ABOUT THIS REPORT

This is the 18th 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 Programme 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 Programme Officer
FFS	Farmer Field School
FLW	Flowering
FYM	Farmyard manure
gm	gram
ha	hectare
P.ht.	Plant Height
ICRISAT	International Crops research Institute for the Semi-Arid Tropics
ICARDA	International Centre for Agricultural Research in the Dry Areas
IDRC	International Development Research Institute
IET	Initial Evaluation Trial
IPM	Integrated Pest Management
IPNS	International Plant Nutrient Study
IRRI	International Rice Research Institute
K	Potassium
LSD	least significant difference
m	meter
MAT	maturity
MoA	Ministry of Agriculture
MP	Murate of Potash
MPTS	Multipurpose Tree Species
N	Nitrogen
NASEPP	National Seed and Plant Program
NPPC	National Plant Protection Centre
No.	Number
n.s.	Not significant
P	Phosphorus
PET	Production Evaluation Trial
PRET	Pre-production evaluation trial
RCB	Randomised complete block
RGOB	Royal Government of Bhutan
RNRRC	Renewable Natural Resources Research Centre
s.e.	Standard error
S.E.D.	Standard error of difference
sqm.	Square meter
SSP	Single Super Phosphate

EXECUTIVE SUMMARY

FIELD CROPS

Field crops research aims to increase and sustain the productivity of cereals (rice, maize, wheat, and minor cereals), oilseeds (rapeseed-mustard) and grain legumes (mungbeans, groundnut, soybeans) in the long run. The short-term objectives are to identify, adapt or develop appropriate and affordable technologies, including varieties, for optimising the production of field crops.

Research on rice attempts to improve rice production using appropriate varieties and production management techniques. The general aim of rice variety trials is to identify suitable varieties with high yield potential, medium height, medium maturity (120-150 days) and resistance to prevailing pest and diseases. In AET, 19 entries including checks were tested. Several test lines yielded significantly lower than the check varieties Bajo Kaap 1 (8.38 ±0.41 t/ha), Bajo Maap 1 (7.76 ±0.41 t/ha) and IR 64 (7.64 ±0.41 t/ha) but higher than the local Zakha (5.83 ±0.41 t/ha). IR64683-87-2-2-3-3, GUOJING 4 and SPR 87036 SPR 87036-7-1-1-2 gave yield comparable to above standard checks with a mean plant height of 102 ±3.46 cm and maturity days of 118 ±1 days. The IET was composed of 22 breeding lines and introductions aimed to identify high yielding varieties for further evaluation. Analysis showed that several test varieties produced significantly higher grain yields than Zakha. Highest yielders were RP 2233-10-16-9 and B2983B-SR-85-3-2-4 (7.38 ±1.11 t/ha) but were comparable to Bajo Kaap 2 with a mean yield of 7.32 ±1.11 t/ha. The days to 50% flowering ranged from 108 to 139 ±1.28) days. The selections from this trial will be further evaluated.

The Observation Nursery consisted of 86 introductions from the IRRI-INGER program. Observed grain yield ranged from 2.5- 9.03 t/ha; plant height 77- 131 cm and 50% flowering of 108-139 days. Some lines from Nepal were also evaluated. Selected entries based on selection criteria such as plant vigor, maturity and height, grain yield and panicle types and general performance will be further assessed.

The on-farm trials consisted of the evaluation of varieties for mid-altitudes in Tsirang and Dagana. IR-62467-B-R-4-1 performed well compared to the locals. Besides this, BUCAP activities were implemented on-station, in Thedso and in Guenshari geogs.

In other cereals (wheat, oilseeds), not much evaluation work could be carried out due to shortage of new test materials. Basic agronomic work on the released varieties has already been done. There is a dire need to explore sources of new test materials. Research on crop production management continued with the evaluation of a combination of organics and Effective Micro-organisms (EM) in cereals.

HORTICULTURE

The main objective of horticulture research in RNRRC-Bajo is to improve the quality and yield of vegetables, nut crops, low chilled temperate fruits and subtropical fruits through introduction and diversification of these crops, with emphasis on high value crops that would improve both nutritional standards and cash income of farming community. These

objectives can be realized through the introduction and evaluation of exotic horticultural species besides the evaluation and improvement of local germplasm. Production management (crop establishment, pest control, nutrient management), crop rotation, intercropping, kitchen gardening and homestead orchard and demonstration orchard development are also given adequate research attention.

Setting research priorities and outlining clear strategies have been the essential elements of the horticulture research in the West Central region. On-station and on-farm-client-oriented participatory horticultural research are key approaches being adopted by the center. Besides collection of local and exotic germplasm for screening outstanding cultivars and establishment of orchards for demonstration and training purposes in the research centre, emphasis is also given to on-farm research and participatory evaluation of horticultural crops. Depending upon the ecological feasibility and distance from the market outlet, RNR-RC Bajo has a focus on cash crops like vegetables, citrus, grapes, crops that are non-perishable in nature such as nut crops and other sub-tropical and low chill temperate fruits crops.

The research activities for the sector have been developed in line with the 9FYP document of Ministry of Agriculture (MOA) and collaborative activities with regional Dzongkhags. The highlights on the research and developmental activities being carried out by this centre in the field of horticulture in 2002-2003 are as follows:

- Varietal Improvement of subtropical fruits, low chilled temperate fruits, nuts and vegetables
- Production management and post-harvest study of subtropical fruits, low chilled temperate fruits, nuts and vegetables
- Development of propagation technique of subtropical fruits, low chilled temperate fruits and nuts
- Vegetable breeders seeds maintenance and production of released crop cultivars
- Maintenance of mother plants of newly released fruits cultivars
- Identified 1 orange and 2 mandarin, 1 lime, 1 peach, 2 almond, 2 grape cultivars for release and general cultivation and few walnut promising cultivars for further evaluation.
- Leaflets on apricot (newly release Bajokhamchu-1), tomato (Bajolambenda-1), chilli production with emphasis on chilli blight management, vegetable seed production, walnut propagation, persimmon air drying and marketing and mango production are in the process of production.

LIVESTOCK

The livestock research program started in the region with the inception of RNR Research programs in 1995. However, the livestock program remained focused mainly on feed and fodder research owing to the critical problem of feed shortages of cattle owners in the region. Research program gained progress in initiating fodder trials both on-station and on-farm as a demand driven research program in solving farmers' immediate problem of winter fodder shortages in the rice-based system. In the wetland areas, though cropping intensity has increased, the fodder situation has not improved. The introduction of some popular winter fodder species like Oat, winter legumes like Vetch, Desmodium species, Fodder Peanut and maximize a usage of paddy straw with green fodder has over-come this problem to some extent. It has become very apparent that winter fodder shortage is critical in the region that limit livestock production. The situation might worsen further

with increasing livestock population and the Bhutanese religious sentiments attached to culling unproductive animals.

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. Efforts continue to have better understanding of the system. 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 of the major constraints are inadequate suitable feed/ fodder crops to meet the increasing requirements, lack of appropriate fodder production techniques, lack on fodder resources, 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 focuses and 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 the year, there were 16 activities of which 6 were new and 9 were ongoing. These activities were both regional in nature and nationally coordinated. From these activities, 9 were on- station and 7 were on- farm collaborative trials. Out of these, 13 activities were on feed and fodder and 3 were on breeding and management. During the year, 4 activities were reported, as completed and 12 activities are ongoing for further evaluation and assessment. Over the years, the livestock research has expanded to cover-up activities under the sub-program breeding and management also. Recent changes that have taken place are initiating breeding and management activities, apiculture practices at the centre, nationwide pig and poultry genetic resources survey and on- farm poultry hatchability trials. About 60% of the activities related to both feed and fodder and breeding and management have been implemented in collaboration with Dzongkhag extension staff in the farmers' fields.

FORESTRY

The forestry sector's main focus was on social forestry research, with emphasis and initiatives into the mainstream forestry research, collaborative research and other activities. Land degradation due to soil erosion and lack of tree resources were clearly identified as among the major constraints by the diagnostic survey of 1997. Accordingly rehabilitation of degraded areas through community forest plantations and handing over of natural forest as community forests were priority areas to be addressed by the forestry group.

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.

For the purpose of handing over the natural forest in the watershed to the local communities as community forest a number of activities have been implemented to elicit local communities' perceptions and aspirations and assess resource in terms of quality, boundary and quantity. These include participatory forest management for local use, permanent resource monitoring plots, rapid silvicultural assessment and forest function mapping.

At the station, the sector maintained a multipurpose tree species nursery 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 for further screening.

SYSTEM RESOURCE MANAGEMENT

Community Based Natural Resources Management (CBNRM)

The CBNRM research consisted of cross-sectoral on-farm trials and other related activities conducted in participation with the farmers of Lingmuteychhu watershed, where CBNRM has been piloted since 1997. This section of the report concentrate more towards the improvement of farmers' livelihood through the use of improved agricultural technologies through participatory approaches.

Two best rice line selections (PP3-31-2-1 and PP4-8-1-1) from previous year were tested. PP3- and PP4- lines have high yielding potential and are now adopted and cultivated in small-scale by farmers. The seeds of the test varieties are saved and exchanged within the villages. *Sochum* (*Potamogeton distinctus*) hand weeding campaign was also continued this year with the same farmers. For evaluating the performance of groundnut varieties at farmers' management conditions, small seed packets of two cultivars (*Kadari* and *ICGV_87920*) were distributed to 13 farmers of Nabchhey during the year.

Planting of fruit plants, monitoring and data gathering from the demonstration orchard was continued. During the year, additional 7 grafted pear seedlings of 5 different cultivars were planted increasing the total number of plants to 117. Activities on improving the farmer's backyard fruit cultivation, and farmers training on fruit propagation were continued. A walnut plantation activity was started in the watershed. A private horticulture nursery was also established at Omteykha village with technical support from the research centre. The farmer co operator was trained on the basics of nursery raising last year in the centre.

The committee members of the breeding bull management group have changed with new appointees, still retaining the old bull keeper. The bull is very healthy as the community continued providing maintenance ration on rotation basis. The production performance of the bull is recorded well. The committee had extended cross breeding activity beyond the community on payment basis. Fodder grass and legume species were planted along the contour maize trash lines at Nabchhey as additional source of fodder, for controlling soil erosion and stabilization of the trash lines.

Integrated Plant Nutrient System (IPNS)

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

Survey on the farmers' management and use of FYM (farmyard manure) was conducted in the Limbuteychhu watershed. The general aim of this study was to obtain a better understanding of the existing FYM management and use practices. The survey comprised of farmer interviews; field measurements, sample collection and lab analysis and it lasted for one and half years. Result showed that there was a significant difference in FYM quality between sampled villages and FYM quantity is a factor of labour and number of cattle heads a farmhouse owns. Nutrient budget analysis revealed that there was great imbalance in the present practice of farmers' soil nutrient management and most of the fields in the sampled villages are depleted of most nutrients.

A number of balanced fertilizer trials were conducted both in and outside the watershed with the aim to improve farmers' practice of fertilizer uses, to disseminate research recommended practices and to let farmers know the cost- benefit of using fertilizers at farm level and its implication on soil resources in the long run. Different approaches such as Farmer Field School and individual farmer cooperators were used. In general the result showed that rice yield could be improved greatly by following research recommended fertilizer practice. The limitation in adoption of the research recommendation was that of farmer's affordability of the fertilizers, which was a concern for all cooperating farmers. However, the result also suggested that, there was a good potential to substantially improve the rice yields and profitability by simply improving the use of urea that farmers are already applying in a single application.

A simple technology called maize trash line to minimize surface soil run-off was demonstrated in Nabji aiming to make use of locally available resources such as maize stalks to minimize the loss of soil. An A-frame was used for determining the contour lines and farmers were trained how to handle it. Three years' soil accumulation behind the trash lines had raised bunds of 1-meter height. Number of cooperating farmers has also increased from one to 12. Farmers commented that this technology was farmer friendly and inexpensive. The outcomes of the specific technical interventions suggested that farmers are interested to expand or try again these interventions and most of them saved their own seeds of the tested crops.

Integrated Pest Management

The period July 2002 – June 2003 saw IPM sector providing need-based technical plant protection services to the client Dzongkhags through field visits, disease-pest verification, surveillance and monitoring of rice blast and citrus greening disease vis-à-vis surveillance of psyllid vector. Major research activities included chilli blight management trial, long term *Shochum* management trial, S*hochum* Control Awareness Campaign, *Parthenium* weed control campaign and citrus fruit fly study. Additionally *ad hoc* activities were also taken up, viz. cardamom survey in Tsirang and Dagana Dzongkhag coordinated by RNR-RC, Jakar. A rapid survey on prevalence of citrus greening disease/Citrus Huanglongbing (HLB) was conducted in Tsirang and Dagana. Subsequent to one-day training for extension staff, citrus leaf samples were collected from HLB suspected orchards in Tsirang and Dagana for diagnosis of citrus HLB via polymerase chain reaction (PCR) test. The sector provided training on chilli blight management and rice blast control to farmers of Dangchu and agriculture extension staff on the request of Agriculture Sector, Wangdue Dzongkhag administration. As a routine activity, the sector also coordinated at least four rounds of Parthenium weed campaign within the research farm and residential area. Concurrently local agencies and institutes within Wangdue and Punakha Dzongkhag

were informed on the campaign. On the request of Nature Club, the sector also briefed the students of Wangdue Middle Secondary School on Parthenium weed and its ill effects on health and available control methods. Rubber hand gloves and coloured leaflets were distributed to the schools and Hesothangka government workshop as a support towards the campaign.

Agricultural Economics

In rice research, improved varieties have been released for promotion in farmers' field after rigorous evaluation. Through the initiation of this program, there had been an increase in rice production in the country increasing food self-sufficiency both locally and nationally. To have a holistic view of rice research impact in the country, an impact assessment study was done nation wide in 2002.The objectives were to study and document number of modern varieties released, extent of adoption, adoption of crop management practices, magnitude of yield difference, increase in value of production, increase in net income and other aspects.

The sample Dzongkhags and Gewogs for the survey were selected based on rice producing areas in Bhutan covering different AEZ. The data were collected using structured questionnaires from 2 Dzongkhags in the low altitude, 4 Dzongkhags in the medium altitude and 4 Dzongkhags in the high altitude. The survey data are being processed, the detailed nation-wide results are not available yet for reporting. The regional impact assessment on rice was a part of the national impact assessment survey; data were analysed and assessed for two Dzongkhags of Wangdue and Punakha. Data show that the popular varieties adopted in these Dzongkhags are IR 64, IR20913, No. 11, Bajo Maap 1 and 2, Bajo Kaap 1 and 2, and Khangma Maap. It was also found out that majority of the farmers practise growing both modern and traditional varieties of rice. The survey result showed that Bajo Kaap had the highest yield of 4.82 t/ha followed by Khangma Maap at 4.60 t/ha. The survey also tried to address area of adoption for different varieties, yield levels and adoption of improved managements practices. Looking at the surplus and deficit of rice at household level, the survey result indicated that only 25% of the surveyed household were deficit in rice. A survey was also undertaken extensively aimed to get more clearer and conclusive picture on economics of rice production in the different Dzongkhags and for agro-ecological zones. Detailed analysis is not completed yet.

Water Management Research (WMR)

The Water Management Research started in 1997 as a Water Management Research Project with support from SNV and became part of the RNR Research System by 2000. In the initial years good progress was made in the field of water management research. Lately the WMR team is struggling to keep the same momentum due to staff shortage. Besides carrying out the mandated research activities WMR team also oversees civil engineering works that demand major staff time.

This annual report provides a full report on Stabilisation of Gully in Dompola while it highlights on the activities that are on going. Full report on other activities will be reported once the trials are completed. The gully study provided some background and understanding to the irrigation system that had existed since time immemorial. The

irrigation system, needed gully stabilization work was important for continuous use for the future.

Rainfall and stream gauging data collection activity had been started since 1998 mainly to determine water balance study in the watershed and for assessing water shortage scenario. Old MS Flumes needed replacement in most of the irrigation schemes in the watershed to avoid high risk of soil erosion and landslides besides lowering the conveyance efficiency of the irrigation canals.

Citrus irrigation scheduling trial had been established in Bichgoun in Tsirang, Gelephu and Dakpai in Shemgang for assessing the benefit of irrigation. On-station direct seeding trial for rice had been started from 2002 season. The main objective of this trial was to study the advantages of direct seeding compared to delayed transplanting due to irrigation water shortage problem. Results will be reported after conclusion of the study.

Extension Programme

The change of staff and restructuring within the Ministry affected the completion of programs of EPO. The change in roles for EPOs as a result of restructuring annulled some of the planned activities. The Office provided technical support to Dzongkhags by visiting Gogona, Shelly, Jala and Khotokha centre along with ADLO of Wangduephodrang Dzongkhag; co-coordinated study tours for RNR extension agents; and coordinated 9th Annual Regional Review and Planning Workshop. Farmers' field day was organised at RC Bajo for making the farmers aware of new and emerging technologies, where 25 farmers participated from Wangdue Dzongkhag. This field day also served as demonstration to the farmers for carrying out some of the management aspects of new and emerging technologies.

FIELD CROPS RESEARCH

1 FIELD CROPS RESEARCH

1.1 Variety Improvement

1.1.1 Advanced Evaluation Trial (AET)

In 2002, AET consisted of 19 lines including local checks and standard varieties. The objective of the trial was to identify suitable varieties with high yield potential, medium height, optimum maturity and pest resistance for mid-altitude rice valleys. The trial was laid out in randomized complete block design with three replications. Seedlings were transplanted in 10 sqm plots at 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. Butachlor 5G was applied at the rate of 1.5 kg a.i./ha in order to control the weed. Hand weeding was done whenever necessary. Grain yield was estimated from a harvest area of 5.04 sqm and grain moisture content was standardized at 14%. Standard and local checks were used for comparison. Results are in Table 1.

The varieties were found to give significantly different yields. Several test lines yielded significantly lower than the check varieties Bajo Kaap 1 (8.38 ±0.41 t/ha), Bajo Maap 1 (7.76 ±0.41 t/ha) and IR 64 (7.64 ±0.41 t/ha) but higher than the local Zakha (5.83 ±0.41 t/ha). IR64683-87-2-2-3-3, GUOJING 4 and SPR 87036 SPR 87036-7-1-1-2 gave the yield comparable to above standard checks with a mean plant height of 102 ±3.46 cm and maturity days of 118 ±1 days. Occurrence of insect pest and diseases was negligible. The best performers, with significant yield difference from local check and suitable maturity and plant height, from this trial will be advanced for evaluation in the farmers' field in the ensuing season.

Table 1: Yield and agronomic traits of entries in AET, 2002

Variety	50% FLW days	P.ht cm	Yield t/ha
Bajo Kaap 1	113	101	8.38
Bajo Maap 1	122	107	7.76
IR 64	115	103	7.64
IR 64683-87-2-2-3-3	117	99	7.53
GUOJING 4	115	100	7.45
SPR 87036-7-1-1-2	122	108	7.36
Bajo Kaap 2	119	96	7.35
CNAX 4506-3-2-2-1-B	121	97	6.91
UPR 84-21	122	97	6.89
IR 62745-B-R-B-20-1-B	109	137	6.86
ZHONGYO 5	121	100	6.85
IR 62467-B-R-B-F60-1-B	110	146	6.66
IR 65239-B-B-68-1-B	115	139	6.64
CNT 87040-33-1-1	122	95	6.61
Bajo Maap 2	108	119	6.57
SPR 88090-30-1-2-4	122	85	6.49
IR 62467-B-R-B-24-1-B	112	155	6.02
Local Zakha	113	138	5.83
ST 8240-15-3P-21-11-21	117	98	5.59
CV%	3.2	2.7	1.0
S.E.D.	0.41	3.7	1.2

1.1.2 Initial Evaluation Trial

The objective of this preliminary replicated yield trial was to identify promising lines in terms of grain and straw yield, maturity, height and resistance and tolerance to biotic and abiotic stresses. The trial in 2002 consisted of 22 lines, including 5 checks, advanced from previous years' observation nursery. 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 top dressed at PI.

Butachlor 5G was applied at the rate of 1.5 kg a.i. /ha to control the weed. Hand weeding and irrigation was done whenever necessary. Grain yield was obtained from a harvest area of 5.04 sqm. The data and the results are presented in Table 2.

Analysis of variance showed that several test varieties produced significantly higher than the check varieties Local Zakha and IR 64. Highest yielders were RP 2233-10-16-9 and B2983B-SR-85-3-2-4 (7.38 ±1.11 t/ha) but were comparable to Bajo Kaap 2 with a mean yield of 7.32 ±1.11 t/ha. The days to 50% flowering ranged from 108 to 139 ±1.28) days. Plant height ranged from 92 to 130 ±9.55) cm. No notable insect pest and disease were observed during the crop period and hence the differential ratings among the entries were not done. The elite selection based on yield, plant height and maturity days would be advanced for further evaluation.

Table 2: Yield and agronomic traits of entries in IET, 2002

Variety	50% Flw days	P.ht cm	Yield t/ha
RP 2233-10-16-9	113	95	7.52
B2983B-SR-85-3-2-4	112	123	7.24
Bajo kaap 2	117	102	7.23
BR5969-3-2	115	111	7.21
VN 93-1	121	101	7.12
TOX 3098-2-2-1-2-1	139	95	7.04
IR 68077	112	96	7.01
IR 64	112	97	6.99
IRGA 440-22-3-4-1F-1	115	106	6.97
IHH 351-19CX-7CX-2CX	121	96	6.95
RHH 33025-CX-3CX-024	113	97	6.87
IET 12884	111	110	6.78
IET 13711	119	92	6.42
Bajo Kaap 1	111	101	6.38
Bajo Maap 1	117	103	6.32
IR 63896	121	126	6.21
BR5513-38-1-3-2	121	94	5.95
Bajo Maap 2	108	117	5.94
IR 56383-77-1-1	109	98	5.77
IET 13245	110	93	4.74
RP 1667-301-1196-1562	112	93	4.02
Local Zakha	117	130	2.19*
CV%	4.7	3.9	0.3
S.E.D.	1.1	9.5	1.3

- severe blast infection

1.1.3 Observation Nursery

The observation nursery in 2002 consisted of 86 lines, including checks, from International Irrigated Rice Observation Nursery (IIRON) of IRRI, as apart of the collaborative exchange of elite lines and varieties from the world's rice improvement program and the initial evaluation under a wide range of irrigated rice environment. Thirty days-old seedlings were transplanted at a spacing of 20 x 20 cm in mid 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 trial was laid out in single plot of 10 m^2 for each entry under evaluation.

Observed grain yield ranged from 2.5- 9.03 t/ha; plant height 77- 131 cm and 50% flowering of 108-139 days (see Appendix for details). No significant damage due to insect pest and diseases were noted. Selected entries based on selection criteria such as plant vigor, maturity and height, grain yield and panicle types and general performance will be further assessed.

1.1.4 Germplasm Collection and Development

Seventeen local landraces from wet low-altitude rice growing zones were rejuvenated and observed for their general agronomic characteristics (Table 3). The objective of this trial was to establish a close understanding of test lines for further improvement and use in future crossing programs.

Table 3: Agronomic traits of Wet mid-altitude landraces of rice

Varieties	50% Flw days	P. height (Cm)
Ompakhey	150	-
Kati	152	109
Timburay	152	112
Juwa	138	166
Attey	138	154
Bakrekhot	153	131
Timburay	153	120
Manjara	174	-
Pakhay	173	-
Japakha	169	119
Rudhuwa	139	158
Nuniya	-	-
Baoni	-	-
Katiksali	153	116
Mansara	-	-
Musaley	151	88

1.1.5 Germplasm from Nepal

Total of 10 lines from Nepal were rejuvenated and multiplied at the station for future research use in crossing programs (Table 4). General agronomic traits and basic observations were also noted for possible exploitation and use of theses lines as direct cultivar release in Bhutan. Attempts shall also be made to improve these landraces and promising accessions will be further analysed in replicated trials in different research stations.

Table 4 :General traits of new Nepal lines

Varieties	50% flw (days)	P. Ht (cm)
No 242	110	104
Khumal 6	133	118
Himali	114	80
NR 10291	136	95
NR 10375	110	100
Kancha	110	104
Taichung	110	112
NR 10353	139	100
NR 10276	110	145
Khumal 4	110	146

1.1.6 Rice Seed production

About 1658 samples of nucleus seed in total was produced for maintenance and production of pre-basic seed (Table 5). Production of pre-basic and basic seed of different released and promising lines totalled to 2987 kg (Table 6) for different research use and supply to DSC.

Table 5: Nucleus Seed Production

Sl. No.	Variety	No. of Samples
1.	Bajo Maap 1	206
2.	Bajo Maap 2	217
3.	Bajo Kaap 1	200
4.	Bajo Kaap 2	218
5.	IR 64	217
6.	BR 153	200
7.	IR 20193	200
8.	IR 62467-B-R-B-B-1-1-B	200

Table 6 Pre-basic and basic seed production

Sl. No.	Variety	Pre-basic (kg)	Basic (kg)	Total (kg)
1.	IR 20193	-	200	200
2.	BR 153	-	125	125
3.	Bajo Maap 1	130	450	580
4.	Bajo Maap 2	145	270	415
5.	Bajo Kaap 1	135	200	335
6.	Bajo Kaap 2	170	250	420
7.	IR 64	180	300	480
8.	IR 62467-B-R-B-4-1	-	50	50
9.	IR 62467-B-R-B-1-1-B	32	180	212
10.	K.B	-	80	80
Total		**792**	**2105**	**2897**

1.1.7 On-farm trials on mid-altitude rice varieties

The objectives of this trial were to assess the yield performance of varieties under farmers' management conditions and to study the preference of farmers for these varieties. Two mid altitude lines after thorough evaluation at on-station level at RC-Bajo were advanced for on-farm testing. Two major sites selected for the testing were Tsirang and Dagana, which were representative of the target population of environment i.e. mid-altitude rice growing zones. Testing sites within the dzongkhag were selected at random

in collaboration with the extension staff. The test line yielded higher (Table 7) than the local Attey.

Table 7: Yield of mid altitude lines in Tsirang

Variety	Mean yield t/ha	Remarks
IR-62467-B-R-4-1	4.12	Mild damages by birds due to little bit early maturity. Mild damage due to Gundhi bug
Local (Attey)	2.92	

1.2 BUCAP activities

With the support of BUCAP Project through National Biodiversity Centre at Serbithang and technical assistance from RNRRC-Bajo, an on-farm PGR conservation activity was started in 2001 with pilot site at Thangu, Thedsho geog under Wangdi Dzongkhag. The site represents the mid-elevation rice area where traditional varieties are poised to be gradually replaced by improved varieties. As per plan for 2002-2003, new site at Nob Sechekha, Guenshari geog under Punakha Dzongkhag, was added to the program which represent high altitude rice area where research and new technology intervention has made limited impact.

In continuation to the previous years' seed selection activity at Thangu three local varieties were compared for their yield with the yield of the seed selected by farmers for the same varieties. The yield differences were demonstrated to farmers during the field day conducted. Seed selected by FFS showed an improvement in yield over farmers' seed selection method. With continuous selection and improvement yield is expected to further increase.

Three local varieties and one improved variety were cultivated at farmers' field to study yield and its general performance at Nob Sechekha. A survey was conducted to study the past and present rice PGR in the area. In line with the activity a seed selection and handling training was conducted to FFS group for better management and improvement of existing local varieties.

1.2.1 Project location at Nob Sechekha, Guenshari

In keeping with the FSS approach/principle of BUCAP project, besides above mentioned activities and baseline studies, routine activities such as field exercises/studies, field days and monthly meetings were conducted to promote farmers' participation, extension processes and capacity of farmers group. Discussions and exercises touched upon some of the basic topics which are necessary educational tools to build the capacity of the farmers group such as morphology of rice plant, cultural operations, identification of common disease and pest of rice, weed management and field sanitation. Details of each activity are presented below.

FSS group working in trial site-Nob Sechekha

1.2.1.1 Baseline Survey

As per the plan pertaining to Biodiversity Use and Conservation Asia Pacific (BUCAP) for 2002-2003 the proposed project implementation site is Nob Sechekha in Guenshari Geog under Punakha Dzonkhag. This new site is the representation of remote and isolated site for high elevation rice area. To kick-start with proposed activity, it is essential to first document the information regarding the Rice PGR in the locality. The information collected will serve as the basis for a clearer understanding of the past and present Rice PGR available in the area. This baseline survey was thus designed to capture the Rice PGR information and its past and likely future genetic erosion and/or enhancement in the area. This survey will also help the extensionist and researchers to solicit views of the farmers regarding the Rice PGR changes and in determining workable solutions to such changes. This paper reports the findings of the survey that was carried out in September 2002 in collaboration with the geog extension staff.

The objectives include:

- To co-learn and understand with farmers the existing rice PGR status
- To enable farmers to better understand problems and potentials related to rice PGR and its management in high elevation
- To serve as a basis for measuring genetic erosion and/or enhancement
- To enhance farmers' motivation and involvement in the project
- To use as benchmark for BUCAP project monitoring and impact study
- To help farmers to identify their breeding and crop improvement objectives

A total of 11 member farmers (1male and 10 female) participated for the survey. Survey team briefly introduced themselves and explained the purpose of the meeting with more emphasis on the importance of Rice PGR, their genetic erosion and the ultimate chances of losing native rice varieties. The objectives of the survey were also clearly explained to the farmers. Farmers were then introduced to the tools of data gathering and the procedure for each tool. Survey team also explained to the farmers on how these data will be used and what will come up as follow-up of this survey in the area.

1.2.1.2 PRA tools used

The following PRA tools were used:

- Time line – for rice varieties cultivated in the area
- Matrix ranking – farmers' criteria for selecting rice varieties
- Matrix scoring – for different rice varieties

1.2.1.3 Rice varieties cultivated in the past and at present in the area

A total of 6 rice varieties were cultivated in the area. Each household cultivated at least 1 to 2 rice varieties in a season out of the total. All 6 varieties are of local origin. Intervention of modern variety and technology is very limited and there is very small change in their traditional farming system.

1.2.1.4 Local rice varieties in the past

There were 4 local rice varieties in the pasts (mid 1980s), which are still being cultivated at present namely Phulaychu , Gyemja Maap, Wangda kaam and Gyemja Kaap

1.2.1.5 Present rice varieties

The local rice varieties of the past are still intact without any replacement from the improved varieties. The advent of new varieties, Bunap Naap and Bunap kaap, has made little difference in the production system because it is recently cultivated by only few farmers and its yield is comparatively lower than existing traditional varieties. On-farm testing of improved varieties, like Khangma Maap, in smaller scale in the past has made no impact. This site provides us with appropriate situation for implementing BUCAP project activities whereby proper study can be made of the existing rice PGR and suitable approaches implemented to conserve and broaden the genetic base in the locality. Through the project farmers could be made aware of rice PGR and at the same time improve their access to improved materials.

The present rice varieties cultivated in the locality are Phulaychu, Gyemja Maap, Gyemja Kaap, Wangda kaam, Bunap Naap and Bunap Kaap

1.2.1.6 Farmers' criteria for selecting rice variety

The most important criteria considered by farmers in the locality while selecting a variety were high and stable yield with good taste. Being in high altitude rice cultivating regime farmers' preferred for early maturing variety. Besides, they also look at criterion such as multipurpose uses, pest/diseases resistance, easy threshing and good milling recovery, which are all equally important for them.

Table 8: Matrix scoring for old rice varieties

Criteria	Rice varieties			
	Phulaychu	Gyemja Maap	Wangda Kaam	Gyemja Kaap
Yield	3	4	1	2
Price	3	3	4	1
Uses	1	2	4	3
Taste	1	2	3	4
Yield stability	4	3	1	2
Pest/disease resistance	4	3	1	2
Strength	G. price G. yield Stable yield Disease resistant**	Good taste Stable yield Early maturity Used for making *Zaw**	Multiple uses G. taste	Multiple uses
Weakness	Susceptible to leaf blast and limited uses	Susceptible to cold injury	Low yield	Low yield

***Variety is susceptible to blast in nursery stage. Resistance referred to is for its recovery at later stage and stable yield. *Zaw = Puffed rice*

Matrix scores: Highest = 4 and lowest = 1

1.2.1.7 Farmers' ideal rice variety

During the discussion on ideotype varieties with FFS group they suggested a rice variety with the following characteristics like: high and stable yielding, early maturing to escape early winter, easy threshing, red variety with minimum milling losses. Yield is the most important criteria that everybody responded immediately after the question was thrown. The other criterions came up slowly as their discussion went on.

Table 9: Matrix scoring for present rice varieties

Criteria	Rice varieties					
	Phulaychu	Gyemja Maap	Gyemja Kaap	Wangda Kaam	Bunap Naap	Bunap Kaap
Yield	6	4	3	1	5	2
Price	4	5	1	6	2	3
Taste	3	4	5	6	2	1
Uses	3	4	5	6	1	2
Yield stability	6	5	4	1	3	2
Pest resistance	6	5	2	1	3	4
Strength	G. price G. yield Stable yield Disease resistant*	Good taste Stable yield Early maturity Used for making *Zaw*	Multiple uses G. taste	Multiple uses	High yield	Good yield Multiple uses
Weakness	Susceptible to leaf blast and limited uses	Susceptible to cold injury	Low yield	Low yield	Poor taste	Poor taste and low market price

**Variety is susceptible to blast in nursery stage. Resistance referred to is for its recovery at later stage and stable yield.* (Matrix scores: Highest =6 and lowest =1)

Results of Yield performance analysis and comparison of tested varieties

Three local varieties, viz., Gyemja Maap, Phulaychu and Gyemja Kaap and one improved variety, Khangma Maap, were cultivated at farmers' field to study yield and its general performance at Nob Sechekha. Above varieties tested were selected by FFS group during the planning discussion. Throughout the season activities were conducted based on farmers' field school approach.

Varieties were transplanted in large single plots under farmers' management practices. Grain yields were estimated from three crop cuts from each plot.

Table 10: Yield performance of different rice varieties

Variety	Cropcut 1 (kg)	Cropcut 2 (kg)	Cropcut 3 (kg)	Average (kg)	Yield (t/ha)
Khangma Maap	2.50	2.30	2.80	2.53	5.00
Gyemja Maap	2.00	2.10	2.30	2.13	4.21
Phulaychu	2.70	2.80	2.00	2.50	4.94
Gyemja Kaap	2.00	2.30	2.10	2.13	4.21

Crop cut area = 5 sq.m

Khangma Maap yielded the highest with an average of 5.00 t/ha, which is half a ton higher than the average yield of local varieties. Farmers are in view that Khangma Maap matures little earlier than the local land races. Their feedback pointed out that it is more prone to wild boar and rodent damages. Phulaychu, highest yielding local variety, has leaf blast infestation during seedling stage, which recovered during later stage of the crop, and has stable yield.

1.2.2 Seed Selection training

A total of 11 farmers were trained on rice seed selection and handling at Nob Sechekha. It was conducted as per the need identified by the farmers during the monthly meeting discussion. The objectives of the training were:
To assist farmers in enhancing their indigenous knowledge in selecting good rice seeds.
To introduce farmers to another alternative to the existing method of their rice seed selecting and storing for the next season

A total of 11 farmers were gathered in FSS meeting place. The Geog extension Officer, Mr. Gyeltshen, briefly explained the purpose of the gathering. Then research staff explained the purpose of the meeting and objectives of the training. Farmers were then explained on the following topics mentioned below.

1.2.2.1 Project Location at Wongjokha, Thangu

In continuation to the seed selection training held in previous year, FFS group decided to compare the yield of different seed selection techniques. Three land races were tested with two different seed selection technique. Trials were laid out in large single plots under farmers' management practices.

Mean yield differences obtained from two different methods are presented in the table below.

Table 11: Yield comparison of local rice varieties with seed selection methods

Variety	Farmers' Seed (t/ha)	Seed selected by FSS group (t/ha)	Difference (t/ha)
Dawa Yankum	3.59	4.14	0.55
Nabja	2.78	4.41	1.63
Apa Dogo	6.47	7.45	0.98

Study showed that yield of local rice varieties could be increased to certain extent through proper seed selection and handling methods. Nabja showed the highest yield improvement of 1.63 t/ha through seed selected by FFS group over the farmers' conventional seed selection. The results demonstrated during the field day convinced farmers about the advantages of seed selection and handling techniques followed for FFS activity. All farmers expressed their opinion to follow this techniques hereafter.

1.3 Implemented activities and results on-station, RC Bajo

Three local varieties, viz., Apa dogo, Dawa Yangkum and Nabja were transplanted in big single plots of 50 sqm. FSS group originally selected seed during seed selection training at Thangu in the year 2001. Varieties were found to be phenotypically uniform and hence it was directly bulk selected after thorough roughing. About 20 to 30 kg seed for each variety were purified by above means and which shall be made available to member farmers in the coming rice season.

Out of three, Nabja was susceptible to panicle blast incidence. All three varieties relatively gave high straw yield than the improved varieties. Seed selection awareness was demonstrated to many visiting farmers from other dzongkhags and geogs. Characterization of three local varieties was done according to the IRRI standard (see Appendix for details).

1.4 Grain Legumes

1.4.1 Soybean Varietal Trial (on-station)

The objective of the trial was to identify the suitable varieties under Bhutanese condition. Data could not be obtained due to some problems during the trial implementation. Six varieties of soybean were tested in single observation plots. Enough seed has been collected for all lines, which will be further tested in replicated plots next season.

1.4.2 Groundnut seed production

About 20 kgs of three promising groundnut lines namely ICGV, Kadiri and ICGV were produced for further evaluation on-station and on-farm.

1.5 Oilseed Crops

1.5.1 Mass Selection in Mustard

1.5.1.1 Creation of source population

The creation of source population with adequate genotypic variability is essential as a basis for selection of superior plants that will ultimately form variety. It has been observed that there is no sufficient variation, at least phenotypically, in the existing local varieties on which population improvement could be carried out effectively. Therefore, a variable source population was created using all available varieties, both local and introduced.

1.5.1.2 Mass selection of local varieties

Past experience indicate that farmers of this valley have not taken up the four improved varieties (T-9, M-27, PT-30 and BSA) on a large scale, mainly because of problems related to seed availability and generally poor performance of improved varieties in the farmers field. Locally adapted cultivars are relatively stable performers but their genetic deterioration is evident, owing mainly to inbreeding and lack of seed selection. Mass selection therefore could be effective in improving the overall performance of local cultivars.

1999
- Collected locally grown, rice-based mustard varieties from Tsirang farmers
- Grown in large plots
- Bulked the seeds

2000
- Planted bulked seeds from year 1 by broadcasting
- Selected 150-200 superior plants and bulked seeds
- Each plant was harvested and kept separately and rest bulk harvested

2001
- Each plant selected last year was sown in individual line
- Row selection of individual plant progenies done
- Selected rows will be further tested as observation plots for general agronomic traits and selection

2002
- Best performing plots/lines/rows selected and bulked
- Lines to be tested in yield trials

1.5.2 Mustard seed production

A total of approximately 153 kilograms of five released varieties of mustard seed were produced for research use.

Table 12: Mustard Seed production of released varieties for 2002

Sl. No.	Varieties	Quantity(kg)
1.	T-9	7
2.	Bajo Peka 1	60
3.	Bajo Peka 2	45
4.	M-27	21
5.	89 LSVE	20

1.6 Crop Production Management

1.6.1 Nature Farm/Organic Farming

This activity, started in 1995 and as earlier reported, was continued. The updated grain yields are in the table below.

Table 13: Grain yields (t/ha) of various crops from 1995-2002.

Crop	Year						
	95-96	96-97	97-98	98-99	99-00	00-01	01-02
Rice	8.7	4.4	5.05	6.26	6.5	6.80	5.64
Wheat	0.766	1.25	1.058	1.2	1.9	1.5	2.04
Mustard	0.26	0.27	0.406	0.485	0.49	0.26	0.22
Maize	6.37	5.82	6.84	7.7	5.0	5.25	4.14

The yields as presented in the table 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 increased to about 6.8 t/ha. There is slight improvement of yield of wheat from last year. The yield of maize has decreased in the year 2000-2001 as compared to the previous year.

HORTICULTURE RESEARCH

2 HOTRICULTURE RESEARCH

2.1 Subtropical fruits and low chilled temperate fruits and Nuts

2.1.1 Varietal Improvement

2.1.1.1 Nobgang Local Persimmon diversity and Characterization

There are two major types of persimmon fruit based on fruit astringency. One type the non-astringent types, may be eaten while the fruit is still mature, orange colored and firm. Fruit of the other type, the astringent types of persimmon must be soft before astringency is lost and ready for fresh eating. The astringent types are picked when fully matured, soft and ripened on the tree. Seeds are generally not produced in the non-astringent fruit although some varieties may produce seeds in some years.

The existing varieties of persimmon in the Hon'ble Yab's orchard at Nobgang, Punakha were planted supposedly as Japanese varieties (non-astringgent type), but were found to be astringent types of varieties (also Japanese variety) as the plants came into bearing about two years ago. A team of fruits researchers from RNRRC Bajo and Khangma visited the orchard in March 2001 and 2003 and top-worked it with Fuyu, Jiro and Hanagosho (all non-astringent varieties from Japan. RNRRC-Bajo also evaluated the Nobgang farmer's persimmon fruit types and quality to improve existing orchard and to characterize the local persimmon.

Farmers were closely involved during the field visit, sample collection and participatory evaluation of local persimmon varieties. Criteria for characterisation included type of tree, type of fruit and local nomenclature for different persimmon fruits. The Nobgang local persimmon germplasm will be collected by October, 2003 by RNRRC-Bajo.

The Nobgang local persimmon, a Japanese persimmon (*Diospyros kaki L.*) is an easy-to-grow tree and presently grown in Nobgang village at an altitude of 1500m asl to 2000m asl. The tree has a spreading growth habit and low maintenance requirements as per the farmers' assessment. The beautiful orange fruit and bright red foliage in the winter makes it an attractive plant in the home landscape. Persimmon trees are relatively free from serious insect and disease problems. However, few pests like a persimmon trunk borer that tunnels into the trunk of young trees near the soil line were noticed. The primary problem the homestead farming farmer faces with persimmon culture is alternate year bearing and marketing of fruits which is common in most varieties and is related to factors such as crop load (too heavy or too light), tree age or vigour, soil moisture, and pollination requirements.

In Nobgang village there are three district persimmon fruiting varieties (Figure 1) known locally as:

- **Aundeybom**- Fruits large, orange red and sweet when ripened
- **Pemchen**- Fruit medium size with skin four folds around the calyx giving the fruits the district *Pem* design used in Bhutanese house construction.
- **Lamchu**- Fruits small in size, oblong with pointed tips and very sweet when ripened.

Figure 1: Aundeybom, Pemchen & Lamchu from left to right

The detailed horticultural characteristics of these three varieties are described in Table 14. All of these cultivars are astringent types. Astringency is due to the presence of tannins that slowly disappear when ripe. Flower or fruit thinning and creating an open canopy within the fruit zone can help to reduce soluble tannins by improving fruit size and diluting the soluble tannins concentration. Loss of astringency in fruit can also occur during the post-harvest storage period.

Table 14 : Fruit and horticultural characteristics of local persimmon varieties.

Fruit Variety	Fruit colour	Fruit shape	Fruit dia. (cm)	Fruit length (cm)	Fruit weight (gm)	Ripening season	Astringent (yes or now)
Aundeybom	Orange-red	flat	8.1	6.62	233	October-November	Yes
Pemchen	Ornage-red	flat	6.68	5.02	110	Octo-November	Yes
Lamchu	Orange-red	Flat-conic	5.76	5.5	71	November-December	Yes

The fruits have to be picked when fully matured, soft and ripened on the tree. The shelf-life of these ripened fruits is very short, less than half a week but it is good for processing into pulp, jam, ice cream topping and bake goods like puddings, breads and cookies. The time of its introduction to Bhutan is unknown and farmers believe that it was there since a long time ago. The non-astringent types of persimmon were introduced to Bhutan by the Ministry of Agriculture at the start of the planned development activities.

Farmers sell their persimmon as fresh fruits for Nu 5 per piece of large fruit (*Aundeybom*) and Nu 5 for two small fruits (*Pemchen and Lamchu*) in the local market. However fresh fruits are highly perishable and also require harvest at ripe stage. This makes fresh fruits marketing a problem, and thus farmers have initiated a technique slicing the fruits for sun drying. The sun-dried slices in the local market fetch about Nu 30/kg. The slices and dried persimmon are also sold as far as Varanasi, India. Farmers get a better price for fresh fruit but they incur loss when dried products are sold due to the low drying recovery rate of 1: 4 (4 kg of fresh fruits give approximately 1 kg of dried product) and extra effort in slicing and sun drying. The local market for fresh fruit is sensitive to oversupply and the current price can fall if all fruits are brought to the market as fresh fruits.

2.1.1.2 Peach variety evaluation

The peach variety evaluation trial was established in 1994 with the help of Integrated Horticulture Development Project (IHDP-1), Ministry of Agriculture at the centre. The objective of the trial is to select the suitable peach cultivars for dry sub-tropical ecological zones.

The peach cultivars were introduced from Solan, Himachal Pradesh, India Three cultivars of peach with five plants each were planted in the trial orchard in 1994 at a spacing of 4m x 4m row-to-row and plant-to-plant. The three treatments or peach cultivars are: Flordason, Shan-I-Punjab and July Elberta. Trees were pruned follwing open-centre system and irrigated during the dry period coinciding with the time of flowering and fruit setting period (February to March). Weeding, basin making and mulching were done as appropriate. The parameters considered for evaluation were time of fruit maturity, crop yield and above all fruit qualities and consumers acceptance. Grafted peach fruited 3 years after planting. Fruits mature in 90 to 120 days after flowering**.** Of the three pear cultivars, Flordason was identified as the earliest peach cultivars maturing by the mid of May and July Elberta as a late cultivar maturing by mid July in the mid altitude areas. Floradasun and July Elberta are better varieties in terms of fruit quality, time of fruit maturity and ease of marketing. Fruit size did not differ significantly among the varieties with average fruit diameter of 5.1cm and length of 5.9cm. Tree trunks were also similar. Flordasun has been released by Variety Release Committee (VRC), Ministry of Agriculture for general cultivation under mid altitude regions (1300 – 1500 m) as Bajokham-1 on April 2001.

This year July Elberta will be proposed for release as Bajokham-2 for general cultivation in mid altitude conditions (1300-2000masl). It is a late flowering, leafing and maturing cultivar. Its fruits' characteristics bear a resemblance to the local peach cultivar popularly known as *Lhosukha* but the fruit taste is superior to the local variety. July Elberta is pubescence while *lhosukham* is not, giving it a better appearance. The morphological features are given in Table 15, fruit quality and characteristics in Table 16 and average yield performance of five trees in

Table 17.

Table 15: Morphological characteristics of peach cultivars

Cultivars	Tree appearance	Bloom time	Leafing time	Harvest time
Flordasun	Semi-vigorous and spreading	Early (late January)	Early (mid February)	Early (1st week of May)
Shan-I-Punjab	Vigorous	Early (mid February	Early March	Second week of May
July Elberta	Semi-vigorous	Late (Early April)	Early April	Late (Mid July)

Table 16: Fruits characteristics and quality aspect of peach cultivars

Cutivars	Shape	Size	Flesh colour	Taste	TSS
Fordasun	Round with red blush	Medium	Yellow	Acidic sweet	11%
Shan-I-Punjab	Oblong	medium	Yellow	Acidic sweet	9.6%
July Elberta	Round with pointed tips and heavy pubescence	medium	Redish-yellow	Acidic sweet	11%

Table 17: Average yield (kg/tree) trends of peach cultivars

Cultivar	1997	1998	1999	2000	2001	2002	2003
Flordasun	4.3	27.75	18.5	20.5	15.1	31.4	29.5
Shan-I-Punjab	20.5	50.1	17.1	24.3	15.0	21.3	22.3
July Elberta	2.1	16.5	14.2	19.6	16.3	23.1	27.1

Although the trial has been terminated, RNRRC-Bajo is mandated to maintain its germplasm and accordingly 5 mother plants each of Floridasun and July Elberta are maintained at the Centre.

2.1.1.3 Almond Variety Evaluation

Established in 1994 with the support of Integrated Horticulture Development Project (IHDP-1), Ministry of Agriculture, this trial includes almond cultivars introduced from Solan, Himachal Pradesh, India and has the objective to select suitable almond cultivars for dry sub-tropical ecological zones.

Eight cultivars of almond (Taxes, Drakes, Kagzi, thinshelled, JK-55, Nonpareil, Pathak Wonder and Dhebar Badan) with three plants each were planted in the trial orchard with a spacing of 6m x 6m row to row and plant to plant. Trees were pruned following modified centre leader system and 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. Manure and fertilizers were also applied as required. Parameters for evaluation included time of crop maturity, yield and above all kernel qualities and its production economics.

Three years after planting six almond cultivars started bearing fruits. The fruit matures in 160 to 190 days after flowering depending upon the cultivars**.** The vegetative growth of all almond cultivars except JK-55 (did not survive) was good but the kernel yield was low (Table 18). There were no major pest and disease problems observed during the study period excepting gummosis in Kagzi almond cultivars. Gummosis or bacterial canker is caused by *Pseudomonas syringae* and is controlled by using resistant rootstock. There were no significant differences in the kernel yield of different cultivars tested over the years. Of all the almond cultivars, Dhebar Badan and Kagzi performed better. Taxes and Kagxi are the earliest maturing (third week of July) and D. Badan is a late cultivar (mid August).

Table 18: Average Kernal Yield (g/tree) and taste of almond cultivars

Cultivars	1997	1998	1999	2000	2001	2002	2003	Taste
Texas	127	79	0	0	0	600	466	Sweet
Drake	5	58	0	400	0	150	200	Sweet
D. Badan	109	94	0	1500	1150	515	350	Sweet, less creamy
Kagzi	32	214	0	1100	727	370	365	Creamy and sweet
Pathak Wonder	3	0	0	950	0	0	210	Sweet
Nonpareil	0	0	0	450	0	0	0	
Thinshelled	11	129	0	500	0	180	150	Slightly bitter

Kazi has the problem of Gumosis. In the market, almond competes with other nuts like walnut that produces much more quantity per unit area than the almond, so the demand depends on their prices. Almond has no comparative advantages or is less profitable than others fruits and nuts like subtropical apple, apricot, pear, peach,

citrus, walnut, pecan etc. so investment in almond cultivation may not be very attractive.

The trial has been terminated this year, however, the four almond cultivars' mother plant or scion 'Bank' will be maintained as mandated at the centre.

2.1.1.4 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 were to select suitable grapes cultivars for dry sub-tropical ecological zones and to evaluate the feasibility of grapes cultivation in Bhutan.

Nine cultivars of grapes (Muscat, perlette, chasselas, pinot blanc, Gamay-N, Cab Franc, Pinot Noir, Monduese and Chardornnay) 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 cultivars introduced in 1996 were Protland, Campbell and Stuebern and in 1999 Muscat of Allexander, Calmeria, Ruby seedless, Waltham and Sultana M12 were introduced. The vines were 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. Manure and fertilizers were applied as appropriate. Parameters considered for evaluation were time of crop maturity, yield and above all bunch and berry qualities and pests problems.

Perlette and Muscat of Alexander are the best table cultivars. Perlette is the earliest maturing (mid of June) and escapes the powdery mildew disease. Muscut of Allexander is a late cultivar (Early August) and fruits heavily. It has no problems of fruit splitting unlike other cultivars through it is late maturing, coinciding with monsoon rain Differences in yield among the various cultivars could not be compared as proper yield were recorded due to severe birds and wasps damage. Grapes cultivation in mid altitude areas of Bhutan is very expensive as it requires protection from birds, fruit fly and wasps through netting or by wrapping individual bunch with perforated polybags. Powdery mildew is also very severe and needs frequent sprays to control it.

Later introduced grapes cultivars such as calmeria, Ruby seedless, Walthem and Sultana M12 started fruiting but have not been harvested since the yield is very low. The trial will be continued for few more years and efforts to find effective measures to protect the fruit damage by birds, fruit fly and wasps shall be made.

2.1.1.5 Maintenance of Fruits mother plant or Scion 'Bank'

The mother plant or scion 'Bank' of newly released Bajo apple, Bajokham-1 and Bajokhamchu-1 for general cultivation are being maintained at the Centre as mandated. The DSC and private nursery growers have been informed about the availability of mother plants of these crops. 28 citrus cultivars as a germplasm collection and sources of scion wood are also maintained at the centre.

2.1.1.6 Pear variety observation

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

Of all the varieties evaluated, Flaming Beauty and China have similar fruit shape (bell-shape) and taste quality (sweetnes) and are the best varieties. Gala and Tsirang local fruits are round in shape and slightly acidic in taste. Gala has smooth fruit skin while Tsirang local has rougher skin with granulated fruit peel. There were no significant yield differences among the varieties tested. The plant growth and yield performance of all the varieties evaluated were excellent. All the pear varieties except Tsirang local are susceptible to birds and wasps damage.

2.1.1.7 New fruits and nuts variety evaluation

The fruits and nuts variety evaluation initiated during 2002-03 year are:

- Persimmon variety evaluation
- Japanese pear variety evaluation
- Walnut variety evaluation

2.1.2 Production management

2.1.2.1 Effect of time of grafting on walnut graft success under different altitude ranges.

Varying temperature has been reported to increase the rate at which callus, or wound parenchyma is produced, thus increasing the percentage of successful unions. In this experiment, the effect of altitude (temperature) on graft success was studied to test the hypotheses that altitude (temperature) can determine the success of grafts, and that temperature is a source of variation for graft survival.

To investigate the optimum time of walnut grafting across different altitudes ranges walnut scions were collected from the farmers' field and stored in a refrigerator in sealed plastic bags until grafting. Scions consisted of shoots about 15 cm in length with two-three buds. The scions used for the study were of the one- year-old shoots and rootstocks were two-year-old of *J. regia* seedlings, the diameter of scions did not match that of the rootstock. The rootstock was cut off 10cm above the root-shoot junction and all the lateral branches in the graft region were removed. Whip grafting was done for all the treatments to make sure the uniformity of grafting techniques.

An experiment was also conducted to investigate the effect of six levels of time of grafting under four different altitude ranges on walnut graft survival. A randomised block design was used with three blocks and 24 treatment combinations. Four different altitude ranges where grafted walnut was grown were 2100masl (field condition), 2100masl (under polytunnel), 1400masl and 700masl.

Grafting was done in mid of Dec.2001, Jan., Feb., March, April and May 2002. In total, 360 grafts were made with 15 grafts for each treatment combination, comprising of 3 replications of 5 grafts. Whip grafting was used for all the treatments and assessed three months later. Failed grafts scions had shrivelled, desiccated, and became necrotic by then while successful grafts showed considerable shoot growth. The data were analysed using two-way analysis of variance (after angular transformation of data) for graft survival percentage.

Table 19 shows the rate of graft success obtained at different times of grafting under different altitude ranges. The time of grafting had a marked influence on graft survival (Fig 2 & 3). December grafting produced lowest and March grafting the highest graft survival across the different altitude ranges. Grafting performed from the month of December to March showed increasingly higher graft survival in the subsequent months and later grafting showed decreasing trend across the agro-ecological zones. Two-way analysis of variance after angular transformation of data showed a significantly higher ($P < 0.001$) graft survival between the different time of grafting, March grafting being the best among all month of grafting (Figure 2 and Figure 3).

Table 19: Effect of time of grafting on graft success under different altitude ranges

Overall success for time of grafting (inclusive of four different altitudes)
Percentage success

Time of grafting	Percentage success
December grafting	00
January grafting	17
February grafting	55
March Grafting	83.3
April grafting	62.5
May grafting	35

Overall graft success for four different altitudes (inclusive of six time of grafting)

Altitude range	Overall success
2100masl (field condition)	43.7
2100masl (poly tunnel)	33.8
1400masl	47.3
700masl	42

Date of grafting	Altitude (masl)			Total	
	2100m	100 (polytunnel)	(1400m)	(700m)	(%)
December	00	00	00	00	**00**
January	00	30	10	30	**17**
February	5	**85**	60	70	**55**
March	**95**	**68**	**90**	**80**	**83.3**
April	85	20	87	58	**62.5**
May	77	00	37	26	**35**
Total (%)	43.7	33.8	47.3	42	42

LSD at 5% probability

Time of grafting	12
Altitude range	15
Time x Altitude	24

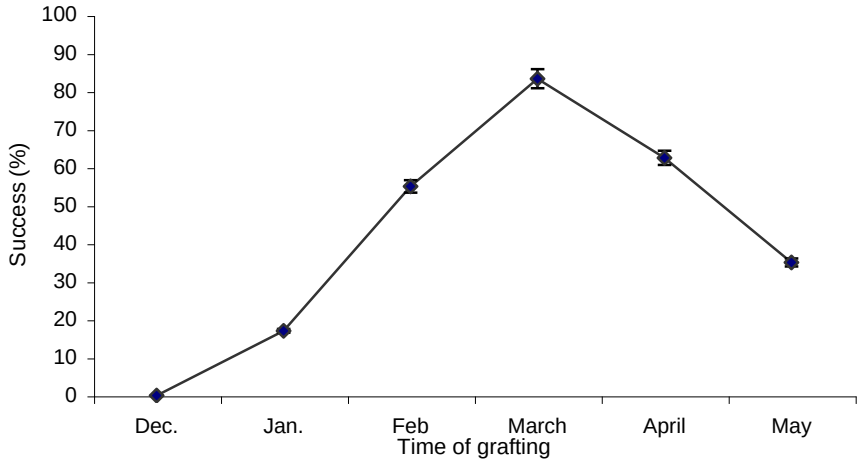


Figure 2: Effect of time of grafting on overall graft success

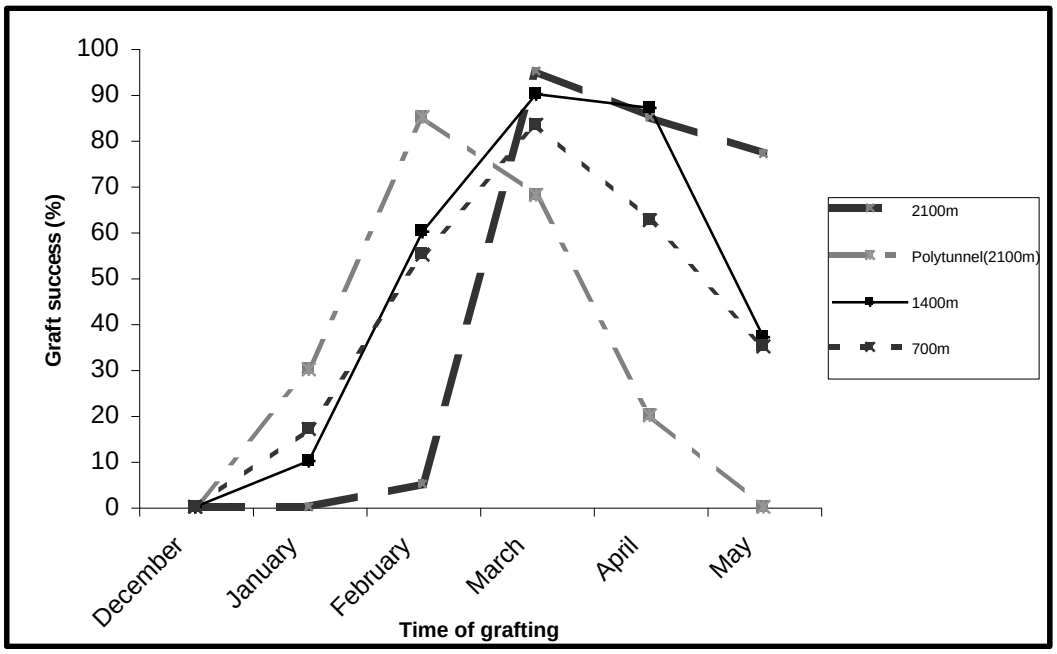


Figure 3: Effect of time of grafting on walnut graft success under different altitude ranges

December grafting resulted in total graft failure and January grafting also resulted in a high rate of graft failure. The failed grafts made in December and January were characterized either by failure of grafts to sprout or, if sprouting occurred, failure to grow further. March grafting 2100masl gave the highest graft survival.

There were significant differences (P = 0.05) between different altitude ranges on overall graft success (inclusive of six time of grafting). Time of grafting is one of the important factors affecting the walnut graft survival (Fig 2 & 3). High rates of graft failure in the case of December and January grafts may be due to the physiological condition of stock and scion, the effect of dormancy and low temperature. This point that callus production is essential for graft union formation and successful union formation follows the callus production. Walnut grafting can be successfully carried out under different altitudes from mid of March to mid of April under ambient

condition. March grafting also produces superior grafted plants in terms of shoot height, diameter and leaf production.

2.1.2.2 Top-working of persimmon, pear and walnut orchard in Lingmutey Chu watershed

RNR RC Bajo promoted improved cultivars of fruit plants tested successful on station on farmers' field in small backyard scale. Farmers reported poor quality of persimmon, local pear and walnut and requested support to improve the existing orchard of persimmon and back yard orchards of pear and walnut. The sector together with the farming systems sector conducted three days top-working exercise/training in farmers' field to improve/change the existing poor quality.

The top-working of local pear, persimmon and walnut were done in three communities, viz. Limbukha, Dompola and Nabchhey villages that covers the upper catchments of the watershed between the altitude ranges of 1800 – 2100 masl.. Shinko and Hoshi, improved pear cultivars, Fuyu-a non-astringent persimmon cultivar and Pyane-lateral bearer walnut cultivar were used for top-working of local fruits and nuts. In total 90 fruit plants were top-worked consisting of 44 pear (15 *Shinko*, 19 *Hoshi* and 10 *Limbukha*), 31 Persimmon (*Fuyu*) and 15 walnut (*Pyane*). 100 percent top-working success was reported for all above crops and some of the farmers also managed to do it on their own. In Limbukha, walnut top-working failed because top-worked walnuts were damaged by children or cattle disrupting the graft union formation as walnut plants were not fenced.

2.1.3 Nursery management and plant propagation

The nursery management and plant propagation techniques assessment are conducted simultaneously with crop variety introduction and evaluation. The propagation techniques successfully tested and planting material of various fruits and nuts crops multiplied areas are given in Table 20.

Table 20: Grafting technique and no. of promising fruits and nuts cultivars produced

No.	Crop	Grafting Technique	No. of planting materials produced	Remarks
1	Sub-tropical apple	Whip	600	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	1,000	
3	Peach	Whip	80	
4.	Apricot	Whip	50	
5	Walnut	Whip	200	
6.	Pecan rootstocks and grafts	Whip	200	
7.	Pomegranate	Cutting	50	
8	Guava	Air-layering	30	
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		800	
11	Avocado rootstock		300	
12	Apple rootstock		500	
13	Peach rootstock		100	
14	Apricot rootstock		70	
15	Pear rootstock		50	

2.1.4 On-farm Fruit and Nuts demonstration orchards

The promising cultivars of various fruits and nuts were planted on-farm for demonstration purposes and also serves as multi-location evaluation of different fruits and nuts cultivars. Two demonstration orchards of assorted fruits crops in each of the five Dzongkhags of West-central region have been established (appendix 2).

Performance of Bajo apple in Omtekha, Rubesa and Dagapela is reported to be good with farmers expressing interest to expand cultivation. The fruit however has very short shelf life (less than a week), so its commercial cultivation may need to be cautioned. Pomegranates started fruiting in Rubesa and farmers report good acceptance in the local market. Lime and orange (Valencia) which also fruited in Rubesa is reported to be difficult to sell in the local market. However, lime has a huge market in India and Valencia is sweet and internationally popular, Peach (Flordasun and July Elberta) has also fruited heavily in Yamina, Kabji, Omtekha and Dagapela demo-orchards. Farmers prefer the improved peach cultivars to local cultivars and find it easy to sell too.

2.1.5 Improved Persimmon Processing, product development, Packaging and Presentation to the Consumers

Farmers in Punakha-Wangdue Valley grow mostly of astringent type of persimmon cultivars (viz. *Aundeybom, Pemchen* & *Lamchu*) in their homestead. This type of persimmon although sold currently as fresh fruit, is good for processing when fully ripened as it has a short shelf life when fully ripe. Farmers current practicing of slicing the fruits with the skin intact, sun dried, packed in gunny bags is poor in quality and fetches only about Nu. 30/kg which is very low compared to the fresh fruit market price[1]. The local market is small and sensitive to oversupply and farmer can't sell the entire persimmon from their homestead production as fresh fruits. As such improved processing is of great importance. RNRRC-Bajo initiated the sun dried persimmon product development with an objective to add value to the persimmon fruits.

The fruits are harvested when in full colour leaving a bit of the branch attached to the stem while harvesting to form a cross bar of 'T' at the base. The fruits should be washed in running water to remove any adhering materials and peeled using simple kitchen knife or potato peeler. Peeled fruits are strung around a piece of string around the base of the 'T' and tied to a rope to dehydrate naturally. The fruits splits are prepared by peeling and splitting the fruits into four or. Fruit slices are prepared by slicing them into thin round slices without the skin. These slices, splits and peel are laid on simple dehydrator trays prepared from locally available bamboo and left in open space for dehydration. Guarding from birds and animals is important. A more complex procedure is to watch until the persimmons turns brown and then gently over-turning the splits and slices to promote even drying. Once the fruit becomes leathery, they should be removed from the strings or trays and once dried should be packed and sealed in plastic bags of 200g capacity and heaped in a clean storeroom or boxes to leave for curing (sugar crystallizes especially on whole fruit surface) for a about two weeks. It is then ready to be sold.

[1] Nu. 5 per piece of large fruit and Nu.5/two pieces of small fruits

The samples and posters of various dehydrated persimmon products was exhibited during the RNR-Expo, March, 2003 at Changlingmethang, Thimphu and feed back from visiting people in the exhibition and staff of RNNRC-Bajo and Ministry of Agriculture were excellent. Table 21 gives the time taken for sun drying and drying recovery rate of various persimmon products and details of the five different dried persimmon products and their prices are given in Table 22.

Table 21: Sun drying of various persimmon products

Dehydrated Persimmon products	Time taken for drying (hours)	Drying recovery (%)	Remarks
1. Whole fruits	120	31.17	Drying recovery is high and still products contain about 8 to 12% moisture.
2. Fruit splits	72	30.12	
3 Fruits slices with peel removed	48	32.5	
4. Fruit slices with peel intact	48	32.13	
5. Fruit peels	24		Drying recovery not recorded

Table 22: Persimmon Products, packaging, pricing and their quality rating

Dehydrated persimmon products	Net weight (gm)	Price (Nu.)	Consumers rating
1. Whole fruits	200	40	Excellent
2. Fruit splits	200	30	Good
3 Fruits slices with peel removed	200	30	Good
4. Fruit slices with peel intact	200	20	Poor
5. Fruit peels	150	5	Rejected as dried product

2.1.6 Trainings of farmers and extensions personnel

The sector also trained the extension agents of all the five Dzongkhags in the West-central region on the following:

- Citrus grading, packaging and Bhutanese citrus quality standards for export market.
- Citrus greening disease symptom identification, sampling and its management in collaboration with Plant Protection Section of this Centre.

2.1.7 Translating research into communication materials

Publications and recommendation submitted or produced from by the sector include:

- Leaflet for RNR Expo 2003.
- Strategy and Plan for Management of Citrus Greening Disease and Alternative Fruits Crops for Punakha-Wangdue Valley: technical recommendation (in collaboration with NPPC and NSSC).
- Evaluation of Potential Fruit Crops cultivars and Orchard Plan For Phuntsho Pelri and Sonagasa: a proposal.
- Fruit Crops Options and Orchard Plan for Nyinzergang.
- Alternative crops project feasibility at Changjukha: a report
- Leaflets on Apricot (newly release Bajokhamchu-1) Production, Bajo apple (under development).

2.2 Vegetables

2.2.1 Integrated germplasm development

2.2.1.1 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, farmers' cultivation methods, time of sowing and other agronomic information were also collected. The varieties were from Wangdue Phodrang, Punakha and Tsirang. It is important to confirm their yield and quality performance across locations before their release. As such 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 a completely randomised block design (CRBD) with three replications for the on-station trial and treatments consisted of 9 beans cultivars. The plot size was 5 m^2 per treatment. Each farmer was given the 9 varieties and served as a replication for the on-farm trial. Seed sowing was done on 11th March 2002 with spacing of 50cm plant to plant for pole type, 25cm for dwarf type and 50cm between the rows for both types. Fertilizer application was at 25:50:40kg /ha with 40t/ha FYM. Three hand-weedings were done. The detailed 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. The on-station data was analysed using the statistical package GENSTAT (one-way analysis of variance with blocking) and the mean yield and their horticultural characteristics are given in Table 23. The dwarf beans cultivars can be first harvested at about 9 weeks after sowing while pole types take about 10 weeks. There were no significant differences in the yield performance of various beans cultivars. Consumers' acceptance did differ based on the pod quality. Farmers reported that Geobori, Punakha yellow, Kanchi boni, Tsirang local and Nobgang black can be easily sold compared to check cultivar (Borlotto).

Table 23: Mean yield, type and horticultural traits of beans cultivars

Cultivars	Mean Yield (t/ha)	Type	Pod colour	Pod quality rating
RNRRC Dwarf	13.87	Dwarf	Light green	fair
Borlotto	11.67	Dwarf	stripe	excellent
Rajma	11.67	Dwarf	green	fair
Nobgang black	11.47	Dwarf	Dark green	excellent
Geobori	9.07	pole	stripe	excellent
Kanchi boni	12.00	pole	green	excellent
Tsirang local	12.13	pole	Dark green	excellent
Punakha yellow	10.67	pole	green	excellent
Chitokha local	11.00	pole	purple	good
LSD (0.05)	2.8			
CV%	14			
s.e.d	1.32			

2.2.1.2 Water melon variety observation

Watermelon is not popularly grown in the region with the local market being supplied from either Southern Bhutan or India. The lower elevation of the region is suitable for growing watermelon. The sector as such, procured 15 watermelon hybrids with seeds from Marcopolo Seed Company, Thialand through the IHDP-II, MOA in 2002 for evaluation and set up and observation trial with sugar baby as the local check was carried out in 2002. The aim is to evaluate and assess the performance of the hybrids under Bajo condition.

Seed sowing was done in May 4, 2002 with a plot size was of $30m^2$ and single plots design without replication. The plants were planted at a spacing of 1m. Fertiliser application was at the rate of 45:35:25 kg/ha NPK and with 1kg of FYM per pit. Pit size of 25cm wide and 25cm depth was dug and filled with soil and FYM mixture. Weeding and irrigation were done as appropriate. Harvesting was done in 4^{th} week of July for all the varieties except for 1100601 and 11001601 which were harvested in 1^{st} week of August. The yield and horticultural traits are given in Table 24.

The germination percentage of all varieties was low except for 100301 and the yields were very low. The fruit size was small to medium and with moderate fruit quality and none of the varieties performed well. The heavy soil together with strong wind and heavy monsoon rain may be the limiting factors and may explain why farmers are not interested in watermelon cultivation. The trial has now been terminated.

Table 24: Average Yield and horticultural traits of different varieties

Cultivars	Yield (t/ha)	Fruit size	Fruit shape	Fruit colour	Flesh colour	TSS (%)
1100101	4.1	medium	round	Green	red	11
1100201	3.5	medium	round	light green	red	15
1100301	11.06	medium	round	light green	red	8
1100401	4.9	medium	round	Light green	red	7
1100501	4.0	medium	round	green	red	10
1100601	1.1	medium	round	green	red	10
1100701	3.13	small	round	green	red	10
1100801	1.9	medium	round	green	red	8
1100901	2.0	medium	round	Light green	red	12
11001001	8.66	medium	round	Light green	red	10
11001101	2.7	medium	round	Light green	red	10
1001201	2.2	medium	round	Light green	red	9
1001301	2.5	medium	round	Light green	red	9
1001401	2.6	medium	round	Light green	red	8
1001501	1.4	medium	round	Light green	red	11

2.2.1.3 On-going vegetable variety evaluation

The vegetable variety evaluation trials that are on-going are:

- Tomato Variety evaluation
- Chilli resistance line screnning to *Phytophthora* blight
- Vegetable soyabean variety evaluation
- Brinjal variety evaluation
- Bitter guard variety evaluation
- Cabbage variety evaluation

2.2.2 Production management

2.2.2.1 Maintenance of breeder seeds of released vegetable cultivars

As mandated the sector maintains breeder seeds of various vegetable crops cultivars. Breeder seeds14 vegetable crops and 22 vegetable cultivars released are maintained (Table 25).

Table 25: Vegetables Breeder seed produced and maintained by RNRRC-Bajo

No	Crop	Varieties	Total quantity BS supplied to DSC	Remarks
1	Brinjal	Pusa Purple long	200g	Under selection (2004Sept)
2	Beans	Borlotto	10kg	8 kgs handed over 11.2.2003
		Kentuky Wonder	10kg	Under selection (2003 Nov)
		Pusa Parvati	10kg	4 kgs handed over (2004 June)
		Top Crop	10kg	8 kgs handed over
		Rajma	10kg	8 kgs handed over
3	Cabbage	Golden Acre	200g	Under selection
		Copenhegan Market	200g	Under selection
4	Cauliflower	White Top		Failed in 2002, trying in 2003-04
		White Summer	200g	No germination at all
5	Capsicum	California Wonder	200	On going target for Dec 2003
6	Carrot	Early Nantes	100g	100 grms handed over (2002)
7	Onion	Bajo Gop-I	500g	600grms handed over in (2002/2003)
8	Sag	Phul Maya	200g	Under selection targeted in June 2004
9	Spinach	All Green	200g	Ready for supply
10	Okra	Pusa Sawani	500g	Var. kranty was supply in 2003
11	Radish	Bajo Laphu-I	200g	600grms handed over in (2002/2003)
		Spring Tokinashi	200g	Under 2003-2004 program
12	Tomato	Bajolambenda-I	300g	200grms handed over in 2002/2003
		Cht-160	300g	Under 2003/2004 program
		Roma	300g	On going targeted in Oct. 2003
13	Jap. Green	Taisai	200g	Under program in 2003-2004
14	Watermelon	Sugar baby	200g	On going
	14 crops	22 varieties		

2.2.3 On-going production management trials

Ongoing vegetable production trials are: 1) Effect of plant density yield and blight incidence of chilli ; 2) Effect of seed source and type of planting on yield and disease incidence; 3) Effect of different cultivation method on the yield and blight incidence; 4) Effect of time of planting on yield and blight incidence; 5) Asparagus production economics and 6) Brocoli, Radish and cabbage seed production economic study.

2.2.4 Publication and Translating research into practices

The activities are: leaflet on newly released vegetable cultivars and some of potential cultivars for RNR-EXPO 2003 and technical recommendations for vegetable production under rice-based farming system and quality vegetable seed production (under development).

LIVESTOCK RESEARCH

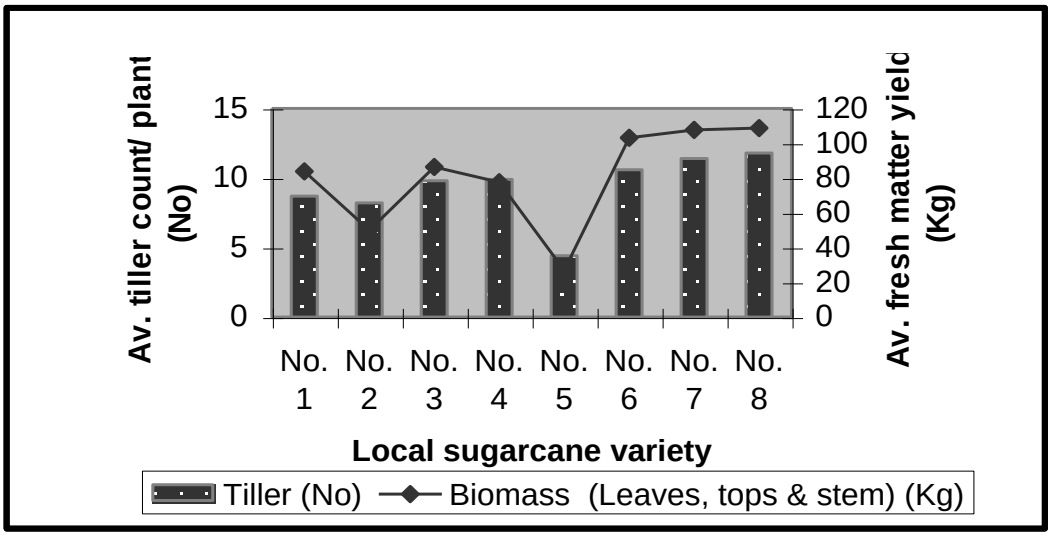
3 LIVESTOCK RESEARCH

3.1 On- Station Research

3.1.1 Sugarcane (Saccharum officinalis) accessions and evaluation

The objective of this trial was to evaluate local and improved sugarcane varieties for adaptation to Bhutanese conditions; suitability for use as winter fodder and dry matter production. Initially, eight local collections were planted at the station to observe its biomass yield, height and vigour after every 100 days interval. The consolidated data from the last three years are presented in Figure 4.

Figure 4: Tillers and Fresh Matter yield of local sugarcane varieties



5 6

(1- Ap Tandin, Bajo; 2 - PD kitchen garden; 3 - Zingsay white; 4 - Zingsay Black; 5 - Bap, Wonjukha; 6 – MG kitchen garden; 7 – Tshering, Lhaku; 8 – AF Nursery)

The findings from last three years revealed that all local collections are adaptable to Bajo's prevailing climatic and soil conditions although susceptible to winter chill and further indicated that fodder yield in winter in terms of quality and quantity was poor. This is mainly because the leaves are then matured, hardened and dry. All eight local collections performed well in terms of height and growth.

Fresh matter yield from Collection No. 6, 7 and 8 (Figure 4) were comparatively better than other entries corresponding to highest number of tillers (biomass yield is dependent on the tillering capacity of plant). Production increased drastically in the subsequent years once the plants were well established thus stabilizing the production. Sugarcane cannot make wholesome qualitative forage roughage especially during winter owing to its declining nutrient value (TDN, DCP) and poor re-growth under our conditions. Its growth period is from June to September and ripens in October Low temperature in winter retards the ripening from December to mid March.

The trial needs to continue and include evaluation of acceptance by the farmers. The station evaluation trial has ended last year. The centre maintains about 15 different collections of sugarcane from different locations as basic planting material for on-farm research purpose and distribution to farmers in the region.

3.1.2 Potential Dry Matter Production Trial

The objectives of this trial were to quantify potential dry matter production across a range of environments, generate data for production models and other planning tools and compare yield potential of selected grass species

The species selected were: T1-*Pennisetum purpureum*, T3-*Paspalum dilatatum*, T4-*Dactalis glomerata*, Y5-*Seteria secephalata*, T6- *Medicago sativa.* The trial was established at RC Bajo station at 1200masl during July 2002. It was replicated under irrigated and non-irrigated conditions.

The initial observations indicated that under irrigated condition, most of the treatments have satisfactory stand form except for *Dactylis glomerata*. Under non-irrigated condition, only Napier and Lucerne have good stand. The details of their growth and performance data are indicated in (
Table 26 and Table 27**).**

Table 26: Mean yield and dry matter percentage under irrigated condition

Treatment	Fresh Matter Mean yield (t/ha)	Dry matter Mean yield (t/ha)	Av. Dry matter%
Sataria	8.16	0.058	34.93
Paspalum	5.65	0.062	37.13
Napier	4.27	0.045	27.00
Lucerne	4.18	0.066	39.52
CV%	22	8	-
SED	0.969	6.79	-
LSD	2.490	16.62	-

Table 27: Yield and Dry Matter percentage under non-irrigated condition

Replicates	Treatment	Fresh Matter yield (t/ha)	Dry matter yield (t/ha)	Dry matter%
Rep I	*Napier*	4.59	0.046	27.8
	Lucerne	1.94	0.068	44.6
Rep II	*Napier*	3.34	0.050	30.6
	Lucerne	7.02	0.068	40.8
Rep III	*Napier*	2.23	0.047	28
	Lucerne	5.28	0.065	38.8

The fresh biomass yield of *Sataria* was highest while *Lucerne* produced higher dry matter in replicate one and two compared to all other forage species. The fresh and dry matter yield of *Cocksfoot* was not taken as it did not attain the standard recommended minimum plant height of 8-10 cm during the first harvest. Analysis of variance (ANOVA) showed that there were significant yield differences in both fresh matter and dry matter production between the treatments and among the replicates. *Napier* yielded 4.27 T/Ha of fresh biomass from irrigated plots compared to 3.38 T/Ha from the non- irrigated plots. On the other hand, the dry matter production was 54.01 gm/12m2 and 57.62 gm/12m2 respectively from irrigated and non- irrigated plots. *Lucerne* yielded 4.17 T/Ha of fresh biomass from irrigated plots when compared to 4.75 T/Ha from non- irrigated plots while dry matter production was 79.09 gm/12m2 and 80.17 gm/12m2 respectively from irrigated and non- irrigated plots. The findings indicate that *Lucerne* has higher fresh biomass as well the dry

matter production compared to *Napier* from irrigated and non- irrigated plots (Table 28).

Table 28: Comparative yield and performance data on Napier and Lucerne

Treatments	Napier		Lucerne	
	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Fresh Matter (t/ha)	4.27	3.38	4.17	4.75
Dry Matter (t/ha)	0.045	0.048	0.066	0.069
Dry Matter percentage	27	28.8	39.52	41.4

3.1.3 Sweet Clover (Mellilotus species) Varietal Trail

The objective of this trial 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 at Bajo with seven sweet clover species. Data recorded include germination percentage, persistence, height and the flowering percentage of *Melilotus* species (Table 29). Initial observations showed that the species *Melilotus albus* SA 35639 and *Melilotus* SA *36999* had 100% flowering followed by 50% flowering from *Melilotus officinalis SA 37409*. Although there was no flowering observed 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.

Table 29: 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

No pest and diseases incidences have been observed until date among these species except frostbite in winter contributing to stunted growth.

3.1.4 Establishment method of Fodder growing on paddy bunds

The objective of this trial was to identify appropriate species and establishment methods of growing forages on paddy bunds and also to best utilize the scarce land and optimize fodder production under marginal land. The trial was established in 2002 and included species such as *Desmantus virgatus, Medicago sativa, Pennisetum perpureum, Flemingia macrophylla, Melinis minutiflora, Brachiaria, and Paspalum species*

Few harvests of *Desmanthhus virgatus* and *Medicago sativa* were done. *D. virgatus* was maintained as a garden hedge and seeds of this species were also collected for future use as forage and garden beautification.

3.1.5 Napier propagation/distribution

The sector maintains about half an acre of *Napier* as a propagation block. The main objective is to maintain and produce healthy *Napier* slips for distribution to farmers of the region for fodder production. Demand for slip for on- farm fodder production by the farmers is increasing as the centre is the only the source of Napier root slips. More than 30,000 slips were distributed during the year 2002-2003. The block will be maintained for basic planting materials and distribution.

3.1.6 Live Herbarium

The purpose of the live herbarium is to serve as a showcase for visitors including the farmers study groups and the extension agents. It also serves as an easy and rich source of planting materials (seeds/seedling/slips) for future experiments and studies. There are plans to add more promising species including recently released varieties in future.

3.1.7 Bee keeping at Bajo

The objectives of this trial are to test beekeeping in terms of adaptability, survivability and productivity for honey production on pilot basis. Once tested introduction in the region for practice by the farmers shall follow. An apiary with three *Apis Mellifera* colonies bought from Bee keeping Association in Bumthang was set up in the centre in July 2001 and evaluated for the above criteria.

The findings indicate that colony development was effective and fast during the first year. By the start of the season, additional super were added to increase the colony strength and trap the honey flow of the season. About 70 Kg of honey was harvested during the first year. During the second year, the performance of the colonies had drastically gone down and by the end of May 2003, all the three colonies were wiped out due to the following reasons: the Queens were old and unproductive; they were not laying eggs for colony propagation; all these beehives were found toppled and damaged by night strollers; lot of death of adults bees were recorded due to cold and external disturbances while wintering. Further the foundation sheets were reused after honey extraction; as a result, the brood were diseased, probably with Europeon Foul Brood. The existing apiary should be revived for two reasons. First the scope of bee keeping for honey production for cash generation and the crop pollination is gaining its importance in the country. It will be quite profitable when proper management are in place. Second demonstration by the centre could encourage farmers in the region to take up the activity.

3.2 On- Farm Research

3.2.1 Legume cover-crop in orange orchard

The main objective was to optimise forage production with horticulture crops (especially with plantation crops like orange, arecanut and apple). It was further aimed to study the comparative advantage and suitability of leguminous forages inter-cropped in orange orchards in terms of labour, input requirement, soil conservation

and soil fertility management, ground cover as cover crop with the traditional existing system of management and production of forages separately.

In addition to the earlier two test sites of Phaduna and Kamichu from Punakha and Wangdue Dzongkhags, 3 more trials sites were established at Lower and upper Tshokana, and lower Goshi under Tsirang and Dagana Dzongkhags to have more replicates in other Dzongkhags for representability. Three prominent legume species namely *Desmodium Intortum, Arachis Pinto*i and *Stylo* were used iniatially. It was observed however that *Stylo* was not performing well as there was very little growth. As such, *Desmodium intortum* and *Arachis pintoi* were compared with a control plot separately.

The findings reveal that both of these legume species perform well under orange orchard at different altitude levels (from low to mid). *Green Leaf Desmodium* performs better at lower elevation below 1500 masl than *Arachis pintoi.* Farmers prefer *Green leaf Desmodium* to *Pintoi* due to its fast growth and higher yield when used for cut and carry. However, *Arachis pintoi* performs better in the long run with values of soil conservation and as a live mulch.

3.2.2 Assessments and Monitoring of Grassland Resources

The immediate objective was to describe the natural grassland, identification of grass and legume species and establishment of a live herbarium. In the long term, it will achieve to monitor trends in production, soil quality, population composition and nutritive quality and finally aid in drawing the long-term natural grassland management strategy and action plan. The preliminary results are presented in (Table 30 and Table 31).

Table 30: Results from the first field monitoring

Components of grasslands	Frequency 1.5 m
Broad leaf	5.92
Grass	11.81
Barren	7.42
Stone	0.54
Potentila	0
Premola	0
Cortenestester	3
Molases	0.04
Rodo	0
Spruce	0
Anophalos	0
Juniper	1.23
CV %	0.3
SED	1.682

The detailed analysis showed that grasses are the major component of natural grassland, with a frequency of 11.81(± 1.682) in the region, followed by broadleaf species with a frequency of 5.92(±1.682). Barren land and Juniper components contributed for large area under the grassland with a frequency of 7.52(±1.682) and 1.23(±1.682) respectively. Other components such as contenestester and juniper are also observed but at lower frequency compared with grass and broadleaf species.

Table 31: Results from second trial monitoring

Components of grasslands	Frequency 1.5 m
Broad leaf	6.4
Grass	10.98
Barren	7.06
Stone	0.44
Potentila	0.11
Premola	0.39
Cortenestester	2.48
Molases	0.65
Rodo	0.29
Spruce	0.04
Anophalos	0.81
Juniper	1.06
CV %	4.6
SED	1.459

During the second monitoring, grasses still predominated the natural vegetation cover, with a frequency of 10.98(±1.459) per 1.5m, followed by broad-leafed species, 6.4 (± 1.459) per 1.5m. Contenestester, juniper, molasses, rodo, anophalos and spruce still formed the vegetation cover but in lesser quantity. Barren land and stone components are still the major part of natural grassland area. These findings are quite preliminary as it is a long-term activity. The field monitoring and information collection on natural grassland and other aspects will be continued.

3.2.3 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. The trail was set up in July 2001 with two farmers under Tsirang Dzongkhag however one farmer opted out as the seeds did not germinate. Apparently this was because the land where seeds were sown was ploughed. About twelve subtropical fodder species are under evaluation with the remaining farmer.

The initial observation showed presence of some stand of all the species except Velvet bean. Velvet bean is seasonal forage. Farmers prefer fast growing and high fresh matter yielding forage to slow growing with poor biomass production. For instance, *GLD* is preferred over *Arachis pintoii*. This is because, *GLD* grows much faster and yield better fodder compared to Arachis initially. However, at the end, *Arachis* would be better than *GLD* once fully stabilised and formed a thick blanket suppressing all weeds around. The farmers assessment combined with observations made by research and the extensions staff will be used to select the promising species.

3.2.4 Lucerne germplasm evaluation

The main objective of this trial was to evaluate and select the most promising Lucerne varieties. Thirty-one varieties of *Medicago sativa* were sown in a single plot design with the plot size of 1 m x 4 m. The trial was established at NRTI, Lobeysa in keeping with Lucerne's soil requirement (dry and infertile land). The trail along term one (for four years), was established in 31 July '01. Details of data gathered are presented in Table 32.

Table 32: Plant Density and Fresh Biomass yield of 31 Lucerne entries

Variety	Density of plants				Fresh biomass (kg)		
	30 days	60 Days	90 Days	Av.	60 days	90 days	Av.
L238	288	260	262	261	1.0	0.8	0.9
L330	278	271	270	273	1.6	1.4	1.5
L583	297	351	345	331	3.0	2.6	2.8
L603	340	418	405	388	3.6	2.4	3.0
L634	234	242	245	240	2.0	1.8	1.9
L635	299	261	263	274	3.4	3.0	3.2
L636	247	363	354	321	4.0	3.2	3.6
L754	225	270	275	257	3.6	3.0	3.3
L755	201	287	277	255	4.4	3.8	4.1
L792	208	210	212	210	4.4	3.4	3.9
L794	230	234	233	232	3.6	2.6	3.1
L813	183	224	223	210	3.0	2.0	2.5
SA 32087	105	108	109	107	2.0	1.8	1.9
SA 32088	466	270	271	336	1.4	0.6	1.0
SA 32089	291	307	311	303	1.4	1.0	1.2
SA 32090	249	246	243	246	0.8	4.0	2.4
SA 32091	483	437	432	251	2.0	1.0	1.5
SA 32092	308	414	405	376	2.4	1.8	2.1
SA 32138	495	347	329	390	2.4	1.4	1.9
SA 32140	309	312	315	312	3.4	1.9	2.65
SA 32147	333	399	401	378	3.4	1.5	2.45
SA 35067	300	254	254	269	3.0	1.6	2.3
SA 35068	236	219	221	255	2.2	1.0	1.6
SA 35088	161	250	245	219	2.4	1.6	2.0
Eureka	113	127	129	123	2.6	1.7	2.15
PL 34HQ	59	56	55	57	1.2	0.9	1.05
PL 55	130	156	154	147	3.0	2.0	2.5
Prime	111	120	121	117	4.4	3.2	3.8
Super 7	36	45	43	41	2.0	1.6	1.8
WL 414	25	19	21	22	1.8	1.2	1.5
15 L 756	90	99	97	95	1.2	2.0	1.6

Germination percentage, growth and plant height were satisfactory for all varieties. The highest biomass production was recorded from *L755*, followed by *L792, Prime, L636*, and *L 635* during successive two cuttings at 60 and 90 days of sowing. *SA 32138, L603, SA 32147 & SA 32092* recorded highest average plant density count (3 counts).

Further evaluation of their production variables needs to be continued.

Growth and plant height of Lucerne entries

3.2.5 Comparative hatchability of local and exotic eggs and their post trial performance

The long-term objective of this trial is to improve living standard of farmers through the sale of eggs. The short-term objectives were to compare hatchability, growth, adaptability and survivability of local compared to exotic chicks under farmers' management condition. Further it was to assess the production performance and other variables of these birds in terms of lay till the end of their economically viable period. Growth, adaptability, mortality and production performance of their crossbreeds under local conditions (post-trial data) were also considered.

The trial was set up in Dzomi, Chubu, Taewang and Limbu Geogs under Punakha Dzongkhag. In total 350 eggs were distributed to 35 households. 42 local broody hens were selected for the hatchability trial. Each broody hen was given on an average 8 eggs of both local and improved for brooding purpose. The local eggs were used here for the purpose of easy acceptance by the local hens and for also as preferred by the farmers.

Table 33: Hatchability percentages from trial birds of four Geogs

Geog	Improved	Local	**Remarks**
Dzomi	83%	100%	10 broody hens either did not brood / spoiled all eggs
Chubu	85%	100%	From 1 broody hen information was not received
Taewang	82%	73%	4 broody hens either did not brood / spoiled all eggs
Limbu	71%	50%	3 either did not brood / spoiled all eggs
Average	80.3%	80.7%	Hatchability is quite positive

The initial findings indicate about 80% hatchability percentage of both improved and local eggs (Table 33). The hatchability percentage was calculated from 29 local hens brooding improved or both improved and local eggs and 10 broody hens brooding improved or both improved and local eggs. About 40 % of the birds did not brood, spoiled all eggs, or were brooding at the time when this information was collected. Farmers showed keen interest in the activity although some commented that brooding is difficult especially during winter and that although hatching is successful the chicks do not survive during winter.

This trial shall continue till the end of 2005. The findings is hoped to help in formulating the guidelines to Breeding Farms in supplying the fertile eggs on pilot scale to the farmers for cross breeding programme and ultimately lower the cost of production in the Central farms, reduce pullets mortality during transportation, and encourage farmers participation. A similar kind of experiment needs to be conducted during summer months to compare the hatchability, mortality percentage and other production variables.

3.2.6 Study on pig and poultry genetic resources: a survey

Majority of Bhutanese population are subsistence farmers. Bhutan has a high diversity in terms of domestic animal genetic resources. One of the focuses of the National effort on using indigenous breeds, which have been gaining importance in the recent years, is the native pig and poultry breed conservation. This is because pig and poultry are adaptable to local conditions, help rural household to meet nutritional requirement and fulfil the urgent cash requirement of the poor farmers.

Pigs are third largest domesticated animals in the country constituting 61,010 heads in 1997 and by 2000 the pig population declined to 41,464 heads only of which 10,655 are improved pigs. In 1997 poultry population was estimated at 1,57,663 numbers but increased to 230,724 in 2000. It is believed that about 90% of poultry are indigenous breeds and considered to be descendents of red jungle fowl. There has been a decrease in native pig population by about 28 %, while the population of improved pigs increased by 2.8 times. However, the overall pig population over the period of 10 years (1988 -1998) has declined by 17 % (DALSS, 2001).

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Two native pigs breeds (*Deophab* [2]and *Jituphab*[3]) and 9- 12 local poultry breeds are believed to have existed in the country. Detailed information on their origin and distribution and breed characteristics are yet to be confirmed. DNA mapping of these local pig and poultry breeds crucial. As such the current study is expected to generate information on the above. Eggs or the pullets of local poultry and typical pig breeds from the pocket areas within Bhutan will be collected. An experimental trial will then be initiated in Central Farms to evaluate the production performance and ultimately lead to recommendations on appropriate strategies for conservation and utilization of these breeds especially in the Breeding Programme and also produce indigenous breeding stock.

The short-term objectives of this survey were to generate and document detailed information on phenotypic characterization, production traits, parameters and the population size of native pig and poultry breeds. Hair and blood samples was collected for genetic distance studies (DNA mapping) and identify potential pockets where native pig and poultry breeds are available.

The national survey on genetic resource of native pig and poultry breeds was initiated in May 2003. A minimum of 40 individuals per sample were collected which are as far as possible unrelated. Use of semi-structured open-ended questionnaires together with a format for recording individual physical description were used.

Figure 5: Typical indigenous pig and poultry breed in Bhutan

[2] Deophab is believed to be descendent of wild boar; it is a pig with large body size, small flat erect ears.

[3] Jituphab is a small size native pig with a bulging belly.

Typical pig and poultry breeds (Figure 5) were recorded for purposes of documenting and future breeding to explore their production potential and the conservation. Blood and the hair sample were collected on Isocode Stix and assayed using micro satellite markers for DNA analysis to obtain genetic distance within the local breed of pigs and poultry. The survey report shall be available once the DNA report comes in.

FORESTRY RESEARCH

4 FORESTRY RESEARCH

4.1 Lingmutey Chu Watershed

4.1.1 Rehabilitation of Degraded Areas

Land degradation due to soil erosion and lack of tree resources were clearly identified as among the major constraints by the diagnostic survey of 1997. Accordingly rehabilitation of degraded areas through community forest plantations and handing over of natural forest as community forests were short-listed as priority areas to be addressed by the forestry sector.

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.

For the purpose of handing over the natural forest in the watershed to the local communities as community forest a number of activities have been implemented to a) elicit local communities' perceptions and aspirations b) to assess the resource in terms of quality, boundary and quantity. These include participatory forest management for local use, permanent resource monitoring plots, rapid silvicultural assessment and forest function mapping.

4.1.1.1 Community Forestry Nursery

A CFN was created at Omtekha village in 1999 to identify and generate diverse tree species suitable for fodder, fuel, timber, community plantation, gully plugging, hedgerow planting, and reforestation in heavily degraded areas. This also has a further aim of making implementation participatory and accessible to beneficiary communities and expose communities to nursery establishment and seedling handling techniques. Species raised include both native and exotic and are chosen by the community and based on the experiences of the participating institutions. The nursery is now fully managed by the communities with minimal input from the centre.

The seedlings generated from the nursery were planted on-farm/site for evaluation with regards various purposes and the appropriately identified species are to be promoted. The list of species available in the nursery is given in Table 34 below.

Table 34 Species available in the CFN

Scientific name	Local name	Scientific name	Local name
Quercus griffithii	Sisishng Dz	*Macaranga denticulata*	Malata Lh.
Quercus lanata	Gumshing Dz	*Dendrocalamus spp*	Pakshing Dz.
Robina psedoacacia	Robina Co.	*Salix babylonica*	Changmashing Dz.
Alnus nepalensis	Gamashing Dz	*Albizzia procera*	Setosiris Lh.
Leucaena leucocephala	Ipil- ipil Co.	*Cupressus cashmeriana*	Tshenden Dz.
Dodonea viscosa	Dodonea Co.	*Albizzia spp.*	Siris Lh.
Ficus roxburghii	Bakushing Dz	*Schima wallichii*	Puyumshing Dz.

4.1.1.2 Community Forestry Plantation

The areas near the homestead were characterised by heavily eroded soils with very little vegetation cover resulting in formation of deep gullies. With the objective to help reforest such lands, the degraded 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 35 below presents the area planted in various years.

Table 35: Community plantations (from 1999-2002)

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

4.1.2 Participatory Forest Management Plan for Local Use (PFMPLU)

In December 1998, two multi-disciplinary PRA teams camped in the watershed and met with all six-watershed communities to identify with them their forest resources, forest use, views on the present centralised management system, and interest in developing a PFMPLU. The objective was to explore with the Lingmutey Chu watershed communities the possibility of their increasing participation in the planning, management and protection of the watershed forest.

The dominant view of the communities was general satisfaction with the existing system, which they regarded as having improved forest cover, reduced inter-community disagreements over forest resource use, and able to provide them legally or illegally with the resources they needed. The communities raised a number of issues with which they were unhappy such as the time required for permit processing; the occasional untimeliness of tree marking and their inability to protect their local forest from legal extraction by outsiders. These issues and some suggestions have been forwarded to the concerned FSD authorities. On balance, the communities clearly preferred to continue with the present system rather than develop an inter-community PFMPLA for the whole watershed forest. They doubted that they could achieve the necessary co-operation within and between communities; and doubted whether they would see any extra benefit for the increased input that they would have to make.

Nonetheless, all villages were keen to have protection powers over their immediate forest and some villagers (more often men than women) were interested in further discussions on inter-community collaboration towards a PFMPLA, provided that FSD staff would maintain their forest protection role. The PRA team members recognised that the PFMPLU concept was probably introduced too suddenly and with inadequate

explanation. This made it difficult for community members and watershed leaders to fully grasp its potential benefits as well as its potential drawbacks.

Consequently, the forestry sector of the centre together with the BG-SRDP and the District Forestry Office has been holding detailed discussions about the possibility of a community forest with the local communities and initiated activities to proceed for handing over of the watershed forest as community forest.

4.1.3 Permanent Resource Monitoring Plots

The rural people depend on the forest for a lot of products viz. fodder, firewood, construction and fencing materials and leaf litter and also grazing. Forest exhibit significant changes over time and these changes are mostly determined by the use of the forest. Wanton cutting down of trees for firewood or construction would ultimately lead to forest depletion. Also more often than not some species are preferred over others and as a result these species are continually taken out from the forest leading to forest degradation. Collection of leaf litter has also been suggested to be detrimental to forest quality as this activity removes the organic material from the forest floor whose decomposition otherwise would help in maintaining the fertility of the soil. The extent to which a forest is used depends on its species composition and proximity to the homesteads i.e. diverse and forest closer to the homesteads is used more intensively.

Establishment of sample plots for monitoring forest change according to use at different altitudes, aspects and according to dominant species (forest type) and periodical observations would over time generate information on the forest dynamics of such forest with respect to the use they are put to. Information gathered in this way would help in understanding the dynamic processes, which is important from both scientific, and management perspectives.

The objectives of the activity are to 1) monitor forest change in terms of growth and species diversity over time; 2) ascertain the effect of current forest use on the sustainability of these forests; 3) to understand and document the ecological dynamics of the forest types under study. As such 8 permanent plots were established in the watershed in 2001. Assessments in these monitoring plots over time is hoped to generate information on the forest dynamics of such forest with respect to the use they are put to. Information gathered in this way would help in understanding the dynamic processes, which is important from both scientific, and management perspectives.

The plots were distributed to achieve a representative sample of the forest in terms of forest type, altitude and aspect as follows: 2 in the Rhododendron dominant forest; 2 in the oak dominant forest; 2 in the transition zone of the oak and pine forest; 2 in the pine forest. The sizes of the plots were 20 x 20 m and selected randomly in the four areas as above.

A map of location indicating the exact site of the plots has been prepared. Complete inventories of trees consisting of tree height, diameter, etc. in the plots were taken and individual trees were marked using paint. Other plot-wise observations such as slope, aspect, soil type were also recorded. Recordings were envisaged every three years and as such the second measurements would be due in 2003.

4.1.4 Rapid Silvicultural Assessment

In co-operation with NRTI, BG-SRDP, Lobeysa and RNRRC, Yusipang, a Rapid Silvicultural Assessment (RSA) of the Lingmutey Chu watershed forest was carried out from 22-27 May 2000. The objective was to elicit through discussions with the community focus groups on their perception of the forest quality and quantity and rapidly verify these perceptions in the field.

Three types of forest in the watershed viz. Chirpine forest, Mixed Chir-broadleaf forest, and broad-leaved forest were identified. On the southern slopes one finds *Michelia* and *Carpinus* sp. as dominant species while *Q. Lanata* and *Q. Semicarpifolia* dominate on the north facing slopes. *Q. Griffithii* is the dominating species on the base of the slopes near the homesteads and serves as sogshings ideally. *Rhododendron* sp. Forms the major understorey species with occasional *Lyonia* sp. And *Symplocus.* Topography is defined by hill slopes which are occasionally steep and characterized by rock outcrops in certain areas. The forest slopes down towards north and slope giving the two major aspects viz. North and south. The elevation of the forest goes from about 1600 m above sea level on the lower Chir forest dominated slopes to upto 2500 m at the top with *Quercus* forest.

Red soils are predominant in the lower slopes while brown sandy clays are characteristic of soils on the upper slopes. Deeper and higher up into the forest brown earth with dark and thick humic layers are found. Bilberry (*Vaccinium* sp.), bramble (*Rubus* sp.), and *Illex* sp. are the major ground vegetation. The soils have fairly good drainage although some poorly drained and marshy areas are present.

Forest in the watershed has increased in area in the watershed consequent to protection after the nationalisation of the forest. This is apparent from the young stand especially chir pine, growing in the former pasture and waste lands. However with no proper sivicultural system having followed, the villagers taking out the best trees and leaving the poor trees to be seed bearers and those closer to the homestead the quality of the forest particularly those around the settlements have considerably deteriorated. Existing trees in the forest exhibit low yield and as such productivity of the forest may be doubted. Even deep inside the forest in some areas visited the forest is poor in terms of quality with inadequate or no regeneration at all. Grazing may be one of the primary reasons for the lack of regeneration manifested by frequent citing of browsed seedlings. Another reason may be because of a paucity of seeds falling on the ground or a lack of a favourable microsite.

4.1.5 Forest Function Mapping and Forest Zonation

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 forest function mapping exercise was carried out in the Lingmutey Chu watershed in collaboration with the BG-SRDP, Lobeysa in 2002.

Forest function mapping defines for all the forest areas within particular area ecological, environmental and social functions to allow a balance between the

oftentimes conflicting management interest of the local forest users, nature conservation and environmental protection.

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 36.

Table 36: 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		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**

Forest functions have different impacts on forest management. Some protective functions prohibit the felling of trees while 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.

4.2 On-station

The forestry 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.

4.2.1 MPTS Evaluation

The list of species evaluated is given in Table 37. *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 37 : 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.

4.2.4 Germination trial of Terminalia spp

A germination trial of graded seeds of *Terminalia* spp which were collected locally was established in MPTS nursery on 6 June 2003 with the following three treatments:

T1 = control (no seed treatment at all)
T2 = seeds soaked in hot water for 12 hours
T3 = seeds soaked in cold water for 12 hours

Seeds were sown in three conditions namely open area, shaded bed and shed in a randomised block design of three replications in each of the conditions. Germination assessments were done at 3 weeks and 4 weeks after the date of seed sowing. Preliminary results are presented in Table 38.

Table 38: Germination results of Terminalia spp.

Sowing date	Replication	Treatment	Nos. of Seed sown	Nos. of seed germinated	% germinated after 3 weeks	% germinated after 4 weeks
Open area						
		T3	45	22	49%	93%
06/06/03	R1	T2	45	20	44%	69%
		T1	45	15	33%	67%
				Shaded area		
		T3	45	13	27%	64%
06/06/03	R2	T2	45	12	27%	33%
		T1	45	10	22%	27%
				Nursery shed		
		T3	45	16	36%	31%
06/06/03	R3	T2	45	14	31%	11%
		T1	45	5	11%	18%

T3 (seeds soaked in cold water for 12 hours) consistently gave higher germination results as compared to the other treatments in all three conditions considered while surprisingly open area conditions apparently favours *Terminalia* germination more than shaded and nursery shed. This can be attributed to the better light, temperature and air circulation that is afforded by the open area than the other two conditions.

4.3 Extrapolation

4.3.1 Stand stability trial of 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 at the end of the 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 is under preparation by the forestry research coordinating centre, RNRRC Yusipang and a comprehensive research plan on the dynamics of broadleaf forests in Rimchu is envisaged beginning 2003-2004.

SYSTEMS RESOURCE MANAGEMENT

5 SYSTEMS RESOURCE MANAGEMENT

5.1 Community Based Natural Resource Management (CBNRM)

CBNRM research was initiated in Lingmuteychhu Watershed since 1997 after a problem diagnostic survey. CBNRM encompasses a holistic view of a farm household system, intersectoral perspectives, greater farmers' participation that builds on the synergism of interdisciplinary and farmer's partnership in research process. Natural Resources Management is a broader concept that encompass resources management and use, including agricultural production, besides environmental and conservation concerns. Some of the CBNRM related activities conducted in the Lingmuteychhu watershed during the year 2002-2003 are described below.

5.1.1.1 Paddy variety for high altitudes

The diagnostic survey indicated one major problem of farmers as the low yield of local paddy variety in the high altitude. As such high altitude (above 1800 m) paddy variety was tested continuously for last three years. Four test varieties were tested in the beggining and last year the two best selections (PP3-31-2-1 and PP4-8-1-1) were evaluated. The trial kit consisting of 1 kg seed of each variety was provided to two co-operator farmers to be managed under their conditions. The trial seed was distributed to few farmers only on trial and if the varieties were successful and accepted by farmers, it could then be outscaled to include the community. The data recorded and the observations made during the last season are presented in Table 39.

Table 39: Crop-cut results of the tested high altitude rice varieties

Variety/line	T/plant Date	Harvest Date	Yield (t/ha)	Remarks
PP_4-88-1	12/6/02	14/10/02	4.84	Difficult threshing
PP_3-31-2-1	6/6/02	14/10/02	NA	Early variety, damaged by birds
Bomdeling		14/10/02	3.84	Local check

Farmer's feedback

Although the test varieties yielded higher than the local varieties, they are difficult to thresh manually. Also the new varieties were early maturing and were damaged by wild animals and birds. PP3- and PP4- lines have high yielding potential and are now adopted and cultivated in small-scale by farmers.

PP lines growing in farmer's field

The seeds of the test varieties are saved and exchanged within the villages also the numbers of farmers cultivating these varieties are likely to increase. It was recommended that, to avoid yield losses, either the nursery sowing timing or cropping system needed adjustment or the community should adopt the new variety in larger areas so that damage could be reduced.

5.1.1.2 Sochum intensive hand weeding campaign

The intensive hand weeding campaign on *Sochum* (*Potamogeton distinctus*) was initiated in the watershed after a short farmers study tour to Paro Dzongkhag in August 2000. Hand weeding campaign was also continued this year with the same farmers their fields. Three hand weedings were done to remove at an interval of two weeks from transplanting at four locations.

The hand weeding cum demonstration was done in a limited area (one to two plots) per farmer, as it was difficult to cover a large area due to the shortage of farm labour. Unless the whole community agree to take up this program, the *sochum* problem will persist as the farmers share the same irrigation canal whereby *sochum* gets transferred from one field to another through irrigation water. Yield assessment was carried out only for three farmers as one farmer had already harvested his crop. The differences in yield from intensive hand weeding and normal practice were assessed through crop-cut from an area of 2x3 meter and are shown in Table 40.

Table 40: Comparative crop-cut results of weeding methods

Hand Weeding Practice		Normal Practice	
Variety	Yield t/ha	Variety	Yield t/ha
Yusirey Kaap	5.4	Shenga Maap	4.2
Bajo Kaap	6.3	Bajo Kaap	6.6
Bondey	5.4	Bondey	5.7
Average	5.7		5.5

No major differences between the two were observed. The activity will be continued in the coming season combined with a field day to increase awareness on the intensive hand weeding through horizontal exchanges (farmer-to-farmer extension). Elderly farmers during the informal discussions with farmers pointed out that the intensive hand weeding would lead to good yield by reducing sochum pressure in the field and help in formation of more filled heads. Also intensive weeding helps soil to become loose and forming more tillers. Figure 6 shows the average comparative yield differences between the two weeding practices for the last three years.

In the first year, the activity was limited to one site; from second year onwards the hand weeding sites was increased to multi locations in different AEZ. Although there were no major differences in yield in the initial year of the activity implementation, the yield differences in the second year was 1.6 t/ha. This can be attributed to the reduction of *sochum* in rice field, differences in variety grown and fertilizer application.

shows that on an average there is some difference from intensive hand weeding field compared to the normal practice of one hand weeding but since farm labour shortage is one of the primary constraint in farming community, a study on the economic analysis for intensive hand weeding is foreseen.

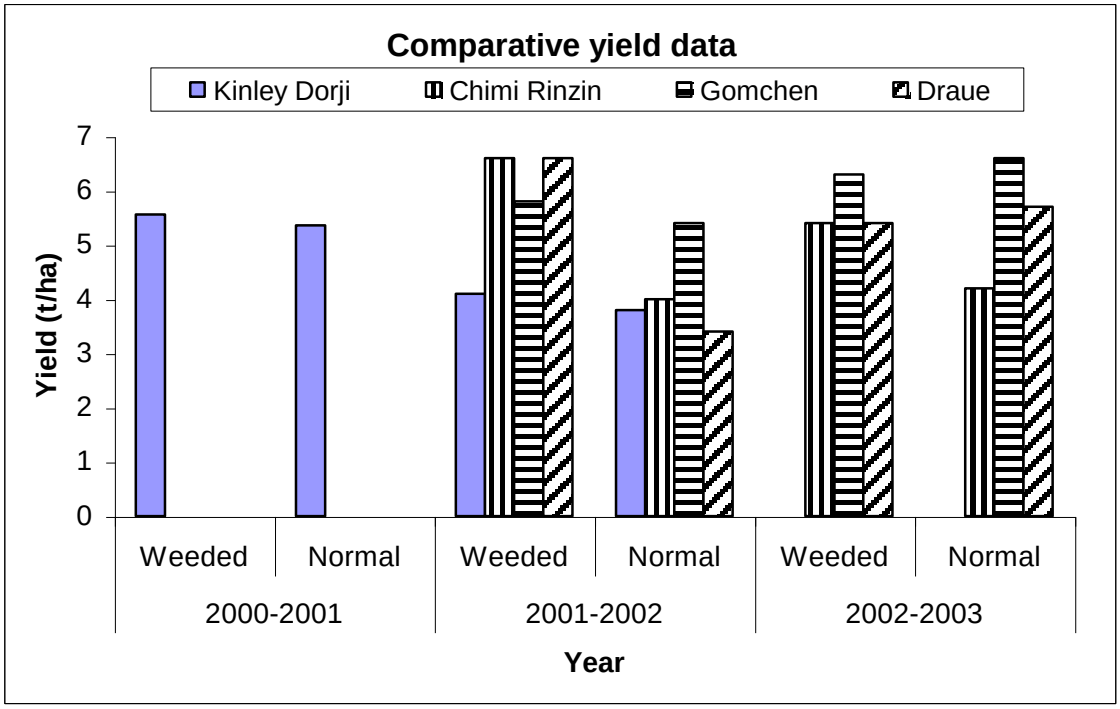

Figure 6: Comparative rice yields from sochum weeding campaign (2000–2003)

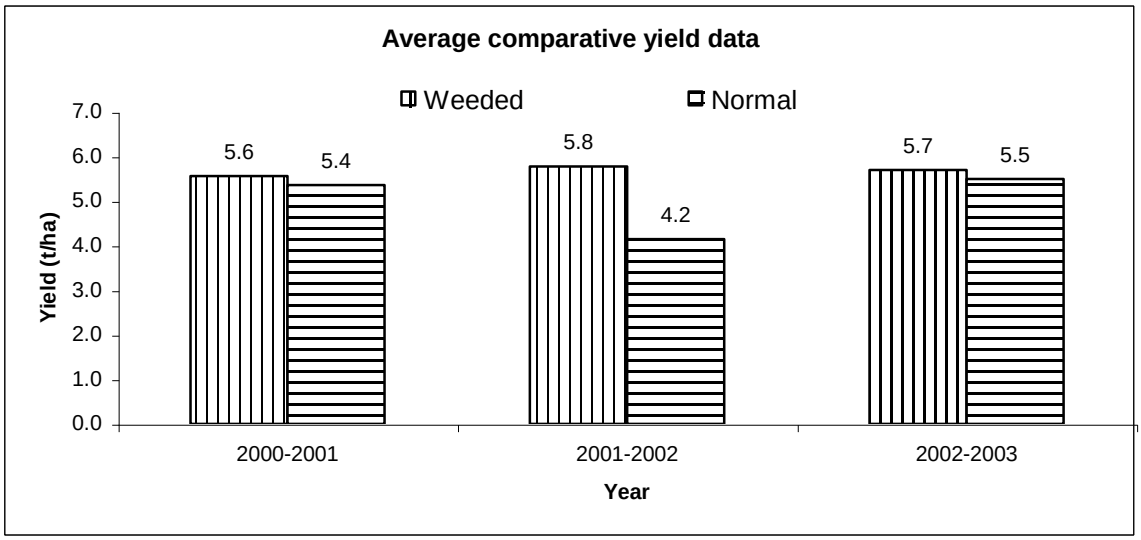

Figure 7: Average Comparative rice yields from sochum weeding campaign (2000–2003)

5.1.1.3 Groundnut On-farm evaluation and Promotion

In order to evaluate the performance of on-station tested groundnut at farmers' management conditions and to improve and conserve soil erosion in farmers' field, small seed packet of groundnut weighing 250 gm each of two cultivars (*Kadari* and *ICGV_87920*) were distributed to 13 farmers of Nabchey during the month of April 2002 and sown within the next few weeks. Monitoring was done during the growth stage and yield assessment done at

harvest, where the total yield of groundnut with pods was measured from the area planted. The details of the crop yield at harvest are shown in Table 41.

Table 41: Groundnut pod yield per farmer and variety

S.No	Farmers	Variety	Yield (Kg)	Remarks
1	Kencho Dorji	Kadiri	17	
3	Yeshi Om	Kadiri	2	
4	Dechen	Kadiri	8	
5	Yuden	Kadiri	6	
6	Tashila	Kadiri	9	
7	Chala	ICGV	1	
8	Jigme	ICGV	4	
9	Yeshi Peldon	ICGV	1	
10	Tshewang Peldon	ICGV	Nil	Did not germinate
11	Sonam Tshomo	ICGV	4	

Farmers find groundnuts suitable for cultivation in areas like Nabchhey where the soil type is sandy-loam. Farmers prefer the variety ICGV owing to its colour (red) and taste which makes it easier to sell compared to white Kadiri. Farmers report good potential of groundnut as a cash income earner for small households of Nabchhey.

5.1.1.4 Demonstration Orchard

A demonstration orchard was established at Omtekha in 2000 to evaluate improved fruit plants in farmers' field and showcase improve technologies to farmers and visitors. Planting of fruit plants, monitoring and data gathering from the demonstration orchard was continued. During the year, additional 7 grafted pear seedlings from 5 different cultivars were planted increasing the total number of plants to 117. The new sub-tropical apples planted during the year 2002 have all died. The best performers this year are chestnut, apricot, walnut and apples.

Apple fruited better this year compared to the last two years with 359 fruits (48.9 kg) from 12 trees. Since the fruits were harvested during the month of July when the temperate apples are not ready, it fetches a higher price (details in Table 42).

Table 42: showing apple yields per tree

Tree No	Number of fruits	Weight (kg)	Remarks
1	25	4.8	
2	42	5.9	
3	47	6.2	
4	60	7.2	
5	0	0	Pollinizer
6	92	10.9	
7	23	3.5	
8	4	0.8	
9	29	3.1	
10	0	0	Pollinizer
11	29	5.3	
12	8	1.2	
Total	**359**	**48.9**	

5.1.1.5 Improving Backyard Fruit Plants

This activity was continued to increase farmers' capacity in managing horticultural crops with a farmers' training on fruit propagation. Monitoring of fruit plants supplied earlier, fruit tree propagation by top working were conducted in Limbukha, Dompola and Nabchhey in April 2003 for pear, persimmon and walnut. Three different cultivars of scion wood were used for pear, one for persimmon and one for walnut (summary in Table 43).

Table 43: Summary of fruit plant top worked in the watershed

	Pear				**P/mon**	**Walnut**
	Top- worked fruit trees					
	Shinko	***Hoshi***	***Limbukha***	Total	***Fuyu***	***Payne***
No. of trees	15 (13)*	21(20)	11(11)	**47(44)**	**28(25)**	**15(6)**
Scion wood used	41(33)**	63(58)	25(25)	**129(116)**	**89(61)**	**31(7)**

** No. of successful top-worked trees*
*** Number of successfully flushed scion wood*

5.1.2 Walnut Plantation at Focus Village

Nabchhey village in the Lingmuteychhu watershed was selected as a focus village for walnut production. This had the objectives to produce soft shell walnut, increase household income utilize fallow lands and for soil conservation. Farmers were provided free rootstock seedlings for one to two *langdos* of land (20 seedlings per *langdo*). Researchers from Bajo helped in the trial layout and planting, while the overall management was left to the farmers. Farmers were also informed that the rootstocks once well established needed to be field grafted. In total 440 rootstock seedlings were planted in 20 *langdos* of land of all the 20 households in Nabchhey.

5.1.3 Private Fruit Trees Nursery Establishment

There is a high demand for the improved fruit plant seedlings from the farmers in the watershed. To meet this requirement and also to generate cash income through sale of grafted fruit plants seedling, a private horticulture nursery was established at Omteykha village with a cooperating farmer. This nursery is also hoped to cater beyond the watershed to other areas in Punakha and Wangduephodrang. The farmer co-operator was trained on the basics of nursery management and some fruit seeds sown in the new nursery (Table 44).

Table 44: Seeds sown in the private nursery

Fruit variety	**No. of seeds sown**	**No. of seedlings germinated**
Walnut	4000	450
Persimmon	600	20
Peach	2000	Nil
Pear	900	Nil

The seeds were sown on raised beds in February 2003 and timely irrigation, mulching and weeding were done. Germination was very low initially but improved with the onset of monsoon especially of walnut and persimmon seedlings. Irrigation has been reported as the main problem during the dry season.

5.1.3.1 Community management of breeding bull

Mithun breeding bull was supplied to the Nabchhey community in 1998 on the basis of community management. A committee for bull management was formed by the members. Members of the management group have changed in the year but the old bull keeper has been retained. As of April 2003, 30 services were preformed out of which 17 progenies were born (8 female and 9 male) but 2 died.

Progenies from the bull

The committee also conducts regular meeting to discuss and plan on bull management. During recent committee meeting, they have agreed to extend cross breeding activity beyond the community on a 'per progeny born payment' where farmers from outside the community pay bull's service charge when the progeny is born at the rate of Nu.1200 and Nu.1000 for every female and male progeny born respectively. This way the committee has accumulated Nu 3000.00 (for three-progenies) which has been handed over to the village *tshokpa* to be used later for buying a replacement bull in the future.

5.1.3.2 Fodder species Plantation on Maize field bunds

Creation of maize trashline in Nabchey was adopted in to control soil erosion during the monsoon. But the raisers formed were not stable as it was simply an accumulation of inorganic matters. Options on stabilization of trashline were discussed with farmers and it was decided that fodder species will be planted on the bunds which will not only stabilize the trash lines but also serve as additional source of fodder and besides the grass leaves can be used as green manure and feeds and tree trunks can be used for firewood and small timber. From the various species of fodder grasses and trees planted, Napier *(Pennisetum purpureum)* and Setaria *(Setaria ancep*) from the grass species and Lucenae *(Leucaena luecocephala)* and Flemingia *(Flemingia congesta)* from the leguminous fodder tree perform well.

5.2 Integrated Plant Nutrient System Research

Research on IPNS (Integrated Plant Nutrient Systems) commenced on station at Bajo as early as 1990 with a long-term trial in rice based farming system in recognition that there was no fertiliser recommendation for different crops and farmers practiced blanket recommendation. However, IPNS on-farm trials were started only in late 1998 in the Lingmuteychhu watershed. Most of the activities were in collaboration with the national SSF&PNM (Sustainable Soil Fertility and Plant Nutrition Management) Project. By 1999 few balanced fertilizer trials were conducted outside the watershed.

The overall aim of IPNS research program is to enable research and extension to work with farmers to improve their soil fertility management systems using an integrated plant nutrient system (IPNS) approach to improve the productivity of the land without depleting the soil resources.

5.2.1 Activities conducted in Lingmuteychhu watershed

5.2.1.1 A survey: Management and Use of FYM in the Lingmutey Chhu Watershed

The application of FYM and other organic matter materials is the major source of plant nutrients for agriculture in the watershed. Despite this importance, the information on the use of FYM is limited particularly with respect to the quantity applied and its quality. A baseline survey in the Punakha-Wangdue valley (RNR-RC Bajo, 1994) provided good agronomic information on the use of FYM in this area although it lacked data on the rate of nutrients applied based on field and laboratory measurements.

Given the importance of FYM as a soil fertility management practices in the watershed, RC Bajo together with the SSF&PNM Project decided to conduct a detailed study into the management and use of FYM as the dominant soil fertility management practice in the watershed.

The general objective of this survey was to obtain a better understanding of existing FYM practices in order to explore the potential for developing interventions that can either improve quantity or quality, or both, of FYM produced, to support a more productive agriculture in conjunction with the appropriate use of inorganic fertilizers. The specific objectives of the FYM Survey were:

- To study the quantities, qualities and timings of FYM/OM being applied by farmers
- To identify factors that determines the quantities, qualities and timing of FYM/OM being applied
- To identify factors that constrains the "improvement" of animal manuring practices (quantities, qualities and timings)
- To document the characteristic methods of FYM preparation, storage and application

The FYM survey was conducted with a random sample of 23 households from three villages in the watershed. The survey took over 18 months to cover a complete cropping/manuring cycle for all fields that are used by the sample households in one year.

The survey questionnaire comprised of three parts for the collection of qualitative and quantitative data namely household information, information on use of FYM, tethering, fertilizer management and finally information on household's characteristics, management, and use of FYM. A total of 93 FYM samples were collected according to a sampling frame designed to ensure that representative samples were collected from each household in each season. These were analysed for total N, P, K Ca and Mg content as well as dry matter content to provide a basis for estimating nutrients supplied by FYM application for all fields. In the following year, the soil samples were taken from 47 of the 137 fields sampled during the survey in order to determine whether there was any relationship between soil properties, the amount and source of the nutrients recorded as applied during the survey. Soil samples were analysed for pH, organic carbon, total N, available P, available K, exchangeable cations and texture.

The survey results were presented addressing specific objectives and other issues arising from the survey at RC Bajo and SSF & PNM Project office, Semtokha in April 2001, and details of

the survey published as a separate report[4]. Highlights of the results under major categories are presented below.

FYM qualities, quantities and timings of application by farmers
FYM quality as reported by respondents depends on the type of material and time of preparation: FYM made from broad leaf *sokshing* in summer is superior to those made from pine needles *sokshing* in winter. The mean FYM dry matter nutrient contents of samples collected in the survey are consistent with those reported in the literature. The amount of FYM applied in the field was determined mainly by the frequency of application. The mean recorded FYM dry matter is consistent over a range of factors (e.g. crop, fields distance from the homestead and field tenancy) and similar to the earlier estimate made in the area (RNR-RC Bajo, 1994). Maize and chilli fields received the most FYM followed by (*inter alia*) rice, mustard and wheat.

Factors that determine quantities, qualities and timing of FYM application
The main factors determining FYM quality were reported as labour availability, cattle numbers and availability of leaf litter. These factors together with type of crop grown, field's soil fertility and its distance from the homestead affects the quantity of FYM applied. Other factors included tenancy (shared-in < owner-managed) and land use (dry land < wetland).

Factors that constrain the improvement of animal manuring practices
Results of the survey and partial nutrient budgets showed that there was widespread nutrient deficit in the watershed. The underlying factors constraining the improvement of usage of FYM were the availability of the household resources of labour, cattle and leaf litter with labour being the major and limiting factor.

The method of preparation, storage and application of FYM
The survey provided little information on the method of preparation and the application of FYM, although the result suggested that tethering was relatively not an important practice in the watershed. Most households collected and stored FYM for later application to cultivated field.

FYM and Soil Properties
Result of the survey suggests that increased FYM application was associated with increased soil nutrient level but the amount of FYM required to increase soil fertility status to even moderate level were not currently practical. Farmers will continue and probably increase their dependence on the use of fertilizers, mainly urea, to maintain soil fertility.

Household SFM (Soil Fertility Management Categories)
There was a significant difference with respect to FYM management and usage related to the household SFM ability categories. Good SFM ability category households cultivated more land than poor SFM ability category households and also shared less of their land. Although all the categories of household experienced the same constraints (labour, cattle and leaf litter) with respect to FYM, the distribution and severity of these constraints differed between categories. Poor SFM category household were more likely to report cattle numbers than labour availability as a constraint and are more likely to use FYM made with pine needles than that of broad-leaf bedding material.

[4] Reference of the survey

Also poor SFM category household were more dependent on the usage of fertilizer than good SFM category household.

5.2.1.2 Balanced Fertilizer trials in the watershed

Low crop yields due to low soil fertility was reported to be a major problem during the diagnostic study of 1997 and subsequent visits revealed that farmers especially in the lower parts of the watershed use chemical fertilizers to main crops like rice, wheat and mustard. However, their fertilizer application practices do not fully conform to research recommendations. As such a simple balanced fertilizer trail on rice was conducted with one farmer in Wangjokha area.

The objective of the trial was to see rice crop yield responses with respect to each treatment used and to see the effect on rice yield from splitting the amount of urea that farmers use in one application. Three treatments were used: farmer's practice, improved farmer's practice and research recommended.

Results from this trial are presented in Table 45. An economic yield response of rice both to improved farmer practice (splitting the urea top dressing that farmers were already) and research recommended practice were obtained.

Table 45: Cost benefit analysis of balanced fertilizer trial on rice

Treatments	Yield kg/ac	Value Nu/ac	Cost Nu/ac	Profit Nu/ac	Cost Nu/ac	Benefit Nu/ac	Rate of return
T1-Farmer practice with single urea top dressing	1640	13,120	168	12,952			
T2- Improved farmer practices	2000	16,000	228	15,722	60	2880	4800
T3- Research recommended practices	2400	19,840	838	19,002	610	3840	630

Results suggest that there is potential to substantially increase crop yield and profitability of rice production both through improved use of urea fertilizer and use of research recommendation on fertilizer application.

5.2.1.3 Farmer Field School for Soil Nutrient Management

Based on the result from the above fertilizer trial and also the need for quick dissemination of such simple technology in the field, a FFS (Farmer Field School) was formed in the year 2000 with eight farmer participants from Omtekha and Matalungchhu. The objective was to enhance each participating farmers' ability to analyse their problems related to soil nutrient management, identify constraints and possible solutions and eventually adopt the practices that are suitable to their farming conditions and farm resources.

In 1999, before the rice-transplanting season, farmers from Omtekha and Matalungchu were introduced to FFS approaches that were carried out elsewhere outside Bhutan at a gathering at Omtekha *Tshokpa's* place. Brief presentations from the research team included:

- FFS for soil nutrient management their advantages and disadvantages
- The role of the participants, what they are expected to share and learn from FFS
- The role of the research team in FFS

After the presentation, interested candidates were selected and the school program with rice transplanting was initiated during the year 2000. One fertilizer trial was established in every participant's field to increase number of replication and to get result from diverse conditions. Three treatments were used for the trials: Treatment 1 was farmer practices (FYM was used as basal with urea top dressing after 30 – 40 day of transplanting), treatment 2 was improved upon farmer practices (split the amount of urea that farmers use as top dressing into two doses, half as basal and half as top dressing at the normal time that farmers follow) and treatment 3 was research fertilizer recommendation (70:40:20 NPK kg/ha) with half the N as topdressing after two week from transplanting. One day meeting prior to the establishment of the trials discussed the following:

- What are Plant nutrients and their source?
- How are nutrients lost from the soil and how does this affect crop yields?
- Duration of the school program and the number of meetings required during the year
- Identification of topics for discussion and dates for the next meeting

Three crop cuts from each treatment were taken and the average was used for comparing rice yield differences between treatments from an area of 2m x 2m with recordings of field moisture content. Results of ANOVA (Table 46) showed significant ($P<0.01$) differences in yield between the treatments.

Table 46: Trial results of school program (2000)

Treatments	Grain mean yield (t/ha)
Farmer practices	3.47
Improved farmer practices	4.67
Recommended practices	5.37
CV	13.3%
S.E.D	0.300

These results were presented to the school participants and few other farmers from the area where farmers agreed that research recommended practices yielded the highest but expressed concern on the affordability of complex fertilizer required in the research recommendation. Farmers preferred improving their normal practices (splitting the urea top dress into two applications: one as basal and the other as top dressing).

During the year 2001, the trial was reduced to one due to a shortage of manpower for taking crop cuts. Farmers selected a representative plot and the same treatments were used. Three crop cuts from each treatment were taken and the average was used for yield comparison between the treatments. Table 47 shows the results of ANOVA which revealed significant ($P<0.01$) differences in yield between the treatments.

Table 47: Crop cut result (2001) from Omtekha FFS program

Treatments	Grain mean yield (t/ha)
Farmer practice	4.47
Improved farmer practice	5.65
Recommended practice	6.47
C.V	11.3%
S.E.D	0.350

Explicit studies on the adoption of the technology was not conducted, however, from field visits, observations and informal farmer interviews, it was found that out of 100 farming

households in each trial site, around 50% of households have improved their fertilizer usage (amount, type and time of application).

FFS approach has also encouraged the participants to talk about communal problems, share individual knowledge and experiences and come up with collective actions to solve them.

5.2.1.4 Maize trash-line to minimize surface soil run-off

Nabchey is a small dryland village with 22 households in the Lingmutey Chu watershed. Farmers in this village grow mainly maize, mustard, wheat and vegetables.

Surface soil run-off (erosion) is a contributory factor in declining productivity and for many years farmers have been trying to contain it through diversion of rainwater from their fields. However, this practices wasn't effective.

View of Nabchey village

Field observations and study findings indicated loss of soil and hence nutrients as a consequence of how farmers use their land (conventional ploughing on hill side and cultivating steep land without any soil conservation measures), and not a primary problem by itself. The objective was to make use of the locally available resources (maize stocks) to minimize surface soil run-off.

A number of known technologies to control surface soil run-off were offered to the farmers, including terracing, hedgerows, and maize trash lines and stonewalls from which farmers preferred to try maize trash lines to control surface soil run-off. Trash lines have been tested elsewhere and proved successful in gradually leading to terracing. An A-frame was used for determining the contour lines and maize stocks were collected and kept along the contour lines. Farmers determined the spacing between two contours. After every maize-harvesting season, maize stocks were collected and kept on the same contour.

Maize trashes were established before the maize-planting season of the year 1998 and by the end of the year, there was quite an amount of topsoil accumulated behind the trash line. Impressed by the amount of soil conserved and increased maize growth and yield in the fields with trash lines, another farmer-started trash lining his field in the summer of 1999. By the end of year 2000, the height of the bunds raised by soil accumulated behind the trash lines was 0.5 - 0.6 meters. The number of farmers practicing trash lines has increased from one in 1998 to eight in 2001.

This prompted one-day training on how to make an A-frame and how to make contour lines by using an A-frame was conducted in the area. An A-frame was also provided to the communities for communal use. By the end of the year 2001, there were 12 farmers practicing it and the average height of the bund had increased to 1m. Crop cuts in 2002 from fields with and without trash lines with fields adjacent (without trash line) as control plots were taken. Previous soil analysis results showed that there weren't significant differences in the initial nutrient status of these fields. The average of three crop cuts is presented in Table 48.

Increase in bund height with trash lines

Table 48: Crop Cut results from maize fields with and without trash lines

Treatments	Shelled maize yield (kg/ac)	Moisture content
Field with trash line	2300	33.3
Field without trash line	1800	33.4

Farmers see maize trash line as a multipurpose technology, which disposes maize trashes in a better way than dumping or burning. The technology is less expensive compared to terracing and does not have direct initial cost or maintenance later on and reported that it is easy to adopt.

5.2.1.5 Other activities

Based on the results of the diagnostic study of 1997 and follow-up field visits in the watershed wherein scarcity of certain vegetable, legumes and cereal seeds, marketing problem of surplus maize, limited cash crop options, winter fodder shortage, shortage of irrigation water in early season, low chili yield and limited crop option to grow in winter in dry land, a number of simple known technologies were tested in different locations in the watershed. The rationale, trial location, technologies tested, number of replications and the observations made and results obtained were briefly presented in earlier reports.

5.2.2 Activities outside watershed

5.2.2.1 Balance Fertilizer trial on first rice crop in Rinchengang

Rinchengang is the only village in Punakha - Wangdue Valley that practices rice double cropping. Farmers in this village have limited land holding with increasing household members. Rice double cropping mustard/wheat cultivation in winter helps them sustain their livelihood. However due to this intensified copping, crop yields have been reported to be very low. Main soil nutrient sources are limited application of farmyard manure and urea fertilizer. Use of inorganic fertiliser although common it is imbalanced with only single nutrient urea and poor timing of application (not enough in the early crop growth) and inefficient methods of application.

With the aim to see the effect of adding 25N: 30P:0K kg/ha as basal with 25kg N/ha as topdressing (research recommendation for first rice crop) and to improve and study the effect of split application of farmer practices of urea top dressing into two splits this trial was established with eight interested farmers, each of them as one replication. The trial was

jointly laid out, implemented and monitored by research together with geog extension and the respective farmer. Three treatments were used namely farmer practices, improved farmer practices and research recommendation with an area of $30m^2$. Fertilizers were supplied by research. Participatory monitoring was done during different stages of the crop and crop cuts of $10m^2$ were made.

Three crop cuts from each treatment were taken and ANOVA (
Table **49**) was used to analyse the treatment differences of which the results are presented in. Results suggest that greater improvement in the first rice crop yield was possible from the usage of research recommended practice (25: 30: 0 NPK kg/ha with 25kh N /ha as top dressing).

Table 49: Crop cut result from Rinchegang

Treatments	Grain mean yield (t/ha)
Farmer practice	5.30
Improved farmer practice	5.62
Recommended practice	6.75
C.V	9.5%
S.E.D	0.354

Greater improvements in the first rice crop yield are possible from the use of research fertilizer recommendation although affordability of these fertilizers is a constraint. First rice crop yields can also be substantially improved by improving the use of urea

5.2.2.2 Balanced fertilizer trail on rice crop in Lobesa

Past studies indicate that the major change in soil fertility management in the past 10 –15 years in Punakha - Wangdue Valley has been the wide spread adoption of chemical fertilizers to supplement organic manure. Two major factors can be ascertained for this trend: (i) farm labour shortage problem (ii) government subsidies on fertilizers. Most fertilizer use on major cereal crops are imbalanced in nutrient supplied, providing mainly nitrogen as a top dressing in the form of urea @ 40–100 kg/ha. Farmers report about 10% - 15% yield increase due to fertilizer application.

The objective was to see rice yield differences between farmer practices and research recommendation of fertilizer use and to improve and study the effect of split application of farmer practices of urea top dressing into two splits.

Twelve interested farmers were selected from the area, each as a replication. Other modalities are same as for the trial in Rinchegang (5.2.2.1). Comparison of treatments with ANOVA (Table 50) revelaed that rice yields would be substantially increased simply by improving farmer practices although the yield would be higher if research recommended rates (NPK) fertilizers are followed.

Table 50 :Crop cut results from Lobesa

Treatment	Grand mean yield (t/ha)
Farmer practices	5.25
Improved farmer practices	5.71
Recommended	6.67
CV	10.1%
S.E.D	0.254

5.2.2.3 Establishing benchmark nutrient status in Demo-orchards

Detailed soil analysis of the demo-orchard sites were not obtained prior to the establishment of these orchards so pit soil sampling and composite soil samplings from these orchards were done later to document the initial soil nutrient status for formulating required supplements.

Pit and topsoil sample collection were done in May 2000 in collaboration with the Bhutan Soil Survey Project (BSSP) together with recording of site information (Global Positioning System (GPS) reading, altitude, site position, slope and vegetation three pits -one in each Demo-orchard). 15 horizon samples were collected from the pits. A total of 27 samples, including 12 topsoil samples were air dried and submitted to SPAL, Semtokha for chemical analysis. All sites are located at the elevation of about 1300 – 1600 masl with similar climate and related parent materials and north-west aspect. The slope gradient is 20% at Omtekha, 65% at Kabesa and 25% at Nelabgi. A brief description of each profile on physical and chemical properties is presented below:

Omtekha: deep reddish brown hill soil with clay texture. Soil structures are moderately strong, dry and compacted throughout profile. Chemical analyses revealed that the topsoil pH is neutral, but the subsoil was slightly acid. Organic carbon content and C: N ratio was moderately very low. The total N and exchangeable Ca were also very low. Available P was moderate to very low with depth. The cat-ion exchange capacity (CEC) and base saturation were low throughout the profile.

Kabesa – deep brown hill soil of sandy clay loam texture. Soil structures were weak and friable consistence throughout. The soil was deep and has good drainage. Chemical results showed that the pH was neutral throughout the profile and faunal activities were relatively high. The available P and C: N ratios were very low. The Cat-ion Exchange Capacity (CEC) was low and the base saturation was high throughout. Exchangeable Ca was moderate to low.

Nelabgi – soils in this site was formed in colluviums soil over old alluvium of sandy loam to silt texture. Soil structures were weak to moderate and friable and consistency was slightly hard throughout. Soil drainage was fairly good. Chemical analysis indicated that the pH was neutral except two horizons (13-23 and 35-45 depth), which is slightly alkaline. Available P, organic carbon content, exchangeable Ca, Mg, and total exchangeable bases were moderate to low. Base saturation was very high and cat-ion exchange capacity was low throughout the profile.

All three sites have deep, well-drained and fine texture soils and would allow for deep rooting and moderate or better available water capacity for the fruit plants. The soils are near neutral pH and have moderate supplies of the mineral nutrients such as K, Ca and Mg. All these soils have moderate to low organic matter in the topsoil with low content of N and P correctable through application of organic fertilizers (farmyard manure).

5.2.3 Other actvities

Other major activities include an 'Adoption study of Bajoka Wheat varieties in Punakha Wangdue Valley[5]' and 'Situation Analysis Study on Farm Household Labour Shortage' for the West Central Region[6], findings of which were reported in a separate reports.

5.3 Agricultural Economics

5.3.1 Impact Assessment of Rice Research Program at National Level

Systemic research on rice and other crops began in 1982 with the establishment of CARD at Bajo, now renamed as RNR-RC. Subsequent operationalization of rice research at Bhur in 1984 and Tsirang and Khangma in 1988 had strengthened work on rice and rice-based systems. Since then lots of rice research and variety evaluation were done, and varieties of improved rice were released for promotion in farmers' field. Through the initiation of this rice research program, there has been increase in rice production in the country increasing the food self-sufficiency. An impact assessment survey was done nation wide in the year 2002 with the consultancy service from IRRI with following objectives:

- To study and document number of modern varieties released and extent of adoption
- Adoption of crop management practices
- Magnitude of yields gain and increase in value of production
- Increase in net income and household cash income of farmers
- Achievement of rice self sufficiency and improved welfare

The sample Dzongkhags and Gewogs for the survey were selected based on rice producing areas in Bhutan covering different agro-ecological zones (AEZ). Structured questionnaires guided collection of data from randomly selected households from 2 dongkhags in the low altitude, 4 dzongkhags in the medium altitude and 4 dzongkhags in the high altitude, (Table 51). The data collected was entered in MS Excel spreadsheet. Since the survey data is still in the process of analysis and documentation, the detailed nation-wide results will be reported later. A preliminary report for the west-central region is presented in the next sections.

Table 51: Household survey representation

Altitude/ Dzongkhag	Number of Geog	Number of village	Sample size
Low			60
Samtse	4	19	40
Sarpang	2	8	20
Medium			83
Punakha	3	6	30
Sarpang	1	5	10
Tashigang	4	21	33
Wangdue	1	3	10
High			105
Paro	5	19	50
Thimphu	2	11	21
Trashigang	3	10	14
Wangdue	2	5	20
Total	**27**	**107**	**248**

5.3.2 Regional Rice Impact Assessment for West Central Region

This regional impact assessment on rice was a part of the national impact assessment survey; data were analysed and assessed for two Dzongkhags (Wangdue and Punakha), major rice-

[5] RNRRC Bajo Technical Document No. 4, 2000
[6] RNRRC Bajo Technical Document No 6, 2001

producing area in the region. Six geogs were selected consisting of 14 villages and 60 households from the two Dzongkhags were covered.

5.3.2.1 Household profile and adoption of different varieties

Average family size in the survey area was 8 members per household out of which 53% of the household were female-headed.

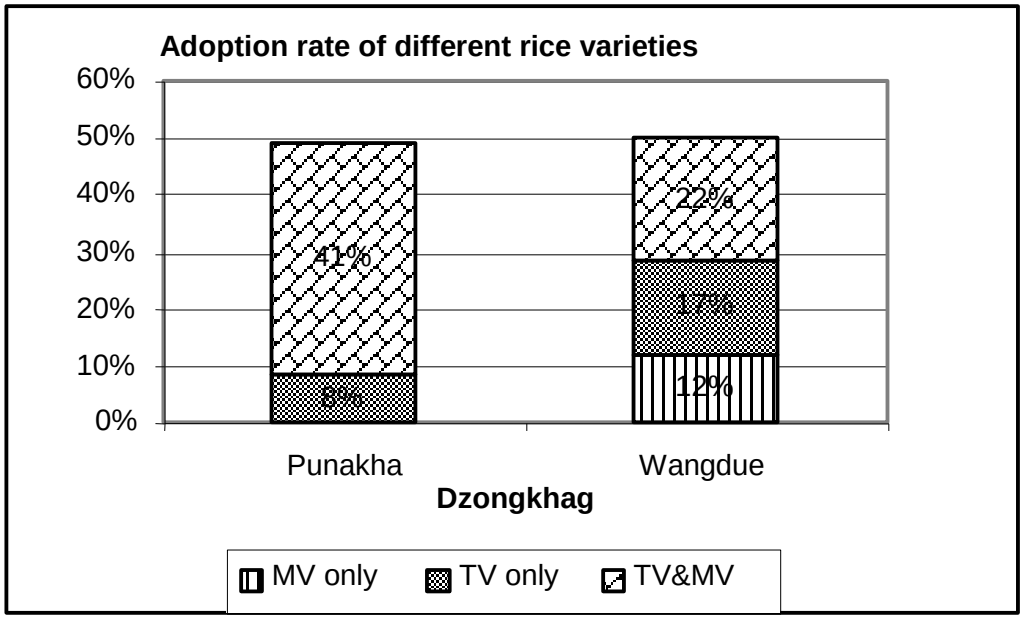

Figure 8: Percentages of different varieties adopted

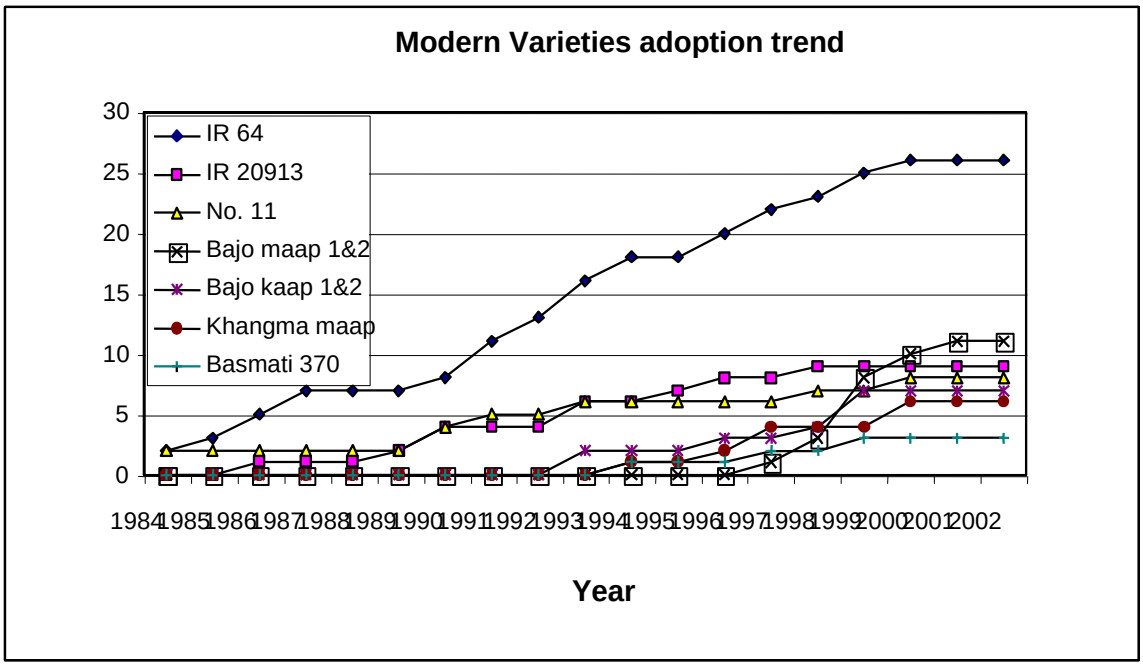

Figure 9: Modern varieties adoption trends

The popular varieties adopted in these dzongkhags were IR 64, IR20913, No. 11, Bajo Maap 1 and 2, Bajo Kaap 1 and 2, and Khangma Maap respectively. The farmers also grew some Basmati 370, an improved variety, for special purposes. Among the local varieties Zakha,

Tan Tsheri, Botali, Dawa yangkum, local maap, and local kaap were also popularly grown. From the 60 households surveyed, 63% grow both modern and traditional varieties of rice, 25% grow traditional variety and 12% grow modern variety only. IRRI varieties are the varieties that were introduced from IRRI (IR 64 and IR 20913); Bhutan modern varieties stand are Bajo Maap1&2, Bajo Kaap 1&2 that are bred indigenously; and other modern varieties are No. 11, Chumro, and Basmati 370.

5.3.2.2 Area adoption of different varieties

IR 64 was the most popular variety and covered 26% of the area from total of 60 households surveyed (Table 52), because of its higher yield and good grain quality. The recently released varieties Bajo Maap and Bajo Kaap also have a good intake due to their quality and yield potential. Although IR 20913 is an old IRRI variety, which yielded higher than local, it covered only a small portion of the area since its milling recovery was not high and its taste was not very much preferred by the farmers. IR 20913 was mostly used in rice double cropping. The cooked rice of No 11 when cooled was said to be hard and it was difficult to thresh. Khangma Maap covered 4% of the area. Basmati 370 (scented rice) was grown in small portion of the area for special occasion. About 56% of the area was covered by different type of local varieties of rice. Zakha, Tan Tsheri, Botali, Aza Dago, and Yangkum were also popularly grown.

Table 52: Percentage of area for different varieties

Dzongkhag	IR 64	IR 20913	No. 11	Bajo Maap	Bajo kaap	Khangma Maap	Basmati 370	Local
Punakha	12.37%	0.68%	0.80%	2.99%	3.05%	0.68%	0.00%	30.17%
Wangdue	13.20%	1.55%	2.12%	0.90%	1.77%	2.95%	0.60%	26.15%
Grand Total	25.57%	2.24%	2.92%	3.89%	4.82%	3.64%	0.60%	56.33%

5.3.2.3 Yield level of different rice varieties

The survey result showed that Bajo Kaap has the highest yield of 4.82 t/ha followed by Khangma Maap 4.60 t/ha. IR 64 ranked third position, which was 4.37 t/h. The average yield of local rice was 3.42 t/ha (Figure 10).

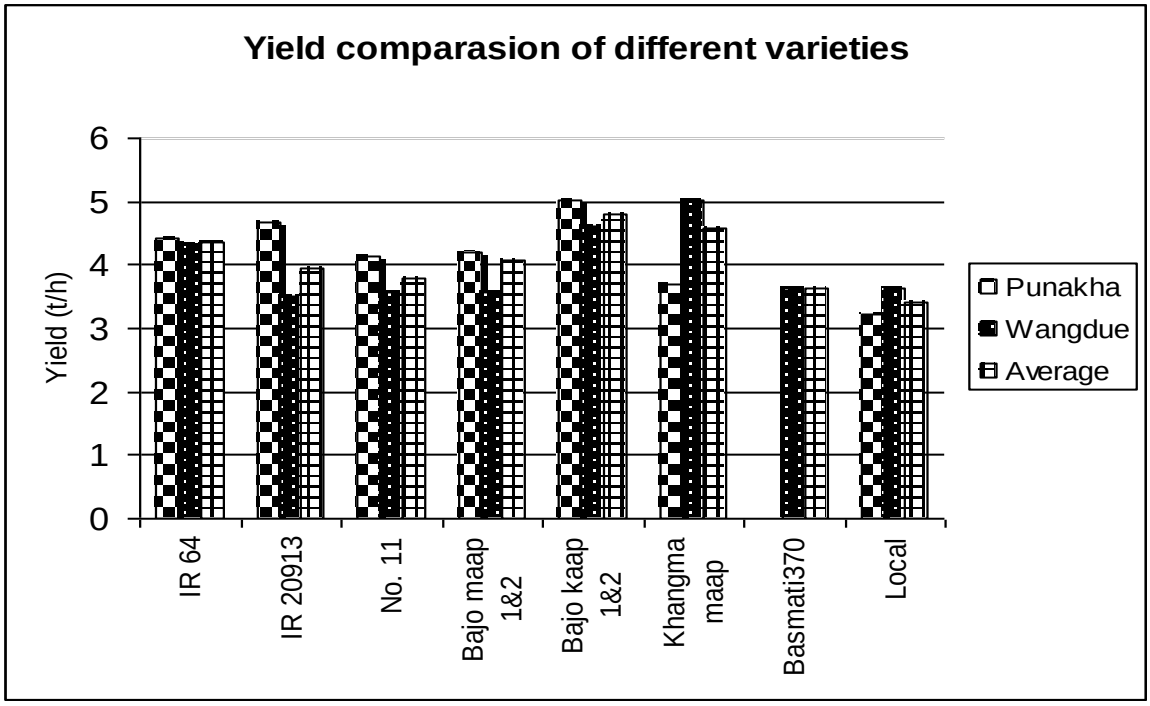

Figure 10: Yield comparison of different varieties

Table 53: average yields of rice varieties (t/ha)

Dz	IR 64	IR 20913	No. 11	Bajo maap	Bajo kaap	Khangma maap	Basmati 370	Local
Punakha	4.42	4.68	4.15	4.21	5.02	3.71		3.22
Wangdue	4.31	3.51	3.56	3.57	4.61	5.03	3.63	3.62
Average	4.37	3.94	3.79	4.07	4.81	4.59	3.63	3.42

5.3.3 Adoption of improved crop management practices

Along with the released of modern varieties, other management practices and technologies were promoted as a package of practices for the farmers. From various management technologies imparted, weed control through usage of weedicide was adopted by maximum sample farmers (88%), followed by fertilizer application (72%) and harvester and thresher (70%) respectively (Figure 11: **Adoption of improved crop management practices**

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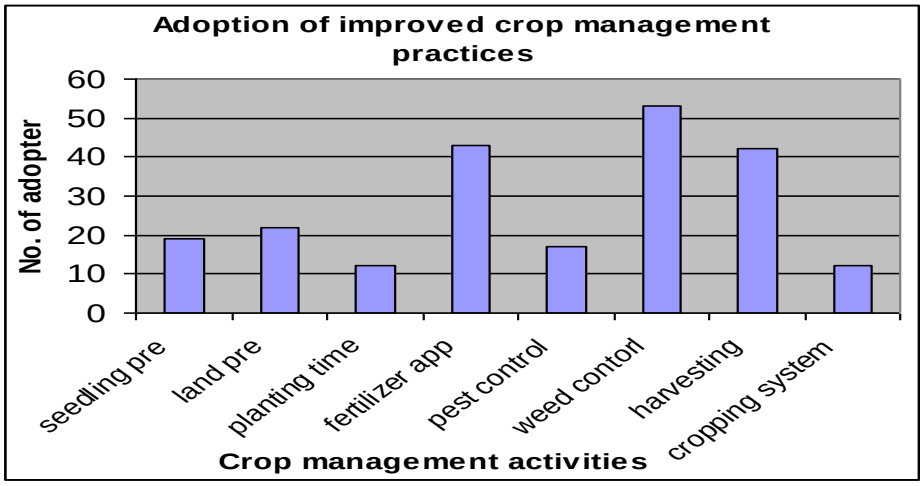


Figure 11: Adoption of improved crop management practices

5.3.4 Rice self-sufficiency and deficit

The survey result showed that only 25% of the surveyed households were found to be deficit in rice. They had to buy on an average of 245 kg milled rice every year from the nearest market. The average period of rice deficit were found to be 2.5 months for each farmer in a year. There was no rice deficit with those farmers that grew modern varieties alone. Only a negligible quantity of rice was borrowed from other sources during the year.

From 75% household surveyed, which were self-sufficient, 6.7%, farmers are just self-sufficient; they neither sold nor borrowed rice from other farmers. These farmers grew both the modern and traditional varieties. About 68% farmers had surplus rice production with an average of 434 kg rice per farmer per year. The surplus rice was sold in the local market with an average price of Nu. 20 per kg earning Nu. 8680 per household per year. The market price for rice varied depending on the varieties; traditional varieties fetched higher (average Nu. 21 per kg) than that of modern varieties (average Nu. 19 per kg).

5.3.5 Rice production Economics

Because of its growing share in the diet of the Bhutanese people, rice is of crucial importance to the Bhutanese society. However, the lack of reliable information on socio-economic aspects hinders the formulation of effective policies and establishing priorities. Although some crop budgeting studies were done in the past few years sample sizes were not large enough for the results to be generalised across different AEZs. Hence, this study was undertaken more extensively and is expected to give a clearer and more conclusive picture of economics of rice production in the different Dzongkhags and for different agro-ecological zones.

The objectives of the study were:

- To quantify inputs such as labour and material inputs to determine the cost of production for growing rice in the different agro-ecological zones in the west central region
- To determine the profitability of rice growing, by assessing its return to land and labour and comparing these with available alternatives
- To assess the effect of changes in input / crop prices on the economic viability of particular crop and technologies

The result from this survey will help in the food policy analysis studies by making available reliable information on the profitability of rice growing in the different Agro-ecological zones. Output would also be useful to scientists and extension officials on farmers' opportunities and constraints. This could be then used as information to guide further research and extension work on developing and promoting improved and profitable land-use technologies.

5.3.5.1 Selection of the commodity

During the 4th Annual field crops coordination workshop held in Gelephu in early 2002, the agricultural economic sector proposed to undertake a study on the economic of some major cereal production in the West-Central region. During this meeting the crop budgeting on rice was accorded the highest priority.

5.3.5.2 Sample selection

Except for Alpine zone, the study covered all the main Agro-ecological zones, from north to south. Due consideration was taken to select sample that was representative of AEZ and the Dzongkhag. As each dzongkhag is subdivided into geogs, which are further subdivided into chiwogs/villages, multistage sampling method was used, wherein sampling was done at several stages. At first stage, simple random sampling was used to select geogs from the Dzongkhags considering where rice is an important crop in the farming system. At second stage, systematic sampling was used to choose the villages within each sampled geog and at third stage households were selected from each of the selected villages by simple random sampling. The sampling was done in close consultation with the concerned Dzongkhag extension staff. The respondents from the households were the head of the family or the elderly persons who are responsible for decision making on inputs and outputs of the crop. In total the survey sample represented 138 households from 4 Dzongkhags.

Table 54 Geogs and households covered in each of the Dzongkhags

No.	Dzongkhag	No. of Geog	No. of Household
1	Wangdue	3	32
2	Punakha	2	28
3	Tsirang	2	40
4	Gelephug	2	38
	Total	**9**	**138**

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 during the data collection stage. Data was entered in Excel spreadsheets. These data are initially analysed per farmer in the excel spreadsheet. Detailed analysis will be reported in the next annual report. The outcome will be grouped per farmer having a 'traditional' or 'improved' technology, and per agro-ecological zone for comparison. Factors causing differences in productivity will be assessed. The following parameters will be taken into consideration: analysis of returns to land; analysis of returns to labour; cost of production; sensitivity analysis and marginal benefit cost ratio (of changing from traditional to improved technology)

5.4 Water Management Research

The Water Management Research [WMR] started as Water Management Research Project [WMRP] in the beginning of 8th Five Year Plan. WMRP originated from the need felt within the Ministry of Agriculture for an integrated sustained national research effort to study the relationship between water management practices, soil and crop water production. The project came to an end in 2000 and water management research was institutionalised 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 are to raise the productivity of existing rice-based irrigation schemes through improvements in water delivery; increase rural incomes by diversifying the range of irrigated crops on wetland as well as on dry land; rationalise the irrigation assistance program with a view to increase the role of water users and the private sector to reduce recurrent government investments in irrigation schemes and develop water resource management plan and policies for sustaining the resource base to ensure continued livelihood support to the rural community.

A general misperception of the water resources that "water is in abundance and there is nothing to be done". Amidst these misperceptions a number of research activities like trials, surveys and case studies were conducted to understand the issues with regard to the efficient management of water resources for enhancing and sustaining the livelihood source. Fair amount of understanding has been gained and documented which has formed the foundation for inducing the formation of new polices (water policy, water act etc) and changing the perceptions on the water resource at least at the policy maker level. Number of constraints and issues has been identified and put in the right prospective for better management of the resource.

The staff capacity is critically low for the mandate WMR Programme has been entrusted with. Since 2001 the sector has only one Assistant Research Officer supported by one Research Assistant. On the other hand, experienced and trained research assistant has been transferred. It will take another two to three years before the new assistant gains necessary skills and experience to support the WMR programme. This is a big disadvantage to the sector.

The main activities of the sector are watershed activities, on station activities, regional activities, training/workshops and minor civil engineering works. The status of each activity under these headings is given in the following sections. Detailed report will be made available once the activities are completed.

5.4.1 Watershed Activities

Lingmuteychu Watershed has been adopted as the watershed research site for RNR RC Bajo since 1997. The watershed has an area of 34 km^2 of which 6% is agriculture land with the major part of it under forest cover. The average annual rainfall is about 900mm, and the rainfall pattern in the watershed is unimodal in shape with more than 90% of the rain occurring during July to September leaving the rest for the year virtually dry.

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.

5.4.1.1 Rainfall and stream flow data collection

Rainfall and stream flow data collection started since the beginning of the watershed studies. Before 2000 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 loggers be used. Table 55 summarises the data collection activities in the watershed.

Table 55: Summary of rainfall and stream gauging data collection

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

Rainfall data collection with automatic data logger is fairly reliable apart form the problem with the bird droppings that clogs the data logger (missing/no data) once in a while which makes it important 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:

- Connection pipe between the stream and the stilling well gets blocked within a 2 days due to the mud and debris in the stream
- Vandalism by the cattle herders from the neighbouring villages (one set of data logger was stolen during last winter season by lifting the roof of the stilling well which also housed the data logger set).

5.4.1.2 Monitoring of Water Sharing

The main issues with regards to irrigation water resources in the watershed are:

- Irrigation water shortage during rice transplanting season,
- Peak rainfall season occurs a month later than the peak transplanting season (rainfally is the primary source as the watershed lacks snow covered areas)
- 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 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); so no effort to improve the conveyance efficiency of irrigation canal can be made. There is also a unique irrigation water sharing arrangement between the 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 is not allowed to take water until 10^{th} day of the 5^{th} Bhutanese month. By the time Limbukha finishes about 90% of transplanting. This is a problem as there is no major viation in terms of altitude between the villages and Dompola village also requires to transplant at about the same time. Further 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 10^{th} day of the 5^{th} Bhutanese month for last five years are 23 June in 1999, 11 July in 2000 [4^{th} Bhutanese month was double but actually water was released on 23 June 2000[7] (21-4_{2nd}-2000)], 30 June 2001, 20 June 2002 [double 12^{th} Month] and 09 July 2003.

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

5.4.1.3 Forest Function Mapping

Demarcating the functions of the forest was perceived to be of critical tool for sustainable management of the resource base in the Lingmuteychu Watershed. As such the Forest Function Mapping activity was initiated by Forestry Sector with support from GTZ. WMR Sector was also involved during the survey in relation to the resource mapping. The water resource mapping included the mapping of springs, streams and irrigations canals with GPS. The main aim was to create buffer zone around water bodies such that the vegetation is conserved for protecting those water bodies only. Forestry Sector does the detail reporting on this activity.

5.4.1.4 Role Playing Game & MAS – Workshop

Role Playing Game (RPG) is a collective learning process providing an avenue for discussion, open doors for unlocking the deadlock that exists with regards to NRM, and allows the player to see the views from different angles. This approach has huge potential for resolving the conflicts and bringing entire stakeholder to a common understanding of the issues related to NRM.

Multi-Agent Systems (MAS) constitute powerful tools 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, etc.) and the related search for simple representations of the real world through a very interactive bottom-up modelling process. Identifying with the stakeholders the conditions allowing the co-viability of environmental or resources dynamics on one hand and socio-economic dynamics on the other hand is increasingly seen as a 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 is well adapted to dealing with this core problem.

As the MAS modeling part is still in the process, only a preliminary reporting on RPG is done at this stage. The Water Management sector in collaboration with Framing System sector organized a Role Playing Game (Farmers Workshop) on irrigation water sharing system in Lingmuteychu Watershed for Limbukha and Dompola Community. The main aim of the exercise was to demonstrate to the farmers the advantages of collective actions with regards to efficient use and management of the common resources. The workshop was conducted at Tshochasa[8] form 14th till 16th May 2003.

The specific objectives were:

- To bring the two communities (Limbukha & Dompola Communities) to a common understanding of the water resources with regards to its sustainable & equitable use;
- To understand coordination pattern in irrigation water sharing and maintenance of the irrigation canal in the community
- To evaluate water use patterns and its interactions with overall agronomic and socio-economic factors to manage irrigation systems,

[8] Technical assistance from Mr. Tayan Raj Gurung, CORE, MoA and two resource persons from IRRI-CIRAD Scientist based in Thailand

- To generate and simulate scenarios with the users to assess impacts of their decision on land use system and
- To test MAS as a tool for resolving conflicts & social issues, enhancing the efficient management of natural resources in Bhutanese context.

This activity will serve as 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 so that it functions as a unit.

5.4.2 On-station Activities

5.4.2.1 Direct Seeding

Irrigation water shortage is the major constraints in Lingmutey Chu Watershed. This is mainly due lag (about a month) between the peak water requirement (transplanting). 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 still standing the fields. Limbukha farmers have first access to Lingmuteychu (irrigation water) and is least affected by the problem, but their management and cropping practices influence water users at the downstream. With the increasing trend of winter cropping in Limbukha (potato, wheat, buckwheat etc) the possibility of early transplanting is becoming almost impracticable to the Limbukha farmers. There is a potential for better management options 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 can over come be appropriate as this does not requir water for transplanting and also requires less labour. However direct seeding can mean high weed infestation, lower yield compared to transplanted rice, lodging due shallow rooting depth and requires good land preparation.

The overall research objective was to see the advantage of direct seeding compared to the delay transplanting at higher altitude. The short-term objective of the research was 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 Lingmutey Chu Watershed. It is also aimed to improve water use efficiency and lower cost of production of rice in the area and help lower the demands on water resources thereby maintaining minimal and continuous flow in the river to uphold the ecosystem supported by the river. The research is to be carried out on-station for three year after which it will be taken on-farm in three upper communities. On-station trials have six treatments with five replications with RCB design as detailed in the following section. However the number of treatments for on-farm trial may need to be reduced depending upon the on-station results and specific field situations.

Treatment one and two (T1&T2) are controls representing traditional farmers' method with two different scenarios normal and delay transplanting (due to delay rainfall or water shortage problem). T3&T4 are directly seeded during the time of nursery land preparation

time. Treatments three (T3) was seeded directly by broadcasting the seeds and treatment four (T4) was seeded in row to study the ease of weed management. Land preparation for T3 &T4 was same as that of land preparation and nursery bed preparation for T1 & T2. The seed rate for T3; T5 & T6 were 120kg/ha. The depth of row seeding was about 8 to 10cm. Comparison of paddy yield between treatments for the last two years is given in

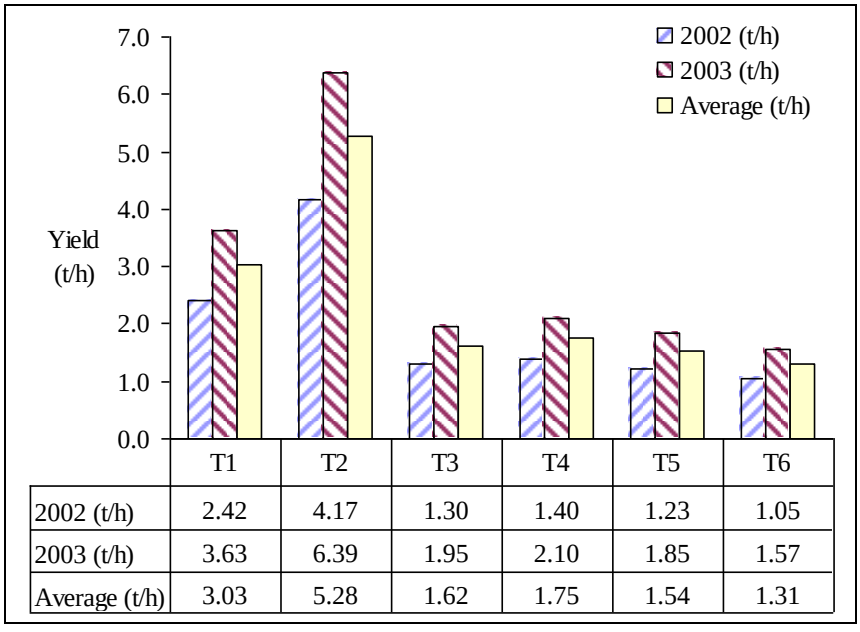
Figure 12.

5.4.2.2 Civil Engineering Works

As the office RNR RC Bajo does not have separate maintenance unit WMR Sector has to devotes 20 % of time for minor civil engineering works and other maintenance works. The sector has to also extend similar support to the Druk Seed Corporation (DSC) and Regional Agricultural Machinery Centre (RAMC) located in Wangdue. The major activities undertaken during the last one year are given in Table 56.

Table 56: Civil engineering activities undertaken by WMR Sector

SN	Activities	Status
1	Signboard construction for RNR RC Bajo	Completed
2	Road/Parking black topping and back entrance gate construction	Completed
3	Routine maintenance of Office and Staff Quarters	Need base
4	Preparation of estimate for RAMC fencing	Completed
5	RNR RC Fencing Wall Construction	Design, drawing, estimating and tendering is completed
6	DSC Office renovation and conversion of existing store to cool store	On-going



	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
Average (t/h)	3.03	5.28	1.62	1.75	1.54	1.31

Figure 12 Comparison of yield between treatments.

5.4.3 Other activities

5.4.3.1 Citrus Irrigation Scheduling Trial

The 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 was to see the yield benefit of irrigating the citrus and to demonstrate the technology to the farmers. The specific objectives of citrus irrigation scheduling trial were:

- To see the yield benefit of irrigating the citrus under the existing management practice
- To improve the quality of the fruits (size, sugar content etc)
- To assess the viability of low cost irrigation technology (simplified drip)

A 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. Irrigation was with held 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 blocked into four blocks as the orchard lacked the uniformity in terms of slope, soil fertility and the size and age of the plants.

Two years results of yield data, the irrigation scheduling trial from Bichgoun, Tsirang are given

Table 57. Detailed statistical analysis will be done and reported once the trial completes.

Table 57: Yield and number of fruits the 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**

Note [T1: *Without Irrigation* and T2: *With irrigation*]

5.4.3.2 Technical Support to Client Dzongkhags

WMR Sector in collaboration with the horticulture sector and the concerned Dzongkhags was involved in the development and management of the orchards in the region. The specific supports by WMR sector were:

- A preliminary study for developing irrigation facilities for developing new orchard near Punakha Dzong.
- Produce base 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.

Although the WMR sector based in RNR RC Bajo is mandated to coordinate national water management research program it has been not able to fulfill this mandate due to low capacity of the staff both in terms of quantity and quality.

5.5 Integrated Pest Management (IPM)

The period July 2002 – June 2003 saw the IPM sector providing need-based technical plant protection services to the client Dzongkhags through field visits, disease-pest verification, surveillance and monitoring of rice blast and citrus greening disease vis-à-vis surveillance of spieled vector. Major research activities included Chilli Blight Management Trial, Long term *Shochum* management trial, S*hochum* Control Awareness Campaign, *Parthenium* weed Control Campaign and citrus fruit fly study. Additionally *ad hoc* activities were also taken up viz. cardamom survey in Tsirang and Dagana Dzongkhag coordinated by RNR-RC, Jakar. A rapid survey on prevalence of citrus greening disease/Citrus Huanglongbing (HLB) was conducted in Tsirang and Dagana. Subsequent to one-day training for extension staff, citrus leaf samples were collected from HLB suspected orchards in Tsirang and Dagana for diagnosis of citrus HLB via polymerase chain reaction (PCR) test. The sector provided training on chilli blight management and rice blast control to farmers of Dangchu and agriculture extension staff on the request of Agriculture Sector, Wangdue Dzongkhag administration. As a routine activity, the sector also coordinated at least four rounds of Parthenium weed campaign within the research farm and residential area. Concurrently local agencies and institutes within Wangdue and Punakha Dzongkhag were informed on the campaign. On the request of Nature Club, the sector also briefed the students of Wangdue Middle Secondary School on Parthenium weed and its ill effects on health vis-à-vis available control methods. Rubber hand gloves and coloured leaflets were distributed to the schools and Hesothangka government workshop as a support towards the campaign.

5.5.1 Chilli Blight Management Trial

The objective of this trial was to streamline agronomic practices for chilli blight management through raised bed method, maintenance of proper drainage system between beds throughout the season and using locally grown chilli seedlings. It was established on farm at Goensakha, Kazhi geog in Wangdue Phodrang in an area known to be a hot spot for chilli blight and set up as a five replicate RCB with proper drainage to drain out stagnant water. Two treatments were implemented, farmers' practice which served as control and recommended practice. The results are presented in Table 58.

Table 58: Chilli yield and plant stand

Treatment	Means	
	Yield (kg/plot)	Plant Stand (no.)
Control	3.305	108.8
Recommended	3.455	66.4
CV%	0.687	13.4

As per the research protocol, three harvests could not be done as farmers at this altitude had harvested once when the chillies were fully ripen and matured to be dried and sold or bartered later. Chilli blight incidences (stem and foliar) were observed in both the treatments though lesser in-recommended treatment. This is apparent from the plant stand in Table 58 where control means show 84.2 and recommended 91. Following farmers' practice the lowest number of chilli seedlings per bed (6X1 m^2) was 116 and highest 154. On average, each bed hold 130 plants via farmers' method while the recommended raised bed accommodated 78 plants on average per bed maintaining a standard spacing of 40cm row to row (RR) and 20 cm plant to plant (PP). The plant stand in control and recommended plots were 83.8% and 85.12% respectively. No significant difference in plant stand between the two treatments was observed.

Similarly no significant differences in yield between the treatments were observed. However fruits harvested from control plots varied in shape and most of them were not marketable where as fruits from the recommended practice plots possessed uniform and marketable shapes according to the collaborator farmer. This variation in shape of fruits could be attributed to plant density. In the control plots, due to high density of plants there was competition for nutrients, water and space, which ultimately affected the fruit shape whereas in the recommended practice plots standard plant spacing was maintained allowing enough room for the plants to grow without competition for nutrients and water. Further the beds and drains in both the treatments were maintained throughout the cropping season as opposed to actual farmers' practice. The usage of recommended practice package would save farmers seedling cost and labour without decrease in yield. But maintenance of drains and other management practices (timely weeding) should not be neglected.

5.5.2 Shochum Management Awareness Campaign

As a regular seasonal activity *Shochum* management campaign was continued with the collaborator farmers in Ligmuteychhu Watershed and Gaselo.

Farmers in Punakha-Wangdue valley practice only one hand weeding, as chemical control is prohibitive, due to the high chemical price (Nu. 600/kg SANBIRD). As such an intensive hand weeding campaign was initiated by the center in two locations in 2000. Limbukha, Wangjokha and Thangu villages and two locations in Gaselo (upper and lower) as an interim option were selected. The weeding was done at 2, 4 and 6 weeks after transplanting (WAP). The same field was used every year to record changes or improvement due to additional weeding. The crops cut results for Gaselo are given in Table 59**.**

Data for Shochum control campaign for watershed was available only for one location, Limbukha. In other villages, campaign was done and field days conducted. Farmers in the watershed are convinced that additional 2 hand weeding 2 and 4 WAT reduced rice yield loss to Shochum significantly. But it was doubtful whether the farmers in view of farm labour constraint at the household level could implement additional hand weedings timely. Until other control methods (weedicides?) become available, awareness campaign is expected to continue for a few more years in these locations.

In Gaselo, 2 farmers (1 from Gase Tshogom & 1 from Gase Tshowom) were involved in the awareness campaign. The collaborator farmers implemented three intensive handweedings in each of the field at 2, 4 and 6 WAT. A joint crop cut with Dzongkhag Extension officials and farmers was done during the field day (Table 59). Three crop cut for each treatment was done from an area of 6 m^2. The difference between yields from each observation plots were displayed to the participants attributing the yield difference to timely weeding.

Table 59: Crop cut results from Gaselo *Shochum* Control Campaign (2002)[9]

No.	Village	Average Yield (Kg per Acre)		Yield difference (Kg)
		Weeded (3 weeding)	Farmers' Practice (1 weeding)	
1.	Hintylo	1822.22	1000.00	822.22
2.	Shanggu	1866.66	1600.00	266.66

In Hintylo village, the intensively weeded field yielded 822 kg more per acre compared to farmer's practice of one hand weeding. This translates to 45% reduction of total yield loss to *Shochum*. Similarly a difference of 267kg of paddy was recorded between the intensive weeded field and farmer's plot in Shanggu. Though much lower than in Hintylo, the yield loss was reduced was 14% which is substantial in farmer's field. Besides the yield difference in both the sites, farmers saw for themselves the difference in the field. They accepted that additional two weedings at critical period definitely reduces yield loss to *Shochum* but pointed out that it would only be possible if labour was available.

5.5.3 Citrus Fruit Fly Management study

Based on preceding years' results, bagging and efficacy of timed cover sprays and protein bait sprays were implemented in Salami, Tsirang. The objectives of this study were to evaluate the efficacy of different treatments for the control of the Chinese citrus fruit fly (*B. minax)* and to bag fruits and expose to determine the period of oviposition. The trial is on going, with the exception of partial raw data collected so far. The terminal report will be prepared at the end of 2003.

[9] Average moisture content <18%

6 EXTENSION PROGRAM

The change of staff and restructuring within the Ministry affected the completion of programs of EPO. The change in roles for EPOs as a result of restructuring annulled some of the planned activities. In consultation with former EPO, following activities were carried implemented during the reporting year.

6.1 General

With the objective of giving support, backstop and advice, the extension activities in the region, following activities had been carried out.

- Visited Gogona, Shelly, Jala and Khotokha centre along with ADLO of Wangduephodrang Dzongkhag.
- Attended GTZ co-ordination meetings at Punakha.
- Attended some of the Dzongkhag quarterly meetings.
- Co-ordinated various extension agents on study tours.
- During the year, twenty-one DYT/GYT members accompanied by 4 EAs from Chukha Dzongkhag, 25 progressive farmers along with 2EAs from Paro Dzongkhag, 18 extension agents from Sarpang and 12 extension agents from Tsirang visited the centre. They were briefed on the mandate and responsibility of the centre besides taking them around and showing them some of the emerging technologies in the research fields.
- Organization and participation on National Food Festival at Thimphu from the regional Dzongkhag.

6.2 Research-Extension Linkage.

The sector coordinated 9th Annual Regional Review and Planning Workshop. With the participation from regional Dzongkhag RNR sector heads, representative from the central agencies, PPD, line departments and other relevant stakeholders of the region, various issues of extension and research were discussed. The sector was involved in the logistical arrangement, rapporteuring and then subsequent compilation of workshop resolution and proceedings. The report is on the process of publication.

Farmers' Field Day

To make the farmers aware of the new and emerging technologies from the research centre, one field day was organised at RC Bajo. A group of 25 farmers from Gogona, Shelly and Jala under Gangtey and Rubisa gewog of Wangduephodrang took part in the field day. This field day also served as demonstration to the farmers to carry out some of the management aspects of new and emerging technologies.

6.3 Research-Extension Collaborative Activities

The former AEPO participated in the food security survey along with the agriculture conomist of the centre. The sector also visited Samdingkha and Chuzomsa along with horticulture team to set up on-farm integrated horticulture management trial and participated in the Play Role Game organised by WMR sector.

Promotion and support of Farmers' group.

Frequent visit to Dompola under Punakha Dzongkhag was made to give advice and support was given to Dompola Farmers' saving group. It was noted that this groups was successful in terms of operational and organizational set up. As of now, there are 21 members with the total saving of Nu 20,000. The members are already drawing the benefits by lending money from their common saving during the low cash flow from their economic activities. The groups are mature enough and ready to take up some economic activities.

Two new Farmers Saving Groups were formed. One Farmers Saving Group were formed at Phubjikha, and Hogeena under Wangdue Phodrang Dzongkhag. This was done in line with the important mandate of Extension support division of CORE for promoting cooperatives and farmers' group.

The sector also conducted three days training on small farm group formation and mobilization of livestock extension staff of Wangdue.

7 APPENDICES

7.1 General agronomic traits in Observation Nursery 2002

Sl. no.	Variety	50%flw days	Height cm	Yield t/ha
1.	IR73887-1-8-2-1	119	77	9.03
2.	YOU MI 18	122	100	8.55
3.	IR73888-2-10-3	119	80	8.43
4.	JIANG-ZHOU-XIANG-NUO	112	97	8.41
5.	M92-2	119	82	8.29
6.	NANJING 70272	122	84	8.13
7.	IR69716-87-1-3-1-1-3	119	88	8.09
8.	TOX902-5-102-2-103-101	119	93	8.02
9.	XIANG ZHONG XIAN 3	114	91	7.84
10.	WAB 340-B-B-10-112	106	131	7.83
11.	BG90-2	126	82	7.81
12.	IR17146-97-1-2-1-3	112	94	7.81
13.	CNAX 4345-5-5-1-1-2	114	83	7.77
14.	IR71143-223-3-2-2-3	119	89	7.76
15.	Bajo Kaap1	120	86	7.73*
16.	BR 4676	132	80	7.71
17.	Bajo Kaap 2	121	87	7.71*
18.	IR68007-82-2-2-2-3	121	82	7.69
19.	RHS 392	125	96	7.59
20.	IR72102-3-135-1-1-1	112	88	7.47
21.	P 4	122	93	7.4
22.	CH6	133	97	7.37
23.	IR 68077-33-1-3-3-3	112	83	7.34
24.	CT9883-9-2-M-5-4P-M	108	93	7.3
25.	ITA416	119	87	7.25
26.	CT9737-6-1-1-2-2P-M	121	82	7.07
27.	9939	132	85	7.05
28.	JIN-GANG 30	121	78	7.02
29.	IR71144-201-1-2-3-1	114	90	6.98
30.	TOX3145-TOC-15-2-1	125	103	6.98
31.	ZHONG-XIANG 1	114	103	6.94
32.	IR71137-243—2-2-3-3	114	90	6.92
33.	SPR87032-2-1-1-4	126	104	6.91
34.	IR73885-1-4-1-4-3-6	119	75	6.9
35.	BW348-1	126	106	6.89
36.	BR (BE) 6163-R1-3	114	77	6.87
37.	87614-6	114	83	6.84
38.	IRGA 318-11-6-9-2-A3	119	91	6.77
39.	CT6163-8-9-5-2-M-142-M	121	88	6.77
40.	CH 5	125	111	6.66
41.	MK 9-87	132	100	6.65
42.	UPR 990	137	88	6.62
43.	IR69020-144-3-1-3-1-2-3	132	93	6.62
44.	BR (BE) 6158-RWBC2-6-5	121	90	6.6
45.	Bajo Maap 1	119	95	6.6*
46.	B7003D-MR-3-1-3	126	90	6.55
47.	CNAX 4602-6-3-3-2-1	112	84	6.54
48.	FAROX 315-2-2	119	85	6.5
49.	IRGA 440-22-4-4-1F-1	119	90	6.48
50.	FAROX 317-8-2	121	96	6.42

Sl. no.	Variety	50%flw days	Height cm	Yield t/ha
51.	IR69000-105-3-2-2-1-1-3	132	86	6.42
52.	UPR79-11	121	84	6.39
53.	CT9506-12-10-1-1-M-3P-M	108	93	6.29
54.	IR71138-251-1-3-2-1	126	85	6.25
55.	8344	122	97	6.19
56.	CT 9737-5-2-1-2-4P-M	119	91	6.16
57.	TOX1308-17-2-2-2	132	80	6.16
58.	BR4656-1-2-3-2	122	97	6.13
59.	IR 71604-4-4-3-7-2-2-3-3	119	96	6.09
60.	IR 64	121	94	6.02*
61.	Bajo Maap 2	108	111	5.95*
62.	BR1543-9-2-1	125	111	5.78
63.	TOX3741-5-3-1	125	82	5.78
64.	BR1711-7-2-4-2	119	125	5.72
65.	87604-2	119	118	5.68
66.	BR4726-2B-6-1-2-J4	114	127	5.65
67.	IR71606-2-1-1-1-3-3-1-2	119	79	5.62
68.	MTU 1001	139	78	5.58
69.	TOX 981-5-1-1	133	84	5.56
70.	C 74	132	90	5.54
71.	CT 6163-8-9	121	92	5.48
72.	ITA306	139	76	5.46
73.	IR9090-136-2-2-3	132	89	5.43
74.	WAB 224-16-HB	107	108	5.41
75.	CNTBR 82075	121	84	5.25
76.	4-1-2-1-2	126	94	5.13
77.	IR69002-90-1-2-3-3-1-3	141	80	5.06
78.	XUAN SO 9	139	91	4.78
79.	CT9868-16-3-1-2-3P-M	121	79	4.71
80.	CT 9846-1	137	89	4.47
81.	RP2246-7-2	132	84	4.31
82.	XUANG SO 6	139	92	4.21
83.	TOX3440-16-3-1-1-3	138	80	4.12
84.	BR5672-16-3-2	121	97	3.24
85.	BR4828-54-4-1-4-9	139	85	2.75
86.	Local Zakha	119	130	2.5*

7.2 Characters of three traditional varieties

Sl. No	**Traits**	**Apa dogo**	**Nabja**	**Dawa Yangkum**
1	Blade Pubescence	Intermediate	Intermediate	Intermediate
2	Blade color	Light green	Green	Dark green
3	Basal leaf sheath color	Green	Green	Green
4	Leaf angle	Erect	Erect	Erect
5	Ligule shape	2 cleft	2 cleft	2 cleft
6	Ligule color	Whitish	Whitish	Whitish
7	Collar color	Light green	Green	Green
8	Auricle color	Light green	Light green	Light green
9	Culm angle	Intermediate	Open	Erect
10	Node color	Green	Green	Green
11	Internode color	Light gold	Light gold	Light gold
12	Culm strength	Intermediate	Mod. Strong	Weak
13	Flag leaf angle	Erect	Erect	Horizontal
14	Panicle type	Compact	Compact	Compact
15	Secondary branching	Light	Heavy	Heavy
16	Panicle exsertion	Just exserted	Just exserted	Well exserted
17	Panicle axis	Droopy	Droopy	Droopy
18	Awning	Absent	Absent	Absent
19	Awn color	Awnless	Awnless	Awnless
20	Apiculus color	Straw	Straw	Red
21	Stigma color	White	White	Purple
22	Sterile lemma color	Straw	Straw	Straw
23	Variety group	Indica	Indica	Indica
24	Leaf length	Intermediate	Intermediate	Intermediate
25	Leaf width	Intermediate	Intermediate	Intermediate
26	Culm length	31-150cm	111-130cm	>150cm
27	Culm number	Medium	Medium	Medium
28	Culm diameter	Thick	Thick	Thick
29	Panicle length	Medium	Medium	Medium
30	Sterile lemma length	Medium	Short	Medium
31	TG Weight	30 gm	23 gm	22 gm
32	Grain length	8.9 mm	7.2 mm	7.1 mm
33	Grain width	3 mm	3 mm	2.8 mm

7.3 Details of demonstration orchards

Crop	Cultivars	Year of planting	Location	Dongkhag	Remarks
Walnut	Thinshell	2002	Yamena, Kabji, Omtekha, Dagapela, Tashiding, Tshokana Salmbi	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, Tashiding, Thedtsho, Tshokana, Salmbi	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	Peaches 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	Valentia, encore, bears, meyer, satsumas, freemont	1999-2002	All location except under Dasa	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	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, Pinsa, Rubesa, Dagapela, Tashiding	Five Dzongkhags	Good vegetative growth and not fruited yet.
`	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, Rabit feeding dmange in Bhur farm

7.4 Other IPNS specific technical interventions and their results

	Problem	Location	Chosen solution	No. Trials	Outcome

	Problem	Location	Chosen solution	No. Trials	Outcome
1	Limited legume cultivation in cropping system. Soyabean grown on a small scale but seed scarcity limits increased cultivation	Dompola Nabchhe	3 new soybean varieties	3	None out yielded local; one had poor taste. Farmers liked the big seeded and early maturing variety (Bragg). Seeds were saved for the next season
2	Low yield of chilli due to blight and possible nutrient deficiencies. Soil analysis results showed soils low in P& K.	Dompola	NPK basal dressing + early N application	1	Vigour improved and first harvest yield + profit doubled by fertilizer but increased blight so total yields similar. affordability of fertilizers a problem
3	Farmer in Nabchhe cannot selling surplus maize and would prefer other cash crops. Beans an alternative	Nabchhe	Borolloto beans	2	Poor germination & yield from early March sowing better than from July sowing until horse grazed.
4	Early season irrigation water shortage constrains wetland rice cultivation. Chommro is good but weeds a problem for upland rice	Nabchhe	Chommro rice variety	2	Good performance of Chommro due to the good rainfall. Heavy early season weed growth.
5	Chronic winter fodder shortage constrains livestock and manure production. Steep and eroding bank near house.	Dompola	Sudan and Lucerne sown on banks. Oats to be sown in winter	1	Lucerne failed to establish after germination. Sudan yielded well but is a biennial. Both replaced by perennial Napier grass during the following season.
6	Fallow fields in Nabchhe in winter become vulnerable to soil erosion. Fodder shortage in another recurring problem in the area.	Nabchhe	Hairy vetch	2	60%-65% germination with 100% nodulation. 50%-60% effective nodules are found. Biomass 12-15kg from each cutting from an area of $10m^2$. Farmer find it suitable fodder in winter
7	Use of FYM for soil fertility management is found to be very limited in Wangjokha [FYM survey report]. Proposed changes to fertilizer supply and distribution system in Bhutan to end subsidies will mean that fertilizer use will be very expensive.	Wangjokha Nabchhe	Dhiancha	2	70%-80% germination with good nodulation [80%-90%] in both the sites. Crop height 30-40cm tall when incorporating. Farmers liked the technology, but their fear was that freely grazing cattle during Dhiancha growing season might graze on Dhiancha.
8	Steep slope cultivation and soil erosion. Farmers want to terrace but too expensive. Maize trash lines are not very stable. Farmers want to stabilized the trash lines with legume fodder species in the form of hedgerow.	Nabchhe	Legume fodder hedgerow	2	Average height of bunds built behind the trash lines was 40 cm tall. Health of maize plants behind the bunds was better than in other parts of the field. Five legume fodder species planted on 15m long contour line in both the sites.
9	Sudan grass was tested and proved successful to solved the chronic winter fodder shortage constraining livestock and hence manure production. Farmer wants to replace semi perennial sudan grass with a perennial species.	Dompola	Napier grass	1	Napier grasses were planted on the edge and boarder of the maize fields. They were well established and farmer said that it served two purposes – as soil conversant and as animal fodder in winter.

7.5 Training/Workshop/Study tours

Name of staffs	Date	Purpose
Dawa Zangpo	21st Aug – 27th Aug	On Lib & procite installation course at NRTI, Lobesa

Dawa L Sherpa	18th Aug 01 – 18th June 02	Tropical Animal production at Netherlands
Karma (ARO)	5th Aug – 23rd Aug	Training on Planning Rice Breeding Program for impact at IRRI, Los Banes, Philippines
Thinley Gyamtsho	14th Oct – 25th Oct	Multi – Agent system (MAS) and integrated Watershed management training in Chang Mai University.
Chengay	25th Nov – 13th Dec 2002	International course on Community based integrated Watershed management at IIRR, Headquarters & Asia Regional Center, Philippines
Kalpana Rai	16th Feb – 28th Feb	Rice Production Training at International Rice Research Institute, Los Banos, Philippine
Sangay Gyeltshen	14th Oct – 22Nov 2002	Store Management with computer appliance held at system plus computer college at Lubaco, Quezidu city, Philipines
Dawa Zangpo	18th June – 16th July 03	Training on Advanced Library Management through use of networking system at Sunrise Computer Training institute, Pune, India

7.6 Consultancies

Following consultants and resource persons were fielded during the reporting period:

Economic Impact Assessment of Rice Research

Ms Samjhana Shrestha, freelance consultant based at IRRI, was fielded to carry out an economic impact assessment of rice research program at the national level. Her ToR were to:
Design an impact assessment study for the RNRRCs to quantitatively and qualitatively measure the effects of research and development interventions on farm productivity, food production, living standards, food sufficiency level etc.
Assist in field testing and fine-tuning of the study questionnaires in order to make them amenable to field realities and practical situations.
Provide leadership and assistance in the synthesis and analysis of the field data and in writing up the study report.
Make recommendations on follow-up actions and studies after completion of the impact study.
Provide on-the-job training to selected national counterparts through out the consultancy period on the whole cycle of designing, analyzing and reporting of impact assessment studies.

The consultancy has been successfully executed and a final report is due.

Basic Statistics for Agricultural Research

Dr. C McLaren, Head of the Statistics Division, IRRI, was hired to provide a basic training on agricultural statistics and computing in November 2002. About 15 agricultural research scientists and field assistants from all the RNRRCs attended a week-long course.

CD-ROM production workshop

Dr. Sandra Brown of the University of the British Columbia, Canada, conducted a week-long training workshop for the research staff of RNRRC Bajo in the first week of October 2002. The purpose of the workshop was to upgrade the skills of Bajo staff in the production of CD-ROMs using ToolBook software.

Effective Presentation Workshop and Agro ecosystems Analysis Workshop

Mr. JA Lapitan, Senior Associate Scientist of IPMO, IRRI, conducted an Effective Presentation training workshop for the staff of all RNRRCs and NRTI in May 2003. Following this workshop, Dr. VP Singh, ICRAF Coordinator based in Delhi, India, conducted an Agroecosystems Analysis workshop at Bajo.

7.7 Visitors to the Center

Name/Address	Date	Purpose
Dr. Monique Garnier, Director to Research Industry	27/9/02	Consultant of IHDP for citrus greening detection
Dr. Animesh Shrivastava Economist, FAO,Rome	,,	To develop TCP Food Security in Bhutan
Stefan J. Rell, Economist	,,	Consultant for SEZAP, Evaluations Mission's, Team Leader
Paul James, Horticulture Consultant, Temperate Fruits, South Australia	01/10/02	Horticulture Consultant for Temperate Fruits
His Serene Highness Prince Bhisatej Rajani, President, Royal Project Foundation, Thiland and other delegates accompanied by G.B Chettri, Jt. Director, DRDS, Mrs. Pema Lhamo, PD, ICS, Mr Dorji, IHDP	19/10/02	As a goodwill visit to the centre
Dr. Sandra J. Brown, Research Associate and institute for Resources and environment, University of British Columbia.	04/10/02 to 10/10/02	To provide CD Rom Training
Dr. Guy Trebuil, Systems Agronomist, IRRI, Thailand	04/10/02 to 10/10/02	To provide seminar on multimedia
Dr. Samjana Shrestha, IRRI	25/10/02 to 6/10/02	Training on impact assessment to RCs economist
Dr. Chistopher	4/11/02 to 9/11/02	Computing and basic statistic
Mr. jammuna Krishna Tamrakar, Director General, Department of Forest	18/2/03	To familiarize with Research System in Bhutan
Dr. Swoyambhu Man Amatya, Director General, Department of National Oarj and Wildlife conservation	,,	,,
Dr. Chandra Prasae Gurung, Country Representative, WWF, Nepal Programme	,,	,,
Dasho Sangay Thinley, Honble Secretary, MoA, Thimphu	24/3/03	To discuss on CBNRM Training /Workshop
Grant Vinning, Marketing Consultant- Organic and Natural Products, Rural Enterprise development Program	26/3/03	To discuss /explore possibility of exporting organic products from Bhutan
Ms Samjana Shrestra, IRRI	8/4/02 to 30/4/02	Consultant for impact assessment training and report production
Paul Singh and his daughter, & Jojo Lapitan	5/503 to 8/3/03	Training workshop on effective communication
Olivia M. Hartmann Faessier, Adviser NRTI	16/6/03	Familiarization visit

7.8 Expenditure statement for the fiscal year 2002-2003

RGOB Contribution

Object Code	Object Classification	Amount in (Nu)
1.01	Pay & Allowance	37,92,185.84
2.01	Other Personal Emolument	11,80,800.00
11.01	Travel	19,65,015.00
12.01	Utilities Telephone	93,375.00
12.02	Utilities Fax Postage	22,701.16
12.03	Utilities Electricity	37,349.79
14.01	S & M Office Supplies	67,063.58
14.03	S & M Fertilizer Manures	35,537.71
14.04	S & M Seed & seedling	15,667.50
14.06	S & M Uniform Ext. Kits.	40,107.50
14.07	S & M Text Book & Jonals	7,118.40
14.08	S & M Supply & Consumable	14,899.00
15.01	MoP Building	32,172.50
15.02	MoP Vehicle	5,46,019.23
15.05	MoP Equipment	84,235.58
15.06	MoP Agro Forestry	52,131.00
15.07	MoP Computer	6,330.00
17.03	Opt. Expense Transportation	7,000.00
24.03	Contribution Provident Fund	2,71,132.00
45.01	Training	29,838.00
51.02	Expenditure on Structure. Roads	1,85,868.32
	TOTAL	**84,86,547.11**

EPNARM PROJECT CONTRIBUTION (IDRC)

Object Code	Object Classification	Amount in (Nu)
12.01	Utilities Telephone	38,165.56
14.01	S & M Office Supplies	95,102.34
14.06	S & M –Uniforms, Extension kits	81,250.00
14.07	S & M Text Book & stationeries	20,881.00
17.07	Op. exp- others	47,192.00
45.01	Training	9,90,059.34
52.08	Plant & Equip. Genera tools & instrument	1,29,820.00
54.03	Computers & peripherals	2,21,000.00
55.01	Professional services	4,50,299.68
	TOTAL	**20,73,769.92**

SDC/Helvatas

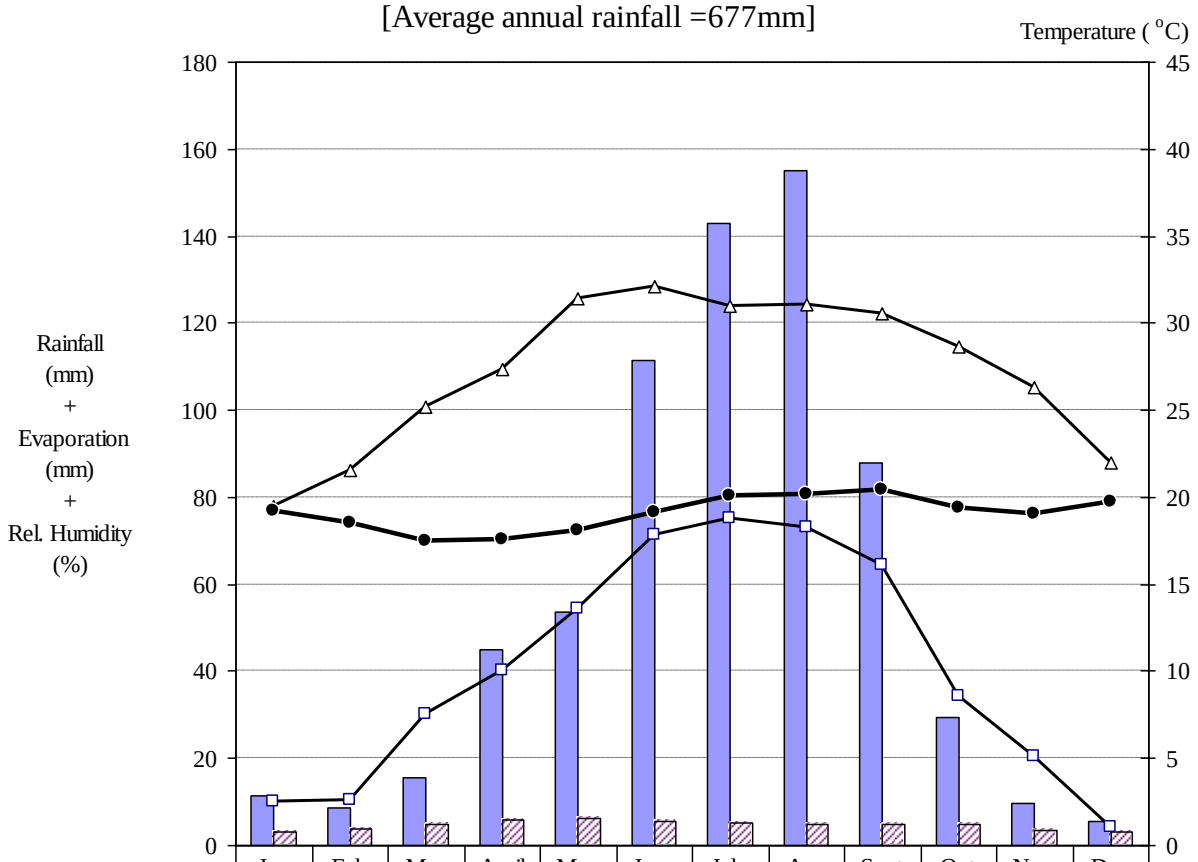
Object Code	Object Classification	Amount in (Nu)
12.01	Utilities Telephone	33,822.00
14.08	S & M -Others	22,450.00
15.07	Maint of prop. -Computers	19,000.00
17.07	Op.Exp-others	1,22,856.45
54.03	Computers & peripherals	90,782.20
	TOTAL	**2,88,910.65**

Financial achievements for first year (2002-2003) of the 9th FY Plan

Sector/Agency	**Plan Outlay**			**Expenditure**			**% achieved**
	Rec	Cap	Total	Rec	Cap	Total	
EPNARM PROJECT	0.828	7.300	8.128	0.481	1.882	2.363	
Others Receipts	0.135	-	0.135	0.135	-	0.135	
Total	0.963	7.300	8.263	0.616	1.882	2.498	30.23%
RGOB	48.600	7.700	56.300	8.271	0.216	8.487	
Others Receipts	0.219	-	0.219	0.151	-	0.151	
Total	48.819	7.700	56.519	8.422	0.216	8.638	15.28%
G/Total							45.51%

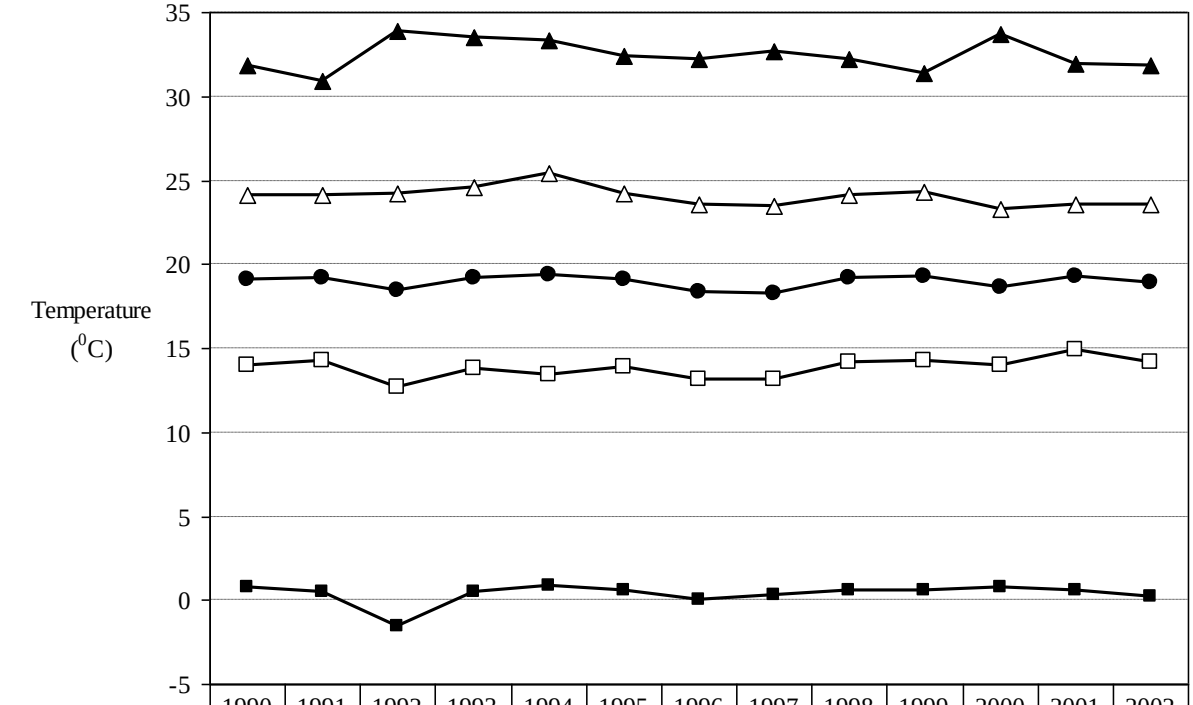
7.9 Annual Weather summary

Climatic Data for RNR RC Bajo: *Monthly average from 1990-2002*
[Average annual rainfall =677mm]



	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Rainfall (mm)	12	9	16	45	54	112	143	155	88	30	10	5
Evaporation (mm)	3	4	5	6	6	6	5	5	5	5	4	3
Min. Tem (0C)	2	3	8	10	14	18	19	18	16	9	5	1
Max. Tem (0C)	20	22	25	27	31	32	31	31	31	29	26	22
Rel. Humidity (%)	77	74	70	70	72	76	80	81	82	78	76	79

RNR RC Bajo Temperature Trend



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Average Temp	19.1	19.2	18.5	19.2	19.4	19.1	18.4	18.3	19.2	19.3	18.7	19.3	18.9
Min. Temp	0.8	0.5	-1.6	0.5	0.9	0.6	0.0	0.3	0.6	0.6	0.8	0.6	0.2
Max. Temp	31.8	30.9	33.9	33.5	33.3	32.4	32.2	32.7	32.2	31.4	33.7	31.9	31.8
Min. Average	14.0	14.3	12.7	13.8	13.4	13.9	13.1	13.1	14.2	14.3	14.0	14.9	14.2
Max. Average	24.1	24.1	24.2	24.6	25.4	24.2	23.6	23.5	24.1	24.3	23.3	23.6	23.6