-005 and IFC-006 were printed and distributed to three RNRRCs for further distribution in their region.

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

Following the directives from CoRRB and in response to the 10th ARPW resolution, RNR RC Bajo adopted one RNR EC each from five Dzongkhags of west-central region. Technology Parks were established in 5 extension centers with the objective to showcase and demonstrate successful and revelant technologies for particular geog. The adopted RNR ECs once fully developed would then serve as example for other geog center to replicate. However, many constraints impeded to apply the concept in its full scope. Lack of basic tools and implements, labor, fund for site development, site fencing and common understanding on the concept of Technology

Park were the main issues at the start of adopting these RNR ECs. Following are the selected Model RNR RCs:

- Damji RNR EC in Gasa
- Samdingkha RNR EC in Punakha
- Phubjikha RNR EC in Wangduephodrang
- Dagapela RNR EC in Dagana
- Mendreygang RNR EC in Tsirang

Ground information and site mapping: In all five RNR ECs a team from RNR RC visited the adopted RNR ECs and collected the basic information required for planning future interventions (annexure1).

Tools and implements support: With the fund support from RNR ESP, we have provided the prioritized tools and implements as per the requisition and with in the limit of Nu. 30,000 each. The supplied tools and implements to the model RNR ECs are also attached (annexure 2).

Technology Park Workshop: To establish common understanding on the concept of Technology Park and to develop a workplan for it, a week long workshop was conducted. All the concern EAs from the model RNR ECs participated. A clear common understanding of technology park development was established during the workshop. A work plan along with the roles responsibilities were also drawn as part of the workshop out put. A workshop also took a chance to review the activities that were already implemented in some of the RNR ECs.

Activities in the technology parks: In almost all the RNR ECs, their compounds were left barren and required massive effort and substantial amount for site clearing and field ploughing. Labour charge for this activity was supported from RNR ESP. Having completed site clearing and field ploughing in all the RNR ECs, we have taken following technologies to the technology parks in different centers.

Damji RNR EC

- An orchard for assorted fruits suitable to Damji locality has been established.
- A vegetable garden with newly released and suitable to Damji locality has been established
- Few tree species were planted in the compound boundary.
- Improved Poultry shed has been displayed
- A live herbarium of improved pasture grass species established.
- Fodder grass such as Napier grass along the drainage was also planted.
- We have also work plan to establish forest tree nursery
- A compost pit is also in place.

Samdingkha RNR EC

- Improve pasture with improve grass mixture established

- Improved Poultry shed has been displayed
- Stabilizing the gullies/drainage channel with fodder grass (Napier & gautemala) planting demonstrated.
- Top working on existing fruit trees demonstrated.
- Newly released fruit trees planted
- A vegetable garden hosting all newly released vegetables established.
- Hedges and ornamental plants for beautifying the compound, planted.
- Compound boundary plantation with forest trees species.
- A compost pit

Phubjikha RNR EC

- A live fodder herbarium established
- Provided pasture seeds for establishing improve pasture.
- A few suitable fruit plants were planted to develop an orchard
- A vegetable garden hosting all newly released vegetables established.
- Establishing forest tree nursery and compound boundary plantation with forest tree species are in their work plan.
- Three compost pits dug and in the process of composting with local materials

Dagapela RNR EC

- Fishery pond with fingerlings
- Mushroom cultivation with proper shed
- Vegetable Garden hosting all newly released vegetable suitable to the locality
- Live fodder herbarium hosting improve grass species
- A compost pit
- An orchard hosting selected fruit crops established
- Few ornamental trees, fodder trees and forest trees planted.

The activities implemented in the technology park would serve as technology demonstration on cultivation/management practices of displayed technologies. The sector is continuously monitoring the progress of these models RNR EC development.

5.6.3 Technology Adoption Study

Ever since the research system was instituted, many technologies were disseminated in the extension system from various research institutes. However, these technologies were left unevaluated and there is very little feedback information as how the technologies have impacted on RNR sector development. It would be useful to know some of the reasons for adoption or rejection to guide researchers for future technology development. One day enumerator training on this study was conducted for selected enumerators and questionnaire survey was done in the region with the help of chosen EAs. The sector is yet to collect complete questionnaire from the Dzongkhags. Meantime, we are processing the data in SPSS and the final report on the study will be released by the end 2005.

5.6.4 Farmers Group formation

Dompola saving group which was formed in 2002 was kept under frequent counselling. Particularly the mushroom activity that was initiated by the group was constantly supervised by the sector. Mushroom production started from this year and about 40kgs was harvested. The group sold 20kg mushroom to hotelier in Wangdue and Punakha at Nu. 150/kg while they consumed remaining half. The group is expecting more production in the coming season.

Similar to Dompola saving group, three new farmer's groups have been formed in the watershed itself. Limbukha womens group was formed to market solar dryers and develop savings for overall development. Limbukha farmer's group was formed with the vision of producing vegetables and marketing it in group, besides accumulating saving for micro-credit. Another group in Nabchey was also formed to organize piggery production.

5.6.5 Research Extension Linkage

Pre-Regional Meeting: Based on the resolution of the 5th RNR Conference, Pre-Regional meeting has found a space in the RNR calendar and since then became annual feature for RNR RCs. This meeting was conceptualized as an opportunity for the Dzongkhag RNR sector heads to generate input (farmer's problems, researchable issues, extension problems, information on any special agenda of ARWP, etc.) from their field staff and get prepared for the Annual Review and planning Workshop (ARPW). This would alleviate lengthening of ARPW process and have ready information required for the ARPW. These inputs would help researchers to align their work plan towards addressing field problems during the Annual Review and Planning Workshop.

The sector has organized this meeting for the second time in the west-central region. The meeting was conducted in Dzongkhag 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

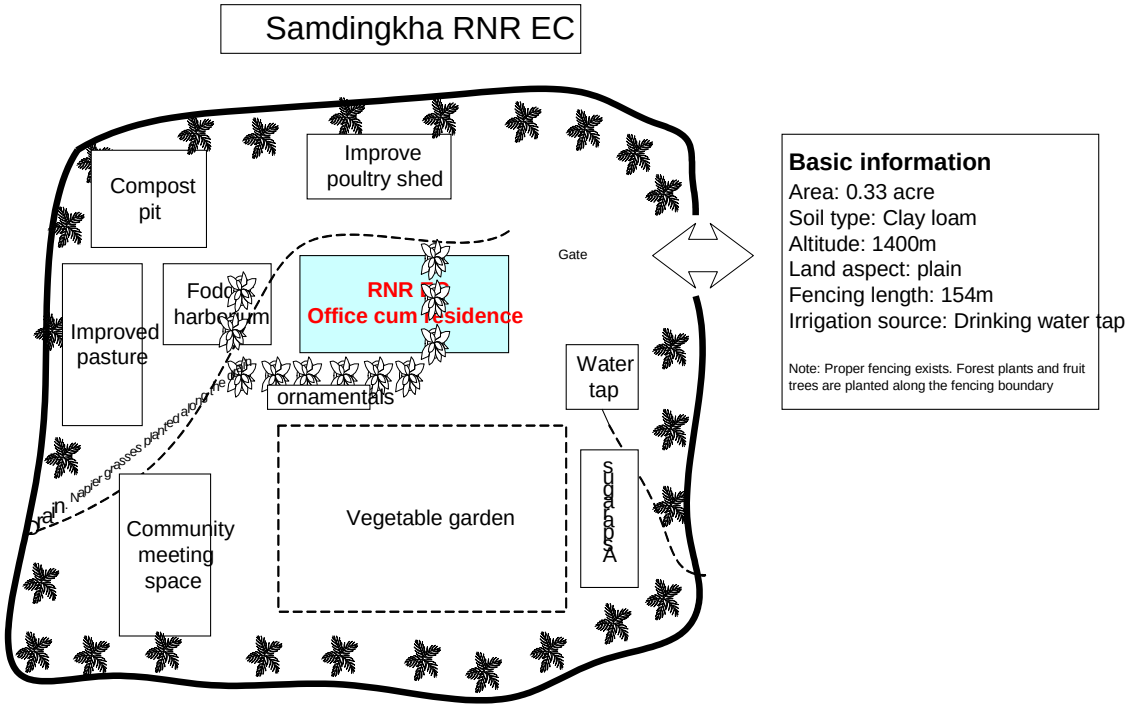
The most important mechanism to strengthen research and extension linkage is the annual feature of every RNR research centres to hold Annual Review and Planning Workshop. It is the single forum in region where Researchers and Extensionists come together and deliberate on field problems in presence of various stakeholders such as central input agencies, Departmental representatives and representative

from PPD. It is in this forum the research technologies are also presented and disseminated. The ARPW was organized by the sector with financial support from RNR ESP and SDC. The workshop proceeded in sectoral group meeting and later deliberated in group for general consensus. The workshop reviewed the progress of previous year's activities and planned 2005-2006 collaborative activities. The workshops also reviewed the annual geog plans and discussed the shortcomings from various collaborators and input supply agencies (refer 11th ARPW proceedings).

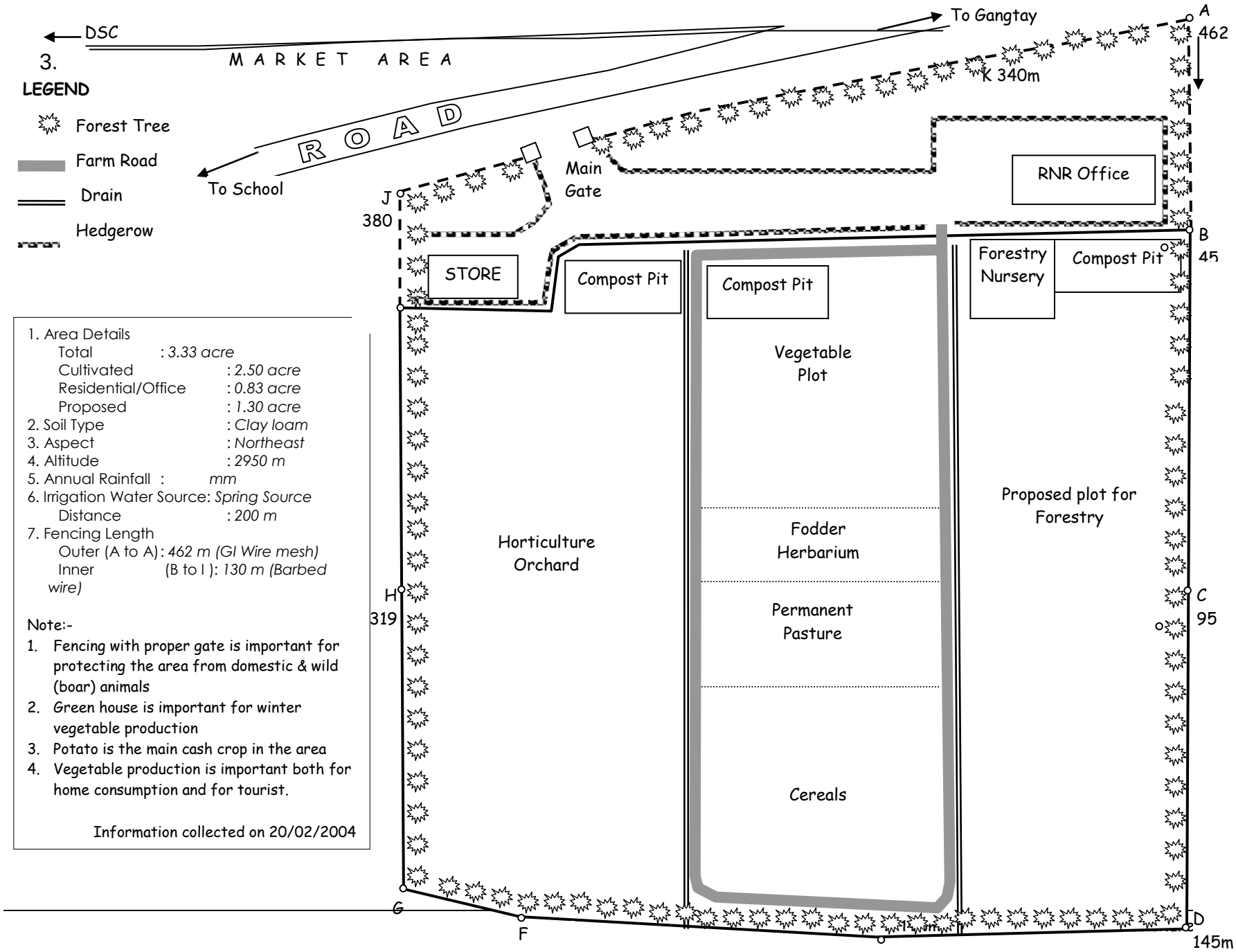
6 ANNEXURE

6.1 Sketch map of model RNR ECs with basic information

1. RNR EC Samdingkha



2. RNR EC, Phobjikha



1. Area Details
   - Total : *3.33 acre*
   - Cultivated : *2.50 acre*
   - Residential/Office : *0.83 acre*
   - Proposed : *1.30 acre*
2. Soil Type : *Clay loam*
3. Aspect : *Northeast*
4. Altitude : *2950 m*
5. Annual Rainfall : *mm*
6. Irrigation Water Source: *Spring Source*
   - Distance : *200 m*
7. Fencing Length
   - Outer (A to A): *462 m (GI Wire mesh)*
   - Inner (B to I): *130 m (Barbed wire)*

Note:-

1. Fencing with proper gate is important for protecting the area from domestic & wild (boar) animals
2. Green house is important for winter vegetable production
3. Potato is the main cash crop in the area
4. Vegetable production is important both for home consumption and for tourist.

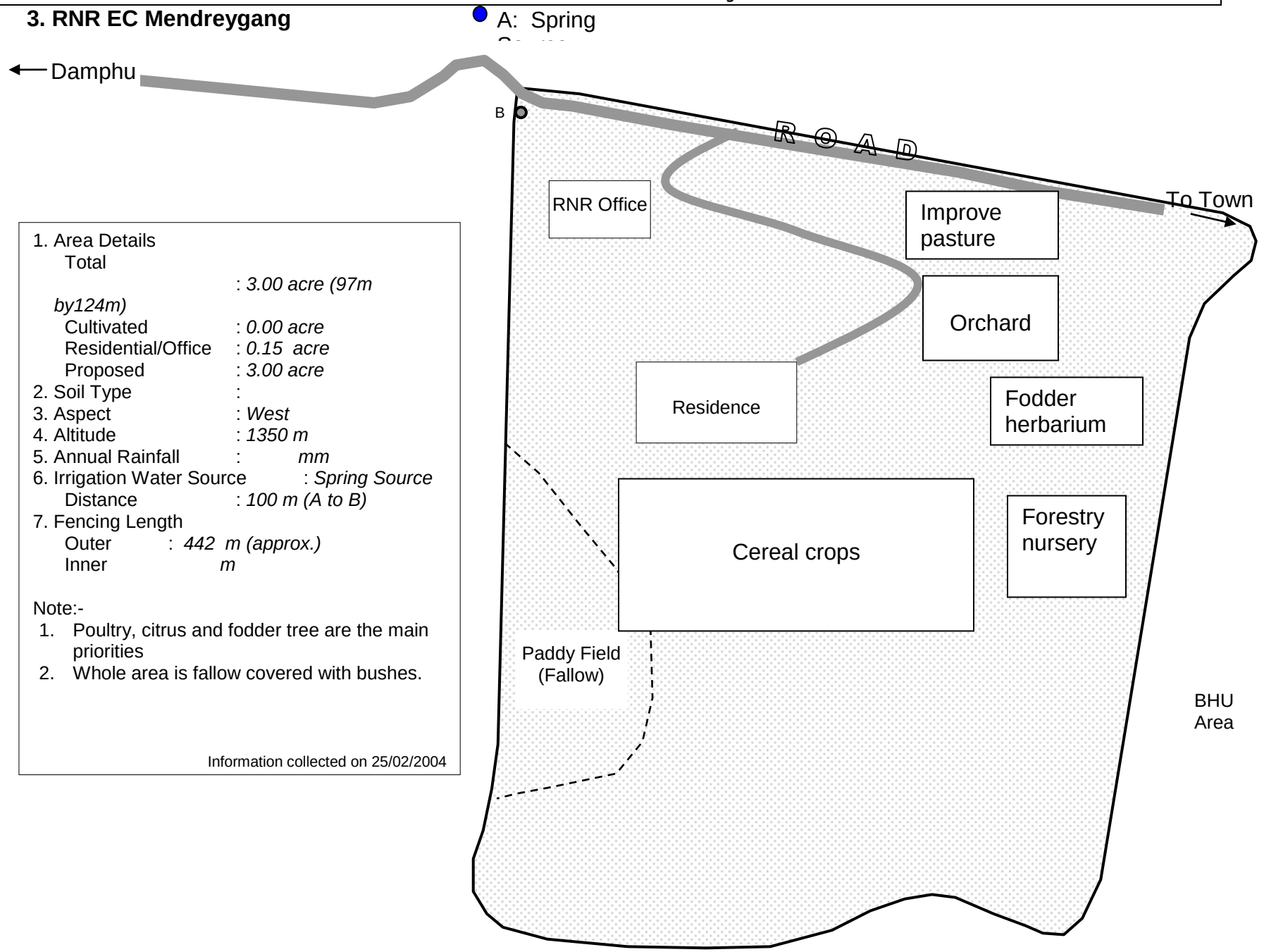
Information collected on 20/02/2004

3. RNR EC Mendreygang

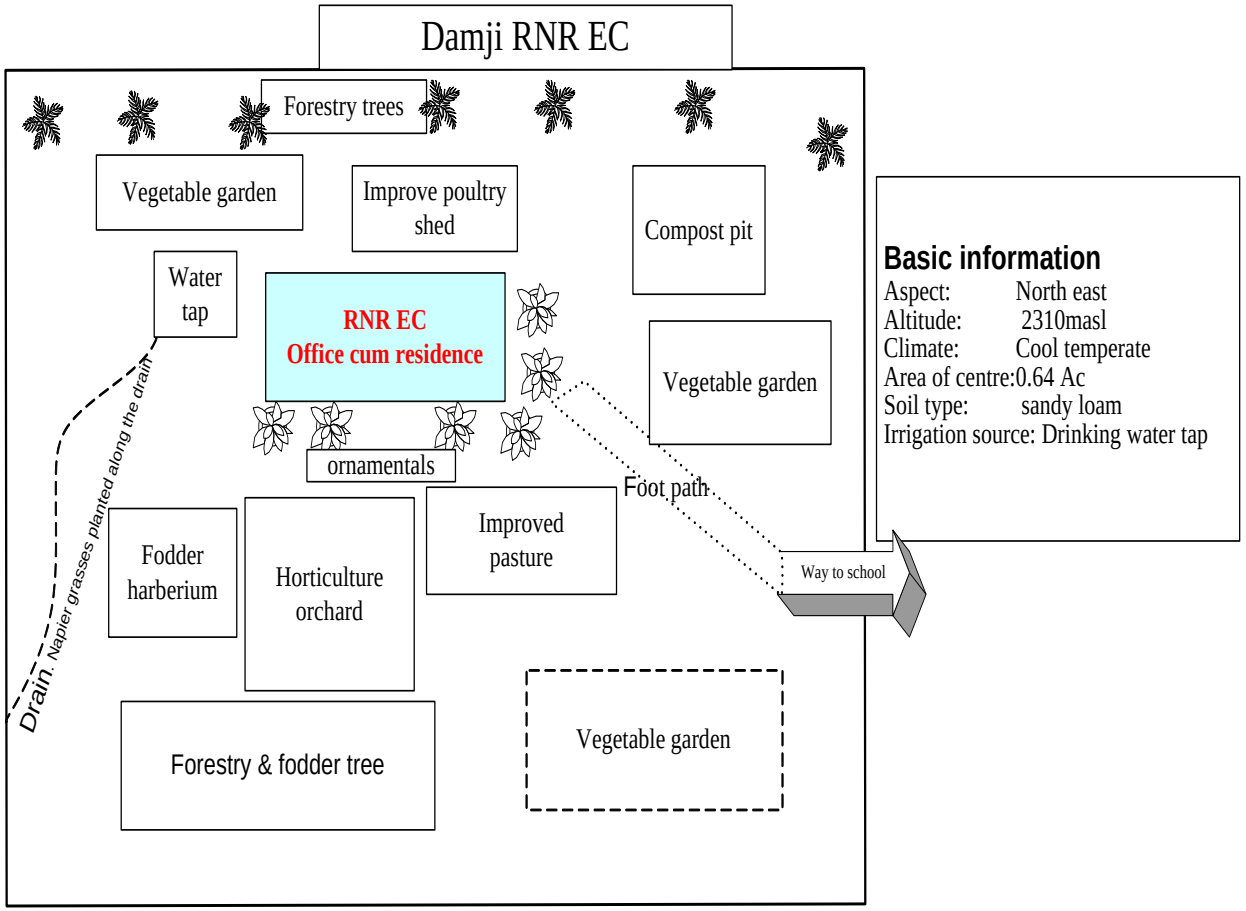
1. Area Details
   Total : *3.00 acre (97m by124m)*
   Cultivated : *0.00 acre*
   Residential/Office : *0.15 acre*
   Proposed : *3.00 acre*
2. Soil Type :
3. Aspect : *West*
4. Altitude : *1350 m*
5. Annual Rainfall : *mm*
6. Irrigation Water Source : *Spring Source*
   Distance : *100 m (A to B)*
7. Fencing Length
   Outer : *442 m (approx.)*
   Inner *m*

Note:-
1. Poultry, citrus and fodder tree are the main priorities
2. Whole area is fallow covered with bushes.

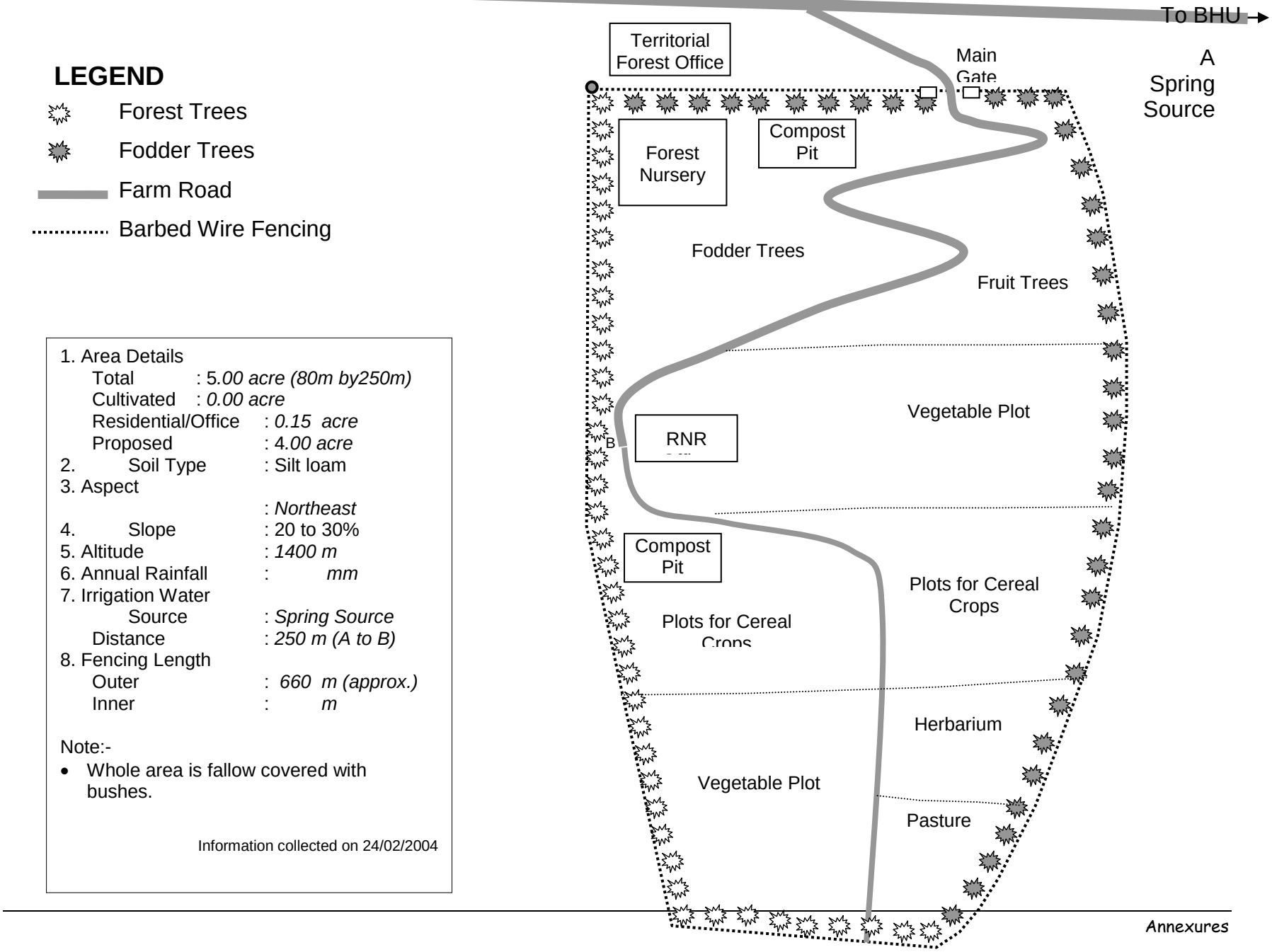
Information collected on 25/02/2004



4. RNR EC Damji



5. RNR EC, Dagapela



LEGEND

- Forest Trees
- Fodder Trees
- Farm Road
- Barbed Wire Fencing

1. Area Details
   - Total : 5*.00 acre (80m by250m)*
   - Cultivated : *0.00 acre*
   - Residential/Office : *0.15 acre*
   - Proposed : *4.00 acre*
2. Soil Type : Silt loam
3. Aspect : *Northeast*
4. Slope : 20 to 30%
5. Altitude : *1400 m*
6. Annual Rainfall : *mm*
7. Irrigation Water
   - Source : *Spring Source*
   - Distance : *250 m (A to B)*
8. Fencing Length
   - Outer : *660 m (approx.)*
   - Inner : *m*

Note:-

- Whole area is fallow covered with bushes.

Information collected on 24/02/2004

6.2 Tools and implements list

Damji RNREC

Sl.No.	Type of inputs	Qty
1	**Cash payment:** 1. For making sign board 2. FYM purchase 3. Compost pit construction **4. Total**	 1 No 1 T/L 1 No
2	HDP ½" dia pipe	200 Mtrs.
3.	Spade -Tata 1.4 kgs	2 Nos.
4	Pickaxe- Tata 2.5 kgs.	2 Nos.
5	Shovel- Tata R/nose	2 Nos.
6.	Serrated sickle-Taiwan	1 No.
7	Domchi sickle - local	3 Nos.
8	Kutty with handle	2 Nos.
9	Pruning secature- Taiwan	1 No.
10	Budding knife	2 Nos.
11	Crowbar-29mm	2 Nos.
12	His Majesty's portrait	3 Nos.
13	Jekhem's portrait	3 Nos.
14	Measuring tape- 15 Mtrs.	1 No.
15	Binding wire	2 kgs.
16	Nail	4 kgs.
18	Water Sprinkler	1 No.
19	White board	1 No
20	Poly pot	4 kgs
21	Water can	2 Nos

2 RNR EC DAGAPELA

Sl.No.	Type of inputs	Qty
1	*Cash payment:* 1. For making sign board 2. FYM purchase 3. Fish tank construction 4. Site clearing & pole cutting/collection **5. Total:**	 1 No 1 T/L 1 No -
2	HDP ½" dia pipe	200 Mtrs Rolls
3.	Spade -Tata 1.4 kgs	3 Nos.
4	Pickaxe- Tata 2.5 kgs.	3 Nos.
5	Shovel- Tata R/nose	3 Nos.
6.	Serrated sickle-Taiwan	3 No.
7	Domchi sickle - local	6 Nos.
8	Kutty with handle	3 Nos.
9	Pruning secature-Taiwan	3 No.
10	Budding knife	2 Nos.
11	Crowbar 32mm	3 Nos.
12	Hand shovel (Planting trowel)	3 Nos.
13	His Majesty's portrait	3 Nos.
14	Jekhem's portrait	3 Nos.
15	Measuring tape- 15 Mtrs.	1 No.
16	Nail	4 kgs.
17	Water Sprinkler	3 No.
18	White board	1 No
19	Poly pot	4 kgs
20	Garden rake	2 Nos
	Total	

3 RNR EC MENDREYGANG

Sl.No.	Type of inputs	Qty
1	**Cash payment:** 1.For making sign board 2. FYM purchase 3.Compost pit digging 3.Site clearing/ land shaping	 1 No 1 T/L 1 pit 1 No -
2	HDP ½" dia pipe	200 Mtrs
3.	Spade –Tata 1.4 kgs	3 Nos.
4	Pickaxe- Tata 2.5 kgs.	3 Nos.
5	Shovel- Tata R/nose	3 Nos.
6.	Serrated sickle-Taiwan	2 No.
7	Domchi sickle – local	3 Nos.
8	Kutty with handle	2 Nos.
9	Pruning secature- Taiwan	2 No.
10	Water sprinkler	1 No.
11	Crowbar 32mm	3 Nos.
12	Hand shovel (Planting trowel)	3 Nos
13	Hand sprayer	1 No.
14	His Majesty's portrait	3 Nos.
15	Jekhem's portrait	3 Nos.
16	Measuring tape- 15 Mtrs.	1 No.
17	Nail	4 kgs.
18	Water Sprinkler	3 No.
19	White board	1 No
20	Poly pot	4 kgs
21	Garden rake	2 Nos
	Total	

4 RNR EC PUBJIKHA

SL.No	Item of Expenditure	Quantity
1	Fodder herbarium seed	1 Package
2	Serrated sickle(Japanese)	3 Nos.
3	Hoe	3 Nos.
4.	Pickaxe	3 Nos.
5	spade	3 Nos.
6	Fork spade	3 Nos.
7	HDP 1” dia pipe	100 Mtrs.
8	HDP ½” dia pipe	50 Mtrs.
9	Chart paper	50 Nos.
10	Marker pen	3 sets
11	H.M.Protrait	1 No.
12	Geog map	3 Nos.
13	Dzongkhag map	3 Nos.
14	Grass mixture	10 kgs.
15	Clover seed	1 kg.
16	Labor charge for compost pit digging	3 pits
17	FYM	4 Tractor load
18	Asparagus seedlings	200 Nos.
19	Cabbage seed	1 packet
20	Weedicide	2 lits

6.3 Training and workshops

SlNo	Name of official	Field of training	Country	Duration
1	Sangay Wangdi	IPM Technology & Food Safety	Netherlands	10 Weeks
2	Rinzin Dorji	Study Tour	India	1 Month
3	Kencho Dorji	Accounting & Financial Mgt.	India	3 Months
4	Sangay Duba	Maize Planning Workshop	Nepal	1 Week
5	Meena Devi Dhungyel	Integrated Watershed Mgt.	Philippines	3 Weeks
6	Meena devi Dhungyel & Zangmo	Participatory Research & Development	Thailand	1 Weeks
7	Mahesh Ghimirey	BUCUP Workshop	Thailand	1 Week
8	Sangay Duba & Doley Tshering	Natural Resource Mgt.	India	1 Week
9	Choki Wangmo	Library Management	Bhutan	2 Weeks
10	Dawa Zangpo	Modern Office Mgt & Administration	Bhutan	3 Weeks
11	Sangay Wangdi	MSc. Tropical Agricultural Development (Crop Protection)	England	12 Months
12	Kencho Wangdi	MSc. Agriculture	Australia	24 Months
13	Dr. Min Prasad Timsina	MSc. Tropical Animal Production (on-going)	Thailand	24 Months
15	Tayan Raj Gurung & Aita Kumar Bhujel	Conference on Use of Commod approach in Natural Resources Management	Thailand	1 Week

6.4 Visitors to the centre

SlNo	Name of the Visitor	Date of Visit	Purpose of Visit
1	Nobuyuki Taniki, Sr. Technical officer, APNAN, Thailand	13.08.2004	Organic farming
2	Sita Giri, UNDP, Thimphu	9.09.2004	Agro-Biodiversity Project Formulation Mission
3	Dil Prasad Sherchan, & Carlos A.Urea Florez, National Maize Research centre, Nepal & CIMMYT	13.09.2004	National Maize Research Program formulation
4	Mr. Simon Thomos and Group, from India	1.10.2004	Familiarization tour
5	SDC MissionDesk Officer for Bhutan	11.10.2004	M & E of Project
6	John Gulettee & Wife	24.11.2004	Familiarization Visit

6.5 Expenditure Statement for 2004-2005

Royal Government of Bhutan Contribution. **Nu in Million**

Sl No	OBC	Particular	Amount
1	1.01	Pay & Allowances	4.899
2	2.01	Other Personal Emoluments	1.228
3	11.01	Travel-In country	2.094
4	12.01	Utilities-Telephone,Fax,Internet,E-Mail	0.059
5	12.02	Utilities-Telegram, Postage	0.025
6	12.03	Utilities-Electricity,Water,Sewerage	0.050
7	14.01	S&M-Office Supplies, Printing, Publication	0.067
8	14.03	S&M-Fertilizer,Chemical,Manures,Innocuments	0.043
9	14.04	S&M-Seeds & Seedlings	0.020
10	14.06	S&M-Uniform, Extension Kits	0.070
11	14.07	S&M-Text Books, Library books	0.013
12	14.08	S&M-Others	0.042
13	15.01	Maint of Property-Building	0.119
14	15.02	Maint of prop-Vehicle	0.600
15	15.05	Maint of prop-Equipment	0.131
16	15.06	Maint of prop-Plantation	0.030
17	15.07	Maint of prop-Computers	0.012
18	17.03	Op Expenses-Transportation	0.007
19	17.04	Op Expenses-Energy/Propulsion	0.005
20	24.03	Contribution-provident Fund	0.292
21	25.01	Retirement benefits	0.033
22	54.03	Computer & peripherals	0.088
23	51.08	Const of Chain Link fencing & Gate	0.786
24	51.01	Const of Staff quarter	1.500
		Total	**12.210**

1. Helvetas/Swiss Development Contribution.

Sl No	OBC	Particular	Amount
1	12.01	Utilities-Telephone,Fax,Internet,E-Mail	0.099
2	14.01	S&M-Office Supplies, Printing, Publication	0.100
3	14.02	S&M-Medicine, Laboratory consumable	0.009
4	14.03	S&M-Fertilizer,Chemical,Manures,Innocuments	0.030
5	14.04	S&M-Seeds & Seedlings	0.030
6	14.07	S&M-Text Books, Library books	0.020
7	14.08	S&M-Others	0.024
8	15.01	Renovation of RNR Sub Centre at Tsirang	0.914
9	15.05	Maint of prop-Equipment	0.034
10	15.07	Maint of prop-Computers	0.060
11	15.08	Maint of prop-Others	0.010
12	17.01	Op Expenses-Advertisement	0.030
13	17.07	Op Expenses-Others	0.110
14	45.02	Training-Others	0.250
15	52.05	Plant & Equip-Agriculture Machinery	0.300
16	54.01	Office Furniture	0.292

17	54.02	Office Equipment	0.300
18	54.03	Computer & peripherals	0.468
19	55.01	Professional Services	0.715
20	51.08	Construction of Green House	0.272
21	51.08	Const of Farm Equipment & Vehicle Servicing	0.096
		Total:	**4.160**

2. CBNRM Contribution

1	45.02	Development for Implementing Bhutan National CBNRM Strategy	0.345
		Total:	**0.345**
		Grant Total	**16.715**

Summary of Annual Weather, RNRRC, Bajo 2004

Rainfall (mm)			Temperature (°C)			Humidity (%)			Evaporation (mm)		
Max	Min	Total	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Total
0.00	0.00	0.00	23.20	1.80	12.69	99.00	50.00	76.71	6.40	2.20	118.00
3.60	0.00	5.60	23.20	1.80	12.95	86.00	27.00	67.31	6.40	2.20	127.50
8.70	0.00	12.70	28.20	6.80	18.87	90.00	55.00	74.97	8.00	2.20	172.30
11.20	0.00	23.20	28.20	10.60	20.48	94.00	50.00	73.57	8.40	2.00	161.80
14.70	0.00	52.40	30.70	13.60	22.50	92.00	35.00	67.84	8.60	2.20	167.90
21.00	0.00	77.60	32.10	18.70	23.58	91.00	61.00	75.40	8.40	3.10	165.00
35.90	0.00	121.30	30.20	19.30	23.61	97.00	62.00	80.58	6.40	1.80	138.90
18.00	0.00	86.20	31.20	19.70	25.10	93.00	61.00	72.68	9.70	3.20	177.10
45.50	0.00	83.20	29.10	17.70	23.52	91.00	69.00	80.87	6.40	3.20	140.30
44.00	0.00	79.20	28.20	8.40	19.85	95.00	60.00	77.26	6.70	2.20	150.40
0.00	0.00	0.00	25.00	3.60	15.61	97.00	66.00	74.77	6.40	1.90	113.10
0.00	0.00	0.00	24.10	0.40	12.90	96.00	38.00	78.42	6.00	2.10	99.80