ABOUT THIS REPORT

This is the 19th 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, 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

The principal focus of Field Crops research is to increase and sustain the productivity of cereals (rice, maize, wheat, and minor cereals), oilseeds (rapeseed-mustard) and grain legumes (soybean, mungbean and groundnut). The short-term objective is to identify, adapt or develop appropriate and affordable technologies, including varieties, for optimizing the production of field crops. During the year, a total of 21 activities were carried out, both on-station and on-farm, in collaboration with extension staff and farmers, in various crops.

Rice research aims to improve rice production by using appropriate varieties and management techniques. The main variety selection criteria are yield potential, medium height (100-120 cm), medium maturity (130 -150 days), and resistance to prevailing pest and diseases. In 2003, 20 entries were tested in AET including the checks. Statistical analysis of grain yield showed that GUOJING 4 and UPR 84-21 were the top yielders averaging 8.20 t/ha. Several other lines performed well. The local check, Zakha, yielded 4.9 t/ha. The IET was composed of 24 lines, including the checks. Promising high yielders were RHS 351-19CX-7CX-2CX, SPR87032-2-1-1-4 and NR 10291 with an average grain yield of 8.20 t/ha. Several lines with yield higher than local Zakha and comparable to standard checks were selected for further evaluation.

An observation trial consisting of eleven varieties from Nepal was carried out at RC Wengkhar and RC Bajo. Observation Nursery I consisted of introductions from the IRRI-INGER program of 2001 and selected Nepali lines. The yields of most of the entries were higher than the local check variety Zakha. Other important parameters were days to 50% flowering, maturity and plant height. Observation Nursery II consisted of 18 lines introduced from BARI (Bangladesh Rice Research Institute). Few lines were selected for further evaluation based on phenotypic acceptability and general performances.

The on-farm trial consisted of testing high altitude varieties and advanced lines from RC Yusipang for their performance under Gasa conditions.

The wheat trials consisted of eight entries, including standard checks, to assess the performance of some Indian varieties across locations in Bhutan. Analysis of grain yield showed that UP 262 yielded high, with an average yield of 1.9± 0.9 t/ha. In grain legumes, not much evaluation work could be done at RC Bajo due to lack of test materials.

HORTICULTURE

The objectives of horticulture research in RNRRC Bajo are improving quality and yield of vegetables, nut crops, low chilled temperate fruits and subtropical fruits through introduction, diversification, adaptive trials and demonstrations of these crops. Beside introduction and evaluation of exotic horticultural species, the evaluation and improvement of local germplasm, production management and nursery trials, post-harvest research, crop rotation, intercropping, kitchen gardening and homestead orchard and demonstration orchard development were

also be given adequate research attention. On-station and on-farm participatory horticultural research are the approaches being adopted by the center.

Some of the highlights of horticulture research program for 2003-2004 are:

- Under the variety improvement of fruits and vegetables, the centre released 1 lime, 1 peach, 4 almond, 2 grapes and 1 pear varieties for general cultivation.
- Participatory evaluation of fruits and vegetable is on-going and 11 demonstration orchards in the region have been established.
- It was confirmed through nursery trials that local avocado and improved avocado are graft incompatible.
- Vegetable breeder seeds of 22 cultivars that were released from the centre were maintained.
- Mother plants of all fruit cultivars released from this centre are being maintained.
- Leaflets on apricot (newly released Bajokhamchu-1) cultivation published.
- Leaflet on walnut propagation under ambient conditions published.
- Guidelines on vegetable cropcuts, vegetable seed production, peach, persimmon, avocado and walnut propagation and nursery management are in the process of publication.
- Support and technical recommendations were provided to the client dzongkhags of this region and to MoA from time to time.

LIVESTOCK

The main objectives of livestock research program are to develop more productive and sustainable livestock options for wetland farmers and to strengthen crop-livestock research creating synergistic effect on the crop/livestock production. The scarcity of animal feed and green fodder for cattle especially during winter months is still a serious problem for wetland farmers of the region. Some other major constraints are inadequate suitable feed/ fodder crops to meet the increasing requirements, lack of appropriate fodder production techniques, lack on fodder resources farmers' practices, lack of seed and seed production techniques, limited land for pasture and fodder production and competing cash crops in the wetland. Looking into these issues and the constraints of the region, the sector gives major emphasis on feed and fodder research in trying to mitigate some of these problems. Most of the activities are focussed in fodder production under rice-based farming system.

During 2003-04, there were 19 activities of which 6 were new and 13 were ongoing. These activities were both regional in nature and nationally coordinated. From these activities, 8 were on-station and 11 were on-farm collaborative trials. Out of these, 13 activities were feed and fodder in nature and 6 were on breeding and management. During the year, 6 activities were reported as completed and 13 activities are ongoing for further evaluation and assessment. Over the years, the livestock research has expanded to cover activities under the sub-program breeding and management and socio-economics/ marketing as well. In breeding and management efforts were put in documenting information on local pig genetic resources, yak herd monitoring scheme and in apiculture practices. Documentation of livestock products, processing and marketing aspects were also looked into. 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' needs.

FORESTRY

Community forestry activities in the Lingmutey Chu watershed continued during the past year too with greater emphasis on working with the communities and within their "comfort zone". Consultations with the community forestry user groups gave new directions and defined new priorities for the coming year. A pilot initiative in collaboration with the BG-SRDP Lobeysa and the Wangdue Territorial Forest Division to develop a simple local watershed forest management plan was started with activities such as forest function mapping, forest blocking, demand assessment and resource assessment. The outputs from all these exercises will culminate in the development of a management plan for the watershed forest that matches the site and forest potentials with those of the demands and priorities of the different actors that have a stake in the watershed including the communities, forestry department and the local administration.

On-station activities that include multiplication, propagation and evaluation of multi-purpose tree species (MPTS) continued with newer accessions. Diverse local species of trees, shrubs and grasses of economic importance to the farmers were evaluated for their potential as agrofrestry species. 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. Assessment of the nationally coordinated trial "stand stability trial in blue pine forest at Khotokha" has been carried out. The broadleaf forest dynamics research will get a major impetus with the approval by the Ministry of Agriculture in the later part of the fiscal year, the framework document for adopting Rimchu forest management unit (FMU) as a research forest. Research activities such as regeneration dynamics, permanent sample plot study, grazing ecology and a host of related research can now be conducted in close collaboration with the coordinating centre, BG-SRDP, Lobeysa, the Wangdue Divisional Office and the Natural Resources Training Centre, Lobeysa.

SYSTEM RESOURCE MANAGEMENT

Community Based Natural Resources Management (CBNRM)

CBNRM activities in Lingmuteychhu watershed are continuous processes, where participatory on-farm or action research is done with community participation with the objective of long-term sustainable development of the communities. Participatory Action Research core process is to enable participants to share their perceptions of a problem, to find common ground and then to engage a variety of people in identifying and testing out some possible solutions.

Based on the issues related to livelihood improvement of the farming community raised during the participatory problem diagnostic survey conducted during the

year 1997, initiatives and activities implementation was concentrated to support the broader communities livelihood issues on improving crop yield production, increasing cash crops options and increasing intensity and diversity of farming practices**.**

Integrated Plant Nutrient System (IPNS)
Integrated Plant Nutrient Systems research aims at bringing together the research, the extension and the farmers to improve farmers' soil fertility management practices using an integrated plant nutrient systems approach. The major research work includes studying farmers' soil nutrient management practices and improving upon them through appropriate and affordable technologies that will improve the productivity of farmers' land. Activities mainly focused on studies on the farmers' soil fertility management for different cropping systems, such rice-based oat cultivation, rice-based potato cultivation and rice-rice cultivation, both in and outside the Limbuteychhu watershed. The general aim of the studies was to obtain a better understanding of the existing fertility management practices and their impacts on soil fertility in the long run. Based on the study results, a number of balanced fertilizer trials were done both in and outside the watershed.

An extension material (leaflet) on maize trashline for soil erosion control was developed with the aim to disseminate this simple technology for replication in the areas wherever it is feasible. Around hundred copies were printed and distributed to the client Dzongkhags for all the geogs extension agents, central agencies and other RNRRCs.

Integrated Pest Management (IPM)
The IPM sector mostly provides need-based technical plant protection services to the client Dzongkhags through field visits, awareness campaigns on important crop pests and disease, disease-pest verification, surveillance and monitoring. IPM research for 2003-2004 was concentrated on chilli blight management demonstration in Eto Nesa, Wangdue Phodrang and Khawajara, Punakha, *Shochum* management campaign, and citrus bagging and Chinese citrus fruit fly (*Bactrocera minax*) phenology study in Tsirang.

Chilli blight management demonstration was a success at both the sites. Some of the farmers expressed their desire to implement the package of practice such as raised bed, proper drainage, wider spacing between plants, timely weeding and other horticultural management practices in their own fields. Economic analysis shows that the cost of chilli production for Khawajara (Nu. 3.50/kg) is lower than Kazhi (Nu. 12-13/kg).

The *Shochum* management campaign through intensive hand weeding is an on-going activity in Lingmuteychhu watershed and Gaselo. Three years of intensive hand weeding has reduced rice yield loss of 1-2 t/ha in watershed and Gaselo.

On the citrus front, the Chinese citrus fruit fly still continues to be a major cause of citrus fruit drop in the mandarin growing regions of the country. A bagging and citrus fruit fly phenology trial was done in Salami, Tsirang mainly to bag fruit and

expose to determine the period of oviposition and to determine the critical mean size reached for oviposition.

Other plant protection activities included rice blast monitoring and *Parthenium* weed management campaigns that were conducted from July through October 2003. Plant protection staff were invited as guest speakers to Wangdue Middle Secondary School and Bajo Higher Secondary School to speak on *Parthenium* weed and its management.

Agricultural Economics

Agriculture Economics started in this Research Centre with the placement of Agriculture Economist in 1999. The main activities carried out by the Agriculture Economics section are conducting economics analysis of existing or new land-use technologies using research method like partial budgeting, enterprise budgeting, and cost benefit analysis etc. Th sector also develops enterprise budgeting that presents costs and benefits of crop cultivation, and land use and marketing research is also carried out. During the year 2003-2004 the following activities were carried:

- Impact assessment of the rice research program in Bhutan was completed and published in collaboration with IRRI, IDRC and SDC.
- On-station vegetable seed production cost analysis was carried out.
- On-station rice based potato production economics was carried out from 2000 to 2002.
- Economic analysis of chilli blight disease demonstration and management trials at Khawajara and Bjaktey was carried out and reported.
- Survey on crop budgeting of chilli production was carried out in Punakha and Wangdue dzongkhags. The analysis is under process and will be reported in coming year.

Water Management Research (WMR)

Water Management Research (WMR) started as Water Management Research Project (WMRP) in the beginning of 8th Five Year Plan. WMR was institutionalized as part of regular research program in RNR RC Bajo. The national mandate of WMR program is to conduct and coordinate water management research for enhancing and sustaining the rural livelihood. The main objectives of the WMR program were to raise the productivity of existing rice-based irrigation schemes through improvement in water delivery system. The major activities during this reporting period are as given below.

Rainfall and stream flow data collection started since the beginning of the watershed study. Before 2000, the rainfall and stream gauging data was collected manually by employing local people. However the data collected were unreliable and it was decided that automatic data logger is to be used instead. The water sharing systems and water rights regimes in the watershed are monitored. Water resources management through role playing was tried in the watershed. The main objective of the role-play game was to bring the communities to a common understanding of the water resources with regards to its sustainable and equitable use. Two discussion workshops for three days each were conducted in Dompola. Role playing games (RPG) were used as a tool for forging trust & stimulating discussion with regard to the sharing of irrigation water resource

between the two communities. The RPG results can be used for Multi-Agent Systems (MAS) modelling which constitute a powerful tool for studying interactions between societies and their environment. The outcome of the RPG session has been documented.

Direct seeding of rice was attempted in the station to reduce the water shortage during transplanting. The general findings indicated that the late transplanted (control treatment) over three years yielded 3.03 t/ha on an average basis. The direct seeded have an average yield of 1.55 t/ha. It was noted that there was no significant yield difference between row direct seeded and direct broadcasting methods. Direct seeding method has the potential of addressing the irrigation water shortage problem during the transplanting season.

Citrus irrigation trial was established at Bichgoun in Tsirang, Gelephu and Dakpai in Shemgang following the soil moisture regime monitoring for the last three years. Irrigation scheduling is based on the soil moisture regime under normal rainfall condition. The main objective of the study is to explore the yield benefit of irrigating the citrus under the existing management practices and to assess the viability of low cost irrigation technology (simplified drip). The work is still ongoing.

WMR sector in collaboration with Horticulture Sector and the concerned Dzongkhags was also involved in the development and management of the orchards in the region. The specific support extended by WMR sector were a preliminary study for developing irrigation facilities for developing new orchard near Punakha Dzong; produced baseline maps for redesigning the orchard layout for Sonagasa and Phuntshopelri Orchards; preliminary survey for developing irrigation facilities for orchard near Nyzer Lhakhang and drinking water supply to the Lhakhang and assisted in the survey of Nyzer Lhakhang watershed study.

Extension Program

The Extension Program Office was instituted as an integral part of research system in mid 1990s. Its main focus is to cater extension with research results for extension use and in turn collect field problems to be used as basis for research. This office is a bridge between research and extension bringing integration of research system with line departments' extension wing. Its main responsibility of extension-research linkage is done through organizing Annual Review and Planning Workshops (ARPW). ARWP is the highest forum in the region where all stake holders of research and extension gather, and research technologies and extension problems get exchanged. Prior to ARWP, a dzongkhag level meeting called pre-regional meeting is also organized to collect inputs for ARWP.

Besides organizing ARWP and pre-regional meetings, the sector is also mandated and engaged in technology packaging, farmer's group formation, extension training on cross-cutting issues, organizing extension and farmer study tours and participating in various workshops and meetings of the RNR sector.

FIELD CROPS RESEARCH

1 FIELD CROPS RESEARCH

1.1 Rice Research

1.1.1 Advanced Evaluation Trial (AET)

In 2003, 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 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 applied as and when required. Grain yield was estimated from a harvest area of 5.04 sqm and grain moisture content was standardized at 14%. Results are presented in Table 1.

Table 1 Performance of AET 2003

Variety	Yield (t/ha)	Plant Height (cm)	50% Flw. (Days)
GUOJING 4	8.40	94	121
UPR 84-21	8.00	91	112
Bajo Kaap 1	8.00	94	119
IET 12884	7.89	100	113
SPR 87036-7-1-1-2	7.87	106	114
B2983B-SR-85-3-2-4	7.84	110	112
IRGA 440-22-3-4-1F-1	7.67	94	117
Bajo Maap 1	7.52	101	115
ZHONGYO 5	7.50	104	116
Bajo Kaap 2	7.49	90	124
CNAX 4506-3-2-2-1-B	7.48	87	115
IR 64683-87-2-2-3-3	7.19	94	112
RP 2233-10-16-9	7.16	103	113
IR 64	7.14	89	119
VN 93-1	6.96	102	121
BR5969-3-2	6.90	98	122
IR 68077	6.72	93	112
IR 62745-B-R-B-20-1-B	6.35	126	112
Bajo Maap 2	5.55	101	110
Local Zakha	4.94	126	115
CV %	9.6	7.5	3.3
S.E.D	0.40	4.36	2.19

Analysis of grain yield showed that the highest yielder were GUOJING 4 (8.40+/- 0.4 t/ha), UPR 84-21 (8.00+/- 0.4 t/ha) and IET 12884 (7.89+/- 0.4 t/ha). The standard check Bajo Kaap 1 produced a yield of 8.00+/- 0.4 t/ha that is comparable to the highest yielders. Several other crossbred lines produced yields higher or comparable to Bajo Maap 1, Bajo Kaap 2 and IR 64. Local check Zakha yielded lowest with the grain yield of 4.94 +/- 0.4 t/ha.

Occurrence of insect pests and diseases was negligible during the test season and hence no intervarietal rating was done. The best performers from this trial will be evaluated in the farmers' fields in the ensuing season.

Random soil sampling from the trial sites were done prior to land preparation and the samples were analyzed at NSSC. Analysis results showed nitrogen content of 0.11%, (categorized as low), pH of K of 4.43 (vL) and available phosphorus (Bray) of 9.26 mg/kg (L).

1.1.2 Initial Evaluation Trial (IET)

IET consisted mainly of 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 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 a.i. 1.5 kg/ha to control weed pressure. Hand weeding and irrigation was 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.

Table 2 Performance characters of IET 2003

Variety	Yield (t/ha)	Plant Height (cm)	50% Flw. (Days)
Bajo Kaap1	9.63	101	115
Bajo Kaap 2	9.43	101	121
Bajo Maap 1	8.98	104	112
RHS 351-19CX-7CX-2CX	8.69	111	122
IR 64	8.30	92	119
SPR87032-2-1-1-4	8.15	110	121
NR 10291	8.15	102	115
YOU MI 18	8.10	111	122
IR17146-97-1-2-1-3	8.07	96	112
CH 5	7.97	120	123
BW348-1	7.89	117	137
NR 10276	7.87	132	111
BR1711-7-2-4-2	7.80	119	112
RHS 33025-CX-3CX-024	7.73	102	132
CH6	7.34	110	133
WAB 340-B-B-10-112	7.27	132	115
BR1543-9-2-1	7.21	121	132
TOX 3098-2-2-1-2-1	7.08	102	139
ZHONG-XIANG 1	7.04	109	112
Bajo Maap 2	6.94	105	108
TOX3145-TOC-15-2-1	6.82	116	122
JIANG-ZHOU-XIANG-NUO	5.97	97	111
Local Zakha	4.31	135	110
WAB 224-16-HB	4.19	107	109
CV %	6.4	2.1	0.1
S.E.D	0.481	2.3	0.1

Analysis of variance showed that several test varieties were slightly lower yielding than check lines Bajo Kaap 1, Bajo Kaap 2 Bajo Maap 1and IR 64. However, several lines were yielded significantly higher than the local check, Zakha. RHS 351-19CX-7CX-2CX (mean yield= 8.69+/-0.481), SPR87032-2-1-1-4 (mean yield= 8.15+/-) and NR 10291(mean yield= 8.15+/- 0.481) are few promising lines with mean yields equivalent to the standard checks. 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.

Random soil sampling from the trial sites were done prior to land preparation and the samples were analysed at NSSC. Analysis results showed nitrogen content of 0.10%, (vL), pH of K of 4.69 (vL) and available phosphorus (Bray) of 8.46 mg/kg (L).

1.1.3 Observation Nursery I

This nursery consisted of introductions from the IRRI-INGER program and selected Nepal lines where the 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 3.45-9.03 t/ha. The yields of most of the entries were higher than the local check variety Zakha. Days to 50% flowering ranged from 118- 138 days, while the plant height ranged from 74- 125 cm. No notable insect pests and diseases were observed in the trial. The selected entries will be further evaluated in replicated yield trials.

Random soil sampling from the trial sites were done prior to land preparation and the samples were analysed at NSSC. Analysis results showed nitrogen content of 0.12%, (L), pH of K of 3.93 (vL) and available phosphorus of 11.1 mg/kg (L).

Table 3 Observation Nurseries I, 2003

Variety	50% Flw. (Days)	Plant Height (cm)	Yield (t/ha)
Bajo Maap 1	124	89	9.03
IR 71604-4-4-3-7-2-2-3-3	122	91	8.35
Khumal 6	122	125	8.21
IR73887-1-8-2-1	124	77	8.12
NANJING 70272	125	80	7.76
ITA306	138	84	7.63
CT 9737-5-2-1-2-4P-M	122	86	7.12
IR 64	125	81	7.10
BR4656-1-2-3-2	126	101	7.08
Bajo Kaap 2	129	90	7.05
IR69716-87-1-3-1-1-3	125	73	7.05
NR 10291	124	93	7.02
FAROX 317-8-2	125	83	7.02

BR4726-2B-6-1-2-J4	122	124	7.00
Himali	124	82	6.99
CT9883-9-2-M-5-4P-M	122	76	6.92
IR71143-223-3-2-2-3	118	74	6.83
NR 10375	118	86	6.78
CT9506-12-10-1-1-M-3P-M	118	78	6.78
8344	128	91	6.77
P 4	131	91	6.70
NR 10276	122	116	6.69
242	118	96	6.59
NR 10353	135	95	6.59
C 74	135	111	6.58
MK 9-87	135	93	6.43
TOX902-5-102-2-103-101	120	75	6.39
CT 6163-8-9	124	89	6.36
IRGA 440-22-4-4-1F-1	122	81	6.27
IRGA 318-11-6-9-2-A3	118	88	6.20
TOX3211-14-1-2-1-2	134	91	6.03
Khumal 4	124	121	6.02
IR71144-201-1-2-3-1	122	91	5.87
IR69020-144-3-1-3-1-2-3	131	89	5.70
B7003D-MR-3-1-3	135	91	5.59
RHS 392	131	95	5.56
IR71137-243—2-2-3-3	120	76	5.56
BR (BE) 6158-RWBC2-6-5	129	85	5.54
XUAN SO 9	138	89	5.46
87604-2	124	97	5.45
XUANG SO 6	138	88	5.37
Taichung	122	96	5.10
Kancha	124	82	4.83
Local Zakha	126	125	3.45

1.1.4 Observation Nursery II (BARI lines)

The trial consisted of 18 lines from BARI, Bangladesh. This activity was carried out with a purpose to multiply seed for further replicated trials in ensuing season. During the course of crop growth basic agronomic characters were also noted.

The observed plant height of the study lines ranged from 72- 122 cm and the 50% flowering from 97- 199 days after sowing. Results of the trial are presented in Table 4. Further evaluation of these lines based on phenotypic acceptability and general performances will be carried out in the ensuing season.

Random soil sampling from the trial sites were done prior to land preparation and the samples were analysed at NSSC. Analysis results showed nitrogen content of 0.10%, (categorised as low), pH of K of 4.82 (vL) and available phosphorus (Bray) of 10.15 mg/kg (L).

Table 4 Agronomic characteristics of BARI lines, 2003

Variety	50% Flw. (Days)	Plant Height (cm)
BR 1	102	73
BR 2	104	104
BR 3	122	71
BR 6	97	101
BR 7	123	102
BR 8	122	72
BR 9	120	108
BR 12	122	98
BR 14	111	115
BR 15	125	86
BR 16	111	82
BR 17	111	122
BR 18	123	100
BR 26	199	96
BR 28	97	100
BR 29	120	95
BR 35	120	104
BR 36	102	82

1.1.5 INGER Nurseries

This nursery consisted of introductions from the IRRI-INGER program where the entries were evaluated in single plots of 10 sqm for yield, maturity period, pest resistance and plant height. Seedlings were transplanted at 20 x 20 cm in late June. Inorganic fertilisers 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 1.58- 9.38 t/ha. The yields of most of the entries were higher than the local check variety Zakha. Days to 50% flowering ranged from 94-144 days, while the plant height ranged from 72-120 cm. No notable insect pests and diseases were observed in the trial. The selected entries will be further evaluated in replicated yield trials.

Table 5 Agronomic characters of entries in IIRON I, 2003

Variety	50% Flw. (Days)	Plant Height (cm)	Yield (t/ha)
PR 23416-34	130	95	8.80
IR 20913	104	120	6.58
BM9820	119	106	9.04
C 2732-10-2-1-1-1	132	89	8.40
90059-TR1251-4-1-2	113	82	4.62
OMCS 97	111	75	7.76
IR 50	111	84	7.51
IR 72894-35-2-2-2	132	83	7.08
WAT 316-WAS-B-51-3-5-4-3	105	80	6.92
DM 24	131	107	3.17
IR 69015-119-3-2-3-1-2-3	136	91	5.57
IR 64	125	93	7.43
IR 69003-47-3-3-2-3-2-3	137	98	7.74

89041TR 1161-5-1-1-1	113	86	5.16
TOX 3255-82-1-3-2	139	91	7.99
WU NONG-1	111	88	8.87
PSB RC2	135	81	7.30
IR 71722-8-2-3-1	132	88	7.76
WAB 99-126	111	107	4.60
RP 1125-1526-2-2-3	139	87	8.29
IR 72102-3-221-2-2-3-3	125	86	8.23
IR 72	121	79	8.57
FRX92F3B-14F4BF5	121	105	8.48
TOX3118-12-1-3-1	136	90	7.58
TOX 3916-13-1-3-2-E1	144	91	6.73
IR 50	112	85	7.57
VND 95-19	119	93	6.53
IR 73546-80-2-2-2	132	94	6.98
QI GUI ZHAN	115	95	8.51
WEN XIANG ZHAN	126	97	6.23
PSB RC 2	127	81	7.38
TOX 981-10-3-2	126	96	8.68
MNTK-M4-UL-5	111	85	7.20
RC 85 C-C1-21-1-2-1-3-3-3-3	121	88	8.41
IR 73008-138-2-2-2	121	92	8.08
IR 64	120	93	8.12
ZHE FU	95	83	1.58
PSB RC74	125	93	8.00
UPR 1561-6-3	125	91	9.06
H 3798	98	113	3.68
IR 20913	104	80	5.64
M2-13-26 UL	111	89	6.64
CNAX 4354-5-8-2-3-3	116	99	5.81
TOX 85A-C2-455-3	136	87	8.28
CT6163-8-9-5-2-M-84-M	126	90	7.69
IR 72	125	82	8.64
DIANSHAO 3	126	104	9.17
IR 72891-73-3-3-1	132	90	8.04
CT 9868-3-2-2-3-3P-M	136	96	9.17
IR 72	132	79	7.91
89023-TR1143-5-1-2-1	104	97	6.38
BR(BE)6161-R1-9	115	79	8.01
BR 5538-12-1-2	132	105	7.76
PSB RC 78	121	82	6.20
IR 64	121	90	8.22
IR 72904-195-1-3-2	130	96	7.92
IR 74052-72-1-3	132	96	8.50
LTH-M4-14	121	98	7.36
IR 73439-11-1-3-1	136	87	6.66
IR 50	110	82	7.98
CAN 8023	127	91	8.08
90060-TR1252-8-2-1	103	82	5.56
TOX 3553-36-2-2-2	132	92	8.94
IR 69020-21-3-2-2-2	139	89	8.57
PSB RC2	136	81	7.90
IET 13942	115	85	8.46
WAT 311-WAS-B-23-7-1-1-2	112	83	8.39

ITA 304	130	87	9.48
TOX 3107-39-1-2-1	132	95	8.86
IR 20913	104	113	6.10
SHANYOU 559	127	95	9.06
N 30	121	91	9.38
TOX 3440-47-5-3-2-1	153	91	5.60
IR 64	125	93	9.28
P8	136	101	8.13
IR 73435-29-3-3-1	112	89	8.54
WAS 30-11-1-4-6-1	136	88	7.01
JEQUITIBA	130	92	8.52
IR 20913	104	116	6.62
C3563-B-5-1	126	92	6.83
IR 74052-165-3-2	142	90	7.95
IR 74052-54-3-2	139	97	6.29
WAB 365-B-2-HI-HB	114	108	3.86
IR 72	135	72	7.94
CT 9882-16-4-2-3-4P-M	125	81	7.05
SPR 85013-5-2	126	98	7.52
ITA 328	153	95	5.49
OM 1271	121	110	9.29
IR 50	111	82	7.69
M1-6148 UL	112	92	8.20
CAN 8487	112	91	7.98
IR 73003-151-2-3-1	139	83	7.21
WAS 43-13-1-1-3-3	99	76	7.39
PSB RC2	136	80	7.45
BURDAGOL	132	94	7.79
H12-24-1-3	104	75	5.60
IR 73013	139	93	7.15
PSB RC2	136	84	8.26
CT 9506-44-2-1-2-M-1-3P-M-1	119	90	7.92
HEI BAO	94	69	2.72
GUI 4 XUAN	111	93	7.21
PR 23426-66	126	77	7.43
IR 72	130	72	7.28
TOX 3055-10-1-1-1-1-2	155	86	3.00
CAN 8598	132	96	6.13
M1-6-120 UL	121	103	8.12
IR 73719-23-3-3-1	136	78	6.89
IR 73546-66-1-1-1	94	111	5.69
IR 20913	137	86	7.42
TOX 3118-6-E2-3-2	139	99	7.62
BA GUI ZHAN	115	98	8.57
WAT 310-WAS-B-28-8-3-3-1	115	89	7.78
IR 50	110	83	7.75
IR 59656-5K-1	110	87	7.98
IR 72895-17-2-3-2	132	90	7.96
C 4249-1-2-2-1-2	116	93	8.33
IR 74052-297-2-1	136	99	8.20
IR 64	126	87	8.53
IR 73415-49-2-1-3	129	83	6.73
OM 95-3	104	83	6.20

Table 6 Agronomic characters of entries in IIRON-II, 2003

Variety	50% Flw. (Days)	Plant Height (cm)	Yield (t/ha)
IR 50	111	80	6.96
IR 72158-11-5-2-3	132	86	8.26
IR 71780-1-1-3-2	123	93	7.39
IR 72	126	75	7.53
IR 72176-140-1-2-2-3	123	95	7.95
IR 71698-193-3-2	132	94	5.43
IR 64	121	93	7.82
IR 72176-307-4-2-2-3	125	96	6.49
IR 71676-34-1-1	132	80	6.13
IR 20913	104	110	4.74
IR 73933-8-2-2-3	132	100	6.99
IR 73974-143-6-2-2	130	98	7.14
PSB RC2	136	84	6.73
IR 50	111	84	7.00
IR 73896-51-2-1-3	136	84	7.69
IR 72967-94-3-1-1	135	88	7.56
IR 72	126	79	6.81
IR 71693-111-6-2-2	125	92	5.91
IR 71700-247-1-1-2	125	113	6.77
IR 20913	94	80	3.84
IR 72165-63-2-3-3	126	92	6.17
IR 73944-143-3-2-3-3	132	98	5.94
PSB RC2	139	82	5.57
IR 72981-92-1-1-2-2	128	93	7.45
IR 72158-116-6	130	89	9.13
IR 20913	105	111	4.21
IR 69020-81-1-2-3-3-1-2	132	84	7.19
IR 72967-12-2-3	132	89	9.14
IR 50	111	84	7.17
IR 72164-405-5-1-1	137	93	7.81
IR 72164-201-1	131	96	5.14
IR 64	125	91	7.58
IR 72985-65-3-1	136	89	8.61
IR 75268-45-2-5-3	127	93	4.16
PSB RC2	135	80	6.11
IR 73935-51-1-3-1	132	95	7.63
IR 71701-28-1-4	126	81	7.84
IR 20913	105	112	4.74
IR 72164-352-2-5-5	136	89	8.95
IR 72158-68-6-3	132	85	10.02
PSB RC2	136	99	6.77
IR 74295-22-2-2-2-3	130	128	7.67
IR 67962-40-6-3-3	135	89	7.60
IR 72	126	77	6.96
IR 75282-10-3-3-2	126	99	7.43
IR 72164-110-1-2	132	88	8.02
IR 64	125	90	7.89
IR 73907-53-3-2-2	130	95	8.35
IR 68011-15-1-1-2-3	126	87	6.69
IR 50	111	81	6.58

1.1.6 Observation of Nepal lines

The objective of this trial was to assess the performance and general traits of Nepal lines across locations. The trial was carried out on-station in two locations, viz., Wengkhar and Bajo.

The trial was laid out in randomized complete block design with three replications. Seedlings were planted at a distance of 20 x 20 cm spacing. 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 broad leafed weeds. The results of the trials at two stations are presented in table.

Table 7 Nepal rice evaluation trial, RC Wengkhar & Bajo

Variety	50% flw in (days)		Plant Height (cm)		Yield (t/ha)	
	Wengkhar	Bajo	Wengkhar	Bajo	Wengkhar	Bajo
Hamili	112	124	58	82	6.17	6.99
NR-10291	117	124	73	93	7.46	7.02
Kancha	107	124	74	82	7.02	4.83
NR-10353	116	135	82	95	5.36	6.59
242	111	118	92	96	6.32	6.59
NR-10375	110	118	98	86	6.15	6.78
Taichung	112	122	98	96	5.94	5.10
NR-10276	110	122	105	116	7.17	6.69
Khumal 6	109	122	109	125	8.98	8.21
Khumal 4	116	124	113	121	7.48	6.02
Nakila (Local)	109	-	145	-	4.85	-
Local Zakha	-	126	-	125	-	3.45

1.1.7 On-farm trials on High altitude Rice Varieties

With the initiative of Dzongkhag Agriculture of Gasa, RC Bajo and RC Yusipang collaborated in conducting an on-farm trial on high altitude rice varieties. The objective of the trial was to study the potentials of rice cultivation and to introduce new rice varieties in cold regions of Gasa.

The trial was carried out at Chuwarwog, Damji geog, at an altitude of 2250 masl. Two high altitude varieties released by RC Yusipang, Yusiray Maap and Yusiray Kaap, were evaluated for yield performances and farmers' acceptability. Seeds were sown in dry beds on 13- 14th March 2003 and transplanted on 7th April 2003. The crop was managed as per the farmers' management conditions. The results are presented in the Table 8.

Table 8 Results of high altitude trial at Gasa, 2003

Variety	Village	Yield t/ha	Farmers feed back
Yusiray Kaap	Churawog/Damji	5.17	Higher yield then local Good taste
Yusiray Maap	Churawog/Damji	4.33	Matures early Difficult to thresh
Local	Churawog/Damji	4.20	Damage by rat and birds

1.1.8 BUCAP activities 2003-2004 (West-Central Region)

Introduction

In 2003, BUCAP was implemented in two locations in the west central region of Bhutan, namely Thangu and Nob Sechekha. The cropping season for Thangu site begins from May and ends by December whereas for Nob Sechekha the cropping season starts from March and ends by November. In all, Thangu has experienced third year/season of BUCAP implementation since 2001 and for Nob Sechekha it is the second year of BUCAP implementation.

Farmers Field School at Thangu (Thedtso geog)

A total of 18 farmers were involved in this farmers filed school. Mrs. Pema Lhaden, AAEO of Thedtso, assist in the field exercises in close collaboration with the research centre. Following field activities were implemented through the BUCAP project.

Participatory Variety Selection

The objectives of this activity are:

- To facilitate farmers' access to varieties/genetic materials thereby promoting agricultural diversity
- To initiate and induce Participatory Variety Selection in the community and strengthen the capacity of farmers towards Participatory Plant Breeding (PPB) leading to better PGR management
- Identification of promising local parents to be used in PPB in future

A total of 18 farmers were involved in conducting this activity. The study included nine varieties of rice including local, standard checks and segregating populations.

The activities were carried out as per the seasonal calendar planned by farmers during the planning meeting. A field day was conducted during the harvest time. Farmers used simple tool of phenotypic assessment of individual varieties by ranking them into good and bad varieties in addition to the yield performances. Most farmers ranked SPR 87036-7-1-1-2 as the good line, which also correspondingly showed very good crop cut yield. Hence, few varieties were selected similarly based on the preference ranking and yield criteria by the farmers for further evaluation in the ensuing season. Results of the field day are presented in Table 6.

Table 9 Preference ranking & yield of PVS plot, 2003

Sl. No	Variety	Farmers Ranking		Researcher's Ranking		Yield t/ha
		Good	Bad	Good	Bad	
1	IR 64683-87-2-2-3-3	6	3	5	-	8.77
2	Guojing 4	6	6	4	-	8.82
3	SPR 87036-7-1-1-2	10	5	4	2	8.87
4	CNAX 4506-3-2-2-1-B	2	2	-	2	8.62
5	UPR 84-21	4	7	-	1	8.17
6	ZHONGYO 5	10	5	-	-	7.52
7	IR 62467-B-R-B-F60-1-B	6	5		5	7.70
8	Dago Yangkum	1	5	-	5	1.57
9	IR 64	9	3	2		8.82

In general, this activity has imparted farmers with the knowledge of variety selection through participatory approach that could be employed in future during the Participatory breeding activities. Variety selection would result in identifying promising variety for release by farmers, adding to the existing genetic diversity of the locality.

Farmers and extension taking crop cut of PVS plot

Yield assessment of local varieties

This was a follow up activity of seed selection (panicle selection) of three local varieties conducted by FFS in the previous two years. The activity was targeted to study the yield improvement of local varieties through proper seed selection against the traditional practices. The crop cut results obtained by FFS during the field day conducted during harvest time is presented in Table 10.

Table 10 Yield comparison of farmer's seed & FFS seed

Sl. No	Variety	Yield (t/ha)	
		FFS selected seed	Traditional selection practices
1.	Apa Dogo	4.70	4.05
2.	Dago Yangkum	3.70	3.35
3.	Nabja	6.25	4.55

Result shows a promising gain in yield of local varieties through seed selection method employed by FFS against the traditional practices. This is

indicative of improvement of land races through seed selection which would promote cultivation of locals and hence conservation.

Rice Farmers Field School at Nob Sechekha (Guenshari)

At Nob Sechekha the FFS is run with the objective of conservation development and use of local rice genetic resources. Mr. Yeshey Jamtsho replaced Mr. Gyeltshen as the AAEO of the Guenshari geog who assist in field exercises. In view of the above objectives following activities were carried out in the year 2003 by Farmers' Field School at Nob Sechekha.

Participatory Variety Selection

The objectives of this activity are:

- To facilitate farmers' access to varieties/genetic materials thereby promoting Agrobiodiversity
- To initiate and induce Participatory Variety Selection in the community and strengthen the capacity of farmers towards Participatory Plant Breeding (PPB) leading to better PGR management
- Identification of promising local parents to be used in PPB in future

A total of 9 high altitude rice varieties, five locals and four improved varieties for similar agro-climatic zones were evaluated through participatory selection method. Eleven member farmers of the FFS were involved throughout the activity implementation. The activities were carried out as per the seasonal calendar planned previously by farmers.

Plot size: Large single plots
Sowing date: 25/03/03
Transplanting date: 17/06/03
FYM: 1500 kg/ha
Butachlor: 5 kg a.i/ha

A field day was conducted during the harvesting of the study plots wherein all the member farmers were engaged in assessing the performance of the lines. Farmers evaluated the test lines according to their criteria and yield was the most important criteria for evaluation. The result of crop cut conducted by farmers during field day is presented in the Table 11.

Table 11 Crop cut results of PVS, 2003

Sl. No	Variety	MC %	Yield Kg/plot	Yield T/ha
1	Bunap Naap	17	3.30	5.50
2	Bunap Kaap	19	3.70	6.00
3	Wangda Kaam	20	2.90	4.70
4	Phulaychu	20	3.50	5.65
5	Gyemja Maap	20	3.20	3.25
6	Khangma Maap	16	2.00	3.25
7	PP2-38-4	20	3.40	5.47
8	Yusiray Kaap	19	2.00	3.35
9	Yusiray Maap	17	3.10	5.17

Bunap Kaap yielded the highest with 6.0 t/ha followed by Phulaychu and Bunap Naap with yield of 5.65 t/ha and 5.50 t/ha respectively. These varieties were identified as the potential local parents for PPB in future. Among the improved varieties Yusi Ray Maap yielded the highest (5.17t/ha). In general, improved lines yielded lower than local varieties under the study condition. However, single year of evaluation is not enough to ascertain the performance of these lines and farmers felt the need to do further evaluation of these improved varieties.

This activity has been beneficial to farmers in terms of strengthening their capacity in variety evaluation though participatory method. Participatory Variety Selection is expected to lead farmers towards Participatory Plant Breeding, strengthening farmers' capacity in development and conservation of their rice genetic resources. Besides, identifying potential parents for PPB, eminent in near future, is a notable achievement.

Seed selection of local rice varieties

Yield of local varieties deteriorates over the years due to developmental variation, mechanical mixture, natural crossing with undesirable types, diseased plants, off-type plants and selective influence of certain diseases. Hence, this activity was aimed to improve the quality of seed through panicle selection and bulking, an improved method of seed selection over their indigenous practices. Improvement in quality of seed expected to enhance yield of local varieties, which in turn would promote conservation of the same.

Two varieties of local rice, Phulaychu and Bunap Naap, were cultivated in single large plots under farmers' management conditions. Farmers carried out seed selection on above two varieties. The methods employed were panicle selection and bulking. 3-4 kg of pure seed for each variety were obtained which shall be multiplied in the ensuing season. The produce shall be than distributed to member farmers for their cultivation.

Field visit of BUCAP FFS to RNRRC Bajothang

Farmers form two project sites and respective extension agents of the geogs visited the research centre at Bajo. The study visit was aimed to strengthen farmers' capacity on rice genetic diversity and breeding methods that would in turn enhance their rice genetic resource management.

Community Self Assessment to assess the performance of the project

A ToT on Community Self assessment was conducted through SEARICE at RC Khangma wherein Extension agents form two project sites of West-central region and a researcher from RC Bajo also participated.

In following to the above, Self-Assessment exercises at the community level were conducted at each BUCAP implementation sites to assess the performance and outcomes of the project. Farmers were proactively involved in the assessment exercises. The results of the Self-Assessments were

presented during the National Consolidation Workshop, held by SEARIC and NBC at Zangdopelri Hotel, Punakha. (*Refer a separate report on BUCAP Community Self Assessment, West Central Region, NBC).*

Seed Maintenance and production of released varieties

A total of 2965 kgs of pre-basic and basic seeds of eleven varieties of rice were produced for supply to DSC and future research use.

Table 12 Details of rice production, 2003

Sl. No.	Variety	Pre-basic (Kg)	Basic (Kg)	Total (kg)
1	BR 153	45	-	45
2	Bajo Kaap 1	150	300	450
3	Bajo Kaap 2	230	350	580
4	Bajo Maap 1	130	595	725
5	Bajo Maap 2	120	375	495
6	IR 64	125	300	425
7	Kashmiri Basmati		50	50
8	Milyang 54		140	140
9	BW 293		15	15
10	No 11		40	40
Total		800	2165	2965

1.1.9 Crop Production Management

Nature Farming using EM technology

EM activities were started in 1995. Since then a demonstration plot on Nature Farming has been established to evaluate as well as demonstrate the merits of organic agriculture and the value-addition of EM.

Table 13 Grain yields (t/ha) of various crops, 1996-2004

Crop	Year							
	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04
Rice	8.7	4.4	5.05	6.26	6.50	6.60	6.80	5.73
Wheat	0.766	1.25	1.058	1.2	1.9	1.5	2.33	
Mustard	0.26	0.27	0.406	0.485	0.49	0.26	0.142	
Maize	6.37	5.82	6.84	7.7		5.0	5.25	4.5

The yields as presented in the Table 13 and figure below are good and comparable to those where agro-chemicals may have been used. Yield of rice for the first year was high because the field was under green manure (*Sesbania aculeata*) for more than 3 years which increased rice yield. After a drastic decrease in the following year, rice yield has gradually stablised to 5.73 t/ha. The yield for wheat for 1999-00 was good (1.9t/ha) and gradually increased to 2.33 t/ha. The yield of maize in the year 2003-2004 is 4.5 t/ha, a slight decrease compared to the past years.

1.2 Maize Research

1.2.1 Seed Maintenance and Production of released varieties

A total of about 260 kg of four corn varieties/types were produced for research use. Below Table shows the details of maize seed production.

Table 14 Details of maize seed production, 2003

Sl. No.	Variety/type	Amount (kg)
1	Super Sweet Corn	80
2	Popcorn	20
3	Khangma Ashom 1	40
4	Khangma Ashom 2	120
Total		260

1.3 Minor Cereals

1.3.1 Seed Production and maintenance Limithang Kongfu 1 & 2 (Millet)

The objective of this activity is to maintain and produce seed of millet varieties released from Khangma for research and unforeseen imminent use. A total of 20 kgs of seed was produced for two varieties, Lingmethang Kongfu 1 and Lingmethang Kongfu 2.

1.4 Wheat Research

1.4.1 Wheat Advance Yield Trial

The trial consisted of five varieties from India and three standard checks. The objective of this trial was to critically assess the performance of these lines under Bhutanese conditions. The trial was laid out in complete randomized block design with three replications. A spacing of 20 x 20 cm was maintained between plants. Inorganic fertilizer was applied at the rate of 60:30:20 NPK kg/ha with half a dose of N top-dressed at 35 days after germination. Regular hand weeding was done.

Amongst the test lines, Bajoka 1 yielded the highest with 2.0 ± 0.9 t/ha followed by UP 262 with an average yield of 1.9± 0.9 t/ha. The results of the trials are presented in the table below

Table 15 Agronomic traits of Wheat AT, 2003

Varieties	Maturity days	Plant height	Yield (t/ha)
Bajoka 1	142	100.7	2.0
Sonalika	142	95.3	1.7
Raj 3077	142	102.3	1.6
PBW 343	136	86.0	1.6
HD 2189	142	90.0	1.7
UP 262	138	87.0	1.9
UP 2338	137	83.3	1.4
Bajoka 2	136	102.7	1.1
LSD	0	13.15	0.40
CV %	0	4.20	9.70

1.4.2 Seed Maintenance and Production of released lines

About 565 kg of seed of three released varieties of wheat was produced and maintained at RC Bajo to supply breeder's seed to DSC and further research use. The details of production are listed in the Table 16.

Table 16 Wheat Seed production, 200-2003

Sl. No.	Variety	Quantity (kg)
	Sonalika	326
	Bajoka 1	185
	Bajoka 2	55
Total		566

1.5 Grain Legumes

1.5.1 Soybean Observation Trial

The objective of the trial was to assess and evaluate the performance of soybean lines under different agro-ecological conditions of Bhutan. The trial design was laid out in single plot and a spacing of 30 x 30 cm was maintained between plants. The test lines showed poor germination and pod formation across locations. Hence adequate yield data could not be obtained. Table 17 presents some of the agronomic data recorded from two on-station trials, Jakar and Wengkhar.

Table 17 Soybean Observation Trials, 2003

Treatment	Days to Maturity		Yield (t/ha)	
	Jakar	W/khar	Jakar	W/khar
Chinese Black Soybean 1	203	134	0.92	0.081
Chinese Black Soybean 2	203	203	1.26	0.62
Japanese Black, Grade L	203	134	0.35	0.08
Japanese Black Soybean 1	203	130	0.97	0.05
Japanese Black Soybean Grade LL	203	134	1.33	0.30
Khangma Libi 2	-	130	-	0.86
Khangma Libi 1 (AGS 258)	-	134	-	0.62

1.5.2 Seed Maintenance and Production of released varieties

A total of 13.5 kg of three released varieties of Soybean, AGS 258, Bragg, GC 60184-273 (Khangma Libi) was produced at RC Bajo for further research and extension use. In addition, about 16 kgs of promising groundnut lines were also produced for the purpose of on-farm trials for the ensuing season. Seed production and maintenance were also done for the two local varieties of mungbean from Tsirang. The details of seed production in grain legumes for 2003-2004 are provided in Table 18.

Table 18 Seed production of grain legumes, 2003

Sl. No.	Variety	Quantity (kg)
Soybean		
	AGS 258	4.5
	Bragg	4
	GC 860184273 (K Libi 2)	5
Groundnut		
	Kadiri	3
	ICGV 87920	3
	ICGV 88699	10
Mungbean		
	Tsirang Local Yellow	2
	Tsirang Local Black	2.5

1.6 Oilseeds Research

1.6.1 Mustard Observation trial- BARI lines

The trial was conducted with an objective to evaluate the performance of mustard lines from BARRI, Bangladesh, under the Bhutanese agro-climatic condition. A total of seven varieties including three released varieties as the standard checks, were evaluated for yield, maturity days, flowering time and pest and disease incidences. The trial was laid out in single observational plots of size 10 sqm. Table 19 presents observations from the trial.

Table 19 mustard observation trials 2003-2004

Variety	50% flw	Mty date	Pest &disease inc.	Yield/ plot (gm)	Yield in t/ha
Sonali sarisha	19/1/04	29/3/04	Aphids, larvae of cabbage butterfly	100	0.10 t/ha
BARI mustard 2	23/1/04	6/4/04	Aphids	300	0.30 t/ha
BARI mustard 6	19/1/04	26/3/04	Severe aphids, larvae of cabbage butterfly	140	0.14 t/ha
BARI mustard 9	19/1/04	29/3/04	White rust	190	0.19 t/ha
Bajo Peka 1 (BSA)	23/1/04	29/3/04	Mild aphids	450	0.45 t/ha
Bajo Peka 2 (PT- 30)	21/1/04	29/3/04		120	0.12 t/ha
M – 27	19/1/01	29/3/04		60	0.06 t/ha

1.6.2 Selection of lines from Mass Selected mustard

In the year 2001-2002, different modern and local cultivated varieties of mustard were raised and seed yields were bulked together. In 2002-2003, the same bulked lot was planted and selection carried out. Seeds from every 10 rows were collected and assigned selection number, which shall form the base of accession numbers for evaluation next season. A total of twenty-three selections were made from the whole lot and their yields noted (Table 20).

Table 20 Selection numbers of mustard, 2002-2003

Sl. No.	Selection Number	Seed yield (kg)
1	Bajo Selection 1	1.95
2	Bajo Selection 2	2.29
3	Bajo Selection 3	1.65
4	Bajo Selection 4	1.50
5	Bajo Selection 5	1.52
6	Bajo Selection 6	2.20
7	Bajo Selection 7	2.34
8	Bajo Selection 8	2.04
9	Bajo Selection 9	1.74
10	Bajo Selection 10	1.66
11	Bajo Selection 11	0.90
12	Bajo Selection 12	1.03
13	Bajo Selection 13	1.07
14	Bajo Selection 14	1.40
15	Bajo Selection 15	1.06
16	Bajo Selection 16	1,91
17	Bajo Selection 17	1.40
18	Bajo Selection 18	1.10
19	Bajo Selection 19	1.15
20	Bajo Selection 20	2.17
21	Bajo Selection 21	1.76
22	Bajo Selection 22	1.86
23	Bajo Selection 23	1.54

1.6.3 Seed Maintenance and Production of released oilseed crops

A seeds of five released varieties of mustard was maintained for research and supply to DSC. Details of seed production are provided in Table 21 below.

Table 21 Mustard Seed Production (2003- 2004)

Sl. No.	Varieties/type	Quantity
	BSA – Pre basic	43 kg
	BSA – Basic	6 kg
	T – 9	3.2 kg
	M – 27	1.7 kg
	PT – 30	2.6 kg

HORTICULTURE RESEARCH

2 HOTRICULTURE RESEARCH

2.1 Subtropical Fruits and Low Chilled Temperate Fruits and Nuts

2.1.1 Peach variety evaluation

The trial was terminated, two peach varieties released for general cultivation. Floridasun released as Bajokham-1, an early maturing variety and July Elberta as Bajokham-2, a late variety for general cultivation in altitude of 1300-2000masl. RNRRC-Bajo is maintaining two released varieties' germplasm (mother plant) as we are mandated to so (for detail see annual report 2002-2003).

2.1.2 Almond Variety Evaluation

The trial has been terminated with effect from this year; the Variety Release Committee, Ministry of Agriculture, notifies Drake, Texas, Dhebar Bhadan and Kagzi for cultivation in May 2004. We maintained above four almond cultivars' mother plant or scion 'Bank' (refer RNRRC-Bajo's annual report 2002-2003).

2.1.3 Grapes Variety Evaluation

The grapes variety evaluation trial was established in 1994 and 1999 with the support of Integrated Horticulture Development Project (IHDP-I & II), Ministry of Agriculture. The objectives of this trial are to select the suitable almond cultivars for dry sub-tropical ecological zones and to evaluate the feasibility of grapes cultivation in Bhutan.

Nine cultivars of grapes with ten plants each in a single plot were planted in 1994 and four additional cultivars in 1999 with a spacing of 1.5m from plant to plant and 2m between the rows. The nine grapes cultivars introduced in 1994 are: Muscat, perlette, chasselas, pinot blanc, Gamay-N, Cab Franc, Pinot Noir, Monduese and Chardornnay. The cultivars introduced in 1996 are: Protland, Campbell and Stuebern and in 1999 Muscat of Allexander, Calmeria, Ruby seedless, Waltham and Sultana M12 were introduced. The vines trained into trellis and pergola system. The plants were irrigated during the dry period coinciding with the time of flowering and fruit setting period (February to April). Weeding, basin making and mulching were done as appropriate. The manure and fertilizers were applied as appropriate The parameters considered for evaluation were time of crop maturity, yield and above all bunch and berry qualities and pests problems.

Of all the grapes cultivars, perlette and Muscat of Alexander are the best table cultivars. Perlette is identified as the earliest grapes cultivars maturing by the mid of June thereby in most of the time escaping the powdery mildew disease, however it is good to spray calaxin to as a prophylactic spray before the onset of pre-monsoon to control this disease. Muscat of Allexander is the late cultivar maturing by Early August in the mid altitude areas. There was no significant difference in yield among the various cultivars except proper yield could not be recorded due to severe birds and wasps damage. Grapes

cultivation in mid altitude areas of Bhutan is very expensive as we need to protect it from the birds, fruit fly and wasps through netting or by wrapping individual bunch with perforated polybags. Powdery mildew is very severe and needs frequent sprays to control it.

Later introduced grapes cultivars such as calmeria, Ruby seedless, Walthem and Sultana M12 have started fruiting but not yet harvested since the yield is very small. Muscat of Alexandria fruited heavily this year and it is best table cultivars evaluated. It has no problems of fruit splitting unlike other cultivars though it is late maturing, coinciding with monsoon rain. Perlette and Muscat of Alexandria were released for general cultivation in the mid altitudes areas during 10th Variety Released Committee meeting in May 2004.

The trial will be continued for few more years till we find effective measures to protect the fruits damage by birds, fruit fly and wasps which is very severe and to the extent of having no harvest at all.

2.1.4 Maintenance of Fruits mother plant or Scion 'Bank'

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

2.1.5 Pear variety observation

Pear variety observation was established in 1994 with an objective to select variety suitable for mid altitude dry sub-tropical agro-ecological zone. Tsirang local, China, Gala, Flemish Beauty were the four varieties evaluated. There was only two plant per variety planted with a spacing of 5m x 5m. They are trained into open-centre system. Annual pruning, weeding, basin clearing, mulching, irrigation, fertilizer application and fruit thinning were done as appropriate.

F. Beauty

Of all the varieties evaluated, Flemish Beauty and China have similar fruit shape (bell-shape) and eating quality (sweetness). They are best varieties among the variety evaluated. Gala and Tsirang local fruits are round in shape and slightly acidic in taste. Gala has smooth fruit skin while Tsirang local has rougher with granulated fruit peel. There was no significant yield difference among the varieties tested. The plant growth and yield performance of all the varieties

evaluated were excellent under Bajo condition. All the pear varieties except Tsirang local are susceptible to birds and wasps damage.

Flemish Beauty was released in 2004 for general cultivation as Bajolea-1**.** The fruit is large, ovate, smooth and attractive with average diameter of 5.33cm and length of 6.37cm. The flesh colour is pure white with a lot of juice. It has a TSS value of 14%, which is sweet for pear. It has originated as chance seedling in Belgium. The tree is big, spreading due to more branching, and a high yielder, but susceptible to fire blight. It is a self-fertile and a good pollenizing cultivar as well. It matures in first week of August under Bajo condition. It is recommended for cultivation in altitudes of 1300 - 2300m. The pear trial is terminated and mother plants of released cultivars will be maintained.

2.1.6 New fruits and nuts variety evaluation

The fruits and nuts variety evaluation initiated in this financial year are:

- Persimmon variety evaluation
- Japanese pear variety evaluation
- Walnut variety evaluation
- Chestnut variety evaluation
- Avocado Multi-location variety evaluation

Production management

2.1.7 Peach seeds germination trial

An experiment was conducted to investigate the effects of time of sowing and chilling treatment under mid-altitude dry subtropical climatic areas on peach seeds germination percentage and seedling survival rate. Peach seedling is used for raising peach rootstock. The treatment consists of:

1. October sowing without artificial chilling treatment,
2. January sowing with 1.5 months chilling treatment at $4^{o}C$
3. March sowing with 3 months chilling treatment at $4^{o}C$

100 peach seeds were sown in poly pots in mid of October 2003, January and March 2004. All these seeds were sown in the poly pots of same size, potting mixture and all other growing conditions being similar to all the treatment. The germination of all treatment was observed at weekly intervals and last count of germination was done 2 months after March sowing. Number of survival of germinated plant of all treatment was recorded in August 2004.

The germination percentage was significantly higher for March sowing compared to other time of sowing, January sowing, resulting to lowest germination. There was 50% germination of peach seed sown in the month of October though there was no chilling treatment provided indicating that natural chilling over the winter breaks its dormancy under Bajo conditions. However, soil moisture needs to be maintained at field capacity over a period of 5 months in pots or nursery bed where seeds are sown, otherwise no germination takes place. October sowing took the longest time (> 5 months)

for germination after sowing while March sowing took less than 3 weeks for germination after sowing.

It may be concluded from this trial that moist chilling treatment at 4^{o}C for a period of 3 months and sowing in the month of March is best for getting better results for peach seedling production intended for rootstock. If sown earlier than this, germination percentage will be less, nursery maintenance cost high thereby effecting cost of seedlings.

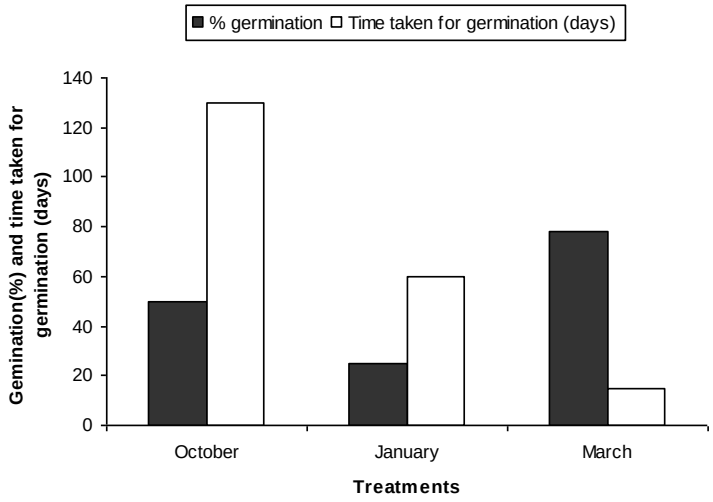

Figure 1: Peach seed germination observation

2.1.8 Pear, persimmon and chestnut germination trial

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

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

100 seeds each of pear, persimmon and chestnut were sown in poly pots in mid of October 2003, January and March 2004. All these seeds were sown in the poly pots of same size, potting mixture and all other growing conditions being similar to all the treatment. The germination of all treatment was observed at weekly interval time and last count of germination was done 2 months after March sowing. Number of survival of germinated plant of all treatment was counted in August 2004.

No germination of pear seed sown in the month of January and 2% germination for October and March sown pear were observed. Similarly, there

was no germination of chestnut for all treatments. There was 31 % germination for October sown persimmon seeds and 5%gpermination for other two treatments. The survival rate of persimmon sown in the month of October was less than 15% due to hypocotyls burning by the scorching winter sun. To offset this problem, shading of persimmon nursery might help to reduce seedling mortality.

Either the local pear and chestnut seeds are not viable or the growing temperature is too hot in spring under Bajo condition since these are temperate fruit crops and mild climatic condition are ideal for their growing. Future works on pear and chestnut must continue with collection of different types of local pear and chestnut and nursery trial be conducted under mid altitude conditions.

2.1.9 Avocado grafting trial

The avocado grafting has eluded the effort of Ministry of Agriculture as of now. The private nursery, Druk Seed Corporation and Horticulture Research Program have used local avocado as rootstock for grafting and failed to produce grafted plant. This has resulted to an experiment to evaluate the graft compatibility between local avocado and improved avocado. The treatments were:

1. Improved scion cultivar grafted onto improved avocado seedlings
2. Improved scion cultivar grafted onto local avocado seedlings

The cleft grafting of Bacon, Hass, Zutano scion (improved avocado) on local avocado seedlings was done in the month of April and May 2004 with same scion cultivar grafted on the improved avocado seedlings as a control. 20 Grafts were made for each treatment for each time of grafting. The 1-2 months old rootstocks and cupper colour stem to light green stem were used and pencil size scion woods were grafted. The grafts were maintained in 75% shade house in a poly pots for a period of two months. The plants were irrigated as appropriate. The graft assessment was done one month after grafting and graft survival assessment was done two months latter.

The result was striking as there was 95 % graft success when improved cultivar was grafted on improved avocado seedlings for both months and 90% graft survival rate when evaluated 3 months after grafting. Interestingly there was only 5% percent graft success when improved cultivar was grafted onto local avocado seedlings and none of these grafted plants survived beyond 2 months after grafting. The sprouted scion starts to decline by drying up from the trip and eventually scion and graft union portion of the plant get desiccated and dead, surviving only the stock plant. It may be concluded from this trial that graft in-compacpatibility exist between the local and improved avocado

2.1.10 Nursery management and plant propagation

The nursery management and plant propagation techniques assessment go side by side with crop variety introduction and evaluation. The propagation

techniques successfully tested and planting material of various fruits and nuts crops multiplied areas as in table below.

Table 22 Grafting technique and no. of promising fruits and nuts cultivars produced

Sl.No.	Crop	Grafting Technique	No. of planting materials produced	Remarks
1	Sub-tropical apple	Whip	300	All the planting materials are used for establishing on-farm demonstration and on-station research trials. Some of the planting materials also made available to Schools, Dzongkhag administration and other Govt. organization on request.
2	Disease free Citrus rootstock	T-budding	800	
3	Peach	Whip	100	
4.	Apricot	Whip	100	
5	Walnut	Whip	200	
6.	Pecan roostocks and grafts	Whip	300	
7.	Pomegranite	Cutting	100	
8	Guava	Air-layering	20	
9	Citrus rootstock	Different Rootstock	1200	All these rootstock will be used for propagating the promising cultivars that are to be used for establishing on-farm demonstration orchard.
10	Walnut rootstock		500	
11	Avocado rootstock		100	
12	Apple rootstock		200	
13	Peach rootstock		300	
14	Apricot rootstock		100	
15	Pear rootstock		4	
16	Persimmon	Rootstock	15	

2.1.11 On-farm Fruit and Nuts demonstration orchards

The promising cultivars of various fruits and nuts are taken to on-farm serving the multi-purposes such as of demonstrating the new crops, crops management to the farmers and it also serves for multi-location evaluation of different fruits and nuts cultivars. We have established two demonstration orchards of assorted fruits crops in each five Dzongkhags of West-central region and details are as in table below.

Table 23 Details of demonstration orchards

Crop	cultivars	Year planted	Location	Dongkhag	Remarks
Walnut	Thinshell	2002	Yamena, Kabji, Omtekha, Dagapela, Tashiding, Tshokana Salambi	All five Dzongkhags	Vegetative growth is good in all location and not yet fruited
Pear	Shinko Atago Chijero	2003	Gasa, Yamina Kabji and Omtekha	Gasa and Punakha	Vegetative growth is good

Apple	Bajo apple	2000,2003	Kabji, Omtekha, Dagapela, Pinsa, Rubessa, Tashiding, Tshokana, Salambi	All five Dzongkhags except in Gasa	Fruited in Omtekha, Thedtsho, Dagapela and Kabji,
Apple	Red, Royal delicious & Lobo	2002 2003	Yamena Gasa	Gasa	Good vegetative growth
Peach	Flordasun & Shani-Punjab	2001 2003	Yamina, Gasa, Kabji, Dagapela, Pinsa, Tashiding, Tshokana, Salmbi	All five Dzongkhag	Peach fruited and are farmers like it.
Apricot	New Castle	2000 2003	Gasa, Rubesa, Kabji, Omtekha, Dagapela, Tshokana, Salambi & Tashiding	All five Dzongkhag	Not fruited yet
Citrus	Valencia, encore, bears, meyer, Satsumas, freemont	1999-2002	All location except under Gasa	All five Dzongkhags except in Gasa	Bears and valentia started fruiting in Rubesa and farmers could not market it.
Pomegranate	Beedana, Khandari	2000 2002	Rubesa, Kabji, Omtekha, Pinsa	Wangdue Punakha	Rubesa famer finds no difficulty in marketing
Grapes	Perlitte	2000 2002	Gasa, Kabji, Rubesa	Gasa, Punakha &Wangdue	Farmer finds it difficult to protect it from the pests.
Pecan	Western Schelley, Burket,	2000 2002	Yamina, Kabji, Tshokana, Salambi, Pinsa, Rubesa, Lower Gasalo, Dagapela, Tashiding	Five Dzongkhags	Good vegetative growth and not fruited yet.
Cheery	Lopin	2003	Gasa	Gasa	
Plum	B. Heart	2003	Gasa	Gasa	
Mango	Dashehari, langra, Himsagar	2001 2003	Rubesa, Pinsa, Omtekha Tshokana	Wangdue, Punakga, Tsirang	Not fruitted
Date Palm	His Majesty	2001	Pinsa Bhur farm	Wangdue	Poor growth in Pinsa and Bajo, Rabit feeding damange in Bhur farm.
Avocado	Hass, Reed, Sharwill & Shephard	2004	Yamina, Rubesa, Omtekha, L. Gasalo, Salambi, Tshokana, Dagapela, Tashiding, Pinsa, Kabjisa & RC-Bajo	Gasa Wandue Punakha Tsirang and Dagana	Multi-location trial established.

Bajo apple performance is good in Omtekha, Rubesa and Dagapela and farmers really want to expand its cultivation. However, we cautioned them for its commercial cultivation since its fruit has very short shelf life (less than a week). It is good for local consumption, local market and not for export purposes. Pomegranates started fruiting in Rubesa and farmer finds it very easy to market in the local market and it has not fruited in other demonstration orchards.

Lime and orange (Valencia) also fruited in Rubesa demonstration orchard but farmer finds it difficult to market both lime and Valencia. Lime has a huge market in India where it is a delicious part of every Indian meal. Through Valencia is sweet and internationally popular, Bhutanese and Indian people are not habituated in consuming oranges since it is difficulty to peel and requires either to be peeled with knife or extract the juice. It will take some time before South Asian market accepts it like the local mandarin.

Peach (Flordasun and July Elberta) has fruited in Yamina, Kabji, Salami, Omtekha and Dagapela demo-orchards. All collaborating farmers except farmer from Yamina, Gasa Dzongkhag feels peach cultivars are better than the local cultivars and found no difficulty in marketing them. Yamina farmers have about 30kg/tree fruits harvested but could not sell since market is far, farmer feels fruits are inferior in quality compared to local *losukham* prevalent in the area and time of harvest of both improved and local peach coincide in high elevation like Yamina (1900m). Therefore from this multi-location trial it may be concluded that the market acceptance of newly released peach cultivar –Bajokham-1 and 2 is high in low and mid altitude region, basically these fruits particularly Bajokham-1 appears first in the market and fetches premium price and not so if they are planted high elevation of 1900m and above.

Preliminary results of date palm trial showed good vegetative growth at Pinsa, Baychu and Bhur farm and very poor growth at Bajo Research Centre indicating that date palm would not perform well under Bajo and alike climatic conditions (1300m). Date palm vegetative growth indicates that it can do well in areas of 900masl and bellow experiencing intense heat in summer and mild winter. However, it is too early to say that it can do well in above-mentioned areas mainly due to the fact that a wet season at the time of flowering and fruit ripening is limiting factor in successful date palm cultivation.

2.1.12 On-going Fruit crops research

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

- Pomegranate variety evaluation
- Guava variety evaluation
- Mango variety evaluation
- Private fruits nursery growers promotion
- Mandarin superior mother plants selection from local diversity

2.1.13 Trainings of farmers and extension personnel

The extension agents of Punakha Dzongkhag were informed and trained on all the newly released fruits and vegetables varieties and their management aspects, and the yield assessment of fruits crops.

2.1.14 Translating research into communication materials

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

- Leaflets on Apricot (newly release Bajokhamchu-1) Production was developed and circulated in the regional Dzongkhags
- Leaflets on walnut (newly release Bajokhamchu-1) Propagation was developed and yet to be mass-multiply and circulate at national level
- Effect of time of grafting on walnut graft success under different altitudes ranges, paper accepted for publication in Acta Horticulturae, 5th International walnut Sympoium, Proceedings. International Society for Horticulture Science (ISHS), November 9th to 13th, 2004.
- Effect of post-graft scion treatment on walnut graft success, paper accepted for publication in Acta Horticulturae, 5th International walnut Sympoium, and Proceedings. International Society for Horticulture Science (ISHS), November 9th to 13th, 2004.
- Top-working technique: A cheap and easy method of walnut orchard development in Bhutan, paper accepted for publication in Acta Horticulturae, 5th International walnut Sympoium and Proceedings. International Society for Horticulture Science (ISHS), November 9th to 13th, 2004.
- Possible alternative to improve the land use efficiency of Buli land owned by Ashi Rinchen Choden and Farmers, Zhemgang, Report submitted to CoRRB, MOA.
- New fruits and vegetable varieties and their striking characteristics: Flip chart is under production.

2.2 Vegetables

2.2.1 Tomato Variety Trial

Tomato is a popular vegetable grown in the early spring summer in the mid altitude regions. Harvest by May-June is the normal trend after which rain and hot weather affects proper growth and yield. However, there is a great demand for year-round tomato production. A set of four hybrids and one open-pollinated commercial variety were brought from Sungro Seed Ltd for testing. The varieties are said to be heat tolerance, also have disease resistance for common tomato disease like yellow leaf curl virus and tomato mosaic virus. The objective is to evaluate the performance of the four hybrids and one open-pollinated heat tolerant tomato varieties from India under Bajo conditions.

The seeds were sown in the nursery on 30th May and made ready for transplanting in July when the rain and heat will be at their maximum. A local

popular variety (Roma) was included as check. A RCB design was used with three replications. Each plot will contain at least 20 plants. The plant to plant and row to row distance should be maintained at 60 cm and 50 cm respectively and planted in beds of about 1 m wide and 6m long. The treatment consist of:

- F1 Hybrid-Krishna
- F1 Hybrid-Arjuna
- F1 Hybrid-SC-3
- F1 Hybrid-S-108
- Novaday (OP)
- Roma (local check)

The fertilizer were apply @ 25:50:40kg /ha with 40t/ha FYM. Three hand weeding were done. The detail yields data, other horticultural traits and incidence of major pests and diseases were record. The data were analysed using Genstat (one-way analysis of variance with blocking) and the mean yield and their horticultural characteristics are given in below.

Table 24: Average yield and others characteristics of tomato varieties

Cutivars	Mean Yield (t/ha)	Mean plant ht.(cm)	Mean fruit length (cm)	Mean fruit dia. (cm)	Fruit colour
H-S-108	12.9	69.3	5.3	5.5	Red
H-Krishna	7.7	68.6	5.2	4.9	Red
H-Sc-3	11.73	67.1	5.0	5.2	Red
H-Arjuna	7.47	57.2	5.3	5.8	Red
Novoda	7.57	60.3	4.8	5.2	Red
Roma	13.23	81.7	5.76	5.2	Red
s.e.d	1.99	7.55	0.33	0.088	
LSD	4.434	16.82	0.72	0.197	
CV %	16.4	15.5	1.9	0.5	
F Probability	0.03	0.098	0.19	0.001	

Released and popularly grown cultivar-Roma yielded significantly higher (P = 0.03) than any other newly introduced hybrids and open-pollinated tomato varieties from India. None of the introduced varieties showed tolerance to blight disease and others superior traits as claimed by the Sungro Seed Ltd under Bajo condition. Therefore, this trial is terminated since most of them are hybrids and no further testing is required. However, we will maintain open-pollinated (OP) cultivar-Navoda and test in multi-locations along with others OP cultivars we had introduced.

2.2.2 Water Melon variety Trial

Watermelon is not popularly grown in the West-Central region but popular among the consumers. Watermelon supply to this region and Thimphu market either are from Southern Bhutan or India. In the lower elevation of West-central region it is possible to grow watermelon. Thirteen watermelon hybrids varieties were introduced from Thia Royal Project Foundation and Marcopolo Seed Company, Thailand IHDP-II, MOA in 2003 and we are instructed to

evaluate them. The aim of the observation trial was to evaluate and assess the performance of the hybrids under Bajo condition.

The on-station and on-farm evaluation of thirteen watermelon hybrids varieties with sugar baby as local check was carried out in 2003-2004. The nursery established in poly pots with potting mixture of 4:1:2 of compost, sand and soil. The transplanting was done in May 11, 2004. There were 3 plants per replication and it is replicated 3 times. The spacing of 2m plant to plant and 2.5m row to row was maintained. Fertilisers were applied at the rate of 45:35:25 kg/ha NPK and with 1kg of FYM per pit. Pits size of 25cm wide and 25cm depth was dug and filled with soil and FYM mixture. Weeding and irrigation was done as and when appropriate. Harvesting was done in 4th week of July for all varieties. The yield and horticultural traits of watermelon varieties evaluated on-station are given below.

Table 25 **Average Yield and horticultural traits of different varieties**

Cultivars	Mean Yield (t/ha)	Fruit size		Fruit Wt. (kg)	Skin or Fruit colour	Flesh colour	TSS (%)
		Length (cm)	Width (cm)				
Shawing 175	40.5	25.5	23.5	3	Green stripe	Red	12.5
Flower Dragon	39.9	22.5	19.5	2.6	light green stripe	Red	12
Jumbo flower	27.8	21	17.5	1.1	light green sstripe	Red	10.5
Jinda manee	43.7	23	13.5	3.2	Green stripe	L. Red	12.5
New dragon	54.6	27.0	17.5	3.7	Light green stripe	L. Red	10
Ten Bow	49.8	31	21	2.8	Light green stripe	D. Red	12.5
Jumbo Jintara	50.0	25	18	4.2	Dark green stripe	Red	12.5
Yatphat	43.8	22.5	19.5	3.2	Dark green stripe	Red	15.5
New Jintara	50.6	23	17	4.2	Light green stripe	Red	12
Red delicious	29.1	21	13.5	2.3	Light green stripe	Red	12.5
Fine light	47.3	19.5	20	4.1	Light green stripe	Red	10
F1 # 555	6.0	25	17	2.1	Light green stripe	Red	10.5
Super Champion	50.9	36.5	22	4.9	Green stripe	L. Red	10.5
F. Probability s.e.d LSD CV%	0.001 5.26 10.86 13.3						

Statistical analysis (one way ANOVA with blocking) showed there is significant different in yield of various watermelon varieties. New Dragon yielded significantly higher (P= 0.001) than all others varieties and F1 555 yielded lowest. The fruit sizes of most of varieties are medium to large weighing as high as 4.9 kg by single fruit. The fruit quality of all the exotic varieties was good, Yatphat being the sweetest (TSS = 15.5%) among all. All of these varieties did perform well under Bajo conditions. The fruits of all these cultivars were mass organo-leptic evaluated during the *Shochum* control campaign in Punakha and Wangdue Dzongkhags by the farmers and government officials of different agencies in July 2004. Feed back from these people were positive but the challenge is all these varieties are hybrids and

cannot be produced in Bhutan. This observation trial will be continued further in coming season to test their performance in multi-location in comparison to open pollinated variety-sugar baby so that government can make informed decision whether to import watermelon hybrid seeds from Thailand. This comparison evaluation was not possible in this trial since sugar baby seeds didn't germinate.

2.2.3 Eggplant variety evaluation

Eggplant is one of the important vegetables in Bhutanese delicacies. There are not many choices of eggplant varieties for Bhutanese farmers and they have been growing Pusa purple long (PP long) for quite some time. There has been host of superior varieties available through out the world. We introduced two open-pollinated varieties from BARI, Bangladesh and two hybrid varieties from Sungro Seed Ltd, India for testing in our condition. The objectives of this trial are to evaluate performance of new eggplant varieties in our conditions and to provide better varieties options to the growers. The seeds was sown in May and transplanted after one month. Transplanting was done at a spacing of 30 x 50 cm in plot sizes of 1m wide and 5m long with three replication. All necessary cultural practices were carried out as appropriate and recommended fertilizer dose for brinjal was used. The treatment consists of:

- BARI-1
- BARI-4
- HYB-PPL-79
- F1-HYB-PK-123
- Pusa purple long as local check

The trial was laid out in RCB design with three replications and observation were made on plant height, fruit type (shape/colour), average fruit length and width, total fresh yield and number of fruits per plant and incidence of fruit borer. The data were analyzed using GENSTAT and the mean yield and their horticultural characteristics are given below.

Table 26: Mean yield and horticultural characteristics of eggplant varieties

Cutivars	Mean Yield (t/ha)	Leaf colour	Mean fruit length (cm)	Mean fruit dia. (cm)	Fruit colour	Fruit shape
PPL	16.6	Green	18.1	3.1	Dark purple	slender
BARI-1	12.2	purple	13.2	3.5	purple	blunt
BARI-4	15.1	purple	13.4	3.7	Dark purple	oblong
HYB-PPL-79	27.1	Dark green	19.6	3.2	Dark purple	slender
F1-HYB-PK-123	13.2	Dark green	15.3	5.0	Dark purple	oblong
F Probability s.e.d LSD CV %	0.65 10.56 24.35 30.1					

There is no significant yield difference (P = 0.05) among the different introduced varieties and the local check. There were 9 pickings in total for all varieties except for BARI-1 & 4. BARI-1 and 4 attended harvestable size a week later than others varieties. The two hybrids varieties showed tolerance to damping off disease at the seedling stage while all others are susceptible to it. However, considering the fruit appearance and cooking quality, many consumers compared to others prefer BARI-1. BARI-1 exhibited tolerance to frost since it stayed alive through out the winter though there was no fruiting during this period. So, BARI-1 can be a potential variety for ratoon cropping in the homestead farming system. The seeds of BARI-1 and 4 were collected since they are OP varieties and will be observed in varied climatic zones in following season.

2.2.4 Local beans germplasm collection and evaluation

The collection and characterization of local beans germplasm was done in year 2000-2001 in order to register these popularly growing varieties and propose for further formal release. The details of the site of collection, farmer's cultivation methods, time of sowing and other agronomic information were also collected. The varieties are mainly from Wangdue Phodrang, Punakha and Tsirang. Prior to formal release of these popular varieties, it is necessitated to confirm their yield and quality performance across locations. This trial was conducted on-station and on-farm to evaluate the yield potential of various local beans cultivars and their reaction to major pests and diseases.

The trial design was CRBD with three replications in on-station trial. The treatments consisted of 9 beans cultivars. The plot size was 5 m^2 per treatment in a replication. In the on-farm trial single plot observation was done and replication is between the farmers in the Lingmuteychu watershed. The sowing was done on 5th August 2003 with spacing of 50cm plant to plant for pole type, 25cm for dwarf type and 50cm between the rows for both types. The fertilizer were apply @ 20:50:20kg /ha with 40t/ha FYM. Three hands weeding were done. The detail yield data other horticultural traits were collected from the on-station trial. Farmers' preference and marketability aspects of the different beans varieties were collected from the on-farm trials as farmers feed backs. The on-station data were analysed using GENSTAT (one-way analysis of variance with blocking) and the mean yield and their horticultural characteristics are given in table below.

Table 27 **Mean yield, type and horticultural traits of beans cultivars**

Cultivars	Mean Yield (t/ha)	Dwarf or pole	Pod colour	Pod quality rating (fair, good & excellent)
RNRRC Dwarf	5.33	Dwarf	Light green	Fair
Borlotto	6.07	Dwarf	stripe	Excellent
Rajma	4.73	Dwarf	green	Fair
Nobgang black	5.33	Dwarf	Dark green	Excellent
Geobori	1.14	pole	stripe	Excellent
Kanchi bori	4.07	pole	green	Excellent
Tsirang local	4.60	pole	Dark green	Excellent
Punakha yellow	7.27	pole	green	Excellent

Chitokha black	6.80	pole	purple	Good
F. probaility s.e.d LSD CV%	0.02 1.34 2.84 21.4			

The dwarf beans cultivars can be first harvested in 9 weeks after sowing while pole types took 10 weeks. There was significant difference (P = 0.05) in the yield performance of various beans cultivars and there is also a huge different in the consumers acceptance which is based on the pod quality. Farmers reported that Geobori, Punakha yellow, Kanchi bori, Tsirang local and Chitokha black are easily marketable and quality is comparable to check cultivar (Borlotto). Chitokha black had yielded significantly higher than most of the varieties while Geoboni yielded significantly lowest amont all the varieties. All of these varieties were evaluated in multi-locations in on-farm at Limbuteychu watershed for participatory evaluation and selections and farmers feed backs on yield performance, quality and marketable aspect is collected.

The farmers feed backs are in line with the findings of variety assessment conducted on-station by the researchers. Punakha yellow, Tsirang local and Chitokha black are susceptible to rust while Geobori and Kanchi bori are tolerance to rust. The pod quality and colour of Geobori is similar to borlotto, a popular commercial bean cultivar. Geobori is a pole type while borlotto is a dwarf cultivar and susceptible to rust. Considering yield performance and pod and cooking quality and market acceptability, Chitokha black and Punakha yellow of pole type and RNRRC-dwarf will be proposed for release for generation cultivation in the next horticulture coordination meeting and variety release committee meeting of Ministry. This trial is terminated and this research centre will maintain only seeds of promising cultivars.

2.2.5 Chilli Blight Resistance Variety Evaluation

Phytophthora blight caused by *Phytophthora capsici* threatened cultivation of chilli in many parts of the country starting 1994, when the disease first sporadically affected Bhutanese chilli production. The reasons for blight were mainly because of the high planting density, improper drainage systems, use of infected seed/ seedlings on traditional flat plots. Starting 1995 till date the MoA conducted several on-station and on-farm researches to address the Phytophthora blight problem of chilli, which led to the present day recommendation of raised bed, proper plant spacing, good drainage system along with the use of healthy seed/ seedling.

Although the raised bed proper plant spacing and irrigation management recommendation do work in some places, it has failed in many parts of the country. Hence a program was initiated to breed for Phytophthora blight resistance in Sha Ema the most popular variety in the country. We are provided two F1 hybrid chillis and two PBC lines resistance to chilli blight by

RNRRC-Khangma for multi-location evaluation. In addition to that we have collected one Daifam local for testing its resistance to chilli blight.

The objectives of this trial were to assess the chilli lines resistance to Phytophthora blight and their acceptability to local consumers.

An area with uniform fertility and slope was selected. Four entries received from RNRRC-Khangma along with Daifarm local and *Sha Ema* as a check was used in the experiment. Each plot was a raised bed of 30cm high and one meter wide and five meters long. Plant spacing was maintained at RR = 50 cm and PP = 30 cm. Seeds are to be sown in a greenhouse or screen house to provide shade and to protect seedlings from rain and pests such as aphids, which transmit viruses like CMV and CVMV. Irrigation was done every day or as needed using a fine sprinkler. A good rule for chilli plants is "Not too wet, not too dry". Prior to transplanting, seedlings were hardened by exposing them open sunlight for 4-5 days. Seedlings were transplanted at five-leaf stage that is four weeks from sowing ideally in the late afternoon to minimize transplanting shock. Plants were buried to ½ its total height and fields irrigated immediately after transplanting, in order to establish good root-to-soil contact. Mulching was done to reduce weed competition, reduce soil compaction, maintain uniform root environment, conserve soil moisture and reduce soil erosion. Suphala (15:15:15) @ 250g/plot ($5m^2$) was applied two weeks after transplanting.

Weeds can be controlled manually as needed. Experimental sites were top-dressed with soil collected from the area where chilli was planted and blight incidence had occurred so as to make sure that there are enough *Phytopthora capsici* inoculums in the site (in the absence of inoculums culture and inoculation). RCB design was used with so-claimed 4 resistant entries and two local checks with three replications. The treatments consist of:

- PBC 995/41
- PBC 9967/40
- F1 Hybrid (Sha Ema x PBC 9957/40)
- F1 Hybrid (Pankhar x 9957/41)
- Daifarm Local
- Sha Ema as check

Phenotypic data such as fresh fruit yield, days to 50% anthesis, fruit breadth, fruit length, fruit type and acceptability by local consumers and incidence and severity of chilli blight (none, mild and severe) were recorded on a plot and replication basis.

Table 28: Phenotypic characteristics and response to blight disease

Varieties	Plant character	Diseases
PBC 995/41	Bushy with heavy branching with medium height, narrow leaves with dark green hairy on shoot and branch. Long and dark green fruit	Good plant stand in the vegetative stage and heavy infection by blight disease at later stage of fruiting
PBC 9967/40	Short plant and short fruits plants and fruits are light green. Most plants	Heavy infestation of blight from the foliage growth

	sowing segregation eg. Some plant upward fruiting.	stage and in later stage completely died.
PBC 9957/40 X Sha Ema	Leaves are same as Sha Ema, fruits were short, small and light green, some fruits looks like capsicum	Less blight incidence in R-I and R-III. But in R-II 6 plant infected by blight disease at late flowering stage.
Pangkhar X PBC cross	Medium height plant, heavy branching and fruiting habits similar to Indian chilli (fruits up curled and parallel to direction of plant growth, has narrow leaves with dark green colour	Mild blight with better plant stand plant at 50% flowing stage. However, heavy infestation of blight at fruiting stage
Daifam Local	Tall and dark green plant with heavy branching, upwards fruiting, fruits are short, thin and black in colour.	Good plants stand till vegetative stage. Heavy infection at flowering/ fruiting stage and all plant perished.
Sha Ema	Medium height dark green plant	Blight infection occurred since foliage stage.

Table 29: Fresh fruit yield and other characteristics

Treatment	Yield (t/ha)	Plant size		Fruit size		Pungency
		ht. (cm)	Width (cm)	length (cm)	Dia. (cm)	
PBC995/41	2.63	41.5	38.4	5.4	1.9	hot
PBC9967/40	2.09	36.3	25.2	2.7	1.9	hot
Sha Ema X PBC9957/40	2.19	40.7	38.8	4.8	2.2	mild
Pangkhar X 9957/41	1.03	45.5	35.6	5.8	1.2	hot
Daifam local	00	43.4	35.6	5.4	1.9	hot
Local Sha Ema	0.93	49.0	36.0	7.1	3.1	hot
F. probability s.e.d LSD CV%	0.008 0.571 1.27 8.7					

No chilli hybrids and others varieties were found tolerance to *Phytophthora* blight through out the crop growth stages. There was significant yield difference between the varieties, PBC lines and F1 hybrids of Sha Ema cross with PBC line as given in Table 6 yielded significantly higher yield (P = 0.05) than other entries and local check. However, consumers didn't appreciate the fruit shape, size and quality of all varieties except Sha Ema. Two hybrids are segregating heavily (fruits variation in single plant and between the plants). Daifarm local (Indian chilli) have no harvest since the disease at flowering and fruiting stages damaged all plants. This trial could not be continued in the coming season since RNRRC-East has not supplied the seeds of all those varieties for nationally coordinated multi-location evaluation.

2.2.6 On-going vegetable variety evaluation

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

- Okra Variety evaluation
- Vegetable soyabean variety evaluation
- Nationally planned multi-location evaluation of cauliflower
- Nationally planned multi-location evaluation of peas
- Nationally planned multi-location evaluation of carrot
- Herbs variety evaluation

Production management

2.2.7 Maintenance of breeder seeds of released vegetable cultivars

The Ministry of Agriculture transferred the responsibility of maintenance of breeder seeds of all released crops cultivars from RNRRC-Bajo to RNRRCs from Druk Seed Corporation. RNRRCs are mandated to maintain the breeder seeds of the various crops released from their Centre. In this regard, horticulture section of RNRRC-Bajo has started maintaining the breeder seeds of various vegetable crops cultivars. The most of vegetable cultivars were released from RNRRC-Bajo and maintaining all the cultivars of different vegetable is not possible in RNRRC-Bajo due to specific climatic requirement of various crops. It also demands one-person full time working on vegetable breeder seeds maintenance since we are maintaining 14 vegetable crops and 22 vegetable cultivars released from this Centre. The status of vegetable breeder seeds produced, maintained and supplied to DSC by RNRRC-Bajo for Foundation seed and certified seed production are given in table 30.

Table 30 **: Vegetables breeder seed produced and maintained by RNRRC-Bajo**

Sl No	Crop	Varieties	Total quantity BS to be supplied to DSC	Remarks
1	Brinjal	Pusa Purple long	200g	Under seed selection
2	Beans	Borlotto	10kg	8 kgs handed over and 10kg in stock
		Kentuky Wonder	10kg	Under selection (2004 Nov)
		Pusa Parvati	10kg	4 kgs handed over (2004 June) and 2kg in stock
		Top Crop	10kg	8 kgs handed over & 2 kg in stock
		Rajma	10kg	8 kgs handed over & 7 in stock
3	Cabbage	Golden Acre	200g	Under selection 2004
		Copenhegan Market	200g	Under selection 2004
4	Cauliflower	White Top		Seed production failed due seed mixture from source
		White Summer	200g	No germination at all
5	Capsicum	California Wonder	200	Seed production failed

6	Carrot	Early Nantes	100g	100 grms handed over (2002) & produced 1.2kg in 2004
7	Onion	Bajo Gop-I	500g	600grms handed over in (2002/2003) and 1.5 kg in stock
8	Sag	Phul Maya	200g	Seed production failed
9	Spinach	All Green	200g	Produced 3kg in 2004
10	Okra	Pusa Sawani	500g	Var. kranty was supply in 2003, 1kg in stock
11	Radish	Bajo Laphu-I	200g	600grms handed over in (2002/2003) and 11.5kg produced in 2004
		Spring Tokinashi	200g	Seed production failed
12	Tomato	Bajolambenda-I	300g	200grms handed over in 2002/2003 and produced 1.2 kg 2004
		Cht-160	300g	Seed production failed
		Roma	300g	Seed production failed
13	Jap. Green	Taisai	200g	Seed production failed
14	Watermelon	Sugar baby	200g	Seed production failed
	14 crops		22 varieties	

In most of the crops seed production failed due to breeder seed received from DSC were genetically mixed, no germination and others due to production technical failure. None of the researchers are trained on breeder seeds production and maintenance.

2.2.8 Brocoli, Radish and cauliflower seed production economic study

The growers did the seed production study of above crops mainly to support the policy of national seed pricing and to evaluate the profitability of investment on seed production. The study was done in collaboration with agri-economic unit and reported in detail under the Farming system section of this financial year annual report of this cente.

2.2.9 On-going production management trials

The vegetable production trials that are on-going during the reporting time and are not in reporting stage are:

- Effect of plant density on the chilli yield and blight incidence
- Effect of seed source and type of planting on yield and disease incidence
- Effect of different cultivation method on the yield and blight incidence
- Effect of time of planting on yield and blight incidence
- Asparagus production economics study

2.2.10 Publication and Translating research into practices

The activities in the process of undertaking are as follows:

- Technical guidelines on vegetable crop cuts as an tools to assess the vegetable yield are in the process of development
- Technical recommendation for vegetable production under rice-based farming system are in process of development
- Technical recommendation on “Quality Vegetable Seed Production” are in the process of development.

LIVESTOCK RESEARCH

3 LIVESTOCK RESEARCH

3.1 On- Station Research

~~3.1.1~~ Potential dry matter production trial

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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: T1-*Pennisetum purpureum*, T3-*Paspalum dilatatum*, T4-*Dactalis glomerata*, Y5-*Seteria secephalata,* T6- *Medicago sativa.* The trial was established at Bajo station under intermediate environment during July 2002. It was replicated under irrigated and non-irrigated conditions. Their fresh yield, dry matter production and dry matter percentage are indicated in **Table 31** and **Table 32** below.

Table 31 Mean fresh matter and dry matter yield in t/ha from irrigated plots

Treatments	*Fresh yield*	*Dry matter yield*	*Dry matter %*
Napier	38.6	8.4	21.6
Setaria	43.53	10.0	23.2
Cocksfoot	4.5	4.67	28.5
Paspalum	16.4	1.26	28.0
Lucerne	21.0	6.1	28.9
LSD	5.52	*5.57*	-
SED	2.39	2.42	-
CV%	1.7	29.5	-

The findings revealed that the fresh biomass production of *Sataria* was highest (38.6± 2.39 t/ha) compared to other species among three replicates from irrigated plots. Even the dry matter production was the highest (10.0± 2.42 t/ha) out yielding *Napier*. ANOVA was used to analyse the data on fresh matter and dry matter production. The analysis of variance showed that there is a significant yield differences in fresh matter production between the treatments and among the replicates excepting to *Paspalum* and *Lucerne.* However, the analysis of variance did not show much significant differences on dry matter production between the treatments among the replicates. We have to still record the fresh and dry matter yield over the season to finally draw the conclusion.

Table 32 Mean fresh matter and dry matter yield in t/ha from non-irrigated plots

Treatments	*Fresh yield*	*Dry matter yield*	*Dry matter %*
Napier	28.7	8.5	29.7
Cocksfoot	3.46	2.5	32.7
Paspalum	7.68	1.14	33
Lucerne	9.65	3.1	32.2
LSD	3.38	6.39	-
SED	1.38	2.61	-
CV%	2.7	27.8	-

From non- irrigated plots, *Napier* yielded the highest fresh biomass of (28.7 ± 1.38 t/ha) as well the dry matter of (8.5 ± 2.61t/ha) compared to other forage species. As *Sataria* did not perform well under non- irrigated conditions the comparison was made only among four forage species only.

ANOVA was used to analyse the data on fresh matter and dry matter production from non-irrigated plots. The analysis of variance showed that there is a significant yield differences in fresh matter production between the treatments and among the replicates. However, like under irrigated conditions here also we did not observe much yield differences in terms of dry matter production between the treatments among replicates. We still have to record the fresh and dry matter yield over the season to finally draw over all conclusions.

3.1.2 Sweet Clover (*Mellilotus* species) varietal trial

The objective was to introduce and evaluate varieties of sweet clover (*Melilotus* species) for fodder production in regions with dry and poor soil conditions. The trial was established in August 2002 under our station condition with seven *Sweet Clover* species. The data recorded for their germination percentage, persistence, height and the flowering percentage are indicated in **Table 33**.

Table 33 Detail growth and performance variables of *Mellilotus* species

Species	Variety	Germination % at 15 days	Gr. Cover/pl. Vigour (45 days)	Plant height (cm)	Flowering % at 90 days
Melilotus albus	SA 35639	5	5	167.5	100
M albus	SA 36999	5	5	188	100
M officinalis	SA 36494	2	1	30	Nil
M officinalis	SA 37409	4	5	175.5	50
M officinalis	SA 37403	2	1	50	Nil
M officinalis	SA 27395	1	1	16.7	Nil
Medicago sativa	Eureka	3	4	46.5	Nil

Our observation showed that the species *Melilotus albus* SA 35639 and *Melilotus* SA *36999* had 100% flowering followed by 50% flowering from *Melilotus officinalis SA 37409*. Rest of the species did not give any flower. Although there was no flowering seen from *M. sativa Eureka,* there was a good ground cover and plant vigour. The records on germination, ground cover and plant vigour are represented by number ranging from 1 to 5, 1 being the lowest or bad and 5 the highest or excellent.

Sweet clover entries at flowering stage

No pest and diseases incidences were observed among these species except the frostbite in winter contributing to stunted growth. Further information on

their fresh biomass production could not be obtained because none of these entries came up well after winter season. All most all species died out completely and hardly anything could be visible after one growing season. Although we initially expected that these clover varieties might be a good perennial fodder but at the end it turned out to be of seasonal nature. It grows well only for one season and dies out completely. In general, we concluded that these clover varieties should not be recommended and propagated as perennial forage. It can only be good seasonal forage.

3.1.3 Establishment method of Fodder growing on paddy bunds

The objective of this trial was to study proper species and establishment methods of growing forages on paddy bunds. It was also aimed to best utilize the scare land and optimize fodder production under marginal land. The trial was established in 2002 under station condition on the paddy bunds. The species tested were *Desmantus virgatus*, *Desmodium cenera*, *Desmodium nicaraguanse, Medicago sativa*, *Pennisetum perpureum*, *Flemingia macrophylla, Melinis minutiflora, Brachiaria, Andropogon* and *Paspalum* species.

Seed harvest was possible from *Desmanthhus virgatus* and *Medicago sativa* during the season. *Lucerne* remained lush green even when all other species were completely dry and can be harvested every after 15-20 days. It can maintain optimum soil fertility and moisture. It is perennial forage and very well appreciated and appeared to be promising technology growing even in the bunds. *D. Virgatus* can be maintained as a garden hedge. Some of the potential grass and legume species were added into and maintained in the hedges for demonstration purpose.

3.1.4 *Napier* propagation and distribution

The centre has maintained about half an acre of *Napier* as a propagation block. The main objective was to maintain and produce healthy *Napier* slips for distribution to the needy farmers of the region to carry out on- farm fodder production. It is proven as one of the most promising fodders having fast growth with high biomass yield. There is a great demand of the slip for on-farm fodder production by the farmers. The centre is the only the source of Napier root slips for distribution to any demanding farmers in the region. More than one lakh slips were distributed during the year to needy farmers of the region and other Dzongkhags outside the region. This block will be maintained as a source of basic planting materials for the coming season.

3.1.5 Live Herbarium

The main objective of the live herbarium was to introduce, evaluate and maintain fodder species as showcase for any visitors including farmers study groups and the extension agents. It also served as an easy and rich source of planting materials (seeds/seedling/slips) such as fodder grasses, legumes and leguminous shrubs for future experiments and studies. We have maintained

more than 45 varieties of forage grass, legumes and leguminous shrubs. Any newly release variety/ species will be added and maintained in the block.

3.1.6 Evaluation of selected Lucerne varieties for Bhutanese environment

The objectives 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 with RCBD design having three replicates. Eleven Lucerne varieties as treatment were tested such as Kaituna, Venus, PL55, Prime, Super 7, WL414, Aurora, SA 35076, SARBU 2 and Eureka. The seed were sown in rows with spacing maintained at 20cm between rows, 50cm between plots and 1 m between replicates. The seed was sown @ 9gm/ plot with individual plots size of 6m2. SSP was applied @ 40gm/m2 during establishment time.

Our initial observation showed that germination % age and plant vigor from all the entries were recorded as good, their persistence not recorded yet and no pest and disease incidences so far. The average fresh biomass, dry matter yield and their dry matter percentage are indicated in Table 34.

Table 34 Cumulative fresh and dry weight in (t/ha) and DM% from three cuttings

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
Av. Fresh yield	5.3	6.9	6.1	5.0	5.6	5.8	4.5	6.1	7.2	6.2	5.8
Av. DM yield	1.8	2.1	2.0	1.7	1.8	1.8	1.3	2.0	2.2	1.9	1.7
Av. DM %	33.9	30.0	32.7	34.1	33.2	30.6	29.6	32.7	30.3	30.6	30.1

The initial findings indicated that on an average basis entry T9 yielded highest fresh biomass of (7.2 t/ha) followed by entry T2 with (6.9t/ha) compared to all other entries. When dry matter production was assessed, on an average basis entry T9 yielded the highest dry matter of (2.2t/ha) whereas the DM% was highest from entry T4 (33.9%) compared to all other entries. It is a long-term trial and we have to make continuous assessment and series of crop cuts over the season to finally draw the conclusion.

Some of the bottlenecks observed are 42 days is quite a long period to harvest Lucerne to assess its fresh biomass yield. Untimely irrigation and continuous sunshine contribute to early flowering, maturity and hardening of stem and leave shedding, thereby affecting fresh biomass production. It not only affects the fresh biomass but also in dry matter production. The weather/ climatic condition and untimely weeding are other contributing factors affecting poor fresh biomass production. Also untimely weeding especially those weeds that grow faster than Lucerne forage has the shading effect leading to death of Lucerne plants creating gaps within lowering their final yield All these factors have to be taken into consideration to get better biomass as well the dry matter production of Lucerne under this agro- climatic conditions.

3.1.7 Effect of management on performance of selected Lucerne varieties across Bhutanese environments

The objectives were to evaluate the effect of location, different 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.

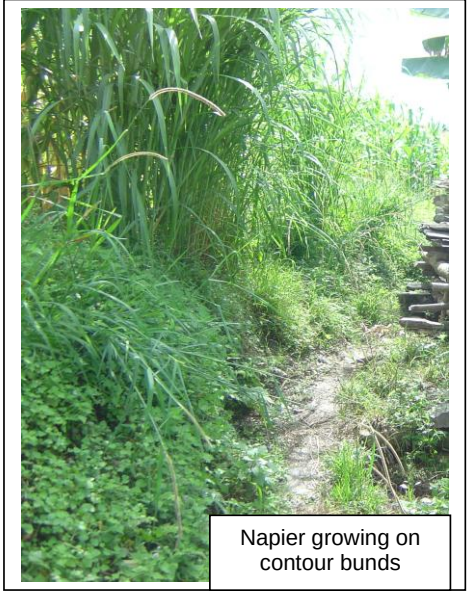
The trial was designed with split plot having 3 replicates. The main plots were 12 m2 with 6m2 sub plots size. The seed was sown in rows having space of 20cm between rows, 1.5 m between main plots and 2m between replicates. The seed rate of 9gm/ subplot was used and SSP @ 40gm/m2 was applied during establishment time.. There were two treatments considered such as cutting and irrigation intervals within the main plots as a management technique. The sub plots treatment were varieties like Prime and Ureka. The trial was established in July 2003 at Bajo station condition

Our initial observation showed that germination and plant vigour was good, no occurrence of pest and diseases incidences, date of first flowering was seen during mid- September and their persistence has not been recorded so far. The seed production is not ready now and we are presently recording flowering and seedpods formation on a regular basis. We did not record fresh biomass and dry matter production from this trial plots because we have basically aimed to maintain this blocks for seed production purpose. However, we are recording fresh biomass and dry matter production from another trial plots that has both Prime and Eureka entries. It is a long-term trial and we need to continuously record their performance and other parameters for at least four years for drawing conclusion.

The bottleneck observed in the seed production of Lucerne is the uninformed maturity of fruits/ pods. The plants keep blooming flowers and keep setting fruits and maturing. Due to this, the ripening of the seedpods is greatly hampered. Most of the pods/ fruits though good looking at the beginning dies out eventually. There is no specific time to harvest Lucerne for seed collection. Secondly, allowing the plants to stand in the field for quite a long time without harvesting harbors pest and disease incidences that kills the whole plants. Although harvesting complete trial plots yield good biomass, allow fresh growth and provide healthy and uniform plants it doe not fulfill the objective of seed production. Some technology or the mechanism is needed to be developed and designed to make the seed production easy and successful. We definitely need technical assistances of a consultant/ expert from else where who has a sound knowledge on Lucerne seed production to make seed production easy and economically viable.

3.1.8 Propagation of Fodder Species on contour 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 area under the watershed.



Napier growing on contour bunds

Two farmers of Nabchey village under Limbu geog had established in July 2001 with grass species of *Napier, Guinea, Molasses, Setaria and Paspalum* and legumes as *Leucaena, Flemingia, Napier and Crotollaria* as hedge- rows along the maize trash line. 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 Sataria* are doing far better in bunds formation compared to other species. The Center has planned to increase the trial sites and the farmers taking some of these promising species for testing.

3.1.9 Bee keeping practices at Bajo

The main objectives of this trial were to assess beekeeping for their survivability, adaptability, and productivity and to demonstrate honey production on pilot scheme basis to visitors and farmers. It was also to enhance cash income for marginal farmers and increase crop production through pollination, particularly in orchards.

An apiary with three *Apis Mellifera* colonies brought from Bee keeping Association in Bumthang was set up in the centre in August 2003 and was evaluated for their adaptability, survivability and their productivity and to demonstrate for honey production on pilot scheme basis to visitors and the visiting farmers.

The findings indicated that during first year, the colony development had been very effective and relatively fast. We did not encounter any diseases that are of economic importance and pathogenic except some lice infestation in one colony. We provided additional super by the start of the season for increasing the colony strength and trap the adequate honey flow. About 45 kgs fresh honey was harvested during the first phase during the month of April 2004. The product was sold among the staff, National Work Force and other interested buyers @ Nu. 160 / kg) and earned hard cash of Nu.7, 200.00. The fund so generated will help us to buy additional materials including the

replacement of queen in future. The colonies are performing well and we expect the second harvest at the end of August 2004. These colonies are closely monitored and optimal management provided for their healthy growth and production.

3.2 On- Farm Research

3.2.1 Legume cover-crop under orange orchard

Fodder peanut (Arachis pintoi) is a leguminous plant. *Arachis pintoi* is widely used as a cover crop for coffee plantations in Colombia and for banana plantation in Australia. In many South American countries it is used in forage mixtures mostly in association with *Brachiaria* and *Ruzi* grasses. It can also be used as a lawn species. The nutritive value of fodder peanut is higher than that of the *Green leaf Desmodium*. Like most leguminous plants, fodder peanut, in symbiosis, with the rhizobium bacteria, can fix atmospheric nitrogen. Some of this nitrogen can become available for other plants grown in association with fodder peanut and become a nutrient source through manure produced from animals after eating fodder peanut. It was first introduced to Bhutan in 1989 and first tested in Pemagatshel at 1600masl. Based on the observations made there it was declared as unsuitable for growing for the prevailing conditions. The species was re- evaluated again by RC, Jakar from 1996 and was tested in introduction nurseries and as a cover crop under orange orchard at different test locations in East- Central and Eastern Bhutan. RC, Bajo felt very imperative to introduce this legume as a cover crop in the West- Central region and evaluate its performance as cover crop at different test locations.

The main objectives of this experiment were to optimise forage production with horticulture crops. It was further aimed to study the comparative advantage and suitability of leguminous forages inter-cropped in orange orchards in terms of labour requirement, soil conservation and soil fertility management and as a cover as cover crop with the traditional system of management and production of forages separately.

Initially, six treatments were designed such as farmers' treatments (slashing weeds), farmers' choice of legume, transplanting *Arachis,* sowing *Stylo, Wynn cassia* and *GLD* after light hoeing. The plot size was maintained as 4 -10 trees per treatment. Farmers' own management was considered as replicates. The trial was established at different test locations at different period of time. The details of the test locations, time, species and their replicates are indicated in **Table 35**

Table 35 Test locations, number of farmers involved, time and species tested

Location	Name of Farmer	Date of trial establishment	Replicates	Species tested
1. Kamichu, Wangdue	Ex. Director, PWD	18.7.97	3 (36 m2)	Arachis pintoi
2. Lower Tshokana, Tsirang	Kapila Mani Parajuli	21.8.00	3 (36 m2)	Arachis pintoi & GLD
3 Kikorthang,	Bishnu Maya	17.7.00	3 (36 m2)	Arachis pintoi &

Tsirang	Dahal			GLD		
3.Samteygangchu, Punakha	Am Bidha,	13.7.98	3 (36 m2)	Arachis GLD	pintoi	&
4. Shengana, Punakha	Thinley Dorji	15.8.00	3 (36 m2)	Arachis GLD	pintoi	&
5. Lhaku, Punakha	Ms Damcho Zangmo	16.8.00	3 (36 m2)	Arachis GLD	pintoi	&
6. Lower Gishi	Ratna Bdr. Dhal	26.6.01		Arachis GLD	pintoi	&

The trial was first established during the year 1997 at Kamichu under Wangdue Dzongkhag. Then it was slowly replicated to Lower Tshokana, Kikorthang under Tsirang, Lower Goshi under Dagana and Samteygangchu, Shengana and Phaduna under Punakha Dzongkhags.

During the initial stage of the trial establishment, both *Green Leaf Desmodium* and *Arachis pintoi* had shown good germination in most of the trial farmers. In due course of time, some of the farmers discontinued their trial owing to their poor management leading to death of legumes in their orchard. At the end, only three farmers from Phudana, Kamichu and lower Goshi under Punakha, Wangdue and Dagana Dzongkhags continued and maintained their trial plots. The finding and the perceptions here are confined to these trial farmers only.

Arachis pintoi as cover crop at Lower Goshi, Dagana

In all of these trial sites, *GLD* showed vigorous growth, good ground cover and faster biomass production compared to *Arachis pintoi* at the initial stage of trial establishment. Farmers had number of cuttings and fed fresh biomass to their milking cow and young calves. However, *GLD* did not last in their orchard for many years, it started dying after 3-4 years of its growth. On the other hand, *Arachis pintoi* took minimum of 2-3 years for its proper establishment and then formed a good ground cover to the orchard. Given the initial care and good management it formed a thick blanket cover under the orchard giving a sure indication of better performer and success as cover crop in (photo plate). The findings revealed that *Arachis pintoi* should be a better legume as cover crop under orange orchard. This is due to the reason that *A. pintoi* is a long-living legume which is very persistent especially under heavy grazing once it gets strongly stabilized. During summer season it is found green giving thick blanket cover but remains dormant during winter in frost prone areas. As the spring starts, it again turns green and grows profusely. Compared to *pintoi, GLD* is a short-lived legume and does not tolerate grazing. *GLD* showed some deficiencies under orchard system for its poor performance due to less amount of light falling on the ground and crippler like trailing habit. For this reason, *GLD* is not desirable if kept long without harvesting because it might even kill plant. Moreover, *GLD* can be propagated only through seeds, which requires tremendous effort and time for the farmers

to produce seeds of GLD. *A. pintoi* on the other hand, can be easily propagated through cuttings. The only advantage of *GLD* over *Pintoi* was its fast growth and higher biomass production. *GLD* is good only under cut and carry system whereas *A. pintoi* has both the attributes. This was the only reason the farmers preferred *GLD* to *Pintoi.* Taking farmers' opinion into consideration, *Arachis pintoi* might not make better yielding fodder but definitely be a good cover crop in a long run. The finding in general recommended *Arachis pintoi* as better and successful cover crop under orchard at the elevation between 600 to 1200masl. Some of its positive attributes and recommended agronomic practices are:

High shade tolerance, suppresses weeds, high fodder quality better than all other sub tropical legumes so far available and recommended, tolerate heavy grazing, compatible with many grass species better than any other sub tropical legume available, can be easily multiplied by planting stolons, can grow on a wide range of soil and under low pH, efficient in P uptake had higher P concentration than grasses, as a P deficiency is often a problem for livestock.

Planting materials has to be made available with vegetative material. Take well-developed stolons, 20-30 cm long from the existing field. Depending on the type of the land, field preparation consists of: removing vegetation by slashing, if tall vegetation such as wormwood (khempa) is present, ploughing and hoeing (if the land is used for cultivation). Make planting hole with a spade and plant stolons at about 30-50cm during the wet season (May to August). Keep 2/3 of the stolons in the ground and press soil firmly with your feet. Weed control is necessary during the establishment time and initial period of its growth.

Because of its prostrate growing habit fodder peanut is best used through grazing. Rotational grazing with rest periods of 4-6 weeks will be recommended. Tethering the grazing animal may be the best method with small numbers. Cut and carry is also possible. It should primarily be given to calves, growing and lactating animals.

3.2.2 On-farm testing of sub-tropical fodder species

The objective was to test the sub tropical fodder species over a range of biophysical conditions under farmers' management.

In the initial phase, the trial was established with two farmers under Tsirang Dzongkhag but at the end only one farmer from Lower Tshokana of Tsirang successfully carried out the trial. A layout of 20m2 was designed for each grass and legume species in a single plot. The legume and the grass species sown were *Lucerne, Wynn cassia, Stylo, GLD, Arachis pintoi, Velvet bean, Sataria, Paspalum Atratrum, Paspalum dilatatum, Bracharia brizantha, Paspalum maximum* and *Napier*. The trial was established at the elevation of 1100masl in the year 2001.

Among six grass and six legumes species established, 8 of the grasses one legume species came up well at the end. The observations were made for a period of four years assessing their growth, biomass production and number of cuttings in a year through routine visit. These findings were based on continuous assessment and the observations made jointly by the researchers, extension agent and the farmer for a period of four years having 8 grass species maintained so far. The farmers had been judging the performance of these species in terms of growth and biomass production over the years. He commented that among the species established *Napier, Paspalum atratum, Brachiaria brizantha* respectively have performed better than other species in terms of their growth, and fresh biomass production his managerial conditions. His assessment was based on fresh biomass production, faster re-growth, number of cuttings and nutritious/ palatable leading to higher milk production when fed to milch cattle. Our regular assessment also indicated that among the species established *Napier* had outstand the performance compared to rest of the species. Even at research station condition, Napier had higher fresh biomass yield under non- irrigated conditions compared to other species. From farmers' perceptive and our judgments *Napier* followed by *Paspalum atratum, Brachiaria brizantha* are mostly recommended as promising grass species for higher fresh biomass production and growing at intermediate agro-ecological zone under Bhutanese environment.

Promising grass species at Lower Tshokaha, Tsirang

3.2.3 *Lucerne (Medicago sativa*) germplasm evaluation

The main objective of this trial was to evaluate and select the most promising Lucerne varieties from these entries. Thirty-one varieties of *Lucerne* were sown in a single plot with a plot size of 4 m2. The trial was established at NRTI, Lobeysa during July 2001 subjected to Lucerne's soil requirement i.e. dry and infertile land. It was then maintained and assessed for its germination, plant density count and fresh biomass production. The entries and their corresponding agronomic data and biomass yield are presented in the **Table 36**.

Table 36 Fresh biomass production in kg / plot and t/ha recorded from 3 cuttings

SL No.	Variety	Biomass production (Kg)			Mean yield (Kg)	Biomass Yield (t/ha)
		Date of Harvests				
		30.7.02	11.10.02	17/7/03		
1	L238	2.5	0.11	1.73	1.45	3.63
2	L330	5.0	0.22	2.5	2.57	6.42
3	L583	6.5	1.25	3.18	3.64	9.10
4	L603	6.5	2.1	3.86	4.15	10.37
5	L634	6.0	2.1	3.63	3.91	9.77

6	L635	6.5	2.3	5.0	4.60	11.5
7	L636	9.0	2.5	4.54	5.35	13.37
8	L754	10.0	2.5	5.0	5.83	14.57
9	L755	10.0	2.7	5.0	5.90	14.75
10	L792	10.0	1.8	5.45	5.75	14.37
11	L794	8.0	1.6	4.10	4.57	11.42
12	L813	7.5	1.4	3.86	4.25	10.62
13	SA 32087	5.0	0.8	1.18	2.32	5.80
14	SA 32088	5.0	0.11	2.04	2.38	5.95
15	SA 32089	5.0	1.7	2.27	2.99	7.47
16	SA 32090	6.5	1.8	3.63	3.98	9.95
17	SA 32091	9.0	1.6	3.18	4.59	11.47
18	SA 32092	5.0	1.25	1.18	2.48	6.2
19	SA 32138	10.5	1.6	2.5	4.87	12.17
20	SA 32140	9.5	1.8	2.04	5.14	12.85
21	SA 32147	10.0	1.4	2.5	4.63	11.57
22	SA 35067	9.5	2.3	3.63	5.14	12.85
23	SA 35068	7.0	1.8	3.18	3.99	9.97
24	SA 35088	5.5	2.3	2.04	3.28	8.2
25	Eureka	4.5	1.7	1.18	2.46	6.15
26	PL 34HQ	4.5	1.4	2.27	2.72	6.80
27	PL 55	5.0	1.0	2.27	2.76	6.90
28	Prime	6.5	1.6	3.18	3.76	9.40
29	Super 7	4.0	2.5	2.27	2.92	7.30
30	WL 414	4.5	1.25	1.18	2.31	5.77
31	15 L 756	7.5	1.13	2.73	3.79	9.47

Lucerne entry No. L755

The first harvest after 90 days of germination was done in July 2002. The biomass production during that time was exceptionally high. The second harvest and the third harvest were not very promising because the trial plots were heavily infested with weeds and some of the trial plots were found damaged and grazed by stray cattle. The free grazing cattle had damaged the trial during the later part of the years as the barbed wire fencing was removed and missing from the site. Although being a jointly implemented trial, the management aspect was not given a serious thought by the collaborating partner. The growth and biomass yield at Lobeysa trial site was quite poor especially during wintertime having no irrigation facility compared to our station trial. All the 31 entries were regularly assessed for its growth and fresh biomass production. Among 31 entries, when fresh biomass were assessed on an average basis, entry L 755 yielded the maximum of 14.75 t/ha followed by L 754 with 14.57 t/ha and L 792 with 14.37t/ha respectively. Some of the entries showed very poor performance in terms of biomass production from all the three cuttings. It is concluded that entries L 755, L 754 and L 792 respectively

are recommended for further on- farm testing to evaluate their fresh biomass production, pest and disease incidences and their persistence. We expect good biomass production of Lucerne varieties under field conditions only during summer when there is ample rainfall.

3.2.4 Assessment and monitoring of grassland resources

The immediate objective was to describe the natural grassland, identification of grass & legume species and establishment of a live herbarium. As a long term, it was to monitor trends in production, soil quality, population composition and nutritive quality and finally draw the long-term natural grassland management strategy and action plan.

During third round of trial monitoring not many changes was observed in terms of botanical composition. However, at different test locations some of the changes that were worth noting were documented. Kuchyachey, one of the trial sites located at the elevation of 4465m, some of the dominant species recorded were grass species followed by broadleaf and conifers and rest barren area. There were hardly few disturbances of animal creation. In general, the site looked mostly dry meadows with few green plants of conifer species. Only few yak herds migrated to this site during the season. The next test site Kuchogo located at an elevation of 4106m was noted nothing different from that of Kuchuyachey. The site was dry with few green meadows mostly of conifer species like Sulu, Balu and other Sangzay. There was hardly any soil disturbance of any origin though the plants species were dry and grazed by animals like Yak and Blue sheep. The grazing was evident as there were few Yak herds in the vicinity and a big group of Blue sheep grazing close by. The third test location located at 3767m had some changes in terms of botanical composition of the plant species. The plant species that were available at higher two sites were not common in this area though the composition looked quite similar. The only difference noted was that the grazing pressure was quite severe because the location was close to village that resulted into more animal interference. Tsheko test site located at the lowest point at an altitude of 11,970 feet asl was greatly disturbed in terms of plant compositions which was attributed mostly by horses grazing. Most of the plants were found dry at this time of the year excepting few grass species that were seen green. We need to visit next year again to collect plant samples for identification and live herbarium and soil samples for nutrient analysis.

Some of the issues worth considering are: trial monitoring is ideal during September-October of the year to ease identification of plant species and collect specimens and seeds for establishing herbarium. We need to install iron cage to protect the area from grazing in order to assess fresh biomass and dry matter production at each site. It is further useful to have additional information on production aspect of rangeland forage species since we already have started the study in the area. As did not get the report on the previous soil samples sent to SPAL for nutrient analysis, we have to collect the soil samples again for nutrient analysis during the next visit. During the visit it is also essential to collect new plant specimens of grass and broadleaf species for identification.

3.2.5 Local feed resources

The main objectives behind this survey were to quantify and qualify different feed sources available in different regions/ Dzongkhags, to document changes in feed/ fodder resources usage over the last one decade, to explore for options for local feed formulation for poultry, pig and dairy cattle with the locally available sources as the major ingredients, to finally develop a feed manual for poultry, pig and dairy cattle production in the country.

The survey was conducted in Punakha, Wangdue and Tsirang Dzongkhags in this region. 30% of the Geogs from each Dzongkhag were considered and 20% of the villages in each Geog and 20% of the households in each village were taken into account for the field survey covering at least 120 households in the region. The geogs surveyed included Goenshari, Kabjisa and Dzomi under Punakha, Sephu, Nahi and Thedtsho under Wangdue and Beteni, Tsholingkhar and Kikorthang under Tsirang.

A joint field survey with the extension agents of the concerned geogs was done using a semi structured questionnaire format. During the survey local feed samples most commonly fed to dairy cattle, pig and poultry were also collected for feed quality analysis work at RNRRC Jakar and NSSC, Simtokha. Some of the areas where survey was focused were livestock production management in general like livestock population distribution, their production, livestock products consumption pattern and their sale and purchase trend, main feed resources, crops cultivated and their surplus any for animal feed, feed ingredients that they usually feed to different categories of livestock, feeding regimes, different crop residues, their feeding practices, farmers constraints, their perceptions and immediate expectations for blending the local feed to feed their livestock. However, this report focuses only on some of these areas like:

The most commonly fed local feed resources to dairy cattle were polished rice, rice bran, maize powder, maize kharang, nettle, chopped banana stem and oil cakes. These local feeds were cooked properly and then fed once a day. Poultry were commonly fed with kharang, maize powder, whole millet and wheat singly or in a composite form @ 200- 250 gm/ day twice a day. Similarly pigs were also fed most commonly with polished rice, rice bran, maize powder, kharang, alcoholic residues, nettle and the kitchen wastes. These local feeds were chopped, cooked and fed to pigs according to body weight of the animal twice a day.

When the farmers were questioned about the availability and abundance of the local feed for feeding their livestock, most of the farmers commented that non-availability of local feed especially oil cakes and other crop by products limited them in rearing large number of pig and poultry at the semi-commercial level. Almost all of the farmers interviewed were very much interested to buy basic feed ingredients like oil cakes, vitamin and mineral mixtures if available at cheap rate and near to road head/ close to their villages for blending them into local feed formulation.

When the farmers were asked on the main feed resources, almost all of the farmers commented that open land/ fallow grazing, hay from any sources, local fodder trees, locally prepared concentrates, crop residues, grazing on improved pasture and forest grazing were ranked in the order of priority. Compared to past the farmers have started growing fodder trees along the boundaries and in marginal land as one of the main fodder sources to mitigate winter and early spring fodder shortage.

Farmers in general did not have surplus food grains that can be used in livestock feeding and for local feed formulation except some quantity of maize and millet with some farmers who had bigger land holdings. The main crop residues produced from their farm land were rice straw, rice bran, maize husk, millet straw, maize straw and bean husk/ straw of varying quantities. Some of the farmers had adequate residues of these kinds to feed where as some have to depend and borrow from their neighbour to feed their livestock on labour payment basis.

Only few farmers interviewed were self sufficient in livestock products like butter, cheese and eggs and sold their surplus for income generation. Still in general, there were shortages of basic livestock products for their nutrition at the household level.

The main bottlenecks in order of importance observed were insufficient feed resources in their locality, lack of exposure and training in the feed balancing for local feed formulation, did not have basic technical know how in modern animal husbandry practices and no hard cash readily available to buy local feed ingredients for feed formulation.

This survey had provided us more insight picture on overall scenario of livestock production, availability of local feed resources, its scope, farmer's perceptions, their constraints and expectations. It has further guided the researchers to initiate the program in training the farmers on local feed formulation for pig, poultry and cattle and also expose farmers in modern animal husbandry practices. RC, Jakar in the later stage, will produce a complete report incorporating nutrient analysis of local feeds which will guide us in blending local feed. It is expected that through technical support in place to some of the progressive farmers, more backyard farms at the semi-commercial level will be operated thereby increasing the flow of livestock products in local markets ultimately increasing the household nutrition and their income.

3.2.6 Poultry hatchability study under farmers management condition

Village chicken production under free-range and semi-intensive system is quite popular and a viable production systems for rural households with little external inputs. This production system supplements protein intake to rural households as well provides them additional income. Rearing poultry is an integral part of livestock farming system in Bhutan. Till date, most of the farmers in distant corners do not have access to raising improved pullets

limited to remoteness, susceptibility to 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/semi-scavenging system with simple housing not to let their resource waste unproductively. Besides, it has been observed over the years that farmers had been facing problems on rearing improved birds under farmer's management conditions. They buy improved pullets of 8-12 weeks of age that have been reared in the farm under intensive medication, care, feeding and housing system. These birds do not receive the same type of management on reaching village farms. Therefore, the farm-supplied birds experience quite a change of climate, feeds and housing system. It takes sometime to get adjusted and accustomed to new environments, food habits and housing conditions. The birds remain under stress due to various factors including transportation stress, which lead to high mortality of most farm-supplied birds. Keeping these issues into consideration, a study on hatching improved eggs by local broody hen and assessing their survivability, adaptability, growth and productivity under farmers' conditions from day-old to 72 weeks of age has become very imperative.

The long-term objectives of this trial were to improve living standard of farmers through the sale of eggs. It was also to enhance small-scale poultry production in the region. The short-term objectives were to compare hatchability, growth, adaptability, survivability and production performance of these birds from the point of lay to 72 weeks (economically viable period) under farmers' management conditions.

The trial was established in Dzomi, Chubu, Taewang and Limbu Geogs under Punakha Dzongkhag. In total 350 eggs were distributed to 35 households. From these trial farmers, we selected 42 local broody hens for hatchability trial. Each broody hen was given on an average 8 eggs of both local and improved for brooding purpose. The local eggs were particularly used here for the purpose of easy acceptance by the local hens and for farmers' preferences. All the trial farmers raised the chicks in their local management and feeding regimes.

The initial observation showed that the hatchability percentage of both improved and local eggs was 80 % on an average basis. There was a good response, interest and appreciations shown by these farmers to brood improve eggs and derive benefit from improved chicken at their doorsteps. Some farmers commented that brooding was difficult especially during winter. Even though hatching was successfully the mortality of chicks was found to be quite high might be accounted to chilling weather during winter.

A joint assessment was made taking into account the perceptions of the farmers and extension agents during the field visit. The findings revealed that although the hatchability was quite successful (80%) in most of the trial farmers, survivability of chicks was noted quite low (30%) only. During the field visit only few layers were found laying eggs and most of them had died before attaining production stage. When questioned to farmers on the possibilities of death, they stated that most of the mortality was accounted to predators' attack, some due to diseases conditions more commonly suspected New Castle Disease. Some death was accounted due to cold as hatching and growing period coincided with extreme cold weather. Cats and predators attacked most of these birds at the growing period because these birds were quite docile compared to local ones. However the findings revealed that the survived birds on an average lay 22-24-eggs/ month during the peak production stage. At the later stage their productivity was decreased to 18-20 eggs/ months on an average basis. The information was collected till these birds attained 72 weeks of age so called as economically viable period of their productivity.

Poultry hatchability trial in Punakha at peak laying stage

At the end of the trial period, the perceptions of farmers as well the extension agents were once again taken into consideration. The farmers were found happy and satisfied, as they had harvested fresh eggs at their doorsteps every day. The trial farmers and the extension agents showed great interest to carry similar kind of trial during summer months to compare the hatchability percentage, survivability, growth rate, disease susceptibility/ resistively, and other production variables in order to validate the present findings. It was then felt very imperative that, we need to conduct a similar type of trial during summer season to validate the present findings before making any recommendations. It was also felt necessary to include New Castle Disease vaccine within the trial treatment to assess the efficacy of this vaccine in curbing disease outbreak that ultimately lead to higher degree of chicks' survivability. In this line, the center has again implemented similar kind of study with most of the previous trial farmers in Guma, Dzomi, Taewong and Chubu geogs under Punakha Dzongkhag in June 2004. The successful completion of this trial will help us to substantiate our present findings for recommendations.

3.2.7 Local Pig breed genetic resources

Bhutan has rich diversity in domestic animal genetic resources. Efforts are underway to conserve and make best use of available indigenous genetic

material. Policy of Royal Government favour conservation of native livestock breeds and utilization of both native as well as exotic breeds to enhance food security and income of rural households.

One of the focus of which has been gaining importance in the recent years, is the native pig breed. This is due to the fact that these pigs are adaptable to local conditions, convert waste food and offal into animal protein, help rural household to meet nutritional requirement and fulfill the urgent cash requirement of the poor farmers. The year 2000 statistics indicate that Bhutan has 41,398 heads of pigs from which 36,290 numbers are local one. This statistics clearly shows that 88% of the pig populations in Bhutan are still of local breed. Nevertheless, over the years there has been decrease of native pig population by about 28% (Statistics of Bhutan 1997) and the overall pig population over the period of 10 years has declined by 17 %. Due to various advantages many farmers still rear local pigs. However, existing native breeds have not been characterized and very little is known on their production parameters. The detail information on their origin, distribution and breed characteristics warrant research. Thus, livestock research has the challenge to characterize and generate information on native pig breeds to recommend appropriate strategies for conservation and sustainable utilization of local pig breed especially in the breeding program.

The main objectives of this survey were to generate and document detail information on phenotypic characterization, production parameters and the population size of native pigs, identify potential pockets where native pig breeds are available, collect hair samples/blood samples for DNA analysis and finally select pockets and suitable native breeds and recommend appropriate measures for conservation and use of these native pigs for conservation and utilization in our breeding program.

A nationwide survey was conducted in collaboration with Central Farms, all RCs and Dzongkhag colleagues. A semi-structured open-ended questionnaire format was used for recording the desired information. The survey was carried out in pocket areas of Dzongkhags where native pig breeds were predominantly available. Within each Dzongkhag, the Geogs were selected based on the existence of local pig breeds taking the assistance of Dzongkhag colleagues. In a geog, one or two villages were selected and most of the households were interviewed using the questionnaire format. A minimum of 40 individuals per population was covered and only one or two pig breed was sampled from one household as a representative sample. The questionnaire format was also used for physical description of local pig. Typical pig breeds were noted and their photographs taken for documentation as well for future reference purpose. At the same time, hair samples were collected for genetic characterization.

Potential pocket areas for native pig breeds

The survey was carried out in most of the pockets where the local pig breeds were commonly available. Among the areas surveyed, the team found out some of the key pockets where typical local pig breeds were available. In the Eastern region, the potential pockets where the local pig breed noted were from Bangyul and Mikuri villages of Dungmin geog from Pemagatshel Dzongkhag. Similarly, in the East- Central region Bardho geog under Zhemgang Dzongkhag was noted as the main pocket area. The villages like Langdorbi and Degala were surveyed and found out some of the typical breeds there. Similarly, in the West- Central region, Drugeygang geog of Dagana Dzongkhag and Chubu and Dzomi Geogs of Punakha were identified as the potential pockets. Under Chubu geogs and Dzomi geogs of the potential villages identified were Tempekha, Jangkholo and Bintskha. Under Dzomi geog Bjipjokha village was identified as potential pocket. Under Drugeygang geog the villages identified were Pangna, Thangna and Pangsabe were noted and the team saw quite a typical local pig breed. From the Western region, Sangbe and Sombe geogs under Haa Dzongkhag were noted as the pocket areas for local pig breeds' availability. From Sangbe and Sama geogs some of the villages identified were Moochu, Nakkha and Sombe Ama, Rebji, Kokha, and Dorethasa.

Population size of local pig and factors contributing it

In total 202 households were interviewed and surveyed across four regions of the country. In all most all of the household that were surveyed the farmers commented that the population of the local pig breed were decreasing over the years. The statistics of Bhutan 1997 further indicated very clearly that 50,355 heads of pigs were of local breed compared to 36, 293 heads only from the statistics report of 2000. This clearly showed that local pig population had decreased nearly by 28% over the years in our country.

Various reasons and factors contributed to decrease in local pig breed in their community. Most of the farmers across the region commented that the religious sentiment is one of the major factors that discouraged rearing pig in their villages. Another reason that came out quite strongly was lack of feed resources in their locality and especially during wintertime when green weed are not available for feeding pigs. Some farmers even commented that there is a strong competition with human feed due to which farmers are losing interest in rearing local pigs. It was also quite clear from the findings that most of the local pigs are fattened and slaughtered for consumption/ sale locally thereby decreasing their population size. Disease incidences and predation by wild animals are contributing to decreasing trend. Manpower shortage has also limited them to rear large numbers of pig contributing to decease in population size. As the farmers have other options like cross breeding with exotic breeds, the population size of local pig breeds are decreased.

Breed preference local vs. the other breed

The information on the preference of the pig breed was collected across four regions of the country. The findings in general revealed that farmers still prefer local pig breed (54%) followed by exotic and then other breed types clearly illustrated in (Figure 2). The farmers have strong reasons for opting it. Major reasons were local pig being easy to manage and require lesser quantity of feed compared to cross and exotic breeds.

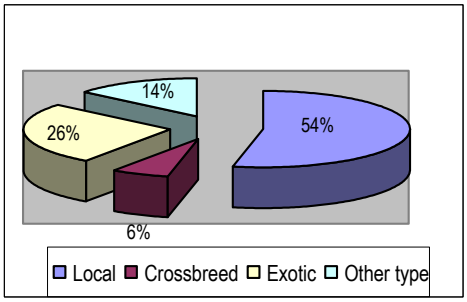


Figure 2 : Breed preference by farmers

The farmers have been rearing this breed since generation for its tasty meat compared to other breed types. Local pigs are highly adaptable in their managerial conditions and have higher survivability rate compared to other pig breeds. This pig breed being easily available to them within their villages are mostly raised for pork production. The only reasons behind for the farmers to opt cross or improved breeds were due better and faster growth rate, large body size providing more meat and returns and higher litter size compared to local pig breed

Reproduction and production variables

The reproduction and production parameters of local pig breed under farmers' management conditions in general are finally summarized in **Table 37**. This information was extracted through interview from the farmers across regions. As the survey team did not do practical recording of the production data, we cannot fully rely on its authenticity.

Table 37 Production and reproduction variables of local breed (Saphag)

Parameters	Unit
Age at first service	5-12 months
Live weight at first service (Gilt)	15-22kg
Litter size at birth (Nos)	3-9 numbers
Litter size at weaning (Nos)	2-8 numbers
Litter weight at birth (kgs)	0.2-0.5 kg
Weaning weight (kgs)	3-6 kgs
Weaning age (days)	90-150 days
Adult live weight (kgs)	70-120 kg
No. Of farrowing /sow/year	2
Mothering ability	Good
Adaptability	Good
Performance Data for Boars	

Age at first service (Young Boar)(months/Years)	5-9 months
Live weight at first service (young boar)(Kg)	15-30 kg
Frequency of mating (Boar/week)	1-3 times
Productivity as stud boar (years)	3-7 years

In general, the age at first service of local pig breed ranged between 5- 12 months when the gilt attained the live weight of 15-22 kgs (Table 7). The litter size at birth ranged between 3-9 numbers whereas the weaning size of 2-8 numbers indicating low mortality rate between birth and weaning age under local management condition. The weaning weight of local pig breed ranged between 3-6 kgs when the piglets attained the age of 3 to 5 months. The adult weight was recorded between 70 to 120 kgs after 2-3 years that depended on local feeding regime and management conditions. The mothering ability of local pig breed was judged as average to good giving 2-farrowing/ year. The local pigs are quite adaptable under local conditions. When the performance of boar was judged, the findings indicated that boar reached age at first service at 5-9 months when the body weight of 15-30 kgs was attained. The frequency of mating by boar in a week was observed as 1-3 times with the boar having its productivity of 3- 7 years.

Bottlenecks in pig production

The findings revealed that lack of feed resources/feed shortage and manpower shortage was indicated as one of the primary constraints followed by religious sentiments. The disease incidences and sanitation problems not having proper housing especially during rainy season were also indicated as a secondary problem. Non-availability of local feed resources in the lean season/winter, farmers not having suitable breed, wild animal/ predators attack were some of the tertiary constraints. Farmers commented that pig rearing was much easier during summer compared to winter due to availability of the local weed weeds in abundance. Major feed shortage was felt especially during the lean season when they had more numbers of pigs in their backyard to feed with.

Diversity of local pig and their characterization

During the survey, the team did not encounter much diversity in local pig population. Two breeds of these native pigs (*Deophab*[1] and *Jituphab*[2]) are believed to have existed in the country. Some of the farmers categorize them as Deophag, which is believed to be descendent of wild boar; it is a pig with large body size, small flat erect ears. While others as Jituphab/ Saphag small size native pig with flat erect ears and a bulging belly.

[1] Deophab is believed to be descendent of wild boar; it is a pig with large body size, small flat erect ears.
[2] Jituphab is of small size native pig with a bulging belly and small erect ear.

Although the survey has found out four local types like Drugeygang, Dungmin, Bardho and Sangbe according to the place of their origination, they looked almost similar to each other. Not much difference was noted in these breed type and they were finally summarized broadly into one local breed as Saphag. Phenotypically there was little variation based on their body confirmation and size and coat colour. The hair colour was found to be mostly black irrespective of sex across the entire region. The colour of skin varied from black to white and few of them even gray in colour irrespective of sex. The hoof colour was mostly noted as black and white. Tail colour again varied from black to white and some gray even. In general, black colour was quite predominantly seen irrespective of sex. Their foreheads were straight, convex and dished shaped with small flat erect ear. The behaviour was observed mostly docile and in some case hostile even. The female most commonly had 10 teats with few excepting to 12 and 13 numbers even. The detail physical characterization, breed types and their actual diversity will be reported later when the DNA analysis report is ready. This is an interim report; therefore the recommendations and the conclusions are not highlighted here.

3.2.8 Yak herd monitoring scheme

Yak herding are 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 from the socio economic changes are going to impact on the life of the herder society, rapidly. Living under high altitude and often-harsh climatic conditions is not an easy life. 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 (Pal, 1997). The situation in Bhutan may be further exasperated by the education for all policy. Unless the yak farming enterprise is made profitable and attractive, it is highly unlikely (at least in the short term) that the young generation educated mass of herders would like to continue with the profession. This may impact negatively to the sustainability of the traditional yak farming system. It is imperative that innovative programs are initiated to ensure attractive and sustainable yak production systems in Bhutan. As an initial attempt, a yak herd-monitoring scheme is being incepted. The Centre in collaboration with RC, Jakar felt very important to under this long term study in potential pocket area within our region.

The short-term objectives were 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 being to sensitize the members under the scheme to become innovative yak herders in initiating various yak herders group 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

The Centre in consultation with the Dzongkhag Livestock had selected Sephu Geog under Wangdue Dzongkhag for carrying out this study. Following the standard protocol adopted by coordinating center Jakar, we had selected ten prominent yak herders and used formal questionnaire format for recording the information. For saving time and the resources, we had chosen the yak herders from one-village/ pocket areas. The yak headers were selected from different herd size like large, medium and small. The main pocket areas where the study was conducted were Gangchukha, Revina, Longley/ Longmey, Gangchudoro and Palela pass. In total ten prominent yak herders were interviewed and information documented. These are some of the general findings documented during the survey.

Most of the yak herders interviewed did not have other categories of livestock. They were predominantly rearing yaks of ranging sizes from large herd to small herd. Only few of the herders kept local cattle, horses (Yuta), and chicken. When questioned for reasons of not rearing other categories of livestock, they commented that it was their age-old practice in rearing yak than other category of livestock. The yak herd varied from 12 numbers to 40 numbers among the herders. Rinchen Pem had the lowest herd size with 12 numbers compared to Nanga who had 40 yaks, the largest among the herders interviewed. 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 yak, manage and made amendment themselves.

Yak herders did not have much technical know- how on the production and reproduction of yak. Very little information could be harvested from the herders during this visit. The age at first calving was recorded at minimum of 3 years. The calving interval ranged from 18 months to 24 months. The average production/ yak/day was noted as 0.5 –1.5 liters. The average numbers of days in milch was recorded as 365 days.

Yak herders when were interviewed commented that the major causes of yak mortality were, predation by tiger, leopard and wild dog, falling from the clips and general weakness in young calves. Few farmers commented that the yaks were dying due to water poisoning (Chuduk) for which the actual causative agents have not been traced out yet.


Yak grazing at Longtey tsamdro under Sephu Geog

The entire yak herders interviewed did not have any newborn calves in their herd during this season. The findings in general no practice buying yak from other areas nor selling out from their herd. Only one superior bull was maintained for breeding purpose and the rest castrated. These castrated bulls were managed easily in

the herd and were kept for carrying load during herding and for meat production. Mostly meat was sold instead of live animal.

The yak herders were found commonly moving together with animals in a group ranging from 4 households to 20 households for their summer and the winter grazing sites. They had tsamdro named as community owned collective by these grazing herders. It was revealed form 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 herders group of Gangchukha village comprising of five members were herding during winter at Zabaden, Lumkhemtey, Zilley, Tabuna, Choley, Nubchey, Gongchudoro and Pudoo. The summer grazing sites for these herders at Sintha, Zakhentha, Bikchimo, Budee, Richey, Tampey, ZeeZee, Rithang and returned back to same route for their winter camping. Some of the herders of Longtey village were operating in a group of twenty members and they had specified sited for their summer and the winter camping as indicated. The quality of Tsamdro in general was graded from as average to good. The tsamdro at higher elevation were better than at lower elevation. Although there were adequate grazing resources during summer seasons shortage of grazing resources was felt strongly during winter. There was some land that was leased out during early HLDP project time where yak herders have locally fenced and used them for grazing their lactating, pregnant and calves during summer months.

The main sources of income for these herders were from the sale of livestock products. Most commonly sold livestock products were Chugo (Beaded hard cheese, Hapairuto (hard cheese), Tarichem (ladies kira), Tshakap (raincoat made out of yak/ sheep hair), yak meat and butter. On an average, each household earned Nu 4000-5000/ year from the sale of these products. They did not have income from other sources except doing some contract work and some support during annual rituals from their family members working in Government service.

This study is first of its kind in the region and we have to annually monitor and record information from these herders to get the trend of population dynamics, the status of grazing their resources and other management aspects. This is an initiative taken by center in monitoring the yak herd and trying to identify the areas for research intervention in future. Although, the herders did not have much to say at this point of time, we have intended to harvest more information and identify their potentials and constraints during our subsequent visit. The information collected will be store in Excel, updated and trends analyzed on yearly basis. It is also planned to map *Tsamdrogs* and migratory routes of these herders in future follow up study. All these aspects when looked carefully will guide us for research intervention in the areas of yak husbandry in Bhutan The present study has triggered us to collect water samples from prominent sites where yaks usually drink water and send samples to RVEC, Serbithang for toxicology analysis to determine the causative organisms to reduce incidences of yak mortality. This is a long-term study and we are finally aiming at to form yak herders associations of different kind for economic gains for the herders' community of the region.

3.2.9 Documentation of local livestock product types, processing techniques and marketing systems

The Livestock Research Program has started describing existing farming systems across major livestock species including yak, Siri cattle, sheep and horse. Result from such study show that there is wide range of farming patterns, rich livestock product diversity and elaborate traditional process involved in finalizing the product. In particular, the yak farmers in different parts of Bhutan have inherently specialized in the production of different products from their livestock. For instance, the herders from Western Bhutan especially in Haa and Dagala produces three different cheese types such as the common beaded hard cheese, *Haapai ruto* and another special cheese for the preparation of porridge. In contrast, the herders in Merak-Sakten prefer to produce *Zedey* (fermented cheese) rather than hard cheese. Similarly, a wide variety of garments and accessories are being produced from yak hair and hide. The production of these products involves several intricate processes and the use of specific local materials. So far, studies to document such traditional livestock products and their processing methods have been limited. If we are to make interventions in diversifying the livestock products, import or adapt processing technologies, it is imperative that we have sound knowledge and understanding of the traditional systems. Keeping these factors into consideration, the Centre felt imperative to under take a study in our region in collaboration with RC, Jakar in documenting livestock products, their processing and marketing system.

The objectives of this study were to document traditional livestock product types, their processing methods, processing equipments and the marketing systems and to generate information for planning future programs on livestock processing and marketing technologies.

We had selected at least ten prominent Yak herders from Sephu Geog under Wangdue Dzongkhag and collected the information on their products making as well the marketing systems. Information were collected using formal questionnaire as well as through informal discussions with elderly members of the family. The selection of the herders was based on the size of the yak population and we had selected large, medium and small herd size for the study. Some of the places like Gangchukha, Revina, Longley/ Longmey, Gangchudoro and Palela pass were covered during the survey and some general findings were drawn.

From this survey, quite interesting information were collected on wide range of local livestock products including processing and marketing systems. The study had clearly revealed that farmers had variety of local products especially from yak milk, hair and skin as raw materials. They had age-old tradition of products processing and strong marketing system in place.

Some of the raw materials that were commonly used by the yak herders were milk, yak hair and skin for making the local products. From yak milk the

herders make two types of cheese like beaded hard cheese locally called as chugo and hard cheese locally called as Hapai ruto. From yak hair various materials were made like ladies dress, raincoat, sack, bag, rope locally called as Kira (tarichem), tsharkap/chaw, and facha, natha some of them were retained at home while others sold for income generation. The yak skin was commonly used as meat substitute after processing.

There was a good market already in place for chugo, hapairuto, ladies dress (tarichem) as well for tsharkap. The yak herders were marketing Hapairuto down to Phuntsholing and selling them @ Nu 120/ kg. The chugos were sold locally @ Nu. 25/ garlands. The ladies dress (Tarichem) was also marketed to Phuntsholing and was sold @. 1,000/ pieces. The tshakap was used for covering loads during transportation as a protection from heavy rain. Few of them were sold locally @ Nu. 600/ piece. It was reported that one family earned Nu 4500 on an average through the sale of these products annually. Lot of the local products have already reached to the local markets and are fetching an attractive prices. The findings in general concluded that the research need to intervene at certain point of time to provide technical support in over all hygienic method of product processing and exploring better market, guide them to organize and operate in groups that will ultimately fetch higher prices for their local products and increase their family income level. Better price for their local products is a way ahead to boost their morale for working harder, more systematically and in a coherent manner.

FORESTRY RESEARCH

4 FORESTRY RESEARCH

For the purpose of this report forestry activities have been divided into four activities in the Lingmutey Chu watershed (the pilot site for multidisciplinary research by the centre); on-station activities (activities conducted at the centre and the fields around it); and extrapolation (activities conducted beyond these two areas and mainly including those in the two forest Management Units in the region.

Lingmutey Chu Watershed

4.1 Community Forestry

4.1.1 Community plantations

Rehabilitation of degraded areas through community forest plantations and handing over of natural forest as community forests were short-listed as priority activities to be addressed by the forestry group during the diagnostic survey of 1997.

Community forest plantations 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.

Degradation of areas near the homestead and surrounding fields is a major concern among local communities in the lower part of the watershed. Soil erosion was already a big problem that formed large gullies near the communities. Forest degradation in and around the villages has compelled the communities to agree and establish community plantations on degraded areas with each household contributing equally in terms of labour and required inputs, benefits are also shared equally. The communities also decided to plant fodder species such as *Ficus* for livestock, in order to save time and efforts in collecting fodder from distant places.

The communities doubted whether they would be granted ownership of their plantations. As such, the team discussed the issue with higher authorities and was assured by the Divisional Forest Office that property ownership and user rights will be given to the concerned communities. Once assured, communities identified the areas to be planted. Preferred species were sourced out and plantation activities began. A community forestry nursery was also established to generate planting materials for successive years. Each household contributed equal share of work such as fencing, digging pits, planting and watering the plants.

With the objective to help reforest degraded areas near the homesteads, the areas were brought under community plantations involving the participation of user group communities. This also has the objective to enable the communities to meet their requirements for tree product from these plantations. A total of 29.04 ha of such land have been brought under community plantations from 1999 to 2002 (table 38 for details).

Table 38: 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**

4.1.2 Inclusion of natural forests in community

The Social Forestry Rules (SFR) 2000 requires that community forest to consist of roughly equal proportion of degraded areas where communities can be engaged in rehabilitation activities and natural forest in fairly good condition which can be used by the communities. While the intentions of the rule has been noble i.e. to give communities with some nice natural forest cover to offset the cost of involving in plantation activities, problems often arise in the field particularly in areas where there are no good natural forest near the communities. Also when communities are only interested in protecting the degraded areas near their homesteads for various reasons and not only for forest products. The community plantations (CP) in the watershed which originally was planned to be handed over to the communities[3] now faced the issue of the need to include natural forest around the plantations to be eligible for consideration and approval as "community forest" as defined by the SFR 2000. This however became problematic for a number of reasons: first, the forest areas near the community plantations are in essence degraded chirpine forests ranging from sparse mature forest to poor quality young forests, this does not give a lot of incentive for communities to engage further effort in managing a greater area as they are already doing it as a part of the CP; second, unlike the degraded areas where the rights of access and use are fairly simple and confined to the two main communities, fencing of areas and inclusion as CP was smooth, the new areas that were identified by the two communities together with the research team from RNRRC Bajo and the Dzongkhag Forestry Office (DzFO), has multiple access rights and with use rights intensely contested and defended by other communities; and third the two communities major interest in involving in the CP was to rehabilitate and stall the process of rapid degradation of the sourrounding areas, which was affecting their agricultural fields and are not very keen on managing forests for the sake of forest products[4].

Although the boundary mapping for the proposed area to be included with the CP as community forest have been carried out and several rounds of discussions and consultations have been carried out with the communities by the forestry sector and

[3] Certificate of ownership for some plantations have already been handed over to the communities.
[4] Local communities are entitled to appropriate any forest product from any forest area upon obtainment of a permit and as such still do not feel/perceive an acute shortage of the forest products to want to engage in community forestry.

the DzFO, no progress has been made so far. The communities have now clearly indicated that their interest is to get the CP approved as community forest and engage in managing these plantations.

4.1.3 Natural forest management

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) was discussed in various meetings of forestry professionals. RNRRC Bajo for the purposes of preparing 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 of the centre 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.

4.1.4 Forest Function Mapping and Forest Zonation

Forest function mapping defines for all the forest areas within particular area ecological, environmental and social functions to allow a balance between the often-times conflicting management interest of the local forest users, nature conservation and environmental protection.

Data collection for the forest function consisted of deriving information from the published reports of the centre and MoA (LUPP), discussions with the local people and the beat officer, aerial photo interpretation and field truthing and finally GIS analysis. 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 below.

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. Three forest zones have been proposed based on the their impact on forest management namely: strict protection zone, protection zone and restricted protection zone. Areas without any defined function can be used without any particular management restrictions except those imposed by the Forest and Nature Conservations Ruels, 2000 and relevant rules issued by DFS from time to time. In this way 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 39: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 slopes	WSh	2493.4	100	77
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**

4.1.5 Mapping Compartment Boundaries

The objective is 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.

Blocking 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.)

4.1.6 Forest Demand Assessment

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. For the simple watershed forest management plan, a simple participatory demand assessment was carried out to achieve this purpose.

For two weeks staff of the forestry sector of the centre, BG-SRDP, Lobeysa and the local BO camped in the watershed and moved around conducting PRA type exercises in each of the villages eliciting their responses for their demand forecast for about 10 years from now.

Forest product demands of the local people were classified as: timber (cham, *drashing*[5], 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 watershed forest. For a detailed description of the method, the reader is referred to "Community Forestry Manual for Bhutan, Part II[6]"

4.1.7 Forest Resources Assessment

It is the objective of the FRA 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. This is important so that exactly what is available and where it is available are recorded. The design is 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.

It follows a point sampling method along transect lines using a simple wedge prism linked with a fixed sample circle for the enumeration of regeneration and saplings. It will be applied in all forest stands irrespective of type or age. The assessment is done for each watershed as a "management unit which is split into village areas and forest blocks. Assessment will only take place in production forest, that means areas

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

identified as soil protection (SP) and Riparian Reserve Protection (WRR) are exempted hence the importance of preparing a forest function map before this execise.

Field assessment was conducted by staff from the forestry sector of the centre and BG-SRDP together with the local BO and he beat officer and his assistant. Block maps were prepared by the GIS unit at the centre and based on the blocking exercise (4.1.2.2) at a scale of 1:10,000 and contained information on block name, size, category (according to function map), village settlements, fields etc. Field work involves laying out transect plots, verification of the block map and assessment of the sample plots.

About 12-24 sample plots were assessed per block depending on its size (see table below). When there are two distinctive different forest types, then sub-blocks were taken with a minimum number of plots to be located in a sub-plot as 6.

Block size	Minimum number of sample plots
Sub-blocks	6
- 20 ha	12
20- 40	16
40-60	20
> 60 ha	24

A starting point of the transect line is identified with the help of the altimeter and the block map. Counting footsteps (graduated earlier) allows identification of plot location. If sample plot that fall into an open area, or in a very dense and difficult place, the position cannot be changed but the plot is treated as a zero plot with no measurements but describing the forest and site condition.

The actual assessment in a plot always follows the same sequence to avoid that measurements are forgotten as below:

Fill header of tally sheet
This includes identifying data such as plot number, sheet number, date, name of official doing the recording etc.

Regeneration sample (3m radius)
Within a radius of 3m regeneration is assessed by counting all trees that are between 30 cm and 1.3 cm.

Prism sweep
With the help of a wedge prism sample trees are identified and recorded into the tally sheet according to their diameter categories. On steep slopes slope correction by aligning the prism to the slope is required. Results of this gives the basal area of the plot.

NWFP Occurrence and Use
The occurrence of NWFP and the current use is assessed by visually evaluating the forest in the immediate surrounding of the sample point. Species name and abundance or rarity of NWFP is recorded. The intensity of browsing, shoksing and lopping are also evaluated visually and marked.

Description of forest cover and site
The site/plot is finally described in terms of forest type, canopy cover, age class, soil type, steepness, soil cover, potential use and silvicultural treatment, stand description and management prescription that are required. The block description is done at the last when all plot assessments are carried out and corresponds to the general characteristics of the plots.

All blocks in the watershed have been assessed and only the analysis of the data remains. Data analysis is done by simply transferring the data recorded in the tally sheet into an EXCEL spreadsheet called Blockdata.XLS which will automatically calculate the stand data and the expected output within the next 10 years and provide a block sheet containing all related block information.

4.2 On-Station

The forest 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 3 shows the number and quantity of species planted.

4.2.1 MPTS Evaluation

The list of species evaluated is given in Table 40. *Ficus cunia, Eriolobus indica, Acrocarpus fraxinifolius, Albizzia procera, Spondis axillaris, Ficus bengalensis, Ficus religiosa, Albizzia lebbeck, Melia azedarach* are some of the better native species observed. While *Desmodium ransoni* (Bush), *Robina pseudoacacia*, and *Acacia arabica* are some of the better exotic species observed.

Table 40 : List of species evaluated in the MPTS nursery

Scientific name	Common/local name	Scientific name	Common/local name
Native species			
Eriolobus indica	Tong (Dz.)	*Albizzia lebbeck*	Siris (Nep.)
Albizzia spp.	Guyay siris (Nep.)	*Ficus bengalensis*	Bar (Nep.)
Melia azedarech	Jashing (Dz.)	*Ficus religiosa*	Pepal (Nep.)
Spondis axillaris	Lopshe (Nep.)	*Chickrassis tubularis*	-
Alnus nepalensis	Gama (Dz.)	*Morus alba*	Kimbu (Nep.)
Quercus lanata	Gum (Dz.)	*Acrocarpus raxinifolius*	Mandanay (Nep.)
Ficus roxburghii	Bakushing (Dz.)	*Michelia champaca*	Champ (Nep.)

Ficus cunia	Khanyu (Nep.)	*Albizzia procera*	Siris (Nep.)
Cupressus	Cypress (Eng.)	*Tectona grandis*	Teak (Eng.)
Trema orientalis	Kuyal (Nep.)		
Exotic species			
Acacia villosa	-	*Robina psedoacacia*	-
Flemingia	-	*Acacia arabica*	-
Calliandra	-	*Tamarindus indica*	Titiri (Nep.)
Tithonia diversifolia	W/sunflower	*Cederla toona*	Tooni (Nep.)
Desmodium ransoni	-	*Cassia spectabilis*	-

4.2.2 Vegetative propagation

The objective was to generate improved vegetative propagation techniques for various multipurpose tree species. Thump sized (10-12 mm diameter) and 15-30 cm long cuttings are made for each of the species with sharp secateurs during February-March and inserted into pre-prepared holes in the nursery and allowed to root. All species tested respond well to the vegetative techniques although *S. babylonica and Poplar spp.* are the most responsive.

4.2.3 Bamboo propagation

Bamboo has multiple uses in the Bhutanese community (e.g. roof mats, fencing pole and post, canning of shoots of edible species, building construction, basket, etc.). Bamboo also plays an important role in soil conservation by virtue of their dense surface root, which helps protect from sheet and gully erosion. Informal interviews done in Tsirang and Wangdue in highlighted that the farmers propagated bamboo only through rhizome and were not aware of other techniques as seed and stem (node) propagation. Six different species of bamboo germ-plasm were collected locally from Tsirang and Wangdue and a simple trail to study the success and comparative advantage of propagating by various techniques were established.

Propagation through rhizome involves burying whole culms with their rhizomes still attached. This produces rooting plants along the culm and each plant develops from the shoot growing from branch buds. This technique involves planting single-node culm sections horizontally with both ends buried enabling the exposure of a large area of the vascular culm tissue to the wet soil. This maximises water entry into the culm section and then into each branch and its buds. Multiplication through seeds ensures that each propagules posses shoot, root and rhizomes even at the time of tiller separation, enabling rapid establishment and very high survival of propagated materials. Seeds are sown between March and July with the pricking done when seedlings have attained a height of about 5-10 cm (i.e. about Aril-August). By the last week of May the next year, about five to six tillers on an average are produced in each plastic tube. Cutting rhizomes for production of more propagules separates these tillers. After separation, each propagule is planted in the plastic tube for further growth and development. By July the following year, a number of propagules for each species are retained in the nursery for production of more propagules next year. The process can be repeated depending on the amount of seedling required.

The results of the trail are now ready to be translated into extension materials. A written communication has already been made to the Information and Communication Services (ICS) of the Ministry of Agriculture (MoA) regading the same.

4.3 Extrapolation

4.3.1 Stand stability trial Blue pine stands of Khotokha FMU

The Khotokha Forest Management Unit is situated in Bjena and Rubisa geogs of Wangdue Phodrang Dzongkhag. It covers an area of 9407 hectares and ranges from 2300m to 3785m in elevation. The dominant tree species in the FMU is blue pine (*Pinus wallichaina*, A. B. Jackson). It has many uses in Bhutan. Besides being the most important species for timber, poles, chams and firewood, blue pine forest are also used for collecting leaf litter for farmyard manure.

A stand stability trial 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).

The trail is located about 2-3 kilometres from Tashi La near the road leading to Soebasa sawmill. The altitude is approximately 2780 m. The site has a gentle to moderate slope with a West to Southwest aspect. Soil is deep and fertile and previous landuse appears to be pastureland.

The main tree species is Bluepine (*Pinus wallicahina*) with only occasional oak (*Quercus semicarfolia*). Bluepine regenerated naturally here and occupied the pasture land. Counting branch whorls the stand age can be estimated to about 18 to 20 years. Tree growth is very good with an estimated stand height of 10 to 13 m. The forest stands are in some places very dense alternating with open areas covered by rose and berberis bushes.

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.

4.3.2 Rimchu FMU

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.

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.

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 remains to be approved by the Department of Forests.

SYSTEMS RESOURCE MANAGEMENT

5 SYSTEMS RESOURCE MANAGEMENT

5.1 Community Based Natural Resources Management (CBNRM)

CBNRM activities in Lingmuteychhu Watershed are continuous processes, where the participatory on-farm research or action research is conducted with the aim to improve sustainable development of the farming communities. Most of the work is done through participatory action research, whereby the farmers are enable to share their perceptions of a problem, to find common ground, and then to engage a variety of people in identifying and testing out the possible solutions. This allowed going through a process of shared learning for different stakeholders in improving the livelihood of the farmers and in managing and using of available natural resources. In addition, a number of activities were conducted to address the livelihood problems, which were reported during the participatory problem diagnostic survey done in 1997. This paper in brief presents the results of the activities carried out in the Lingmuteychhu watershed concerning both CBNRM and Livelihood improvement.

5.1.1 Monitoring of rice transplanting date and its impact on rice yield

At the national level, 20% of the rice-farming households have a major constraint of access to irrigation water for agriculture production, which are managed according to customary and traditional rights.

In Lingmuteychhu watershed as per the traditional water sharing system, Dompola community is scheduled to get their irrigation water share from Limbukha community only from the 10^{th} day of 5^{th} Bhutanese month, which is usually after completion of 80% of the rice transplanting at Limbukha. Since in Bhutanese lunar calendar the months are sometimes double, which when compared with Julian calendar the duration some times escalate up to end of July month. Usually Dompola farmers start transplanting rice from 10^{th} day of 5^{th} to 4^{th} day of 6^{th} Bhutanese months, lasting for 24 days only. In addition to the late receipt of water from Limbukha, within Dompla, there exist a water sharing system, whereby every household don't get their share on the same day, as it is rotated. Therefore, farmers expressed that both the above practices delay their rice transplanting and hence affects rice yields. This activity was done to monitor the variations in yields of rice transplanted at different dates.

Farmers who irrigated and transplanted at different water turns (dates) were selected mentioned in Table 41.

Table 41 Test farmers selection

Farmers	Water turn and date of transplant
1^{st}	10^{th} day of 5^{th} month
2^{nd}	22^{nd} day of 5^{th} month (12 days interval of total 24 days transplanting duration)
3^{rd}	4^{th} day of 6^{th} month

Random crop-cut from the selected farmers field were taken during harvest. The average rice yield and moisture content were measured and recorded.

The major findings of from this activity during the year 2003, were the first water turn on 10th day of 5th Bhutanese month was received by Am Ngawang on 9th July and transplanting was done. The last date on the 4th day of 6th Bhutanese month was on 2nd August, however, since there was enough rainfall in the month of July Table 42 rice transplantation in Dompola was completed by 26th July 2004, before 4th day 6th Bhutanese month. Therefore, the crop-cut results didn't show significant difference in the yields of rice transplanted on different dates. The first water turn receiver, Am Ngawang had 4.6 t ha^{-1} and Ap Bajo who did the last transplantation had 4.2 t ha^{-1}. The result indicates that variation in rice transplanting dates and water conflict between Dompola and Limbukha communities occurs only when there is sever water shortage during rice transplanting season due to extremes of climate change resulting to less or delayed rainfall.

Table 42 Indicating the total and maximum rainfall during the rice season

	Months			
	June	July	August	September
Total rainfall (mm)	167.5	199.5	82.1	112.5
Maximum rainfall (mm)	33	60.6	25.4	50.6

5.1.2 Demonstration of Intermittent irrigation of Paddy

Many rice growing farmers in Bhutan believe that "more water in rice field means more rice" and they try to irrigate their fields almost every other day to maintain the water level to the highest that terrace bunds can hold and this is continued until few weeks before rice harvest. This practice has resulted in low irrigation water use efficiency and created water shortages during peak transplanting seasons in many parts of the country and hence delayed transplanting dates and also created conflicts between communities over irrigation water. In addition this practice also contributes to the loss of water-soluble nutrients through seepage and overflow, which ultimately affects the crop yields.

In this regard, RC Bajo has conducted series of on-station trials on intermittent irrigation for efficient use of irrigation water for producing optimum and stable rice yields and the results were found to be encouraging. So to test intermittent irrigation on-farm and to demonstrate to the farmers the efficient use of irrigation water, two test farmers (1 from Dompola and 1 from Omteykha) were selected and two plots of 1 langdo each were identified for each farmer. verage rice yield under farmers' practice based on farmers' estimation from both the fields were recorded {240 dreys at Omteykha (3.56 t ha^{-1}) and 200 dreys at Dompola (2.96 t ha^{-1})} as baseline information. Farmers were advised on the processes of intermittent irrigation, which include:

- Maintaining standing water two weeks after transplant
- Then flooding once again
- Then the field is kept without irrigating till they are dried enough and soil starts cracking
- Then re-irrigating again

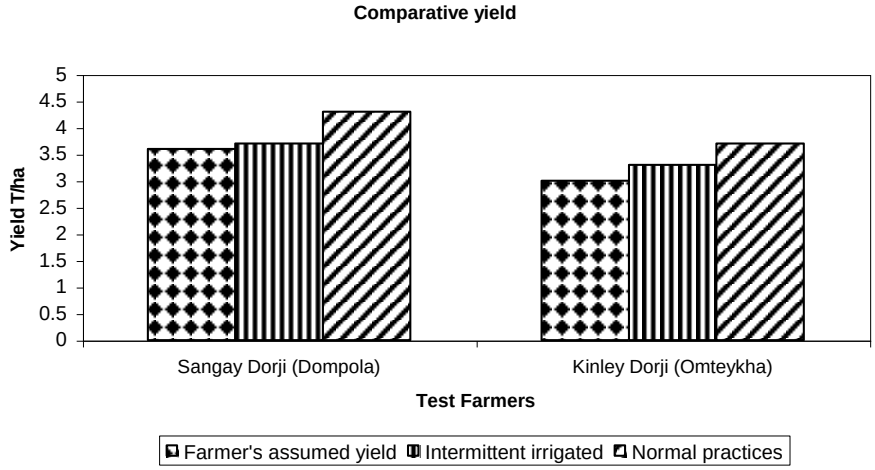
The processes were continued till the crops reached at maturity stage.

The yield assessment was done through comparing crop cut results from the control plot and the normal irrigated plot. Crop cuts were taken from an area of $30m^2$ and farmers' feedbacks were recorded. Crop-cut results were presented in Table 43 and yield in Figure 3.

Table 43Table 43 Comparative crop-cut result of intermittent irrigation

Farmers Name	Village	Variety	Intermittent irrigated Yield T/ha	Normal irrigated Yield T/ha
Kinley Dorji	Omteykha	Maap Phogom	3.3	3.7
Sangay Dorji	Dompola	Reda machum	3.6	4.3
Average yield			3.45	4.0

Figure 3 Comparative rice yield from intermittent irrigation



The above figure shows that, through control irrigation, farmers could produce almost similar yield than in flooded methods.

During the feedback session, farmers reported that rice harvested from the intermittent irrigated plot was difficult to thresh than that harvested from their normal practice plot. As this was the first year demonstration tested on-farm, no clear occlusion could be drawn at this stage. So further comparative assessment will continued for another two years.

5.1.3 Sochum intensive hand weeding campaign

The intensive hand weeding campaign on Sochum (*Potamogeton distinctus*) was an on-going activity to create awareness among the farming communities on the impact of intensive hand weeding on Sochum pressure. The activity is continued with the

same test farmers and at the same field to monitor the changes Sochum pressure over time as result of intensive hand weeding. First weeding was done at two weeks after rice transplanting. The transplanting dates and hand weeding dates are shown in Table 44.

Table 44 showing dates of sochum hand weeding

Farmers Name	Transplanting date	1st weeding	2nd Weeding	3rd Weeding	Harvesting date
Gomchen	15/6/03	29/6/03	13/7/03	27/7/03	14/10/03
Kinley Dorji	28/6/03	12/7/03	26/7/03	9/8/03	31/10/03
Chhimi Rinzin	4/7/03	18/7/03	1/8/03	15/8/03	23/10/03
Draue	8/7/03	22/7/04	5/8/03	19/8/03	21/10/03

It was found that first weeding, which is two weeks after transplanting might not be necessary now, as there was hardly any Sochum emergence. This could be the result of intensive hand weeding over the last three years. In addition, rice seedlings were not well rooted (2 weeks after transplanting) and weeding at this stage is more of harm than any benefits to the crop.

After three years of intensive hand weeding in Limbukha, it was found that there was hardly any Sochum present in the test plot now. This could be because of the altitude, as it is believed that sochum proliferation could be reduced in high altitude (cold areas) through hand weeding than in lower warmer areas where chemical fertilizers uses are more.

Field days were organized after third weeding with the aim to share farmers' views through farmer-to-farmer extension. Also field visits were arranged to see the differences on plant growth and sochum pressure in the fields with and without intensive hand weeding.

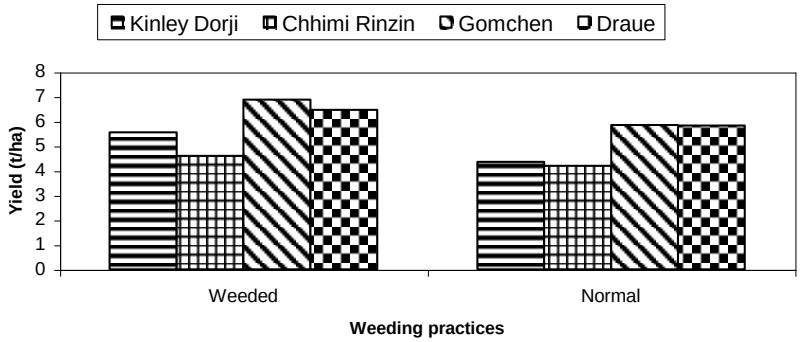
Comparative yields of crop cuts from hand weeded and normal practices were presented to farmers during field days. Because of the yield differences attributed through intensive weeding, Wangjokha farmers wanted try out intensive hand weeding practices in small scale from next season.

Table 45 Comparative crop-cut result of weeding methods

Farmers Name	Village	Variety	Hand weeding	Normal Practice
			Yield T/ha	Yield T/ha
Gomchen	Wangjokha	IR64	6.88	5.85
Kinley Dorji	Omteykha	Maap Phogom	5.55	4.35
Chhimi Rinzin	LImbukha	Yusiray Kaap	4.6	4.2
Draue	Thangu	Bonday	6.46	5.83
Average yield			5.87	5.05

The crop cut results showed an average yield difference of 0.8 t ha^{-1}. Besides, the pressure of sochum has reduced drastically in the intensively weeded plot. This has resulted in lesser labour requirement for weeding the same plot compare to year 1 and 2.

Figure 4 Comparative rice yield from Sochum weeding campaign



Farmers' feedbacks were collected on potentials and constraints of sochum intensive weeding through informal discussions during field days and crop cuts exercises. The information include:

- Farmers in the watershed are well aware on the effect of sochum on rice yields, however, due to the area of land cultivated in this area, which is much bigger (owned or shared -in) in comparison to farmers in Paro Dzongkhag, where the average land for rice production per farmer is 5 langdos, making intensive hand weeding possible.
- Farmers felt that to successfully and to seriously implement the intensive hand weeding activity, they should frame Sochum management by-laws (Chatrims) so as to dispose off the weeded sochum properly to reducing its recycling process.
- They felt that the Sochum pressure in the field depends upon land preparation practices. They experienced lesser sochum pressure when the land is ploughed deep by Power tiller or Tractor and when the lands are kept fallow during winter.
- In addition they realized that the soil type and texture also influences sochum proliferation. In watershed the soils are mostly clay laom, which enhances sochum proliferation and makes difficult for hand weeding. However, in Thimphu/Paro areas the soil type is sandy clay, making hand weeding easy.

5.1.4 On-farm evaluation of Groundnuts

Groundnut on-farm trials were conducted to select the promising varieties based on farmers' observation. The objective of these trials is for cash income generation for the farmers. Based on last year's varietial selection done by the farmers, this year only one variety ICGV 86699 was tested with two test farmers in Dompola. Groundnut seed weighing 250 gm were distributed in May 2003 and were sown within next few weeks in $20m^2$ beds. The management practices such as and preparation, planting techniques, spacing and hilling were briefed to the test farmers. Monitoring and data recording based on the data-recording sheet developed as shown inTable 46 was done for all the test farmers.

Table 46 Groundnut data record sheet

Data collected	Farmer's Name	
	Kencho	Sangay Dorji
Date of Sowing	17th May 2003	16th June 2003
Plot area	4x5 meter square	3x7 meter square
Plant height	15 cm above ground level	15 cm above ground level
Pest and Diseases	No incidences	No incidences
Maturity days	180 days	160 days
Number of pods per plant	38 (Average of 5 plants)	29 (Average of 5 plants)
Date of harvest	5th December 2003	5th December 2003
Yield (dry pod weight/plot)	40 kgs	30 kgs

During monitoring it was found that Sangay Dorji had sown his trial late thus the growth rate and plant density were not as good as that of Kencho's. Kencho's trial yielded better. The trial was implemented on sloppy land and it was found that groundnut roots have good soil holding capacity as there was no sign of small rill erosion compared to the adjacent fields, which were left empty.

Farmers found that Dompola soil is suitable for groundnut cultivation. In addition they also found out that, during pod formation stage hilling up is necessary for better production. They have sold some roasted groundnut in the local market and found that it has good potential for cash generation.

5.1.5 Monitoring backyard fruit plants improvement through top working

In April 2003, short hands-on-training and field exercise were done on grafting and top working with three communities in the Watershed viz. Limbukha, Dompola and Nabchhey with the objectives to improved local fruit plants in the farmers' backyard for better and early production with good quality and taste. In Limbukha, 17 out of 23 households had participated during the top-working activity. To study the success of the field exercise, monitoring was done house-to-house and field-to-field, looking into the fruit trees top-worked survival rates and management practices. Through informal discussions, farmer's feedbacks were collection regarding their perceptions on backyard fruit trees development. During monitoring and data recording, the following results were observed. The results of field top working exercises are shown in Figure 5.

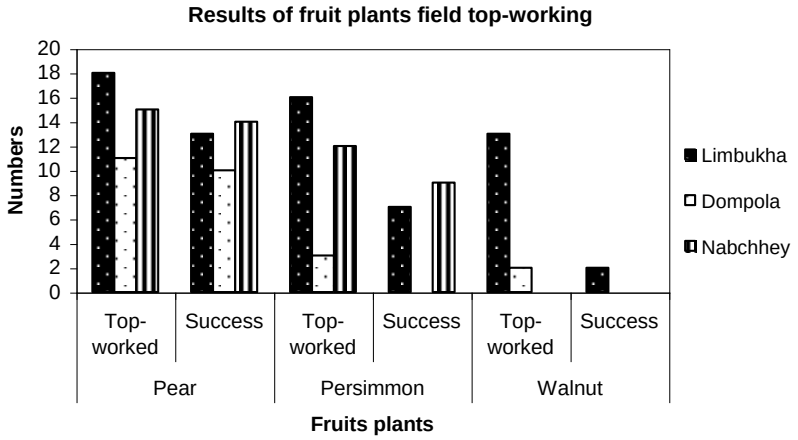


Figure 5 Comparative successful fruit plant top-working results

Out of 18 Pear trees top-worked 13 trees (72%) have thrived and the other 5 trees (28%) failed due to improper management, damaged caused by stray animals as it was not fenced and some failed because of top working not done properly.

From 16 persimmon trees top-worked, 7 trees (44%) survived and 9 trees (56%) have died due to improper management, which include not removing the plastic that had clamped the rootstock and scion, cattle damage, and joints were broken by wind.

From 13 trees top worked with Walnut Scion woods, 2 trees (15%) survived, remaining 11 trees (85%) failed due to improper management, damaged caused by neighbor or community children by removing the grafted scion from the trunk, not removing of plastic which banded the scion and no weeding.

In Dompola, only 6 households participated in top working training and 11 Pear trees, 3 Persimmon trees and 2 Walnut trees were top worked. During monitoring it was found that, out of 11-pear trees top worked, 10 trees were successful. Children damaged one top worked pear tree by removing the grafted scion. The other 3 Persimmon and 2 walnut plants have died because of cattle damage and improper grafting.

In Nabchhey, 16 out of 20 households had participated during the top-working exercise to 15 Pear and 12 Persimmon trees. During field visits to monitor and collect farmers' feedback it was observed that 14 pear trees (93%) have succeeded and one plant was animal damaged

From the 12 Persimmon plants top-worked only 9 trees (75%) survived and 3 trees failed due to damaged caused by children.

General Observation

Most of the surviving plants were trained and are in proper shape but needs proper management. Majority of the plants required immediate weeding, basin preparation and manure application. In general it was found that, farmers are interested in improving their backyard fruit plants, after providing hand-on-training, they have started using their skill and did field grafting themselves and successful. In some areas, top working was done in one branch of a fruit tree and now most of them were found successful. Farmers were advised to slash down the other adjacent branches in order to have proper growth of the grafted scion and to avoid nutrient competition.

Comparatively Nabchhey farmers have better success rate in top working than Limbukha and Dompola farmers. This could be because of better aftercare and management practices performed by Nabchhey farmers.

Limbukha Farmers' feedback on top working

The top worked plants are attacked by ants especially in Pear on the joints between the scion and the rootstock. Farmers have applied chemicals to control ants and in addition they were advised to do cultural control by applying ash around the plants. Most farmers have constraints in managing the top worked fruit trees since the stray cattle in the village cause damages, although efforts were made to fence the plants.

5.1.6 Private Fruit Trees Nursery Activities

With the establishment of Fruit trees nursery at Omteykha, technical support was continued from research centre in order to build the capacity of the farmer co-operator in managing the nursery. The major constraints faced by the co-operator were irrigation (lack of tank to store water) and fencing material. This was supported from research centre and the nursery activities that were implemented during the year were:

Plantation of additional 1000 walnut seeds and 1000 Peach seeds
In order to maximize the planting materials, additional 1000 walnut seeds were planted, of which 50% have germinated. Last year 2000 Peach seeds were sown but it did not germinate, this season the peach seeds were brought to research centre where chilling was done before sowing to break the dormancy and the germination was found successful and in total, 1000 peach seedling have germinated.

Grafting of Walnut and Peach seedlings
In order to have early seedling production, grafting was done in second year, in first round of grafting (spring) 450 walnut seedlings were grafted with soft shell walnut, of which 193 were successful. Additional green grafting (monsoon) was done to 94 walnut, 203 Peach (109_Florida sun and 94_July Albert) and 55 Apricot seedlings.

Plantation of mother plants
To have easy excess to scion wood in future for grafting activities, few selected mother plants of Apple, Walnut, Pear and Pecan were planted around the nursery.

Hand-on-training to co-operator on grafting and budding
The farmer co-operator was provided hand-on-training and involved during grafting exercise to build up confidence in grafting, also the farmer was provided with the grafting tools and other equipment from the research centre.

5.1.7 Farmers Training on Mushroom cultivation for Dompola saving group

In line with the government policy of self-reliance and local institution development initiatives, which is within the broad framework of the Cooperative Act 2001. Dompola small farmer saving group was formally started from April 2002 with support from research centre on the conceptualization, training and execution of the self help group.

As part of the savings group activity, the group has planned to start with the income generating activities to improve their principal saving and start with micro-finance. Based on the available resources and technologies, the group felt Mushroom (shiitake) cultivation would be the appropriate enterprise to begin with.

As planned, five days hand-on-training on Shiitake mushroom cultivation was imparted to the 14 out of 19 group members of Dompla savings group. The balance five non-participating members will be considered still in the group but will not involve in the mushroom enterprise. The non-participating members will contribute in cash equivalent to the amount earned from the mushroom activities, this is because the non-participating members have constraints of labour and also do not to want to take risk in new technologies without adequate experiences.

The training was provided with assistance from National Mushroom Centre and during the training course, it covered the detail aspect of shiitkae mushroom cropping husbandry along with practical works relating to mushroom cultivation.

After the training, the group formed four sub-groups consisting of 3 members in two sub-groups and 4 members in other two sub-groups. The sub-group members worked jointly to construct mushroom shed, water tanks, collecting oak billets, drilling, spawning, waxing, stacking, constant monitoring and irrigation. The training and basic materials required in mushroom activities viz. shed and water tank construction materials were supported from research centre. The four sub-groups have cultivated 3596 mushroom billets in total
The mushroom activity is still in incubation stage and further monitoring will be continued at crop harvest on the group marketing, equity sharing of products and group contribution for the savings scheme.

5.1.8 Community management of breeding bull

To see the processes in breeding bull management by the community as a group and its potentials and constraints while mobilizing community to work in managing one commodity, monitoring was continued to see the behavioral changes and possibility for recommending similar process of breeding bull management elsewhere.

Timely monitoring, community and committee meeting were organized and it was found that all the household in Nabchhey are involved in management of the breeding bull, even those household (4 households) not having cattle also contributes 50% labour contribution for the welfare of the bull but do not provide maintenance feed (4 dreys of maize flour, 1 bottle oil and 1 fita salt).

The community has formed a bull management committee where the responsibility of the Chairman is to instruct committee members to arrange collections of bull feed form the members and also the penalties while violating the committee norms. The chairman also organizes emergency meetings, discuss and endorse on the need based activities and keep the meeting minutes and record, also a copy of minutes is kept with the bull keeper. While the other committee members inspect the bull keeper twice a week for proper feeding of the ration collected, these committee members are rotated yearly.

The bull feed are collected from every households on rotation basis, few household forms sub-group and the feed is collected, once the collection from the sub-group gets exhausted, collection is done from other sub-group consisting of another few households. Once they have collected the feed at one go, but it was found that the feed collected gets spoiled while keeping as a bulk so this practice of collection at one time was withdrawn.

The major problem and constraints is the bull is still looked after by same bull keeper, who is quite old enough and has only female members in the house who are not able to look after the bull. So, the bull keeper feels he could not handle the bull management responsibilities, the committee have decided that if the bull keeper cannot handle the responsibility, he should inform the committee members and through meeting and upon unanimous decision, another suitable bull keeper will be replaced. The other constraints is, having established an acre of improved pasture and planted fodder trees as supplementary fodder for bull, the area is fenced locally by available materials, but this is not adequate to protect from wild life (deer) which frequently enters into the pasture and graze on improve pasture and fodder trees. Also maintenance of bull shed is necessary as it is made of local materials and the floor remains marshy and unhygienic.

For effective management of the bull, the committee has established some norms and conditions and during recent meeting some changes were brought to it that includes:

- Since 2003, due to labour shortage and inconveniences of labour availability, the ‘woola’ which was exempted to the bull keeper was reinforced and in substitution to it, the bull keeper is paid Nu. 200.00 per household annually as bull keeping allowance
- In case of any accidental mishap of the bull, the bull keeper is sole responsible, the bull keeper should inform the committee members for examination, verification and consideration of the case.

Till date the bull’s services record has reached to 38 and has recorded 20 progenies (12 female and 8 male) born out of which 7 progenies (4 female and 3 female) have died due to attack by wild animals and ailing.

Some new initiatives that the bull management group has started are collection progeny born allowance from the neighbouring community, which has accumulated to Nu. 2000 for two male progenies, besides additional Nu.1000 is collected as penalties from group members adding to Nu. 3000. This collected money is now used for micro credit within group to increase its base/capital. The amount collected is kept with Tshokpa and are disbursed as small short-term loan at interest rate of Nu.5 per hundred per month. Basically this process is to increase their bull welfare money to substitute or place another bull, if in case of death or other calamities arises in future.

Some of the female progenies (Jatshams) are old enough for crossing and as a traditional practice, Jatshams are back crossed with local bull (Drangla/Nublang) to produce Yangku, but in Nabchhey village they do not have a good quality local bull to back cross. Farmers are aware on Trihybridization, crossing Jatsham with Jersey cross bull to produce quality animal for better milk production and adaptable to their local environment. They have plan to request one jersey cross bull for Dzongkhag or would like to purchase from the group collection later.

5.1.9 Fodder species Plantation on Maize field bunds

During the year 2003-04, three test farmers in Nabchhey having maize trashline over their maize field were selected to evaluate different grass and legume fodder species as trashline stabilizer and to enhance fodder production on bunds.

The treatments used were four species of legume seeds (Desmanthus, Leucaena, sesbania and Flemengia), and 5 species of grass slips (Napier, Setaria, Paspalum, Chloris gayana and Andopogon), The legumes seeds were sown directly and the grass slips were transplanted along the raisers.

Assessments was done on survival rate of the legumes seeds sown and grass slips transplanted and it was found that grass slips transplanted are good performer than legumes seeds sown because legume seeds were germinated but its growth were not so vigorous so while staking the maize trashes after maize harvest, it covers the plants and also during the navigating plough in the field the legume fodders are easily removed, whereas the grass slips especially Napier, Sateria and Paspalum are well adaptive and grows vigorously, also the fodder biomass production is better.

Farmers' feedback and views were collected on adaptability of the technologies, and all the test farmers feel that the technology is adaptable but appropriate legumes species should be planted as seedlings and not as seeds like the grass slips since it takes time to grow big before the next maize trashes are laid in counter bunds.

5.2 Integrated Plant Nutrient Systems (IPNS)

5.2.1 Soil Fertility Management Practices for Rice Production in Tsirang

Tsirang is one of the top ten rice growing area in the country, but little is known about the early history of soil fertility management for rice production in the dzongkhag. The yields of both local and improved rice varieties are known to be very low with an average of 2.12 t/ha, which is lower than the estimated national average yield of 2.47 t/ha. Socio-economic, nutrient management practices and soil erosion are the main factors affecting soil fertility and hence crop yields. Any nutrient element in the soil is at risk for becoming deficit due to limited use or becoming toxic due to excess use, which ultimately has an effect on crop yields. Minimizing these impacts of soil degradation generally involves reducing the risk of either limited or excess use of any particular soil nutrient. An understanding of how various physical, social and economical factors influencing both the quantity and the quality of nutrient flows into the agricultural systems can provide insights into the management of soil fertility in the dzongkhag. The study aimed:

- To study the relationships between existing soil fertility management practices and soil nutrient status
- To study the farmers' soil fertility management practices in relation to farmer diversity and adaptation to the changing environment
- To draw some helpful research agenda that will help Tsirang farmers to improve soil fertility management practices and hence rice yields.

This study was carried out in collaboration with Tsirang Dzongkhag as part of the FEFUT trial program on rice, addressing low rice yield problem. The study was done with 12 farmers in three geogs viz. Kekorthang (4), Goseling (4) and Mandaygang (4). The study was planned to run for a calendar year to capture a complete manuring and cropping cycle for all the wetland owned and cultivated by the selected farmers. The actual data collection, field measurements, and sample collections were started in March 2003. An initial interview was held with each selected household to check that they were willing and be able to be included in the study. A simple questionnaire was used for recording information and field measurements.

Soil samples were collected before and after rice from all the wetland fields owned and cultivated by the selected farmers. This was done to determine the relationship between soil properties, amount and source of nutrients recorded as applied for each individual field. Samples were submitted to SPAL for analyses. Twelve FYM samples were also collected from cattle tethered fields of the selected households. This provided a basis for estimating nutrients applied through tethering.

A total of 12 crop cuts were taken, one from each farmer to get an idea of the average rice yield under farmers' soil fertility management practices. The results are presented in the following sections. The mean wetland area owned or cultivated per selected household is given in Table 47.

Table 47: Wetland owned or cultivated by households (acre) for tenancy by geog

	Owner managed	Shared out	Shared in	Total
Mendaygang				
Badum	4.5	0.00	0.00	4.5
Pem Tshawang	3.00	0.00	0.00	3.00
Sangay Choden	2.00	0.00	0.00	2.00
N B Tamang	0.00	0.00	1.50	1.50
Geog mean				**2.75**
Kekorthang				
M M Kafley	0.50	0.00	0.50	0.50
Drupchu	5.00	0.00	0.00	5.00
Toupo	0.50	0.00	0.00	0.50
H P Trimshina	1.00	0.00	0.00	1.00
Geog mean				**1.75**
Goseling				
S B Suba	0.00	0.00	3.00	3.00
B B Tamang	0.00	0.00	2.00	2.00
Phub Dorji	1.00	0.00	0.00	1.00
Geog mean				**2.00**

There is significant difference in wetland holding among the farmers. Highest wetland holding in all three geogs is five acres. The average wetland holding is around 2 acres. Of the 12 farmers, three farmers are landless and are totally depending on sharecropping. However, irrespective of total wetland holding, soil fertility management practices are same across all the households.

The mean nutrient content of the analysis of the results of 12 FYM samples collected during the field measurement showed N as 0.84%, P 0.24%, K 0.75%, Ca 0.92% and Mg 0.26%. The mean dry matter content of the sample was 36.5%.

Reasons reported for not using composted cattle manure were unavailability of labour, animal bedding material and cattle. Farm labour appeared to the underlying factor for soil fertility management. The main reason why farmers resorted to animal tethering is because of the intensive labour involvement for transportation of composted cattle manure, if they keep the cattle in cowshed. In addition the number of cattle kept by a household also depends on the availability of household labour for day care and bedding material collection.

Regardless of crop variety and land use type, the use of inorganic fertilizer is very rare. Main reasons reported for not applying inorganic fertilizer on rice include the affordability, availability on time and knowledge on its usage. These reasons fall under two categories. Under ‘affordability’category the households consisted of those farmers who are new under resettlement program and who cannot afford to buy fertilizers. The second category consisted of farmers having limited knowledge about chemical fertilizer usage and availability of fertilizers in the Dzongkhag. Farmers however did express their interest in using chemical fertilizers, but due to lack of knowledge on fertilizer use they were afraid of losing rice yield and damaging their soil eventually.

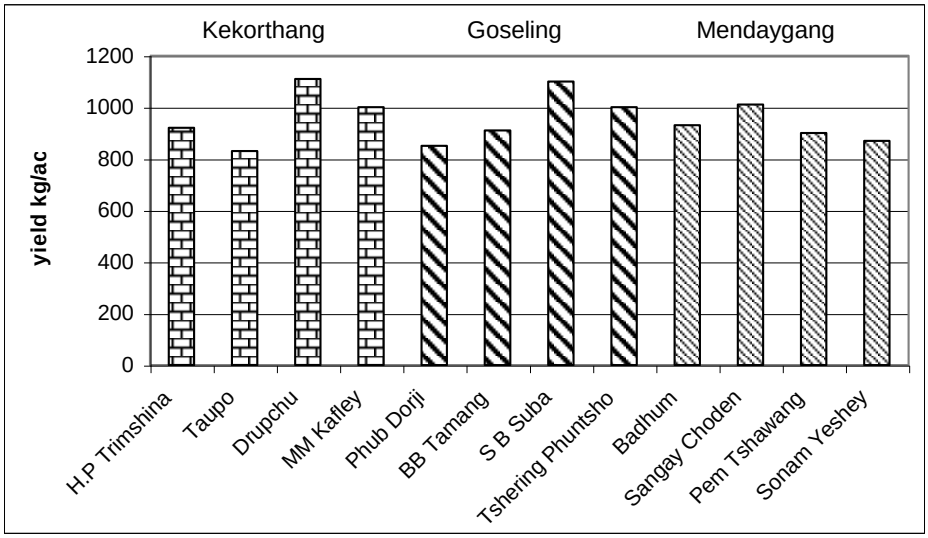
Regarding soil properties, Table 48 shows the soil variables of the soil samples collected from the rice fields of the selected farmers. Both soil analytical results of the soil samples collected before and after rice showed a poor soil fertility status. All the variables are within the very low-to-low range. This indicates the soil fertility to be one of the major factors contributing to the low rice yield in these four geogs.

Table 48: Soil sample analytical results for pre and post rice

pH	Av. P (mg kg-1)	Av. K (mg kg-1)	CEC	BS%	MO%
5.19	6.85	30.14	9.21	23.89	2.63
Results after rice harvest					
5.09	6.45	29.11	9.01	21.39	2.23

The fact there is slight difference between the soil variables before and after rice harvest indicates that soil nutrient input through tethering alone is not adequate and soil nutrient reserve is being depleted. It seems likely that if this practice is continued, the general danger may include the loss of soil fertility as a combination of biological, chemical and physical properties, often also termed soil fertility degradation.

Figure 6: Rice crop cut result from 2003



A total of 12 rice crop cuts were taken to get an idea of the average rice yield for the selected farmers. Rice variety is Chotey (local), which is the most preferred and commonly grown variety in the Dzongkhag. The average rice yield for the 12 selected farmers from three different geogs is 952.5 kg/ac. There is a slight difference in rice yield between farmers, but across geogs, the yields are similar Figure 6. This difference between farmers could be due to site-specific micro-climatic conditions, natural soil fertility status and crop management practices.

An important concern of soil fertility management research and extension in Tsirang dzongkhag is the adequacy of farmers' current nutrient management practices with respect to maintenance of sustainable soil fertility for rice production. The application

of inorganic fertilizers on rice crop is very rare and the use of organic manure is very limited done mostly through tethering. Traditionally, cattle tethering is the only source of soil nutrient input for rice production and the nutrients supplied through this practice is not at all adequate. Use of inorganic fertilizer is very rare due to availability, affordability and limited exposure to fertilizer usage information. The soil analytical result showed the over all soil fertility to be very low with all the variables within very low to low range. Local rice variety "Chotey" is the most preferred variety with an average grain yield of 2.3 t/ha, which is lower than the national average yield. FEFUT trials have been already initiated to address the low rice yield problem and limited exposure to fertilizer usage information. This programmme will be continued to ensure that its coverage is increased and that it has an impact at farmers' level.

5.2.2 Response of varieties to different rates of N fertilizer

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, it is not known to what extent the variation in nitrogen rates affected the rice production in Tsirang. The main objective of the trial was to see the yield response of the improved rice variety "Bajo Kaap II" and the local variety "Chotey" to different rates of nitrogen along with fixed rates of P and K.

This study was conducted in collaboration with the NSSC Simtokha during the cropping season in 2003. The trials were conducted with eleven test farmers in three geogs *viz.* Kekhorthang (4 farmers), Goseling (3 farmers) and Mendelgang (4 farmers) under the Tsirang Dzongkhag. Out of the eleven test farmers, two farmers had the local variety "Chotey" as the test crop and the rest of the farmers used the improved variety "Bajo Kaap II". All the eleven farmers were supplied with the required inorganic fertilizers and the Bajo Kaap II farmers were also supplied with one kilogram of the seed free of cost by the RNRRC Bajo.

Each farmer had four trial plots and these trial plots were either an individual treatment terrace or a terrace divided into different treatment plots. The plots had independent water sources so as to prevent water flow from one plot to another and to contain the applied fertilizer within the plots. The trial had four treatments:

T1 – 30 : 30 : 20 kg NPK ha^{-1}
T2 – 60 : 30 : 20 kg NPK ha^{-1}
T3 – 90 : 30 : 20 kg NPK ha^{-1}
Control- 0 : 0 : 0 kg NPK ha^{-1}

Nitrogen fertilizer (urea) was divided into three doses, half was applied as basal along with P and K fertilizers and the second half split into two equal doses was applied as two top dressings. Based on IRRI's recommendations, the first top dressing was done two weeks after transplanting and the second top dressing was done at time of panicle initiation (5 weeks after transplanting).

Figure 7 shows the grain and straw yields of the two varieties together. The effect of different treatment on the grain yield was not significant (p=0.46) however, a slightly higher yield of about 4 t/ha on average was obtained with the higher rates of 60 and 90 kg/ha nitrogen and the lowest yield of 3.5 t/ha on average was obtained from the

control plot and with the lowest N rate of 30 kg/ha. The average rice yield of 3.8 t/ha obtained in this trial is slightly higher than the estimated national average yield.

The effect of different treatments on the straw yield was significant at 5% significance level. The straw yield increased with increasing nitrogen application rates. The highest average straw yield of 6.7 kg/acre was obtained with the highest rate of nitrogen while the lowest yield of 4.5 kg/ac was from the control plot.

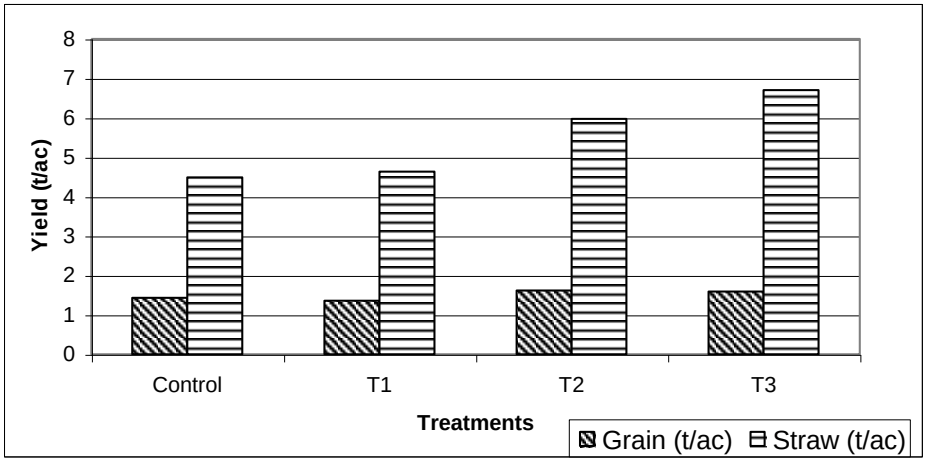


Figure 7: Rice grain and straw yields

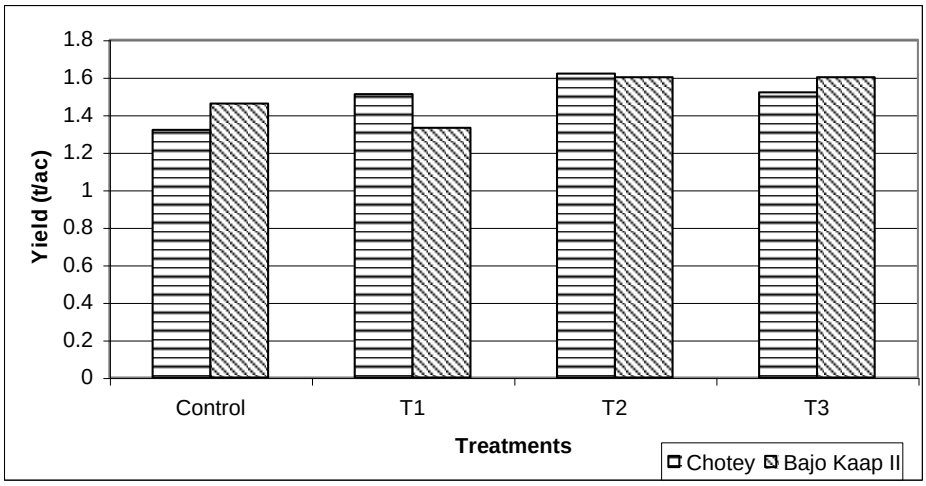


Figure 8: Yields Bajo Kaap II and local Chotey

Although the yields were not significantly affected by the treatments, the grain yields of both the varieties were higher at higher nitrogen rates **Figure 8**. Though the improved varieties are known to yield higher and show greater response to fertilizer applications, in this study the yields of Bajo Kaap II and Choety were similar with 1.5 t/ac and 1.49 t/ac respectively averaged over different treatments.

Nutrient uptake and removal by the rice plants are shown in Table 49. Since the nutrient contents of the two varieties are not significantly different, Table 49 shows the average of the two varieties. Nitrogen, phosphate and potassium contents are similar to those reported by others (Dobermann and Fairhurst, 2000 and Bajo IPNS2 experiment, 1993 and 2000), however Ca, Mg, Fe, Mn and Zn contents are much lower than reported. Nitrogen, phosphate and potassium contents at maturity in straw are within the optimum ranges while that of Ca and Mg are below the critical level for deficiency, <0.15% and 0.10% respectively. Although the N, P, and K contents are satisfactory, the slightly lower contents of others like Ca and Mg could have affected the crop yield. The entire nutrients are equally essential regardless of the fact that they are required and absorbed in widely different amounts. The removal of K and Ca through the straw is higher than through grains while the removal of N and P are greater through grains than through straw. N and P are removed permanently from the soil along with the grains while if the straw is incorporated back into the soil; K and Ca are put back into the soil.

Table 49: Average nutrient removal of the two rice varieties and mineral concentrations in grain and straw

	Ca%	K%	Mg%	P%	N%	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Grain	0.03	0.38	0.08	0.24	0.76	173.50	124.25	9.75
Straw	0.12	1.69	0.08	0.12	0.45	165.93	438.50	28.53
Total	0.14	2.1	0.15	0.36	1.21	339.43	562.75	38.28
Total kg/t	1.4	2.1	1.5	3.6	12.1			

Soil analytical results of the soil samples collected before applying fertilizers show a poor soil fertility status (pH 5.09, Av P 7.05 mg/kg, Av K 32.14 mg/kg, CEC 9.51, BS 24.79%, MO 2.93%). All the variables are within the very low-to-low range. This indicates the soil fertility status to be one of the factors contributing to low rice yield under Tsirang.

Figure 9 shows the soil nutrient status of the soil samples collected after the trial from the trial plots. The soil variables or the soil chemical properties were not significantly affected by the treatments. The soil variables before and after the trials were also not significantly different.

The soil pH ranging between 5.30 and 5.95 falls within the low to medium range. Soils with pH<5.5 would be deficient in most bases like Ca, K and Mg. Generally, within a few weeks after submergence, the soil gains neutral pH. The rate and degree of the pH changes depend on soil properties and temperature. Low temperature and organic matter content retard pH changes in both acid and alkaline soils.

Both the CEC and percent base saturation are within the low to very low range. The CEC refers to the total amount of the positively charged elements (basic cations) that a soil can hold while the percent base saturation tells what percent of the exchange sites are occupied by the basic cations. CEC therefore gives an indication of the soil's potential to hold plant nutrients. The soils from the trial sites may have poor coarse textured soils with low organic matter content as organic matter content of any soil helps to increase the CEC as it holds cations. With low CEC, nitrogen loss from urea fertilizer would be high in these soils (IRRI, 1979).

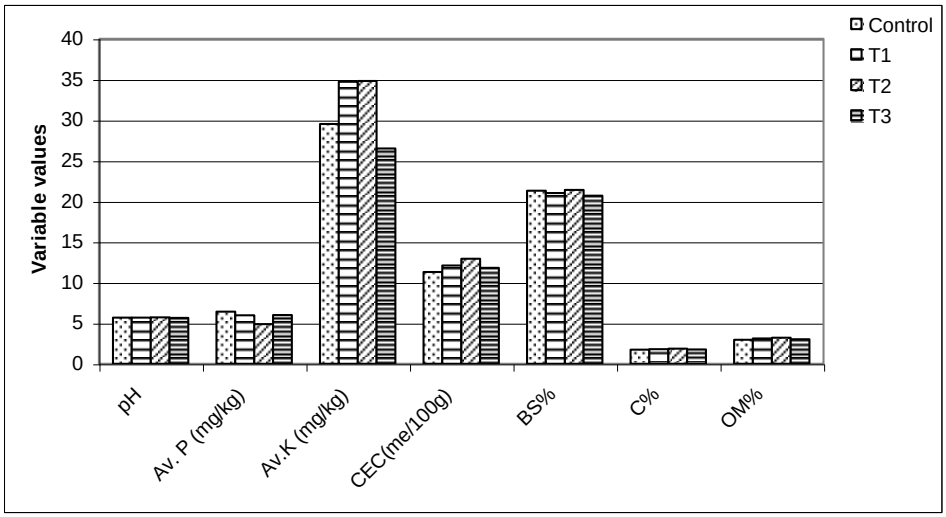


Figure 9: Soil variables before and after the trial

Both the available phosphorus and potassium are within the very low to low range. This probably indicates either an insufficient application of mineral P and K fertilizers, coarse-textured soils containing low organic matter, small P and K reserves or high P and K fixation capacity of the soils. For a target yield of 5 t/ha, an application rate of 105 kg/ha N, 20 kg/ha P and 55 kg/ha K has been recommended for low soil fertility (Dobermann and Fairhurst, 2000), the NPK rates used in this trial were little on the lower side. Low soil P and K result in poor N use efficiency.

The soil organic matter percent falling within the range of >2 and <4% indicates a rather low soil organic matter content of the soils. The soil organic matter contributes to the overall chemical and physical properties of the soils. The main soil type is the coarse textured sandy loam (sl).

The fact there is no significant difference between the soil variables before and after trials or between the yields of the two rice varieties indicates that the recommended NPK rates were not significant enough to bring about any changes in the soil chemical properties and therefore to the crop yields of the two varieties. Whatever extra applied into the soils may have been all taken up by the plants or lost through leaching and leave no residues to see any changes in the soil chemical properties.

The effect of different treatments on the grain yields was not significant but it was on the straw yields. Both the grain and the straw yields were higher at higher nitrogen rates. With an average grain yield of 3.8 t/ha, the yields obtained in this trial were slightly higher than the estimated national average yield of 2.47 t/ha. This study did not show the improved variety “Bajo Kaap II” to be any better (i.e. higher yielding and more responsive to fertilizers) than the local variety as their yields were similar.

The soil analytical results showed the overall soil fertility to be low. The trial site soils are coarse textured with low organic matter content, low pH, CEC and BS% and low available nutrient (e.g. P and K) contents.

The NPK rates used in this study are more suitable for places like Thimphu, Paro and Punakha-Wangdi where the soils are heavy textured clayey soils. For places like Tsirang, with coarse textured lighter soils, higher fertilizer rates should be recommended.

Further studies with higher NPK rates than the ones used in this study and with different rates of P and K beside the nitrogen rates have been planned and initiated. However, acknowledgement needs to be made that even if we can plan all things in detail, it is still impossible to plan the change within people. Often change in people's attitude takes longer time or sometimes do not occur at all, especially if the offered technology needs monetary involvement.

5.2.3 Rice-based potato cultivation and its impact on soil fertility in Limbukha

Limbukha farmers increasingly practise rice-based potato cultivation, as potato is becoming a good source of farm cash income. Number of households and the area under potato cultivation is increasing annually. However, this change in the cropping pattern didn't bring about a change in soil fertility management practices. Both potato and rice are high nutrient demanding crops, and traditionally in Limbukha, the limited use of farmyard manure is the major source of soil nutrient input and the application of chemical fertilizers on any crop is very minimal. Therefore, it is not known to what extent the application of farmyard manure alone will supply the nutrients required by both rice and potato crops. This long term activity was planned to study the impact of rice-based potato cropping system on soil fertility in the long run in wetland and to identify areas for soil nutrient management improvement for rice-based potato cropping system.

A total of 8 farmers, who have been growing rice-based potato for more than 10 years were selected for the program and a simple questionnaire was used to collect information related to soil nutrient management both for rice and potato cultivation. The questionnaire has two parts: part I covered nutrient management, yield trends and cultivation constraints for rice and part II covered the same for potato. From each household soil samples were collected from the plot where potato was grown after rice continuously. Soil sample collection was done twice in a year, once before rice transplanting and once after rice harvesting (before potato sowing). Samples were submitted to SPAL for chemical analysis. Crop cuts were taken both for rice and potato from the selected field to measure the crop yield trend for both the crops. Data on soil and crop yields for the last cropping seasons and the related information collected were analyzed and documented. As this is an on-going activity, the detailed reporting will be done at the end of the completion time of the activity.

5.2.4 Maize trash-line for soil conservation

Detailed information on this particular activity was reported in the previous annual reports. An extension leaflet was also developed, multiplied, and distributed to the client Dzongkhags. Regular monitoring of the trash lines is still continuing. This is partly done to see if there are other farmers who want to try trash line his/her field and also to find out any problem related to trash line as soil conservant and the hedgerows that were planted on few bunds. Till date no problems were reported by

the farmers regarding trash lines and also there are no new adopters of this technology for soil conservation.

5.2.5 Rice-based Oat cultivation and its impact on soil fertility in Thangu

Wangjokha and Thangu farmers increasingly practise rice-oat cropping system, with oat as a good source of green fodder during dry winter season in the valley. Most of the rice fields, which used to be left fallow in winter, are now brought under oat cultivation. Although this practice had brought a change in the land use system, the soil fertility management aspect remained the same. Both oat and rice are high nutrient demanding crops, and in addition, oat grown as fodder is being cut three to four times in a season, which means the rate of soil nutrient removal has also increased. Since there is no information on this type of cropping pattern and its soil fertility management practices, it is not known if the present farmers' soil fertility management practices for this particular cropping system supplies enough nutrients that are required for both rice and oat. This long-term activity is therefore planned and initiated to see the impact of rice-based oat cropping system on soil fertility and to identify areas for soil nutrient management improvement.

A total of 6 farmers who have been growing oat as fodder after rice were selected for the activity. A short questionnaire was used to collect information related to soil nutrient management, both for rice and oat cultivation. The questionnaire has two parts: part I covered nutrient management, yield trends and cultivation constraints for rice and part II covered the same for oat. From each household soil samples were collected from the fields where oat was grown after rice continuously. Soil sample collection was done twice in a year, once before rice transplanting and once after rice harvesting (before oat sowing). Samples were submitted to SPAL for chemical analysis. Rice crop cut were taken from the selected field.

Data on soil and crop yields for the last cropping season and the related information collected were analyzed and documented. As this is an on-going activity, the detailed reporting will be done after completion time of the activity.

5.2.6 Investigation of on-station vegetable plots' soil fertility status

The vegetable sector reported some problem regarding the difficulty in managing the soil in vegetable research plots at the station. The problems include, most vegetables not doing well despite intensive care and inputs, soil becoming hard and forming cracks few days after irrigation or rainfall and formation of big clumps when ploughing. In addition, the sector had never done soil testing for any reason. Inorganic fertilizer application was done based on the particular crop nutrient requirement.

Soil testing is the basis for making scientifically sound management decisions about fertilizer requirements. If organic and inorganic nutrient applications are not being properly matched with the soils' natural capacity, the soil is sometimes depleted and it takes more nutrients every season to obtain the same crop yield. Declining crop responses to fertilizer are inevitable if the application of nutrients is repeatedly unbalanced and does not correspond to the needs of the soil and the crops grown

upon it. A crop's overall nutrients demand and the amount removed from the soil must be replaced sooner or later if soil fertility levels are to be maintained. Both organic and inorganic fertilizer recommendations based on soil testing are the most profitable and economical.

A composite soil sample was taken from each terrace separately and in total 16 soil samples were collected and submitted to SPAL for chemical analysis. The sample analytical results are presented in Table 50.

Table 50: Soil analytical results

Plot no	Ph (H20)	Tot. N %	Av. P (mg/kg)	Av. K (mg/kg)	C %	Ca (me/100g)	Mg (me/100g)	CEC (me/100g)
1	7.09	0.12	61.42	197.93	1.40	8.38	1.45	10.47
2	7.13	0.19	100.26	301.42	1.70	10.30	1.78	13.81
3	7.21	0.16	76.39	270.56	1.70	9.06	1.50	12.04
4	7.49	0.12	51.79	194.89	1.20	8.97	1.39	11.59
5	7.59	0.09	43.75	165.62	1.00	7.16	1.26	9.58
6	6.49	0.14	58.17	370.72	1.70	8.25	1.51	11.76
7	6.45	0.07	10.69	143.25	1.00	4.47	0.70	5.91
8	7.47	0.06	28.20	170.33	0.90	6.99	0.98	8.98
9	7.39	0.07	18.53	162.10	0.90	6.62	0.99	16.29
10	6.72	0.13	14.89	128.33	1.50	8.71	1.05	20.42
11	7.03	0.12	65.37	245.72	1.80	7.79	1.24	20.12
12	6.07	0.11	22.75	172.23	1.30	7.89	1.03	19.56
13	6.68	0.12	32.52	150.94	1.60	8.99	1.22	22.02
14	7.25	0.14	97.73	197.79	1.70	12.24	1.50	15.10
15	7.64	0.11	81.27	208.98	1.70	13.10	1.57	16.04
16	7.60	0.19	213.43	602.97	2.40	12.34	2.17	30.48
Max.	7.64	0.09	213.43	602.97	2.40	13.10	2.17	30.48
Ave.	6.07	0.06	10.69	128.33	0.90	4.47	0.07	5.91
Min.	7.08	0.12	61.07	230.24	1.47	8.83	1.33	15.26

The soil pH ranging between 6.6 to 7.5 falls within moderate to high range. These soils would be rich in most bases like Ca, K and Mg. Soil pH is not a nutrient; it is a measure of soil acidity or alkalinity. The pH level of the soil determines how well the plants are able to use the nutrients in the soil. In general, the ideal pH range for most soil is 6-7. At this pH level, plants are able to draw adequate amounts of nutrients from the soil efficiently. When the pH level of the soil is out of this range, plants are not able to use the nutrients in the soil efficiently. So a land with good levels of nitrogen, phosphorus, and potassium may still not live up to expectations if the pH level is not optimum. Although the nutrients are there, an incorrect pH level will prevent the plants from drawing what they need from the soil. Because soil pH has a tendency to drop over time, it is important to test it regularly.

Total percent of nitrogen is within low to very low range. This probably indicates an insufficient application of N fertilizer in contrast to the high requirement of this element by most of the leafy vegetables. The productivity of most agroecosystems is limited by the availability of nitrogen. In nature, very few soils can sustain satisfactory crop production without the addition of nitrogen from some sources. Plants take up large amounts of nitrogen, while soils generally contain relatively small amounts of this element. Hence nitrogen deficiency is more widespread among crop plants than

the deficiency of any other nutrient. In addition, nitrogen is one of the most difficult nutrients to maintain in the soil. The N level in the soil can, therefore, deplete quickly.

Both the available phosphorus and potassium are within the moderate to high range. The moderate to high level of phosphorus may be an indication of the saturation of phosphorus fixation capacity of the soils that have resulted from repeated application of this mineral over the years.

Percent of organic matter content is within moderate to low range. This probably indicates a rather insufficient application of organic matter (FYM). Soil organic matter is a complex and varied mixture of organic substances that provides much of the cation exchange and water holding capacity of the soils. It is responsible for the formation and stability of soil aggregates that contributes towards soil workability. It also contains large quantities of plant nutrients and acts as slow release nutrient storehouse, especially for nitrogen. Therefore, maintaining soil organic matter content level within 1.2 to 3.1 is important for any agro-ecosystem.

The CEC is within low to moderate range and this gives an indication that these soils have low potential to hold plant nutrients. The low percent of total nitrogen could be because of the low CEC, as nitrogen losses from urea fertilizer are high from soil with low CEC. The low organic matter content might have also affected the soil CEC. To improve the productivity and workability of these soils, adequate application of organic manure is required.

5.2.7 CD-ROM development using Toolbook

A CD-ROM was developed using Toolbook program for the Regional CBNRM Workshop report. More than 200 copies (CD) were burned and distributed to both the national and international workshop participants.

5.3 Water Management Research

Water Management Research (WMR) started as Water Management Research Project (WMRP) in the beginning of 8th Five Year Plan. The project came to an end in 2000 and water management research was institutionalized as part of regular research program in RNR RC Bajo. The national mandate of WMR Program is to conduct and coordinate water management research for enhancing and sustaining the rural livelihood. The main objectives of the WMR program were to raise the productivity of existing rice-based irrigation schemes through improvement in water delivery system thereby increasing farmers income. At the end develop water resource management plan and policies for sustaining the resource base to ensure continued livelihood support to the rural community. The main activities undertaken by WMR Sector during the year are farm watershed activities, on- station trials, regional activities, training/workshops and civil engineering works. Most of the water management activities in the watershed so far have been geared towards understanding the issues and constraints with regards to water resources. Although only few activity interventions are done till date, the sector is now in a comfortable position to implement more of interceptive activities in future in the watershed. The status of each activity under these headings is detailed out in the following sections. Full report on each activity will be done once these activities are terminated.

5.3.1 Climatic Data Collection

Rainfall and stream flow data collection started since the beginning of the watershed study. Before 2000, the rainfall and stream gauging data was collected manually by employing local people. However the data collected were unreliable and it was decided that automatic data logger is to be used instead. The**Table 51** summarises the rainfall and stream gauging data collection activities in the watershed: -

Table 51 Rainfall and stream gauging data collected in watershed

Data Type	Data Logging interval	Location	Data Logger type	Started	Remarks
Rainfall	5 minutes	Limbukha	Tinytag*Plus*	18th Nov 2000	Gets blocked with bird droppings
		Nabchee	Tinytag*Plus*	18th Nov. 2000	
		RC Bajo	Tinytag*Plus*	10th July 2001	
Stream Flow	10 minutes	Limbukha	Thalimedes	13th Aug. 2001	Connection pipe gets clogged with debris frequently
		Matalungchu	Thalimedes	January 2001	

Rainfall data collected with automatic data logger is fairly reliable apart form the problem with the bird droppings that clogs the data logger leading sometime to missing or no data availability. It is therefore necessary to visit the station twice a month to ensure that the clogging is removed. On the other hand, stream flow data collection has been less reliable with the automatic loggers because of following reasons (a) connection pipe between the stream and the stilling well gets blocked within couple of days due to mud and debris in the stream and (b) vandalism by the

cattle herders from the neighbouring villages outside the watershed. Whole set of data logger were stolen during last winter season by lifting the roof of the stilling well which also housed the datalogger set.

5.3.2 Monitoring of water sharing

The main issues with regards to irrigation water resources in the watershed are (a) irrigation water shortage during rice transplanting season, (b) peak rainfall season occur a month later than the peak transplanting season, (c) as the watershed lacks snow covered area, rainfall forms the primary source of water and (d) there is a narrow transplanting season at higher altitudes like in Limbukha and Dompola villages.

Water sharing system between irrigation schemes in the watershed is based on the rigid traditional sharing system. This traditional system is based on two principles "*first come first serve*" and "*any traditional scheme can divert full flow in the stream into their canal regardless of the down stream users*". As result of second principle the seepage from upstream irrigation scheme becomes a legal right for the downstream scheme(s); hence any effort to improve the conveyance efficiency of irrigation canal is not possible. There is a unique irrigation water sharing arrangement between two upper most communities i.e., Limbukha and Dompola. As the intake of the Dompola irrigation canal lies in the middle of the Limbukha paddy fields, Dompola although does not have to depend on the seepage, is not allowed to take water until 10th day of the 5th Bhutanese month. By this time Limbukha finishes about 90% of transplanting while there is less variation in terms of altitude. It meant that Dompola need to transplant almost same time as Limbukha farmers. As the water sharing date is based on the Bhutanese Calendar (Lunar), the date fluctuates in reference to Julian calendar. The corresponding Julian dates for the 10th day of the 5th Bhutanese month for last five years are 23rd June in 1999, 11 July in 2000 [4th Bhutanese month was double but actually water was released on 23rd June 2000[7] (21-4-2000)], 30 June 2001, 20 June 2002 [double 12th Month], 09 July 2003 and 28 June in 2004.

5.3.3 Water Resources Management through Role Playing

Lingmuteychu Watershed is a small watershed drained by Lingmuteychu, which is a small tributary of Puna-Tshangchu. This stream joins the main river at the left bank, opposite to NRTI. The watershed has an area of 3400 ha of which 5% is wetland. There are six villages forming six communities in the watershed. Since all the farmers in the watershed are subsistence farmers, natural resources solely form the primary source of their livelihood. Forest provides timber, fuel wood, grazing area, leaf litter for FYM production and water resources for drinking & irrigation. The water resources have been both the source of coordination (within a community) and conflict (among the communities) in the watershed. In the watershed, irrigation water is share based on two traditional principles "first come first serve" and "any scheme has right to divert full flow in the stream into irrigation canal, but the downstream user has right to the seepage coming out of the upstream user". The rigid traditional

[7] Date negotiated by RC Bajo as the 4th Month was double in 2000.

sharing arrangements and existing cropping systems does not favour in enhancing the improved management interventions of the resources.

Amongst the six communities in the watershed Limbukha and Dompola has been typical case of interest because of unique sharing arrangements and settings, which are listed below: -
Intake of Dompola irrigation canal lies in the middle of the paddy fields of Limbukha farmers, Dompola is allowed to take water only on the 10th Day of the 5th Bhutanese month (lunar calendar) as per the traditional sharing agreement. From this day onwards even as the Dompola gets 50% of the flow in the stream, Limbukha farmers still has right to use from the Dompola's share for the fields below Dompola Canal in Limbukha.

In the past by 10th day of 5th Bhutanese month Limbukha would complete about 90% percent of the transplanting, but increasing potato cultivation in Limbukha delays the transplanting having implication on the water rights of Dompola Community. On the other hand as the water sharing date is based on lunar calendar the date fluctuates corresponding to Julian calendar. Because of characteristic feature of Bhutanese calendar like missing days & extra days and in few years there will be extra month, thus the corresponding date always comes late.

As per the Dompola farmers traditionally they transplant till 4th day of the 6th Bhutanese month. If the transplanting is continued beyond this date there will be hardly any yield formation due to the setting in cold temperature at higher altitude like in Dompola. This gives a month to complete the transplanting in Dompola. If there is adequate rainfall during the season, transplanting is completed within the time, but if the rainfall is less then it is difficult to complete on time. Unlike other downstream users Dompola irrigation scheme doesn't benefit from the seepage coming out of upper scheme. This activity is aimed to serve as a platform for launching Water User Association at Watershed level. Association at watershed level is crucial for managing the resources at the watershed level because the watershed as such is a cluster of sub-watersheds or communities yet it is a unit itself since it is within one physical or watershed boundary. Hence there has to have some mechanism for coordination and cooperation such that it functions as a unit.

The specific objectives of the role-play game were to bring two communities (Limbukha & Dompola Communities) to a common understanding of the water resources with regards to its sustainable & equitable use; to facilate communities to share the perceptions on the common resources in forging common ground to resolve conflicts and develop sustainable NRM; to help communities to understand the dynamics and links between biophysical and social aspects of NRM and to test the RPG/MAS as a tool for resolving conflicts & social issues, enhancing the efficient management of natural resources in Bhutanese context.

Two discussion workshops for three days each were conducted in Dompola. 12 farmers represented each community. Role-playing games (RPG) were used as a tool for forging trust & stimulating discussion with regard to the sharing of irrigation water resource between the two communities. RPG was seen as an essential tool for making communities understand the perceptions on the resources from the other community point of view. The resources persons were Mr. T R Gurung, CORE,

Ministry of Agriculture, Dr. Guy Trebuil and Dr. Francois Bousquet both from of IRRI Thailand Office. The logistic and other necessary support was provided from RC Bajo. During the workshop, the farmers representing different scenarios using a 3D model of the watershed conducted series of role-playing games. Each decision process, interactions & coordination mechanisms between agents were recorded.

RPG was played in three modes depicting the water sharing scenarios between Limbukha and Dompola farmers. In the first mode two communities were not cooperating, the second mode two communities were cooperating & sharing the resources and in the third mode communities has changed their location. The game was played such that Dompola acted as Limbukha farmers and vice versa.

Role Playing Game (RPG) players found themselves in situations similar to the real circumstances where they were experiencing the problems of water resources management. The collective learning process, provided forum for discussion, open doors for unlocking the deadlock that existed with regards to NRM and allowed the player to fore see the problems of other communities. The approach had huge potential for resolving the conflicts and bringing the entire stakeholder to one common understanding on the issues related to NRM.

The RPG result can be used for Multi-Agent Systems (MAS) modelling which constitute a powerful tool for studying interactions between societies and their environment. Development of the MAS approach is closely related to the problem of complexity (multiple scales and organization levels, multiple stakeholders and view points) and the related search for simple representations of the real world through a very interactive bottom-up modeling process. Identifying with the stakeholders the conditions allowing the co-viability of environmental or resources dynamics on one hand and socioeconomic dynamics on the other hand is increasingly seen as key issue for sustainable NRM. Because it focuses on the understanding of interactions between various (individual or collective) agents acting in a given common environment, to identify with them better coordination and negotiation mechanism to improve the viability of the agro-ecosystems, the MAS approach seemed well adapted to dealing with this core problem.

First Workshops was conducted from 14th to 16th May 2003, which was mainly focused to understand the real context of the water resources sharing constraints between the two communities. The gaming sessions were designed to be simple. The second RPG workshop was conducted in December 2003. The game sessions were made as realistic as possible to match with their real life situation. During this workshop community leaders and a representative from other communities in Lingmuteychu Watershed were invited as an observer. The official from concern dzongkhag was also invited to witness the session.

During the second workshop draft water policy, secretary of Bhutan Water Partner Project presented act and vision to get the peoples' feedback. The presentation was made to create awareness on Bhutan's national water policy for sustainable and equitable use of the water resources in the country.

The outcome of the RPG session was documented which can be used for further analysis in Multi-Agent System Modeling. This modeling can help to visualize the

future scenario of the resources. At first the participants had a very low impression about the workshops tool the role-play game. Upon reflection overnight they have realized the huge potential of the tool for addressing the real issues in their practical life. The RPG represented the real situation and facilated self-motivating and non-confrontational interactions among the players. The swapped role helped farmers to compare their constraints and opportunities. Limbukha farmers agreed to give Dompola share of irrigation water by five days earlier (i.e., on 5th day of 5th Bhutanese Calendar instead on 10th day of the 5th Bhutanese Month).

The participants also felt the need to have an institutional body at watershed level to address the issues of the natural resources. In principle, the participants agreed to set such institutions very soon. The workshop also coined "***CHU-LUNG"*** as a local term for watershed. Farmers feedback with regards to national water policy, act and vision revelled that the farmers appreciated the governments effort in safe guarding the farmer interest in future by the legal instruments on water resources, they also felt that they should change themselves rather than the act to address the issues of inequity among the farmer themselves.

The Role Play Game is efficient to make people express individual perceptions on the resources and making them to forge common perceptions for sustainable management of the resources. By developing common understanding on the resources stimulates to people to have single goal. The process of forging common perception is very critical part of the overall process, as it demands understanding of interactions between societies and their environment. Thus RPG provides simple representations of the real world through a very interactive bottom-up modeling process. Such artificial conditions allow people to act as farmer allowing them to understand the co-viability of environmental or resources and socioeconomic dynamics. Because it focuses on the understanding of interactions between various (individual or collective) agents acting in a given common environment, to identify with them better coordination and negotiation mechanism to improve the viability of the agro-ecosystems, the approach seems well adapted to dealing with this core problem.

The ideal RNM is where the concerned stakeholders agreeing and adopting to common perceptions and aspirations. It is also about developing the social capital and institutions based on the ethics of civic norms. The participants agreeing to have watershed level institution development is an indication of the understanding of the people that watershed should function a single management unit with one goal.

5.3.4 Direct Seeding

Irrigation water shortage problem is the main constraints in Lingmuteychu Watershed. This is mainly due to peak water requirement during transplanting time as peak rainfall seasons lags by a month. On the other hand the rigid mountain type of climate does not offer the flexibility of delaying the transplanting season to match with the peak rainfall season either, nor farmers have the options to start transplanting early due to the winter crops standing in their field. As the farmers in Limbukha have first access to Lingmuteychu (irrigation water) is least affected by the problem, but their management and cropping practices influences water users at the downstream of the watershed farmers. With increasing trend of winter cropping in

Limbukha (potato, wheat, buckwheat etc) the possibility of early transplanting is becoming almost impracticable to Limbukha farmers. There is a potential for better management options for water resources especially in terms of irrigation water allocation. But the lack of policy guidelines with the rigid traditional water sharing arrangements does not offer any flexibility of allocating the irrigation water to those farmers whose fields are empty so that they can start transplanting early while others wait.

In such a scenario, direct seeding method is one of the options to over come the constraints of water shortage problems. Apart from not requiring water for transplanting, direct seeding techniques has the advantage of requiring less labour there by reducing the over all cost of production. But it has its own demerits like high weed infestation, lower yield compared to transplanted rice, logging due shallow rooting depth and requires good land preparation. But all these constraints are within the solution of an individual farmer unlike the water-sharing problem that needs decision of whole community.

The objective is to see the advantage of direct seeding compared to the delay transplanting at higher altitude. The short-term objective is to mitigate irrigation water and labour shortage problem during transplanting season.
In the long run, the research interventions if successful will be able to lower the strain on the water resources in the watershed and remove the social and environmental problems resulting directly out of water shortage problem in the Lingmuteychu Watershed. It aims to improve water use efficiency and lower cost of production of rice in the area. It will also help to lower the demands on water resources thereby maintaining minimal low and continuous flow in the river to uphold the balance ecosystem supported by the river.

The trial was laid out with RCBD design having six treatments. Treatment one and two (T1&T2) were controlled group representing conventional farmers' method with two different scenarios normal and delay transplanting (due to delay rainfall or water shortage problem). T3&T4 were directly seeded during the time of nursery land preparation. Treatment three (T3) was seeded directly by broadcasting the seeds and treatment four (T4) was seeded in row to study the ease of weed management. The land preparation for T3 &T4 was same as that for nursery bed preparation of T1 & T2. The seed rate used for T3, T5 & T6 was 120kg/ha. The depth of row seeding was about 8 to 10cm approximately. The detail crop -cut results, the average yields of different treatments for a period of three years are given in **Table 52**.

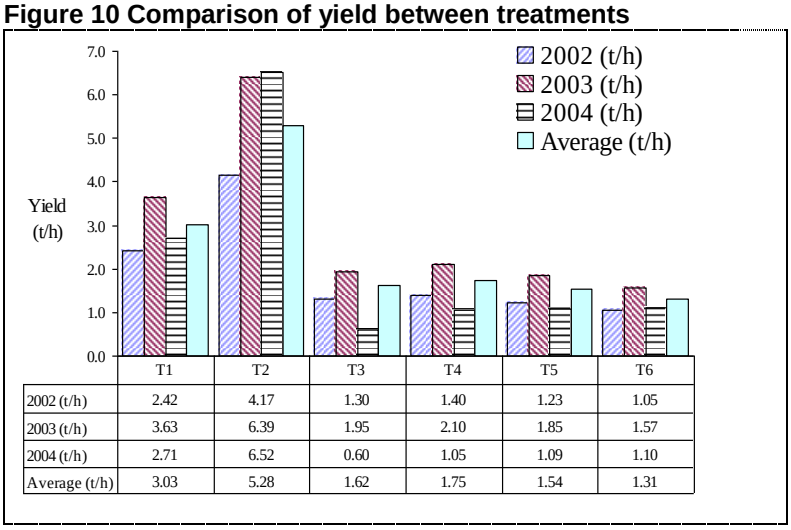
Table 52 crop-cut results for the year 2002 and 2004

Year	Treat.	Method of Establishment	Variety	Date of		Yield (t/ha)					
				Estab.	Harvest-	R1	R2	R3	R4	R5	Average
2002	T1	Transplanting	Kaap2	17-Jun	14-Nov	4.59	2.01	1.65	2.15	1.70	2.42
	T2	Transplanting	Kaap2	3-Jun	14-Nov	5.39	3.38	3.40	3.92	4.75	4.17
	T3	DS Broadcasting	Zhakha	3-Jun	15-Nov	1.37	1.38	1.36	1.71	0.68	1.30
	T4	DS Row	Zhakha	3-Jun	16-Nov	1.70	1.37	1.53	0.68	1.71	1.40
	T5	DS Broadcasting	Kaap2	3-Jun	17-Nov	0.35	1.49	1.50	1.82	0.99	1.23
	T6	DS Row	Kaap2	3-Jun	18-Nov	1.86	0.67	0.66	0.38	1.67	1.05
2003	T1	Transplanting	B Kaap 2	14-Jun	5-Nov	6.89	3.02	2.48	3.22	2.56	3.63
	T2	Transplanting	B-Kaap 2	6-Jun	22-Sep	8.08	5.08	5.10	6.56	7.13	6.39
	T3	DS-Broadcasting	Zhakha	6-Jun	22-Sep	2.05	2.07	2.04	2.56	1.02	1.95

	T4	DS-Row Seeding	Zhakha	6-Jun	22-Sep	2.56	2.06	2.29	1.03	2.57	2.10
	T5	DS-Broadcasting	B-Kaap 2	6-Jun	5-Nov	0.52	2.23	2.26	2.73	1.49	1.85
	T6	DS-Row Seeding	B-Kaap 2	6-Jun	5-Nov	2.79	1.00	0.99	0.58	2.50	1.57
2004	T1	Transplanting	B Kaap 2		3-Dec	2.63	2.97	3.34	2.22	2.36	2.71
	T2	Transplanting	B-Kaap 2		29-Oct	6.69	7.42	3.59	10.05	4.85	6.52
	T3	DS-Broadcasting	Zhakha		17-Nov	0.67	0.66	0.78	0.23	0.67	0.60
	T4	DS-Row Seeding	Zhakha		17-Nov	1.19	1.10	0.26	0.92	1.80	1.05
	T5	DS-Broadcasting	B-Kaap 2		0-Jan	-	-	1.92	-	0.27	0.44
	T6	DS-Row Seeding	B-Kaap 2		17-Nov	1.46	1.24	0.61	-	-	0.66
					Average =						

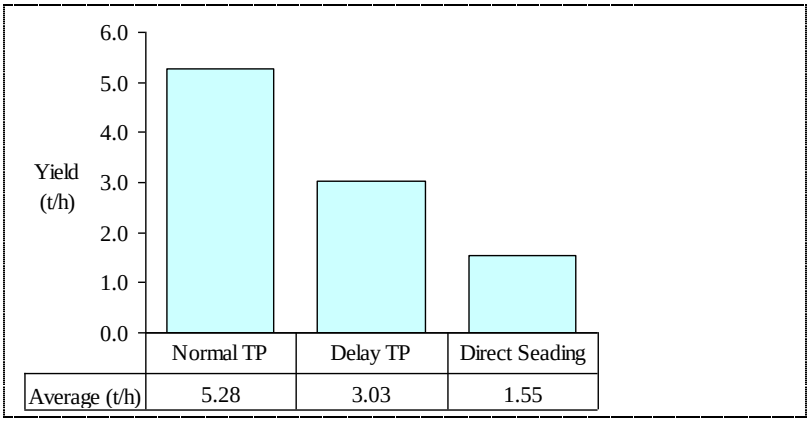
T1: Delay transplanting (Control), T2: Normal Transplanting, T3: Direct seeding by broadcasting-Zhakha, T4: Direct Seeding by row seeding-Zhakha, T5: Direct seeding by broadcasting-Bajo Kaap2, T6: Direct Seeding by row seeding- Bajo Kaap2

Figure 10 Comparison of yield between treatments



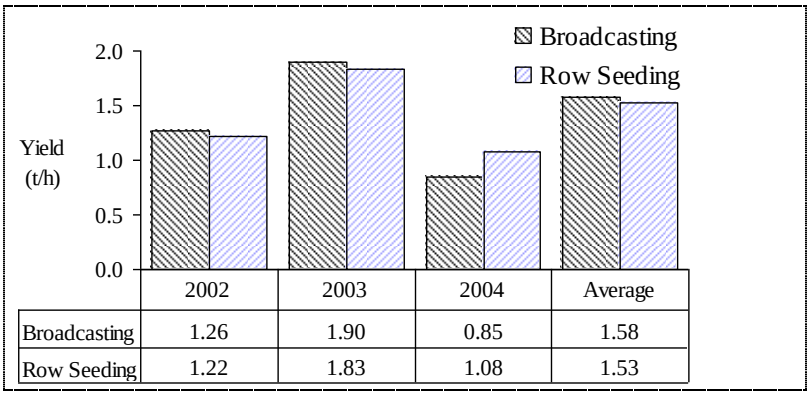
	T1	T2	T3	T4	T5	T6
2002 (t/h)	2.42	4.17	1.30	1.40	1.23	1.05
2003 (t/h)	3.63	6.39	1.95	2.10	1.85	1.57
2004 (t/h)	2.71	6.52	0.60	1.05	1.09	1.10
Average (t/h)	3.03	5.28	1.62	1.75	1.54	1.31

Figure 11 Comparative average yields between crop establishment methods



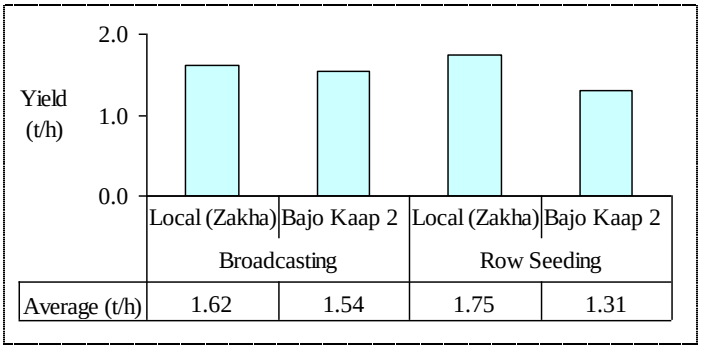
	Normal TP	Delay TP	Direct Seading
Average (t/h)	5.28	3.03	1.55

Figure 12 Comparison of yield between broadcasting and row seeding methods



	2002	2003	2004	Average
Broadcasting	1.26	1.90	0.85	1.58
Row Seeding	1.22	1.83	1.08	1.53

Figure 13 Yield performance of variety for different seeding method



	Broadcasting		Row Seeding	
	Local (Zakha)	Bajo Kaap 2	Local (Zakha)	Bajo Kaap 2
Average (t/h)	1.62	1.54	1.75	1.31

The general findings indicated that the late transplanted (control treatment) over three years yielded 3.03 t/ha on an average basis. The direct seeded have an average yield of 1.55 t/ha as illustrated in **Figure 11**. From **Figure 12** it was noted that there was no significant yield difference between row direct seeded and direct broadcasting methods. **Figure 13** showed that local variety Zakha performed slightly better than Bajo Kaap 2 but the yield difference was not significant. The low yield was due to tremendous non-aquatic weed pressure, poor germination due to bird damage during the sowing time. The bird damage was severe when there were fewer plots with seed in it. The yield can be improved provided above parameters are controlled properly. The average yield of delay-transplanted plot was 3.03t/ha compared to normal transplanted one with 5.38t/ha. The yield difference was noted highly significant. This indicated that there was a yield decline of 43% by delaying paddy transplanting by two weeks at the research station having the altitude of 1300masl.

From **Figure 11** it indicated that two weeks delay transplanted had yielded 3.03t/ha whereas the direct seeded method yielded only 1.55t/ha. However the direct seeded method would be more yield advantage compared to late transplanting. Traditionally farmers stop transplanting by 4th day of 6th Bhutanese month at higher altitude.

Farmers mentioned that there was no grain formation if the paddy is transplanted beyond this date.

Direct seeding method has the potential of addressing the irrigation water shortage problem during the transplanting season. Very often small springs/stream forms the sources of irrigation water sources at higher altitude, which in turn depends on the timely rainfall. As a result the success of paddy cultivation depends highly on the timely rainfall thereby increasing the risk of farming. Hence adopting direct seeding method can minimize this risk. Apart from intensive weed management requirement this method requires less labour compared to transplanting method that will address the issue labour shortage problem in the rural area. Conducting multilocation on-farm trials especially at higher altitude of more than 1800m will be needed for further validation of station results.

5.3.5 Civil Engineering works

As RNR RC Bajo do not have separate maintenance unit, WMR Sector is also mandated to look into the civil engineering works. As such we have to devote significant amount of time and effort for civil engineering and other maintenance works of the centre. At the same time the sector have to cater similar need and support to Regional Agricultural Machinery Centre (RAMC) and Druk Seed Coperation (DSC) located in Wangdue. Some of the civil engineering works undertaken by WRM sector during the year are indicated in **Table 53**

Table 53: Civil engineering activities undertaken by WMR Sector

SN	Activities	Status
1	Boundary Fencing Wall Construction for RC Bajo	Completed
2	Caretaker Residence Construction for RAMC-Bajo	Completed
3	Boundary Barbed-wire fencing for RAMC Bajo	Completed
4	Parking & Approach Road Black Topping for RAMC Bajo	Completed
5	Retaining wall construction for RAMC	Completed
4	Bank protection Gabion-wall construction	Completed
5	Tsirang RNR Sub-centre Renovation	Design, drawing, estimating is completed
6	Routine maintenance of Office and Staff Quarters	Completed

5.3.6 Citrus irrigation Ssheduling trial

Citrus irrigation trial was established at Bichgoun in Tsirang, Gelephu and Dakpai in Shemgang following the soil moisture regime monitoring for the last three years. Irrigation scheduling is based on the soil moisture regime under normal rainfall condition.
The main objective of the study is to explore the yield benefit of irrigating the citrus under the existing management practice; to improve the quality of the fruits (size, sugar content) and to assess the viability of low cost irrigation technology (simplified drip).

Completely randomised block design was used with two treatments T1 and T2. T1 was controlled without irrigation representing farmers practice. Treatment T2 was irrigated using drip system. Irrigation was with holded about a month during the dormant stage to induce moisture stress, which was required for better flushing for

citrus. Each treatment had four replications. The trial was grouped into four blocks as the orchard lacked the uniformity in terms of slope, soil fertility and the size & age of the plants.

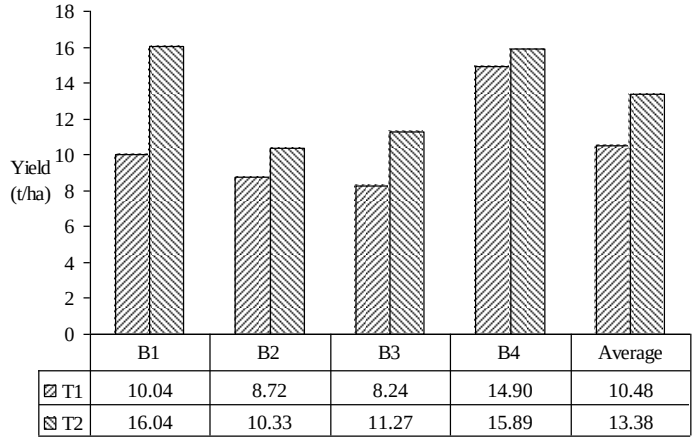
The general findings on yield data for the irrigation scheduling trial from Bichgoun, Tsirang is presented in **Table 54** while their graphs are illustrated in**Figure 14** and **Figure 15**. Detail statistical analysis recommendation and conclusion will be done after four years when we have adequate information generated on this trial.

Table 54: Yield and number of fruits from two treatments

Block	No. of fruits/tree		Yield per tree (kg)		T1 (Without Irrigation)			T2 (With Irrigation)		
	T1	T2	T1	T2	Large	Medium	Small	Large	Medium	Small
B1	527	836	33.9	54.1	13	33	55	35	50	15
B2	402	547	29.4	34.9	3	80	18	9	74	18
B3	443	555	27.8	38.0	9	79	13	9	80	11
B4	749	828	50.2	53.6	20	69	11	13	79	9
Average	530	691	35.3	45.1	11	65	24	16	71	13

T1: *Without Irrigation* and T2: *With irrigation*

Figure 14: Yield comparison in (t/ha) between farmer's practice for different block within one orchard.



	B1	B2	B3	B4	Average
T1	10.04	8.72	8.24	14.90	10.48
T2	16.04	10.33	11.27	15.89	13.38

Figure 15: Fruit size distribution with and without irrigation

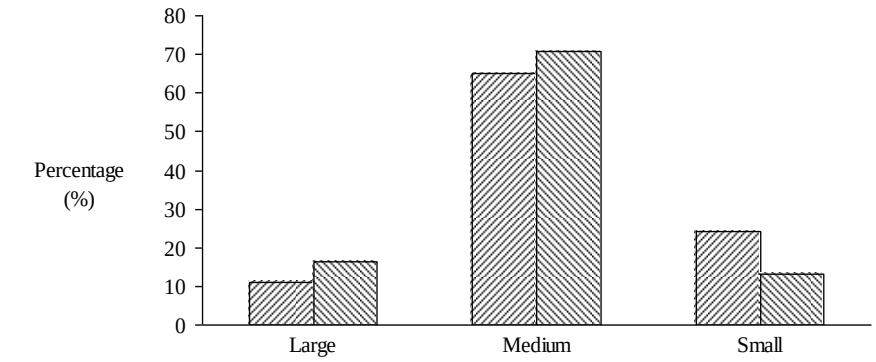
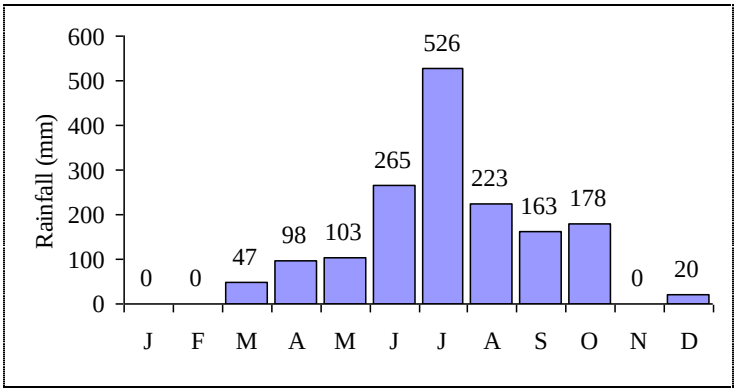


Figure 16: Monthly rainfall at trial site (Bichgoun) 2003



5.3.7 Technical support to client Dzongkhags

WMR Sector in collaboration with Horticulture Sector and the concerned Dzongkhags was involved in the development and management of the orchards in the region. The specific support extended by WMR sector were a preliminary study for developing irrigation facilities for developing new orchard near Punakha Dzong; produced baseline maps for redesigning the orchard layout for Sonagasa and Phuntshopelri Orchards; preliminary survey for developing irrigation facilities for orchard near Nyzer Lhakhang and drinking water supply to the Lhakhang and assisted in the survey of Nyzer Lhakhang Watershed Study.

Although the WMR Sector based in RNR RC Bajo is mandated to coordinate national water management research program it has been not able to fulfil this mandate due to low capacity of the staff both in terms of quantity and quality. At the moment, the sector is struggling at least to fulfill its regional mandate.

5.4 Agriculture Economics

5.4.1 An Economic Impact Assessment of the Rice Research Program in Bhutan

RNR-RC Bajo has the national mandate for field crops and rice research is one of the major components of its program. The objectives of the rice research program are to develop improved rice technologies for raising productivity and farm income so that the national food objective of 70% self-sufficiency in rice can be achieved. In addition, RNR-RC Bajo has the responsibility to coordinate rice technology development, provide policy advice, and develop and manage linkages with national and international institutes. An impact assessment study was done nation wide in the year 2002 with the consultancy service from IRRI with following objectives:

- To study and document the number of modern varieties released and extent of adoption of these varieties
- Adoption of recommended crop management practices
- Magnitude of yield gain and increase in value of production
- Increase in net income and household cash income of farmers
- Achievement of rice self sufficiency and improved welfare
- And also ascertain the institutional impact on capacity building for agricultural research.

The findings were analyzed and documented as “An Economic Impact Assessment of the Rice Research Program in Bhutan” published by MoA in collaboration with IRRI, IDRC and SDC during the year 2004. The rice research and technology development program has been successful in increasing rice production and farm income, and in improving food security. These benefits are likely to increase as rice technologies continue to spread over time.

5.4.2 On-station Seed production cost analysis

Production cost analyses of important vegetable seeds are carried out on station trials with the main objectives to:

- Determine the cost of production of seeds
- Quantify inputs such as labour and material inputs for seed production.
- Guide Druk Seed Cooperation in determining the selling rate of the seeds.

In 2003-2004 four crops were assessed: radish, cauliflower, tomato and broccoli. The data on inputs and outputs were recorded by the researchers. Input data includes labour and material inputs and out put data includes yield.

The data was entered in a data entry form developed using MS EXCEL, linked with an analysis worksheet with each crop data entered and anaylsed separately. Broccoli did not perform very well in this year due to heavy infestation of aphids and continuous rainfall during seed setting. This assessment shall be repeated next year. Table 55 below shows the crop variety, trial area and yield of the crop from the cultivated area.

Table 55: Crop variety, trial area and crop yield

crop	variety	trial area cultivated	Yield(kg/area)
radish	Bajo lhafu	541m^2	6.5kg/541m^2
tomato	Nazomi	200m^2	0.9kg/200m^2
cauliflower	Snowball E-16	324m^2	4.3kg/324m^2

Yield

The seed yield of each crop was measured from each area and converted into kg/acre (figue 18). Cauliflower has the highest seed yield of 54kg/acre followed by Radish at 49kg/acre and tomato at 18kg/acre. Seeds yield includes only quality seed that were graded and dried.

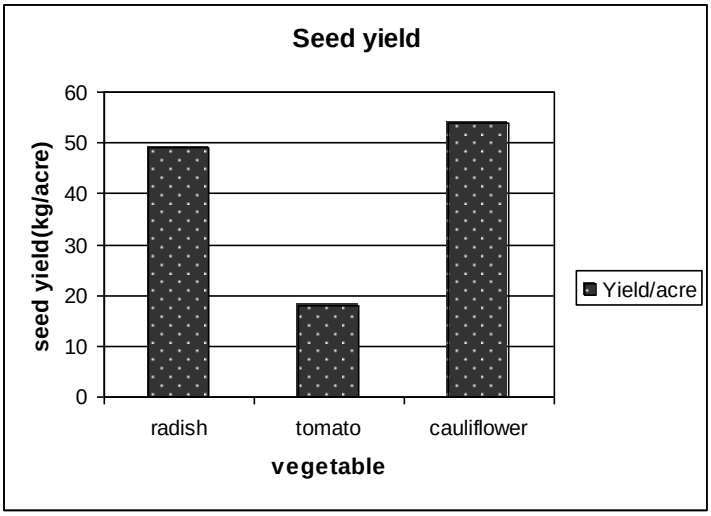


Figure 17: **seed yield (kg per acre)**

Labour cost and material cost

Labour inputs were recorded and computed for each crop for the trial area and for one acre. The daily wage of labourer of Nu 100/day was used. Researchers involved for supervision and working in case of roughing, seed slection were also computed. The graph shows the labour and material inputs used for growing these crops on 1 acre. The labour cost of radish is Nu 13397.87 and material cost is Nu 11969.91 per acre. Radish seed production has low production cost compared to cauliflower and tomato seeds. Cauliflower has high labour cost at Nu 18857.87 per acre and material cost involved at Nu 13750.21 per acre. Tomato has a labour input of Nu 11807.51 and material input cost of Nu 14287.72 per acre as shown in figure.

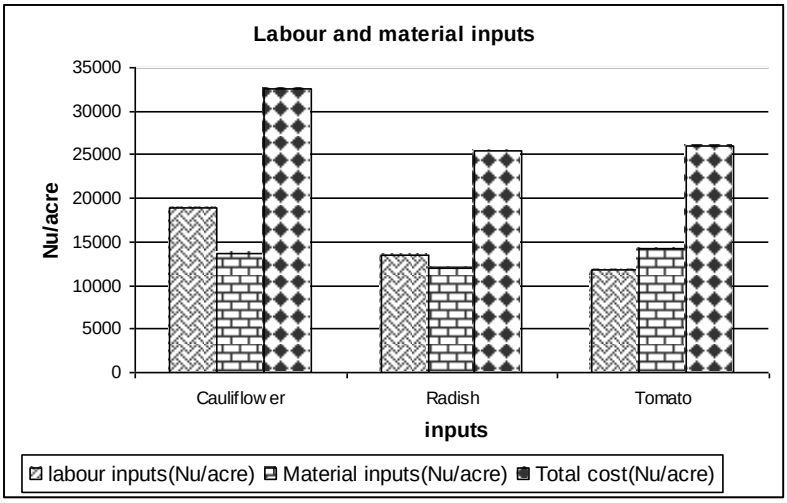


Figure 18: Labour and material inputs

Cost of production and selling price of DSC

Table below shows the cost of production of seed on the on-station farm and the selling price of the seed at DSC/Commission Agent. The radish seed production costs less at Nu 522/kg. Although cauliflower has highest yield, its cost of production is higher than radish because of the higher labour and material inputs/cost incurred. Tomato has highest seed cost of production at Nu 1465/kg because of its low yield and high inputs cost. The selling rate of DSC is higher to account for costs in storing and packaging. The actual price of selling these vegetable seeds can be determine after computing the storing and packaging cost involved.

Table 56: Cost of production and selling cost of seeds

Sl no.	Vegetable name	Seed Cost of production (Nu/kg)	Seed selling price of DSC(Nu/kg)
1	Tomato	1465	2100
2	Radish	522	700
3	Cauliflower	607	1550

Returns

The gross return and total return of the crop are same as there are no other costs and selling cost involved for any of the crop of each seed production is calculated. The gross returns of these vegetable seed have been computed per acre. Although Tomato has lowest yield, it has higher gross returns than radish at Nu 37403.52 per acre owing to its high selling price. Cauliflower due to its high yield and good selling price has the highest gross return at Nu 83272.36 per acre. Radish gross return at Nu 34024.35 per acre is the lowest among the three crops as shown in figure.

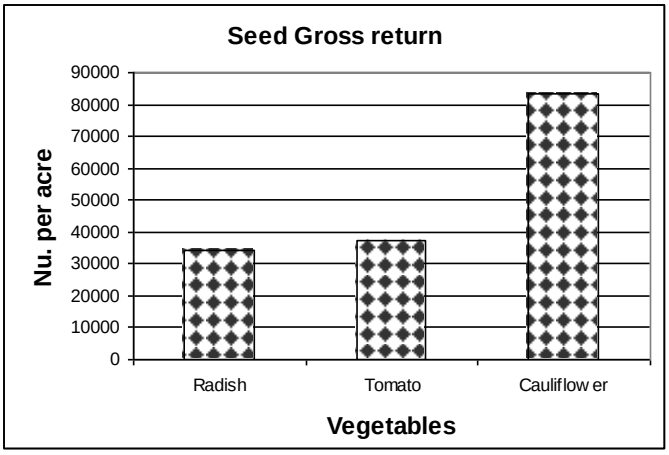


Figure 19: Seed gross return

5.4.3 On station Rice based Potato Economics analysis

The horticulture sector carried out an on station Rice based Potato production economics. The aim is to assess the yield and benefit from the both crops for three years. The objectives of the economic analysis are:

- To determine production costs.
- To determine the profitability of cultivating potato on wetland.
- To determine the yield and production of both the crop.

All the necessary data (on inputs and outputs) were recorded by the Horticulture Research team. Input data includes labour and materials used and output data include yields. The data were entered separately for the three years in a data entry form in MS EXCEL and analysed. The trial was conducted on an area of 518m^2 while results of the economics analysis have been done on a per acre basis.

Yields

Figure 20 shows the yields from trial for the three consecutive years. Average yield of paddy was 333.2 kg/518m^2. The yield of paddy was lower in second year. In the year 2002 the paddy yield increased by about 86%. Potato yield was lower in 2001 and 2002 than in 2000. Potato yield was 1353kg/518m^2 in 2000 higher by 317kg than the yeild of 2001, about 203kg higher than 2000 yield.

Labour cost and material cost:

Labour cost is calculated for the area cultivated and the result converted into a per acre figure. The daily of Nu 100/day per manday was used. The total mandays required was recorded in hours which multiplied by 100 gave the labour cost. Rice is a labour intensive crop and as such has a higher labour cost compared to potato. The material cost which covers machine cost and material inputs is higher in case of potato because of the fact that FYM is applied only to potato. The machinery cost was reduced for rice as only two ploughings are required. The total cost of potato cultivation remains higher than that of rice (Table 57).

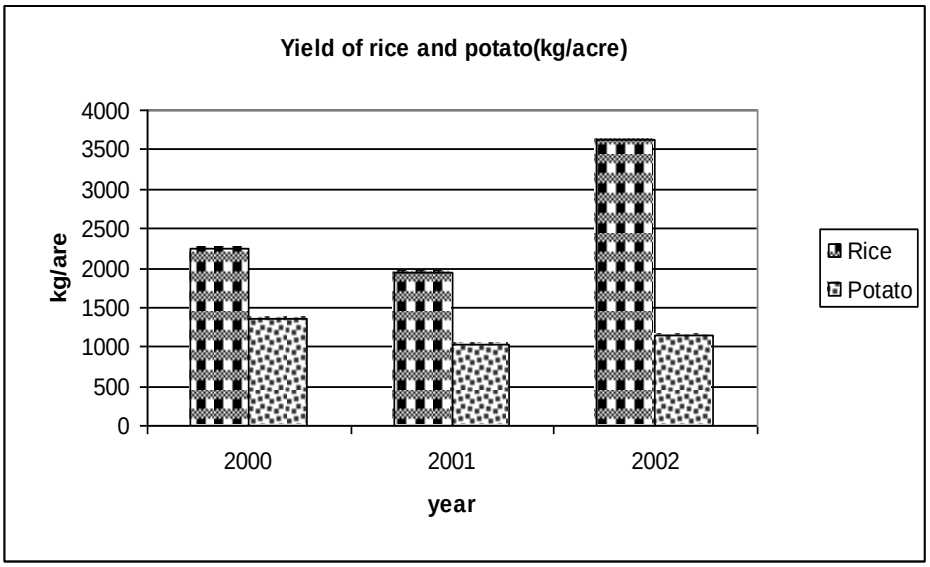


Figure 20: Rice and Potato yield from rice based potato economics trial

Table 57: Comparative cost of rice and potato

Year	Rice			Potato		
	Labour cost (Nu/acre)	Material cost(Nu/acre)	Total cost(Nu/acre)	Labour cost (Nu/acre)	Material cost (Nu/acre)	Total cost(Nu/acre)
2000	8564	10377	18940	6252	23715	29967
2001	8401	9823	18223	6691	23272	29963
2002	8987	10139	19126	6594	23715	30309

Production costs

Rice

The production cost of rice for three years were compared. In the first year it cost Nu 8.42 to produce 1kg rice while it cost Nu 9.38 in the second year and only Nu 5.29 in the third year. This difference in production cost can be explained by the high yield variations. The average production cost per kg of rice is Nu 7.7/kg and the average cost of production per acreis Nu 18763.

Potato

Potato cost of production is less than that of rice. It cost Nu 2.83 in the first year to produce 1kg of potato, Nu 3.7/kg in the second year and Nu 3.37per kg in the third year. The average production cost of potato is Nu 3.3/kg and Nu. 30079.67 per acre (Table 58).

Table 58: Cost of production of potato and rice

Year	Rice cost of production(Nu/kg)	Potato cost of production(Nu/kg)	Rice production cost(Nu/acre)	Potato production cost(Nu/acre)
2000	8.42	2.83	18940	29967
2001	9.38	3.7	18223	29963
2002	5.29	3.37	19126	30309

Gross Returns

The total gross return was as the value of main product plus the value of by-product. This was calculated for the area cultivated and converted to per acre. As no transportation costs were involved, the total gross return is equal to total return which is the total gross in the present case. Potato has the higher total gross return than rice (Table 59).

Table 59: Total gross returns

Year	Total gross return of rice (Nu/acre)	Total gross returns of potato(Nu/acre)
2000	15754	84586
2001	13601	64768
2002	25327	71895

Net returns

The net returns to land, labour and capital is gross return minus cash cost. The opportunity cost of land was taken at Nu 20,000/acre. The net returns to land, labour and capital of rice was negative for the first two years and Nu 6202 in the third year (table 60). This is because in the first two years the production cost was higher than the gross returns. Net returns to land, labour and capital for potato is highest in the first year (Nu 54619/acre) followed by returns in the third year (Nu 41586/acre) and returns in the second year.

Table 60: Net returns

Year	Rice Net returns to land, labour and capital (Nu/acre)	Potato Net returns to land, labour and capital (Nu/acre)
2000	-3186	54619
2001	-4623	34805
2002	6202	41586

Detailed analysis of the data will be carried out and results compared with other based rice cropping systems in the future.

5.4.3 Economic Analysis of Chilli Blight Disease and Management Trial

Chili is a very important cash crop for the farmers in Punakha and Wangdue. In recent years chilli blight disease has become problematic for chilly production. The IPM sector along with collaboration wirh National Plant Protection centre and

Dzongkhag agriculture sectors of Punakha and Wandue conducted large scale demonstrations for blight management under wet and dry land condition, at Punakha and Wangdue dzongkhags in 2003. The agri-economic section of RNRRC, Bajo was invited to conduct an economic analysis of these trials. Two types of blight management demonstrations were conducted: use of the entire recommended management package that includes elevated bed, proper drainage, plant spacing and mulching; and use of the recommended management package in combination with chemical treatment. Cultural operations were identical for both except chemical treatment for the later.

In Wangdue the trial site was at Bjaktey under Kashi geog (dryland). The total area was 1.5 langdo, in which the chemical treatment was 1 langdo and 0.5 langdo was not treated with chemical. In Punakha, the trial site was at Khawajara (wetland) comprising a total area of 1.25 langdo divided equally into the chemically treated and without. All economic variables were collected by the agri-economic section and these data were entered into a MS Excel spreadsheet and analysed. Results have been converted on a per acre basis.

Results

For Wangdue the analysis was done for both treated and untreated plot. In Punakha the result could be analysed separately for treated and untreated since there was no separate data for yield from each plot though there was complete data on labour and materials inputs.

Yield

The yield data were computed for the trail area and also computed per acre. The crop was harvested thrice in Bjaktey trial and in Khawajara it was harvested till fifth round. Bjaktey has separately harvested from the treated plot and untreated plot whereas in Khawajara the owner has harvested together, so we could not calculate it differently as treated and untreated. It shows Punakha has yield is around five times higher than the Bjaktey trial it is because they have harvested five times where as Bjaktey has harvested only thrice. Also the yield could be due to wetland cultivation. For better presentation the treated plot is named as BJ1, untreated as BJ2 and Khawajara as KW1 as in Table 61.

Table 61: Comparative chilly yields from treatments

Plots	Yield(kg/trial area)	Yield(kg/acre)
Treated(BJ1)	801.5kg/1langdo	2408kg/acre
Untreated(BJ2)	431.5/.5langdo	2589kg/acre
Puna(KW1)	3810/1.25langdo	12192kg/acre
Average		5729.667kg/acre

Labour and material cost

The labour rate is kept as Nu 100/day per labour. Usually the household labours are involved in chilli cultivation activity. Officers/staff or EA involved for supervision is not taken.

Table 62: Labour and Material cost for chilly blight trial

Plots	Trial area (langdo)	Labour inputs		Material inputs		Total cost	
		(Nu/trial area)	(Nu/acre)	(Nu/trial area)	(Nu/acre)	(Nu/trial area)	(Nu/acre)
Treated plots(BJ1)	1	5468.80	16406.25	5152.20	15456.52	10620.90	31862.80
Untreated plots(BJ2)	.5	2518.80	15112.50	2545.00	15270.00	5063.80	30382.50
Punakha (KW1)	1.25	6900.00	22080.00	6407.2	20502.96	13307.2	42583.00

Cost of production

The cost of 1 kg chili is calculated from each trial plot. The cost of production is higher in Bjaktey both treated and untreated trial and very low in case of Khawajara, although the total production cost is not that difference as shown in Table 63. It is because Khawajara trial has very high yield compared to Bjaktey trial.

Table 63: Cost of production

Trial plots	Production cost(Nu/kg)
Treated plots(BJ1)	13.23
Untreated plots(BJ2)	11.74
Punakha(KW1)	3.5
Average	9.49

Gross Returns

The total gross returns is the value of main product and the by product. Since chili has no by-product, the total gross returns are the value of main product.

Table 64: Gross return from chilly blight trial.

Plots	Total gross returns (Nu/trial area)	Total gross returns (Nu/acre)
Treated(BJ1)	17253.8	51761.25
Untreated(BJ2)	9297.1	55782.54
Puna(KW1)	76200	243840.00

Net Profit

The net profit which is the total income minus the total expenditure is computed for all the three trials. From the treated plots of Bjaktey the net profit is Nu 6632.80 from 1 langdo which is Nu 19899.25 per acre. The untreated plot gives the net profit of Nu 4233.30 from .5 langdo which is equivalent to Nu 25400.00 per acre and Khawajara has the net profit of Nu 62892.80 from 1.25 langdo which is when computed for one acre it gives Nu 201257.04.

5.4.4 Crop budgeting of chilli production

Chilli is increasingly becoming one of the most important cash crops in Bhutan. It is also one of the only crops grown in almost all part of Bhutan by every household for domestic consumption and in some fertile valleys and dry land fields for selling. As

per the available data chilli is cultivated in 2,316 acres with total production of 2900mt (RNR Census, 2000). In some fertile valleys in some like Paro, Thimphu, Wangdue, Punakha and Trashiyangtshe chilli predominantly grown for commercial purpose. The first harvest of this chilli variety is known to capture very high prices even in the local markets. In West Central region Sha Ema (one of the chilli variety) is very popular among Bhutanese consumers for its taste and flavour over other Indian chilli varieties. It is one of the main ingredients of favourite Bhutanese curry known as "*Ema Datchi*". As a condiment chilli is indispensable in every Bhutanese meal.

Considering the importance of this crop, the Agri Economics section felt the need to do the systematic crop budgeting of chilli in West-Central region. There is a dearth for authentic production economics of chilli which can be confidently use for production planning. The survey was done in 2003 with the following objectives

- To quantify labour and material inputs used in chilli production
- To determine the cost of production of chilli in Punakha-Wangdue valley
- To determine the profitability of cultivating chilli in Punakha-Wangdue valley

Sample selection
The survey was conducted in Punakha-Wangdue valley owing to the importance of chilli cultivation in this area. Chilli growing geogs was selected based on the secondary data available. A structured questionnaire survey was conducted to covering about 20 percent of the chilli growing gewogs in each Dzongkhag. Stratified random sampling was used to select the required number of respondents. Information like inputs price, rate are collected from DSC and Agri. Commission Agents. Prior to start, detail discussions were to done with Dzongkhag Agriculture sector in Punakha and Wangdue Dzongkhag.Their advice and consent were used to select geogs in doing the survey. Table 65 shows the geogs and households surveyed.

Table 65: Geogs and households covered in each of the Dzongkhags

Sl no	Dzongkhag	# of geog	# of Households
1	Wangdue	3	59 hh
2	Punakha	2	48
Total	2	5	107

Data were collected by using structured questionnaires in 'norm' method. For this method, however, the total area under each crop was asked based on farmers' estimate. Market price data for inputs and outputs at different areas were collected from different sources and were crosschecked before using them. Agricultural input data were collected from Agricultural input agents and from the farmers also.The data collected were checked for any errors and omissions.

Data analysis
Spreadsheet is developed in access program and the data were entered. Detailed analysis is being done and will be reported in the next annual report.

5.5 Integrated Pest Management (IPM)

The IPM sector mostly provides need-based technical plant protection services to the client Dzongkhags through field visits, awareness campaigns on important crop pests and disease, disease-pest verification, surveillance and monitoring. IPM research for 2003-2004 was concentrated on Chilli Blight Management demonstration in Eto Nesa, Wangdue Phodrang and Khawajara, Punakha, *Shochum* management campaign through intensive hand weeding, and citrus bagging and Chinese citrus fruit fly (*Bactrocera minax* Enderlin) phenology study. The chilli blight management demonstrations in wetland (Khawajara) and dry land (Eto Nesa) were successfully showcased to the farmers of the respective Dzongkhags. Field days at each location conducted during first harvest indicated that farmers were convinced that chemical application was really not necessary to control chilli blight if the package of practice was strictly implemented in the field. Some of the participant farmers expressed their desire to implement the package of practice such as raised bed, proper drainage, wider spacing between plants, timely weeding and other horticultural management practices in their own fields. Economic analysis shows that the cost of chilli production for Khawajara (Nu. 3.50/kg) is lower than Kazhi (Nu. 12-13/kg). The net profit for Kazhi was Nu. 10,866.10 Ch for 1.5 langdo and Nu 62,892.80 Ch from 1.25 langdo for Khawajara.

The *Shochum* management campaign through intensive hand weeding was continued in Lingmuteychhu watershed and Gaselo. Three years of intensive hand weeding has prevented rice yield loss to *Shochum* as indicated by rice yield assessments in watershed and Gaselo. In the watershed rice yield accrued due to intensive hand weeding ranged from 0.63-1.03 t/ha and 1.15-2.17 t/ha for Gaselo. Additionally collaborative farmers feel that the *Shochum* pressure in the weeding plots has substantially gone done. This was evident from very few flushes that were present 2 WAT and the ease of weeding felt during the first weeding shared by the farmer during field days.

The Chinese citrus fruit fly still continuous to be a major cause of citrus fruit drop in the mandarin growing regions of the country. Likewise a bagging and citrus fruit fly phenology trial was done in Salami, Tsirang mainly to bag fruit and expose to determine the period of oviposition and to determine the critical mean size reached for oviposition. The results indicate that only towards end of June the fruits at Salami attained the critical size of 11mm. The susceptible period for mandarin crop in Salami, Tsirang is about seven weeks starting mid June till July end. To protect the citrus fruits against fruit flies, two cover sprays with Dimethoate 30EC – one before mid June and another in first week of July in orchards infested with fruit fly would be adequate. Among others, a community based fruit fly control campaign was initiated at Batasey village in Tsirang in August 2003. The objective of the trial is to confirm that collecting dropped fruits every 10 days would minimize fruit fly population in the subsequent year over time. Benefits accrued will be recorded through fruit production, severity of fruit drop and farmers' feed back during harvesting season.

Other plant protection activities included *Parthenium* weed management campaigns that were conducted from July through October 2003. All the institutes, offices and armed forces within Wangdue Dzongkhag were informed on the weeding campaigns vis-à-vis the ill effects of the weed on human health and the potential hazard to

agriculture and livestock in future. Plant protection staff were invited as guest speakers to Wangdue Middle Secondary School and Bajo Higher Secondary School to speak on *Parthenium* weed and its management.
A cardamom observation trial was established in farmers' field in Dagapela and Gesarling to determine if Golsey can resist wilt in wilt prone areas earlier planted with Ramsey. The seedlings were raised at sub centre Bhur and were disease free at the time of planting. Results will be collected on an annual basis through the concerned extension agent.

5.5.1 Chilli Blight Management Demonstration

Introduction
Several trials have been conducted in the past to study the effective control measures for chilli blight caused by the fungus *Phytophthora capsici. S*ince 1995, the disease has been reported from all chilli growing areas nationwide. Research findings have indicated and proven that chilli blight can be minimized through raised bed method combined with proper management practices such as proper drainage between the beds, bed height maintenance throughout the cropping season and regular weeding. Supplemented with timely and need based chemical (fungicide) application, the risk of chilli crop failure is further reduced.

However, very few farmers seem to implement the recommendations till date. To address this problem, an awareness campaigns on chilli blight management in chilli growing regions were conducted in collaboration NPPC, Semtokha & concerned Dzongkhags. One such awareness workshop was held at RC-Bajo on 20 August 2002 mainly to brief and inform Gups, Chimis and extension staff of Punakha and Wangdue Dzongkhags on citrus decline and chilli blight management. Research findings and information on citrus decline and chilli blight were presented by the researchers from NPPC and RC-Bajo during the workshop. After a lengthy discussion, it was resolved that NPPC in collaboration with RC-Bajo and agriculture sector of Punakha and Wangdue should conduct a large scale chilli blight managent demonstration in Punakha and Wangdue. It was also agreed that the area should be at least 1.5 langdos in each site representing wet and dry land conditions.

Therefore this demonstration was carried out in Wangdue and Punakha in 2003 cropping season with the following objectives.

To demonstrate that hitherto recommended raised bed package of practice is effective in managing chilli blight irrespective of micro-climate and location.
To make the Punakha-Wangdue valley farmers aware on the integrated management strategies required to reduce the chilli blight incidences and severity.
To study the economic analysis of growing chilli using integrated management methods.

Methodology

As indicated, the demonstration included two treatments. One treatment used all the recommended management package which comprised of raised bed, proper drainage, plant spacing and mulching supplemented by chemical (fungicide and insecticide) treatment at recommended crop stages or on appearance of first visible

disease symptoms. The other treatment included only the recommended management package without chemical treatments.

As per the criteria set by NPPC, site and seed sourcing/selections were done by RC-Bajo, concerned Dzongkhag extension agents, collaborator farmers and respective Gups. Appropriate sites 1.25 langdo in Punakha and 1.5 langdo in Wangdue were selected. A 1.5 langdo of paddy field was selected in Khawajara village, Dzomi geog, Punakha about an hour's drive from Bajo. While in Wangdue, Eto Nesa, Kazhi geog, a village with history of severe chilli blight incidences, was selected as the demonstration site.

Land Preparation
Land preparation in Khawajara was done more systematically than in Eto Nesa. The nursery area was mulched with dry matter after the paddy harvest. The mulch was burnt before ploughing. Prior to nursery raising, the earlier ploughed field was re-ploughed and the soil clods left to dry in the sun. The ploughed field was mulched again with straw. The straw was burnt and the fields irrigated immediately. Suphala and FYM were applied at farmer's rate and the fields ploughed again. A final ploughing was implemented to loosen the soil prior to bed preparation.

In Eto Nesa, two ploughings were done before bed preparation. No FYM or suphala was applied to the fields.

Bed Preparation
In both the sites, same method was used in bed preparation. Big soil clods were broken and leveled properly. Beds measuring 30cm high and 1.2m wide was prepared. The length of the bed was based on the breadth of the terrace. A 25-cm drain was kept between 2 beds. Proper leveling of the beds were done so that no depression were left in the nursery giving way for accumulation of water.

Seed treatment and sowing
Sha Ema chilli seeds were treated with fungicides before sowing. Copper oxychloride (2.5g) and Ridomil (2g) were dissolved in 250ml water and mixed thoroughly. The final volume of the chemical solution was adjusted to 500ml. This chemical mixture solution was used to treat chilli seeds in Khawajara only. While only Ridomil was used to treat the seeds at Eto Nesa.

For Khawajara, the chilli nursery was established on 31 January 2003 and for Eto Nesa 27 February 2003. Both treated and untreated beds were labeled for easy identification. At both the sites, the nursery beds were mulched with straw and leaf litters which were burnt just before seedling emergence following the local practice.

Nursery Maintenance
Nurseries in both the sites were appropriately maintained via timely weeding and need based irrigation.

In Khawajara, at least three weeding was done in the nursery at 21, 31 and 42 days after sowing. Irrigation was done through use of manual sprinklers as many as five times a day to reduce drying of moisture due to dry weather.

While in Eto Nesa, the nursery was fenced with bamboo mat to ward off chickens and domestic animals. At least two weeding was done at 44 and 57 days after sowing. The prevalent weeds recorded were *Rumex nepalensis, Sprengel persicaria, Equisetum diffusum* and *Galingsoga perviflora*.

Transplanting

Land Preparation
In Khawajara, at least 3 ploughings were done in the rice fields meant for chilli cultivation. The first ploughing was to ensure that the weeds and rice stubbles are properly dry before chilli transplanting. After second ploughing, FYM and Suphala @ 20kg for 1.5 langdo were applied. The third ploughing was done basically to break big soil clods. As the fields were accessible via road, power tillers were used to plough and rotovate the fields.

In Khawajara, two ploughings were done prior to transplanting. After the first ploughing FYM was applied at farmers' rate and mixed with the soil thoroughly during the second ploughing.

Bed Preparation
At both the sites at Khawajara and Eto Nesa, same method of bed preparation was followed. The transplanting area (1.5 langdo) was divided into two parts – approximately 1/3 and 2/3. The 2/3 area was demarcated for chemical treated seedlings and the other 1/3 area for non-treated seedlings. A buffer area of 1m was kept between treated seedling and untreated field to avoid chemical drift from one field to other. Beds of 1.2m wide and 30cm high were prepared while the length of the beds were based on field size. The beds were then leveled properly ensuring no depressions were left on the surface of the bed. A spacing of 30cm each was kept between beds for drainage which was maintained throughout the season through weeding and timely clearing of excess water and soil.

Seedling Treatment
The seedlings from treated nursery were dipped in Copper oxychloride (CoC) and Ridomil solution for 30 minutes. The solution was prepared using 2.5g CoC and 2g Ridomil in 1l of water. Seedlings lifted from untreated nursery were not subjected to chemical treatment.

Transplanting
To avoid transplanting shock due to heat of the sun, transplanting in both the sites were done in the afternoon. The fungicide treated seedlings were planted in the demarcated 2/3rd area and the untreated in the other 1/3rd area of the field. In each bed, 4 rows of seedlings were planted on the 1.2m wide bed, maintaining a spacing of 30cm row to row (RR) and 20cm plant to plant (PP).

Irrigation
In Khawajara, transplanted plants were watered using furrow irrigation technique. Individual plants were watered individually from the furrows using cans and mugs. It was ensured that the beds were not flooded with water. Any standing water was drained out right after the irrigation.

In Eto Nesa, plants were watered using cans and mugs after transplanting. As the site was on a slopy area, furrow irrigation was not possible. Irrigation was done using drinking water from a nearby tap for the next 5 days.

Weeding

Timely weeding was done under the supervision of the respective extension agents at both the sites. At Khawajara, the first weeding was done 32 days after transplanting (DAT) and mulched with FYM to suppress new weed growth as well as reduce the impact of rain drops besides supplementing nutrient to the soil. Additionally, rice field bunds were also cleared of weeds and the drains between beds weeded. However at Eto Nesa, mulching was implemented before weeding following the local practice. Mulching was done using FYM 11 DAT followed by first weeding 40 DAT. This weeding was followed by four subsequent weeding.

Chemical Application and other Operations

As recommended, first cover spray in Khawajara was done 7 DAT with Ridomil @ 2g/litre. The first spray was at least a week earlier than scheduled due to incessant rainfall in the locality. Due to concerns that weather conditions might favour disease development the first fungicide spray had to be implemented as a preventive measure. Subsequently the chilli plants were sprayed with contact insecticide Chloropyrifos @ 4ml/litre to control the cutworms that were causing damage to the plants. This was followed by another cover spray of CoC @ 2.5g/litre 25 DAT when a few symptoms (25% of the field) of foliar blight and alternaria spots were visible.

The first spraying of fungicide for Eto Nesa was done 12 DAT followed by second spraying 30 DAT with Ridomil @ 2g/litre. Due to continuous rainfall, Sandovit sticker was used with the fungicide to avoid the chemical from being washed by rain water.

Besides the chemical application, it was observed during anthesis that some of the plants especially in the chemical treated plots in Khawajara exhibited poor stunted growth. On suggestions from the Horticulture sector, RC-Bajo, urea top dressing was done 48 DAT. Cut worm damaged plants were replaced with healthy chilli seedlings treated appropriately at both the sites. At Eto Nesa, on the advice of the collaborator farmer, the demonstration site was fenced with bamboo mats to keep away domestic animals and chickens.

Harvesting

Harvesting was done jointly by the researchers, extension agent and farmers in both the sites respectively. During first harvest, field days for both the sites were conducted. At least 130 farmers including Gups, Mang Aps, Tshogpas and neighbouring farmers attended the field day on 7 th July 2003 conducted at Khawajara demonstration site. A total harvest of 1200 kg green chillies were harvested on the day. No separate crop cuts for chemical treated and untreated were made.

The field day coinciding with the first harvest for Eto Nesa chilli blight management demonstration was conducted on 26 August 2003 attended by 120 participants which included Gups, Mang Mi and Tshogpas from 13 geogs under Wangdue

Dzongkhag. The yields from crop cuts from chemical treated area (2/3 langdo) was 185.5kg green chilli while from the untreated was 143.5kg.

Results and Discussions

In general, chilli blight incidence was quite low during the 2003 cropping season in Khawajara. No blight or disease symptoms were observed in the nursery. After transplanting, few plants were observed to be infected with blight in the untreated plots. The infected plants were uprooted and destroyed by burning. In both the treated and untreated plots, leaf spots caused by *Alternaria spp.* were recorded. However most of the plants infected were suspected to be infected by *Rhizoctonia* sp. based on the isolation works done by NPPC.

Farmers & extension staff harvesting chilli during field day at Eto Nesa

Among others, few treated plots were observed to be stunted with reduced foliage resembling viral infections. But this conditions improved after application of urea 48 DAT as recommended by the Horticulture sector, RC-Bajo. Fruiting was heavy – on average 25 fruits per plant.

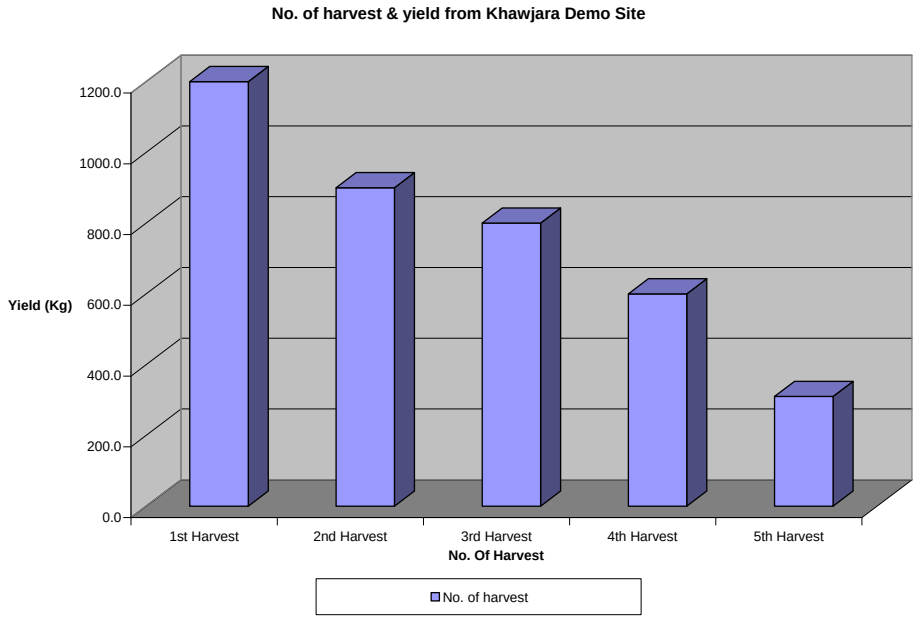


Figure 21 Number of chilli pickings & yield from Khawajara demonstration plot

Figure 32 shows the number of chilli harvest done by the farmer in Khawajara demonstration plot. No separate harvest from chemical treated and untreated was done as the owner had harvested and lumped the produce together. Each harvest

shows the combined harvest from both treated and untreated plots. A total of 5 harvest or pickings were done throughout the chilli season in Khawajara. The first harvest was done on 7 July 2003 which amounted to 1200kg or 1.2 t. Since the Khawajara demonstration site was able to produce green chillies earlier than other areas, the collaborator farmer was able to sell his produce in the local market without any difficulty. Economic analysis shows that Khawajara demonstration plot yielded 12,192 kg of chilli per acre for the cropping season. This could be attributed to the season during which the chilli was cultivated. The crops had already escaped the rainy season by the time last harvest was done. Besides there was heavy fruiting for each plant – 25-28 plants per plant. The cost of chilli production for Khawajara was Nu. 3.50/kg and the net profit was Nu. 62,892.80 for 1.25 langdo.

At Eto Nesa, about 100 plants were observed to be infected in the untreated plot compared to 8 plants in the treated plot. Most infection was through collar rot which was evident 7 DAT. Fruiting compared to Khawajara was low – on average 10 fruits per plant. The infected plants were uprooted and destroyed by burning. The farmer was briefed on the importance of removing infected plants and the reduction of inoculum source. The blight incidence was observed to be severe in the lower part of the demonstration field. It was later known that the part of the field was planted with chilli and brinjal in the preceding years. Hence this condition reinforces the need to practice crop rotation with non-host plants in reducing the inoculum level thereby reducing disease incidence and severity. The farmer was informed and instructed on the need to practise crop rotation to reduce disease incidence such as chilli blight.

Figure 34 indicates the number of chilli harvests and yield accrued from the Eto Nesa demonstration plot. Compared to Khawajara, the number of pickings (3) and yield (1233kg) were lower in Eto Nesa. This could be due to the weather conditions which favour disease development vis-à-vis the micro climate in the field. Almost 80% of the chilli growing season in Eto Nesa was predominated by rainfall. Hence there was a high probability of the disease outbreak due to favourable conditions. But this condition were offset by frequent disease surveillance and monitoring, rouging and destroying infected plants, timely weeding and chemical application. However the fruiting was not good compared to Khawajara in spite of good vegetation growth. Trying to compare chilli plants in neighbouring fields yielded the same observations. Hence the research group speculated that this could be a genetic problem since the same seedlings planted elsewhere had same growth pattern and vigour.

The collaborator farmer revealed that chilli during this season was meant for drying. Therefore they only harvest only once when the chillies were fully mature and red. The three harvests indicate that timely application of chemical can reduce disease incidence which means reduction in loss of chilli due to blight. In terms of yield, no significant difference in yield between the two treatment were observed. Average yield accrued for each treatment through economic analysis were 2.4 kg/acre for treated and 2.6 kg/acre for untreated. This indicates that if the recommended package of practice is implemented rigorously supplemented by timely monitoring for disease and pests, then chemical application may not be necessary. Looking at the harvest yield from treated plots, it is clear that the chemical application was economically not sustainable for the farmer in terms of time and money spent. If a farmer strictly implements the recommended package of practices, then the chilli

blight incidences is certainly going to reduce. The cost of chilli production for Eto Nesa was Nu. 12-13/kg with a net profit of Nu. 10,866.10 Ch for 1.5 langdo.

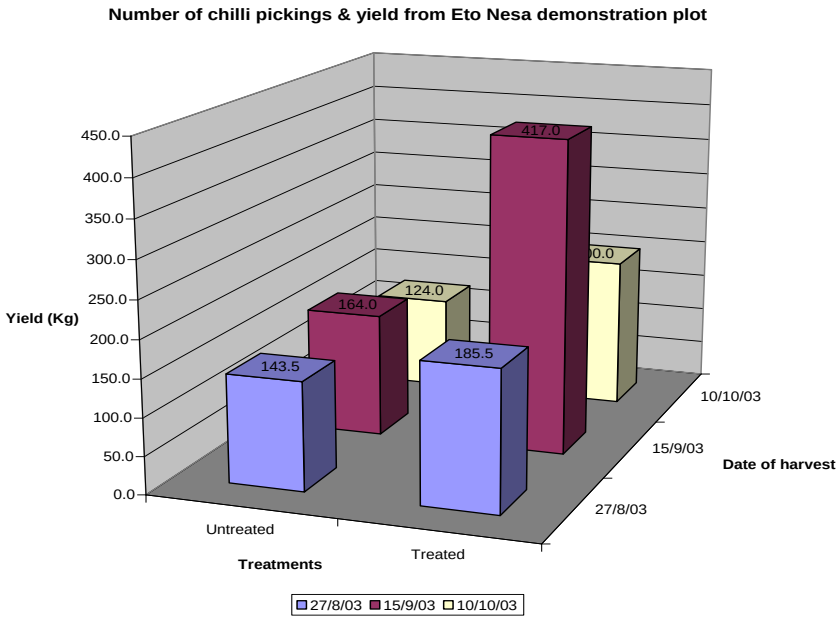


Figure 22 Number of chilli pickings & yield from Eto Nesa demonstration plot

Conclusion

The chilli blight management demonstration as planned and envisaged was very successful at the national and regional level. The objectives set were achieved as planned. This was evident from farmers' feedback session during the field days at both the sites. The farmers during the field days were able to see in person the chilli free of disease in the demonstration plot while the neighboring farmers had already lost their crops. They expressed that they were convinced that the recommended package of practice for chilli did reduce chilli blight incidences. Some even expressed their desire to practise it in their own farm in the subsequent cropping seasons. Some farmers even went to the extent of requesting seeds from the collaborator farmers. Both the field days were adequately covered by the media through Kuensel and Bhutan Broadcasting Service (BBS) through radio. Despite all the successes, there were constraints and lapses on the part of the collaborators in term of implementing the activities as spelled below.

The demonstration scale was too large to handle especially with many collaborators involved and overlapping responsibilities allocated. Research centre should not be involved in large scale demonstration as it is just a showcase of proven technology. Extension staff should be in a position to implement such demonstrations with need based technical backstopping from relevant institutions and research centres.

Economic analysis as envisioned may not be realistic under such circumstances where lot of collaborators are involved. Researchers and extensions' travel cost increased due to frequent monitoring of the demonstration plots as such may increase the input cost for the activity.

Such a demonstration is not a one time show. The extension staff in the geogs should try to constantly monitor the uptake of the technology by farmers in his geog and subsequently develop his strategy to upscale the use of recommended technologies.

5.5.2 Fruit Fly Management Study : Determining oviposition of *B. minax* though bagging and periodic exposure of fruits

The Chinese citrus fruit fly *Bactrocera minax* (Enderlein) is one of the most important pests of mandarin in Bhutan. Losses up to 80% due to premature ripening and subsequent fruit drop caused by the fruit fly has been reported from severly affected orchards in major mandarin growing areas in the southern part of the country. Research studies done till date lack pertinent information such as oviposition period of this fruit fly. Chinese citrus fruit fly oviposition period is instrumental in the implementation of control strategies. Based on this assumption, a trial was established to determine when the mandarin crop is at risk from the fly and requires through bagging studies.

Objective:

- To bag fruit and expose to determine the period of Oviposition
- To find out when the mean size reached the critical size for oviposition.

Methodology

130 mandarin branches were bagged in one of the severely fruit fly infested citrus orchard in Salami, Tsirang in May 2003 (late May –26th May). First set of 15 bagged branches were exposed on 2 June 2003. After 2 weeks, on 16 June 2003, the 15 earlier exposed branches were closed. When the fruits were exposed, eighty fruits were randomly selected on fortnightly interval and fruit size recorded. This was done for all the treatments. On the same day (16 June 2003), another set of 15 bagged branches were exposed for 2 weeks and then rebagged. This process was repeated for subsequent treaments, each bagging and exposure period representing. A set of 15 bagged branches were kept as control which werel not exposed at any period of the year. The bags were regularly monitored for tear and replaced immediately in case of damage. In all there were 8 treatments in the bagging & phenology study. All the bags were removed in October 2003 and examined for infestation.

Treatments

Treatment 1 =1st set of 15 bagged branches exposed on 2 June & closed on 16 June 2003
Treatment 2 = 2nd set of 15 bagged branches exposed on 16 June & closed on 30 June 2003
Treatment 3 = 15 bags opened on 30th June and closed on 14th July
Treatment 4 = 15 bags opened on 14th July and closed on 28th July
Treatment 5 = 15 bags opened on 28th July and closed on 11th August
Treatment 6 = 15 bags opened on 11th August and closed on 25th August

Treatment 7 = 15 bags opened on 25th August and closed on 8th September
Treatment 8 = 15 bagged branches kept as control (no exposure)

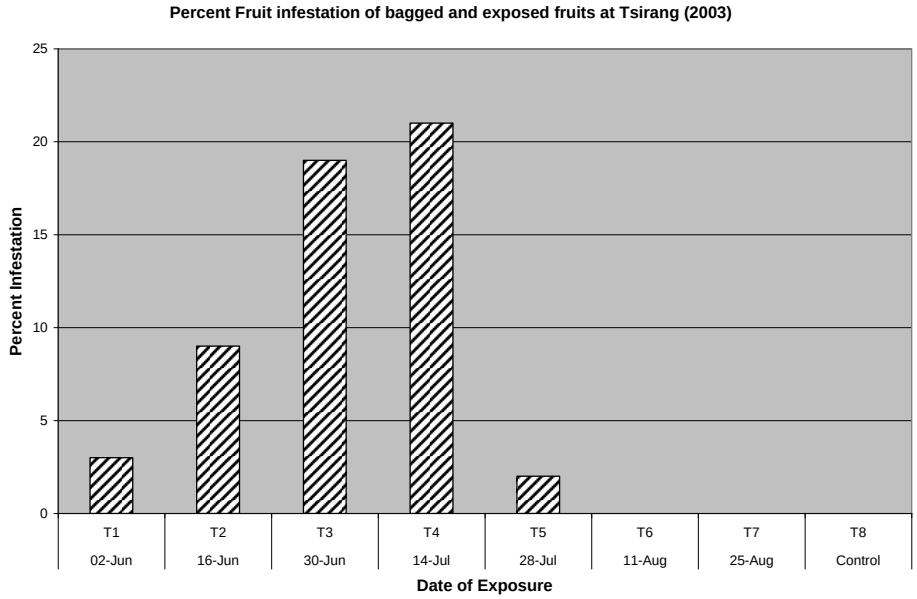


Figure 23 Percent fruit infestation of bagged and exposed mandarin fruits at Tsirang (2003)

Results and discussions

Fruits exposed during June and July were infested more than others. The highest infestation (21%) was recorded on 14th July followed by 19% on 30th June. On the contrary, no infestations were recorded in fruits exposed on 11th and 25th August. In general, the infestation was low which could be attributed to loss of infested fruits that had prematurely dropped. Another reason could be that bags rot and tore easily due to continuous rainfall causing fruits to drop out of the bags. These lost fruits would be unaccounted for.

Based on the infestation rate, oviposition period begins by early to mid June. Main oviposition period falls between mid June to July end based on the results (see figure). No infestations were recorded in august. Hence it can be concluded that infested fruits in August and September are those attacked by the fruit fly in June and July.

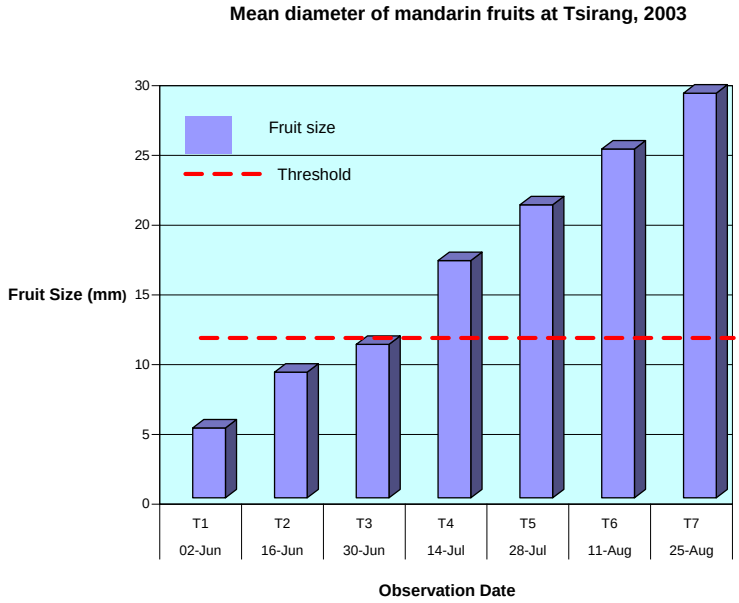


Figure 24 Mean diameter of mandarin fruits at Salami, Tsirang (2003)

Together with the bagging study, mean fruit size of mandarins were also observed. The critical stage for oviposition (11mm) was recorded on 30th June. On 2nd June, the mean fruit size was only 5mm; only 9% of the samples were equal to more than 11mm in diameter. Fruits became susceptible to the fruit fly only from mid to late June. Hence it can be concluded that fruit attain susceptible size (11mm) by mid June and by mid of July most of the fruits are susceptible to the fly.

Conclusions

Based on the field observations and results, it can be said that bagging of fruits protect the fruit adequately. This is evident from the control bags in which no fruits were infested by the fly. In Salami, Tsirang mandarin fruits are attacked by fruits by first week of June. But the main oviposition period is suspected to be after mid June till July end. This concurs with the population phenology studies which is clearly indicated by very low oviposition before mid June. The reasons for low oviposition could be either the fruit size were unsuitable due to small size (<11mm) or the flies were not sexually mature. Only towards end of June

An infested mandarin fruit dissected showing maggots

the fruits at Salami attained the critical size of 11mm. But larger fruits can become susceptible if the flies are sexually mature to oviposit.

Results analyzed so far indicate that the susceptible period for mandarin crop in Salami, Tsirang is about seven weeks starting mid June till July end. Based on this result, two cover sprays with Dimethoate 30EC – one before mid June and another in first week of July in orchards infested with fruit fly would be adequate to minimize the fly population and fruit infestation. This concurs with the recommendations made by NPPC to extension in 2002 (NPPC, 2002).

5.5.3 Shochum (*Potamogeton distinctus*) Management Campaign

Introduction

In continuation to the earlier weeding campaigns, *Shochum* weeding campaign was continued in the farmers' field in 2003. The intensive weeding was done in the same plots done in the preceding years. The weeding sites are in the Lingmuteychhu Watershed and Gaselo. Four farmers from the watershed and two farmers participated in the weeding campaign. The objectives of the weeding campaign is to create awareness among farmers on the rice yield loss due to *Shochum* and to sensitize farmers on timely and adequate number of hand weeding. The weeding campaign has been continuing for three cropping seasons so as to show to neighbouring farmers the effect of intensive hand weeding on *Shochum* pressure. As recommended, hand weeding was done twice in Gaselo and thrice in the watershed at 2, 4 and 6 WAT.

Field days for watershed weeding sites were conducted at harvest time during which the neighbouring farmers were invite to participate. Field days for Gaselo weeding sites could not be conducted due to logistic and manpower constraint. Like in the past, no extra labour were involved in weeding in Gaselo.

Results and Discussions

The weeding sites in the watershed have exhibited some interesting observations. Unlike 2 years ago, no weed flushes were observed in the test farmer's fields 2 WAT. This clearly shows the gradual reduction of *Shochum* pressure due to intensive hand weeding. As recommended, the collaborator farmer had to weed few *Shochum* flushes from the field. In Limbukha, *Shochum* pressure had reduced significantly over the last three years of intensive hand weeding. This was evident from a few weed flushes growing in the test field 2 WAT. Hence the farmer could weed the fields easily and in less time. Their feeling was that they may damage or uproot the rice plants during the first weeding with the less weed pressure.

Table 66 Comparative rice yield between intensively weeded and farmers' practice

Farmer	Village	Variety	Hand weeding	Normal Practice	Yield Diff.
			Yield T/ha	Yield T/ha	(T/ha)
Gomchen	Wangjokha	IR64	6.88	5.85	1.03
Kinley Dorji	Omtekha	Maap Phogom	5.55	4.35	1.2
Chhimi Rinzin	Limbukha	Yusiray Kaap	4.6	4.2	0.4
Draue	Thangu	Bonday	6.46	5.83	0.63

As given in the table above, each of the four farmers has his own preferred rice variety. Nevertheless, the effect of intensive hand weeding can be seen in yield difference. The highest yield difference was 1.03 t/ha and the lowest was 0.4 t/ha. Besides the difference in yield, the farmers were convinced by observing the difference in *Shochum* pressure intensity in the field.

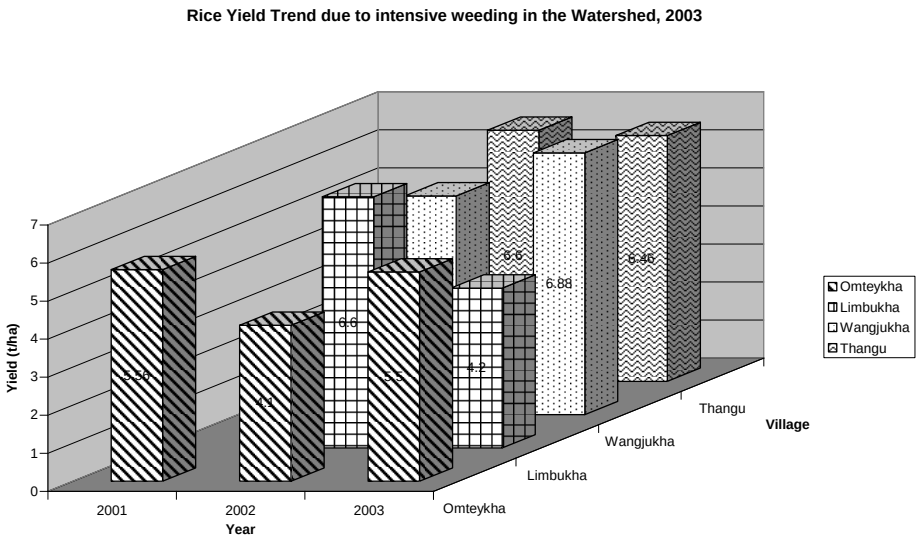


Figure 25 Rice Yield trend as affected by intensive Shochum weeding over three years

The *Shochum* campaign started with one site at Omtekha in 2001. As given in figure 38, the yield has almost remain constant for 2001 and 2003. The yield for 2002 is low because the 2nd weeding could not be implemented on time. It was delayed by almost 3 days vis-à-vis the farmer had changed the rice variety. For other 3 sites, the weeding campaign was started in 2002 only. Hence the data on record are for 2 years only. As such nothing concrete can be concluded from the data. The weeding campaign is expected to continue for few more years so that enough data can be analyzed to show the benefits of additional hand weeding.

Table 67 Comparative rice yield between intensively weeded and farmers' practice in Gaselo (2003)

Farmer	Village	Variety	Hand weeding	Normal Practice	Yield Difference
			Yield T/ha	Yield T/ha	(T/ha)
Rinzin Dorji	Drabchekha	Local Maap	5.4	4.25	1.15
Dorji Om	Changkha	Local Maap	5.50	3.33	2.17

Like in the watershed, the yield difference between hand weeded and farmers' practice was significant in Gaselo. In Changkha, the intensively weeded plot outyielded the farmer's normal practice method by 2.17 t/ha and in Drabchekha by

1.15 t/ha. However the yield trend for 1st years for Gaselo sites could not be synthesized due to variation in rice varieties and change of weeding sites.

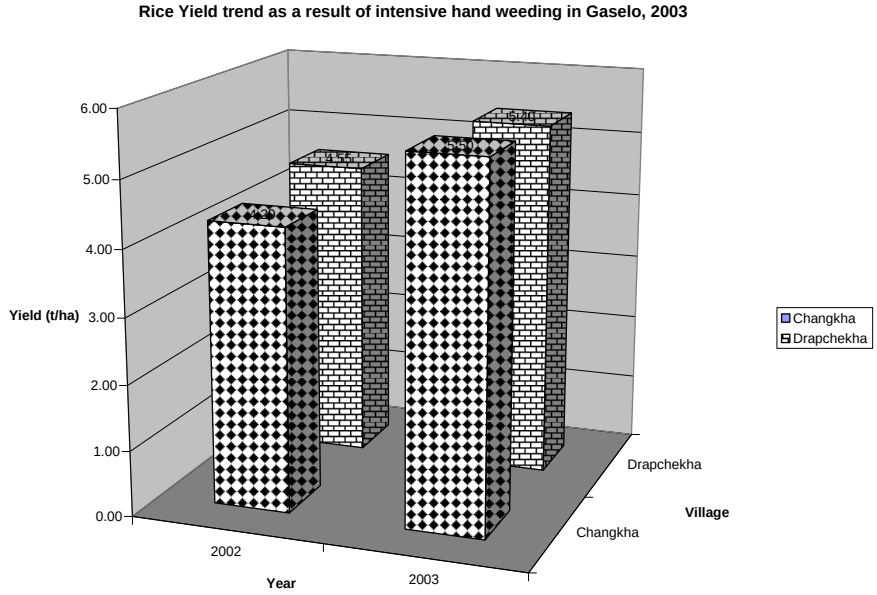


Figure 26 Rice yield trend as a result of intensive weeding in Gaselo (2003)

As given in figure 39, the rice yields for 2 sites (Changkha and Drapchekha) are for 2002 and 2003. The results for 2001 could not be included due to difference in varieties and change of weeding site. The 2003 rice yield data clearly indicate the increase in yield accrued due to intensive hand weeding. There was a yield increase of 1.21t and 0.85t per hectare for Changkha and Drapchekha respectively.

During crop cuts, the concerned extension agent and the collaborator farmer jointly harvested the crop. The collaborator farmers are convinced that intensive and timely hand weeding can reduce Shochum pressure.

Suggestions

Based on the three years of weeding awareness campaigns as well as farmers' feedbacks, it is known that farm labour shortage per se is the main constraint to timely weeding. A more rigorous participatory tool such as farmer field school (FFS) implemented elsewhere may come handy in convincing and developing the analytical skills of farmers. A possibility to incorporate FFS tool into future Shochum control campaigns should be explored.

Agriculture extension staff should be provided a training of trainers (ToT) if FFS is to be used in the weeding campaigns so that research need not intervene frequently in implementing weeding campaigns.

Shochum awareness campaigns should be implemented as a regular extension activity in areas where Shochum is a major problem. The activity should feature in their work plans.

5.5.4 Parthenium Weeding Campaigns

As a routine activity, the IPM sector also coordinated the *Parthenium* weeding campaigns from July through October 2003. Government institutions, offices, schools and armed forces in and around Wangdue were informed on the weeding campaigns and leaflets on *Parthenium* distributed. A few rubber hand gloves were also distributed to Bajo Higher Secondary High School and Wangdue Middle Secondary School to be used by individuals allergic to the weed.

As support to the schools, IPM sector staff also briefed the students and teachers on ill effects to human health and potential danger to agriculture and livestock in the near future. The WMSS adopted the Sunday Vegetable Market area for weeding campaign.

Likewise three rounds of weeding campaigns were conducted in and around the research farm area by the staff and national work force (NWF). As a precautionary measure not to spread the seeds over large areas, the uprooted weeds were destroyed by burning.

6 EXTENSION PROGRAM

6.1 Technology Packaging

A base line date collection and compilation of available research technologies concerning to RC Bajo was done and updated in the inventory (see annexure 1). The technologies ready for development of extension materials were categorized separately from the ones which are emerging. Both EPO and AEPO attended workshop on packaging and flow of extension materials at Yusipang, where the participants were made aware of the standard formatting and other procedures for technology packaging.

The sector packaged and published one technology (Maize trash line to minimize surface soil run off) from Farming system sector, one from horticulture sector (Apricot production), one from Field Crops sector and two from Forestry sector(Tsakusha (Thysanolaena latifolia): Propagation and Management and Tsenden (Cupressus corneyana): Propagation and Planting).

300 copies of "The technical guidelines for measuring crop yields in field crops" were printed and 220 copies were given to Department of Agriculture for further distribution to nation-wide RNR Extension centres. The other four extension leaflets; "Maize trash line to minimize surface soil run off", "Apricot production", "Tsakusha (Thysanolaena latifolia): Propagation and Management" and "Tsenden (Cupressus corneyana): Propagation and Planting" were printed distributed to all users of these technologies in the region.

Numbers of technologies from Field Crops sector are due for packaging and waiting for suitable picture to back up the technical explanations.

6.2 RNR Extension Agent's Study Tour

With the main focus to learn about the farmers group/organizations/cooperatives and in turn promote the same in the region, the sector has organized RNR Extension Agent's study tour for five days for 28 RNR extension agents from the region. The tour has covered the farmer's group/organizations/cooperatives in Bumthang, Trongsa and Wangdue Dzongkhags. The participants were briefed on advantages, disadvantages, history and some activities that were being carried out by the visited farmer's organizations. During this tour, extension staff have also visited RNR RC Bajo and Jakar research station and briefed about available and emerging technologies that are useful for extension. This study tour has made the EAs to understand the essence of farmer's organization and strengthen their knowledge in particular reference to technologies generated at Research stations of Jakar and Bajo. The participants were expected to replicate some of the relevant learning from this tour in their Dzongkhags.

6.3 National Irrigation Policy Training

The need to train agriculture extension agents on National Irrigation Policy (NIP) was felt after the shift of responsibility of irrigation activities from Dzongkhag Engineering

Cell to Dzongkhag Agriculture Sector. Responding to the need five days training was organized for all agriculture extension agents of Gasa, Punakha and Wangdue (total 40 EAs). All 10 modules of NIP along with practical field visits was covered and thoroughly taught with the expertise from DoA and financial support from BG SRDP and RNR ESP. With this training, all agriculture extension agents in the region have received training on NIP. This training would be recommended again only after 3-5 years after substantial numbers of EA have been accumulated with new appointments.

6.4 Establishment of Mushroom Enterprise with Dompola Savings Group

Dompola is one of the poor villages in Lingmeyteychu Watershed. Being resource poor and thus not having cash income, the village has started forming farmer's group with the support from RC Bajo and known themselves as Dompola Saving Group. Although they have nominal saving from their monthly contributions and others, the group had a plan to generate cash income by establishing mushroom enterprise at the beginning of their group formation in April 2002.

As a support to their plan of establishing mushroom enterprise, the sector has supported the group by sourcing fund from RNR ESP and organizing training and other technical backstopping. Five days hands-on-training on shitake mushroom cultivation was imparted to 14 interested members of Dompola Saving group with the help of expertise from National Mushroom Centre (NMC). In the training, each theoretical session was followed by practical session and entertained the discussion on some of the misunderstood topics. All in all the training has covered mushroom cultivation season, various substratum used, preparation billets, drilling of billets, spawning and waxing billets, incubation, watering, dipping, staking, forcing, growth stages, shed and tank construction, packing and processing etc.

Having completed the training, the group members established mushroom enterprise with total of 3696 billets. In order to spread the risk of failure, the 14 members were divided into four sub-groups and set up their incubation sheds at different locations (one at Dompola with 830 billets, one at Kunidingkha with 1030 billets, one at Yudungsha with 886 billets and one at Gumihoo with 850 billets). Each sub-group have constructed water tank for dipping billets after completion of 6 months incubation period. Now the incubation period is near completion and the groups have yet to start dipping and staking in the month of August, 2004.

While the group members have contributed labour and local materials such as bamboo mate, billets, and poles for shed construction and stones for tank construction, the RNR ESP has supported financially to purchase tarpauline, plastics, cements, pipes and training cost. Mycelium was provided through the generous support of NMC.

6.5 Farmers Group Formation Training at Limbukha

In line with the government policy of self-reliance and local institution development initiatives, which is within the broad framework of the Cooperative Act 2001, the earlier extension division of CoRE and extension wing of line departments have initiated and number of various Farmers' self-help groups are formed across the

country. Dompola farmers saving group is one of them which was formed by Extension Program Office of RNRRC Bajo in the year 2002. Featuring back to the success of the Dompola group formation, the next community Limbukha had shown dire interest and initiatives to form similar Self-help group. The need was routed through gewog extensionist working for the community and the request was made to RNRRC Bajo for necessary support.

Extension Program Office of RNRRC Bajo with the financial support from RNR ESP and BG SRDP (GTZ) has responded their request and given training to the community on farmer's group formation with general objective to promote group formation in the region as encouraged and importance stressed in the National policy of decentralization and MoA's policy on group formation. The other specific training objectives were:

- To introduce the concept of group formation to Limbukha community
- To provide awareness of Government policy on group formation
- To train participants on group formation process
- To improve numeric literacy
- To introduce basic banking and book keeping techniques and tools
- To develop by-laws and constitutions for the group
- To draw community action plan for starting of the saving scheme and future plan for sustaining it.

The methodology use for the training was through "adult learning" where; majority of the training course was done through group works, brainstorming, games and role-play. In order to meet the set objectives of training, it was divided into five modules, which are discussed below.

Opening session

The training was started informally after registration of the participants and it covered following:

- Introduction to the course was done through lecture
- Participant's expectation was done through brainstorming and using flash cards
- Workshop objectives was detailed through lecture and
- Scene setting to understand existing rural saving and credit mechanism was done through group work by looking at the trend on the subject for 10 years ago and in future.

Module one: Awareness on group formation

Module one has focused the participants to review, sensitize and create awareness on group formation. This module has covered the following topics:

- Why group formation? – The input to the farmers were provided through theory lecture and brainstorming exercise
- Concept of group was made understood to the farmers through exercise using a micro project exercise, where the farmers were asked to draw a dream house individually and later as a group and compare the results
- Government policy on group formation was briefed through lecture
- Micro finance benefit – Some group success stories from neighboring countries of India and Nepal were shared to the farmers through lecture

- Importance of leadership and spearhead committee was made understood to farmers through exercise using the group to carry the iron safe into the local lhakhang (temple) and later discussions was done on importance of leadership

Module two: Group formation process
In this module, participants were taught on Group formation process. It was designed to expose them step by step on group formation and covered all the steps.

Module three: Banking and Book keeping
This module has introduced the participants on the basic of Banking and Book keeping through presentation and demonstration on the introduction and using pass books and maintaining record registers. The detail course content under this module were:

- Introduction to record keeping and reporting – Done through demonstration and practical where the participants were given opportunities to fill the column demonstrated in the charts
- Using Pass Book
- Operating Saving Ledger
- Loan application procedures – Together with the participants, discussed and adopted the loan application procedure.

Module four: By-laws and constitution development
In this module, the participants were allowed to discuss in a group to develop and frame their own by laws and constitutions for conflict management in future while operationalizing the self-help group. The facilitator helped the discussions by raising facilitating questions related to development of by-laws and constitutions.

Module five: Envisioning and action planning

In this module, the participants were brainstormed on the envisioning of their group's future activities and based on the doable activities in the community by the group, emphasis was given on the activities planning for further implementation and came out with three main activities such as group marketing agriculture products, producing value added potatoes products and diversifying vegetable production.

6.6 Training on Minor Maintenance Repair of Farm Machinery

Labour shortage for agriculture farming is one national problem in our country. To alleviate this problem, RGOB responded by supplying substantial numbers of farm machineries to the farming communities in subsidized rate. Farmers of west-central region with no exception have received numbers of agriculture machineries and implements from Agriculture Machinery Centre. However, farmers are not capable of repairing and maintaining of these machineries in condition. Even for slight screw lose or very minor problem, they have no idea of what has happen to the machine or implement, and have to come to the Regional Agriculture Machinery Centre (RAMC) all the way from remote villages for consultation. In doing this, farmers are wasting lot of time and resources.

With the objective of alleviating the time and resource losses of farmers in coming to RAMC for consultancy of technical problems of their farm machineries, the sector has organized three days (3-5th March, 2004) at RNR RC Bajo with the help of expertise from Regional Agriculture Machinery Centre (RAMC), Bajo.

Although, 24 farmers from the regional Dzongkhags were targeted to train, only 14 farmers from Wangdue, Gasa and Punakha turned up for the training. Participants from Tsirang and Dagana could not reach for the training. Replacing the absentees, RC Bajo staff and labours who are involved in farm machineries have attended the training. During the training, repair and maintenance of power tiller, rice huller, oil expeller and other machineries were covered. These machines were also overhauled and step-by-step installation method was trained to the participating farmers.
The participants expressed their satisfaction on this successful training. They were expected to maintain their farm machineries in condition and able to make use of them properly. Besides, they were expected to act as focal persons in their community to further impart their learnings to other farmers who were not able accommodated in this training.

6.7 Pre-Regional Meetings

The idea of pre-regional meeting was conceived during the 5th RNR Conference and recognized in the Ministry of Agriculture as the part of annual planning process. This meeting was basically to generate input (farmer's problems, researchable issues, extension problems etc.) from the extension and report to Annual Review and planning Workshop (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 first time in the west-central region (WCR). The meeting was conducted five times in five regional Dzongkhags viz: Gasa, Punakha, Wangdue, Tsirang and Dagana with the participation of all the RNR Extension Agents and Dzongkhag RNR officials. Discussed and prioritized problems from pre-regional meetings were reported to ARWP for appraisal and accordingly incorporated in the Research-Extension Collaborative work plan of 2004-2005.

6.8 Annual Review and Planning Workshop

The most important activity to build linkage between Research and Extension is the annual feature of every RNR research centres to hold Annual Review and Planning Workshop. It is the osingle forum in the region where Researchers and Extensionists come together and deliberates important and pressing needs of the field in the presence of various stake holders such as central input agencies, Departmental representatives and representative from PPD. It is in this forum the research technologies are also being presented and disseminated.

This important workshop was organized by the sector with financial support from RNR ESP. For the first time in the history of WCR ARPW, five Gups were invited to this workshop to ensure that we develop plans reflective of the genuine needs of our farmers. Besides, representatives from line departments, central agencies, RNR

projects, research centres and regional dzongkhag RNR sector heads participated in the workshop.

Aside from the regular review and planning of collaborative activities, the workshops reviewed the annual geog plans and planning processes and reconciled it with the required support from the central programs and projects to enable smooth implementation of the planned geog/Dzongkhag activities for fiscal year 2004-05. Total of 17 resolutions and Research-Extension collaborative plans were endorsed as the out come of three days workshop.

7 TRAINING AND WORKSHOPS

Date	Name	Purpose
13th – 16th October 2003	Mahesh Ghimiray	International Rice conference, Alor Sector, Kedah, Malaysia.
13th – 22 October 2003	Thinley Gyamtsho	Training/workshop on multi-Agent system (MAS) social sciences & INRM from progress to
23rd – 26th November 2003	Thinley Gyamtsho	To participate in International Mountain Water summit in
1st – 11th December 2003	Mahesh Ghimiray	Training on DSSAT and GIS tools, held in Chiangmai University, Thailand
8th – 9th December 2003	Doley Tshering	
4th – 15th February 2004	Yonteen Gyamtsho & P.P Nepal	Study tour under the sponsorship of RNR-ESP, CORE, MoA, Thimphu at INdia
5th – 30th May 2004	Sangay Duba & Mahesh Ghimiray	IDRC, Workshop on CBNRM in Tagaytay, Philippines
26th April – 2nd July 2004	Sangay Wangdi	IPM Technology and Food Safety Training, IAC, Wageningen, the Netherlands.
19th June – 1st July 2004	Rinzin Dorji	Study tour to Indian Forest Research Institutes with SDC funding organized by the co-coordinating Research center Rc, Yusipang

8 VISITORS TO THE CENTRE

Date	Address & Name	Purpose
4/7/03	Mr. Harry Franks, European Co-Director	Discussion visit of the center
11/7/03	Mr. Diego (Milan)' RED Program	Discussion on organic farming
12/9/03	Ishwar Sunwar, Site Monitoring Specialist	Soil conservation activities
11/9/03	Lyonpo Sangay Ngedup and his entourage	Familiarisation visit to the center
14/9/03 – 17/9/03	Dr. William Padolina, Dy DG IRRI, Philippines	Consultative visit to the centre on IRRI support
18/9/03	Students & subject teacher of class X & Xl of Bajo High school	Economics study visit to the centre
20/9/03	Chien Yih Lin, Director, Agriculture Research Institute & Professor, National Chung- Hsing University, China, with Jong-Ching Su, Chiu-ya Wabg, Jei-Fu Shaw and Hsin Sheng Tsay	Familiarisation visit to the centre
23/9/03	AVM A.K. Tiwary, VSM.SDS (AIR), Faculty and staff members	Delegation from National Defense College, India
30/9/03	Patricia Goldey, Social Anthropology, Oxford Lecturer	Consultant GIS and Advisor of Phuntsho Namgyel, MoA
1/9/03	26 Farmers from Punakha and Wangdue Dzongkhag	Farmers field day organized through BUCAP
1/9/03	30 Informal Education Instructors	Learning visit
1/9/03	Nature club coordinator & students from Wangdue Jr. High School	Learning about agriculture and farming
14/10/03	Markus Schafer	Preparing for CBNRM Workshop
27/10/03	Mr. Hector Mckilligan, Team leader and other members	EU mission visit for monitoring
31/12/03	Science Lab Techncians of all schools	Learning and familiarisation visit to center
12-16/12/03	Dr. Hans Schreier and Dr. Doug henderson	Formulation of new project proposal
11/2/04	A group of farmers from Tongsa dzongkhag	Feed and Fodder briefing by Livestock sector
16/2/04	**His Majesty the King of Bhutan with Her Majesty Queen Ashi Dorji Wangmo Wangchuk and HRH Dasho Jigme Gesar Namgyel Wangchuck and Dasho Jigyel Wangchuck**	Royal visit of the centre
16-19/3/04	Mr Sherab Gyeltshen, Director DOA	Attend 6th Field Crops Coordination workshop held at RNRRC, Bajo
23/3/04	Forestry Trainees and Instructors	Familiarization tour
27/3/04	Hon'ble Lyonpo Sangay Ngedup, Ministry of Agriculture	Meeting with RNR Officials based in Wangue Dzongkhag
12/4/04	His Royal Highness, Prince of Thailand	Ngizorgang Watershed

	along with delegates	Management proposal discussion
25/4/04 – 30/4/04	Mr. Jojo Lapitan and Mr. Joe Rickman from IRRI	Jojo to conduct training on Project Management for RNR staff Mr Rickman as consultant on rice post-harvest
26/4/04	Alexander G. Flor, Dean & Professor, Open University of the Philippines	Consultant for ICT Master plan
15/5/04	BSC Students of Sherubtse College, Kanglung	See and learn about Agri Research activities
20/5/04	Farmers from Pemagasel and Chhukha	RNR Research activities
21/5/04	Farmers from Haa and Paro	RNR research activities
26/5/04	Students of Sarpang School	RNR research activities
31/5/04	Economics students from Sherubtse college	Familiarisation tour
18/6/04	Dr. Yoshio Yamamoto, Prof. Emeritus, Hiroshima University, Dr/ Koh Nomura, Laborator of Animal Genetics & Breeding Department of Zootechnical Science, Tokyo University of Agriculture	Familiarisation visit
23/6/04	Jean Marie Bompard, Forest Botanist, France	Consultant for Aromatic plants
9/7/04	C.P Ramam, Food Security & Storage consultant, IGMRI, India	Consultant of DoA on maize storage
14/7/04	Dr. Zbigniew Mikolaju, ICIMOD	To explore the possibility of regional linkages on ICT for food/NRM
28/7/04	School Agri Teachers from different schools	Learning about school agriculture program.

9 EXPENDITURE STATEMENT FOR 2003-2004

RGOB Contribution

Object code	Object Classification	Amount in (Nu)
1.01	Personnel Emoluments	3.609
2.01	Other Personnel Emolument	1.199
11.01	Travel	2.000
12.01	Utilities. Tele,Fax,Email Internet	0.120
12.02	Utilities.Telegram,W/T,Postage	0.020
12.03	Utilities,Electricity,Water	0.050
14.01	S&M. Office Supplies	0.080
14.03	S&M. Fertilizer,Chemicals	0.080
14.04	S&M. Seeds & Seedlings	0.030
14.06	S&M. Uniforms,Extension, Kits	0.070
14.07	S&M. Textbooks, Stationeries	0.015
14.08	S&M. Others	0.050
15.01	MoP. Buildings	0.040
15.02	MoP. Vehicles	0.550
15.05	MoP. Equipment	0.125
15.06	MoP. Agro. Plantation	0.030
15.07	MoP. Computers	0.035
17.03	Opt. Expenses Transportation	0.020
17.04	Opt.Exp.Energy/Propulation chg.	
24.03	Cont.Provident Fund	0.269
51.08	Exp. On Structure Others(const.of boundary wall at RC Bajo)	0.727
TOTAL		**9.119**

IDRC Contribution

Object code	Object Classification	Amount in (Nu)
12.01	Utilities. Tele,Fax,Email Internet	0.061
12.02	Utilities.Telegram,W/T,Postage	0.003
12.03	Utilities,Electricity,Water	0.014
14.01	S&M. Office Supplies	0.085
14.04	S&M. Seeds & Seedlings	0.005
14.07	S&M. Textbooks, Stationeries	0.025
45.01	Training -Human Resource Training	0.482
52.08	Plant & Equipment	0.105
53.01	Purchase of Vehicle	0.800
54.01	Furniture	0.028
54.03	Computers & Peripherials	0.135
55.01	Professional Services	0.125
TOTAL		**1.868**

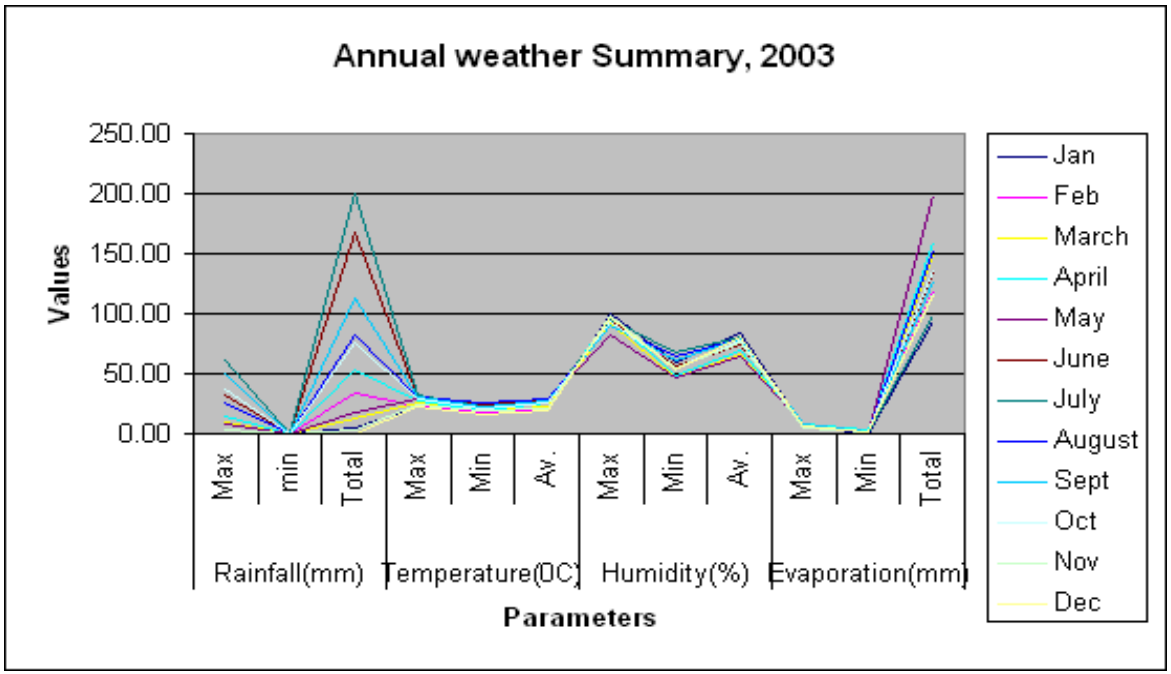
SDC/Helvatas Contribution

Object code	Object Classification	Amount in (Nu)
14.08	S&M. Others	0.020
15.05	MoP. Equipment	0.030
15.07	MoP. Computers	0.023
17.01	Opt. Expenses Advertisement	0.030
17.07	Opt.Exp.Others	0.100
45.01	Training Others(W/shop/Seminars)	0.099
52.08	Plant & Equipment	0.377
53.01	Purchase of Vehicle	0.185
54.02	Office Equipment	0.299
54.01	Furniture	0.093
54.03	Computers & Peripherials	0.019
TOTAL		**1.275**

10 ANNUAL WEATHER SUMMARY

Annual Weather Summary of RNR-RC, Bajo for 2003

Month	Rainfall(mm)			Temperature(^{0}C)			Humidity(%)			Evaporation(mm)		
	Max	min	Total	Max	Min	Av.	Max	Min	Av.	Max	Min	Total
Jan	3.50	0.00	5.00	23.00	16.70	19.50	100.00	60.00	83.20	6.40	0.00	93.90
Feb	15.00	0.00	33.50	22.00	17.00	19.40	97.00	56.00	74.40	8.40	2.00	118.60
March	10.20	0.00	13.60	26.20	18.70	22.00	92.00	47.00	66.30	8.40	2.20	150.00
April	15.20	0.00	52.80	28.20	19.50	25.20	97.00	48.00	69.70	8.40	2.80	159.30
May	8.40	0.00	18.20	29.20	22.50	26.90	83.00	46.00	63.90	8.50	2.10	199.10
June	33.00	0.00	167.50	31.20	24.70	28.20	95.00	56.00	74.70	8.40	1.30	135.80
July	60.60	0.00	199.50	31.50	23.10	27.20	95.00	67.00	81.10	6.40	1.20	99.00
August	25.40	0.00	82.10	31.10	25.40	28.80	91.00	64.00	79.40	8.40	2.20	153.00
Sept	50.60	0.00	112.50	30.10	22.20	27.40	90.00	62.00	79.10	8.40	2.10	127.40
Oct	36.60	0.00	76.30	29.20	20.70	25.40	94.00	55.00	76.80	6.40	2.20	137.30
Nov	3.40	0.00	3.40	24.90	19.20	21.60	98.00	55.00	76.20	4.90	2.20	118.40
Dec	0.00	0.00	0.00	22.70	16.20	20.00	97.00	53.00	80.00	6.40	2.20	116.90


Annual weather Summary, 2003
250.00
200.00
150.00
100.00
50.00
0.00
Values
Max
min
Total
Max
Min
Av.
Max
Min
Av.
Max
Min
Total
Rainfall(mm)
Temperature(0C)
Humidity(%)
Evaporation(mm)
Parameters
Jan
Feb
March
April
May
June
July
August
Sept
Oct
Nov
Dec