ABOUT THIS REPORT

This is the seventeenth 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.

A single asterisk (*) means a significant difference at the 5% level of significance and ns means not significant. Separations of means in a table are usually by Duncan's Multiple Range test at 5% level of significance, unless otherwise stated.

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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, oilcrops, 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 agroecological 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, 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, IHDP, RNR-ESP, BG-SRDP, SSF & PNM and other development projects of the region.

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+ Transferred

ACRONYMS

AET	Advanced Evaluation Trial
AVRDC	Asian Vegetable Research and Development Center
a.i.	active ingredient
BL	Blast
CAN	Calcium Ammonium Nitrate
CARD	Centre for Agricultural Research and Development
CIMMYT	International Maize and Wheat Improvement Centre
cm	centimeter
CV	coefficient of variation
DMRT	Duncan's Multiple Range Test
DAT	Days after transplanting
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
IRCTN	International Rice Cold Tolerance Nursery
IRRI	International Rice Research Institute
K	Potassium
LSD	least significant difference
m	meter
MAT	maturity
MoA	Ministry of Agriculture
MP	Murate of Potash
N	Nitrogen
NASEPP	National Seed and Plant Program
NPPC	National Plant Protection Center
No.	Number
n.s.	Not significant
P	Phosphorus
PET	Production Evaluation Trial
PRET	Pre-production evaluation trial
RCB	Randomized complete block
RGOB	Royal Government of Bhutan
REID	Research, Extension and Irrigation Division
RNRRC	Renewable Natural Resources Research Centre
SAVERNET	South Asian Vegetable Research Network
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, 16 entries including checks were tested. Statistical analysis of grain yield showed that CNT 87040-33-1-1 and IR62467-B-R-B-24-1-B were the top yielders averaging 7.47 t/ha. Several other test lines also performed well. Local check Zakha yielded 2.22 t/ha. The IET was composed of 24 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. The highest yielder was GUOJING 4 (8.38 t/ha) followed by IR 64683-87-2-2-3-3 and SPR 87036-7-1-1-2. The selections from this trial will be further evaluated.

The Observation Nursery I consisted of introductions from the IRRI-INGER program. The grain yields of the entries ranged from 2.77-7.39 t/ha. The yields of most of the entries were higher than the local check variety Zakha. Days to 50% flowering ranged from 95-130 days, while the plant height ranged from 86-126 cm. The second set (Observation Nursery II) consisted of 112 entries IIRON, IRRI, as part of the collaborative exchange and rice improvement program and the initial evaluation under a wide range of irrigated rice environments. Estimated grain yield ranged from 2.75-11.26 t/ha; plant height from 80-143 cm and days to 50% flowering from 85-144. No notable insect pests and diseases were observed among the genotypes.

The on-farm trials consisted of the evaluation of varieties received from RNRRC Khangma for mid-altitudes and Yusipang for high altitudes. Seven lines were assessed in several sites in Wangdue, Punakha, Tsirang and Dagana. Khuma 4 and IR62467-B-R-B-F8-1B were among the best in terms of grain yield and farmers' acceptability.

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. In grain legumes, some groundnut varieties were tested in the farmers' fields in Wangdue and Punakha. Among the varieties, Kadiri and ICGV 87921 were good, producing pod yields over 2 t/ha.

Research on crop production management included organic crop production using a combination of organics and Effective Micro-organisms (EM).

Preliminary and indicative results from the use of organics with EM in cereals (rice, wheat, mustard and maize) showed that moderate yields (average 5-6 t/ha) could be obtained without chemical fertilisers. Improvements in the physical and nutritive qualities of the soil are also becoming evident. Weeds are a major problem. Detailed analytical and economic assessments remain to be done.

Horticulture

The main objective of horticulture research in RNRRC-Bajo involves in improving quality and yield of vegetables, nut crops and subtropical fruits through introduction and diversification of these crops with emphasis on high value crops that would meet both nutritional and cash income requirements of the farmers. These objectives can be realized through the introduction and evaluation of exotic 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 would also be given adequate research attention.

Setting priorities and outlining clear strategies have been the essential elements of the horticulture research in the West Central region for accelerated horticulture industry development. Depending upon the ecological feasibility and distance from the market outlet the RNR-RC Bajo has focused 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. Besides collection of germplasm for screening outstanding cultivars and establishment of orchards for demonstration and training purposes in the research Centres, emphasis was also given to on-farm research.

The activities for the sector have been developed in line with the Horticulture and Regional Research program profile of 9FYP, ongoing activities, collaborative activities with regional Dzongkhags, major work as vegetable and subtropical fruits research, breeder seeds maintenance and as coordinating centre for walnut and other nuts crops research and development. The highlights of horticulture research achievement in West-Central region are as follows:

- Three fruits cultivars (Bajoapple, Bajokham-1 and Bajokhamchu-1 (apricot)) released for general cultivation
- Three vegetable cultivars (Bajolaphu-1, Bajolambenda-1 and Bajogob-1) released for general cultivation
- Identified 2 orange and 2 mandarins, 1 lime and few walnut promising cultivars for further evaluation.
- Purifying and production of various vegetable breeder seeds are on-going.

Livestock

The livestock sector of this research centre is focussing major activities on fodder resource development in the rice-based system. During the year, there were 18 activities out of which 7 were new and 5 on going and 2 completed including both nationally co-ordinated and regional activities. The major emphasis was given on

winter fodder development. About four activities could not be initiated due to some logistical problems and resource constraints and one of the staff concerned was under going training abroad. Over the years, the livestock research expanded to cover-up activities under the sub-program – breeding and management too. One of the recent changes taken place on the process of initiating breeding and management activities is placement of apiculture at the centre. Over 40% of the activities related to both feed and fodder and breeding and management have been implemented in collaboration with Dzongkhag extension in the farmers' field.

Forestry

The centre's forestry sector's main focus is into social forestry research, the sector gave emphasis and initiatives into the mainstream research, collaborative research and other activities. The centre assisted the study on fir/mixed conifer forest ecology carried out by RNRRC, Jakar focal centre for conifer research. The on station research of the seedling, vegetative propagation methods and bamboo rhizome multiplication. A provenance trial on *Thysonalena latifolia* is also established in the station. Proven rhizomes will be ultimately promoted in the community forestry plantations.

System Resource Management

Community Based Natural Resources Management (CBNRM)

The CBNRM research consist of cross-sectoral on farm trials and other related activities conducted in participation with the farmers of Lingmuteychhu watershed, where the CBNRM process is being tested since 1997. This section of the report concentrated more towards the improvement of farmers' livelihood through changing or increasing attitudes of farmers more towards improved agricultural technologies through participatory approaches. Some of the improved technologies tested on-farm were, under Crop production and management activities like testing of high yielding rice varieties (Bajo Kaap I & II, Bajo Maap I & II, IR-64, IR-20913, Chumro, and high altitude rice) were done and promoted to the farmers. Improved varieties of fruit plants (Peach, Pomegranate, Citrus, and Walnut) were supplied to some farmers to improve their existing back yard fruit cultivation. Beside other horticulture fruits, vegetable activities were also initiated in order to improve the nutritional intake, change in food habit and as well to generate cash income.

Farmer capacity building was one of the major goals for sustainable development of the farming community. The farmers capacity were strengthened by conducting farmers training, organising farmers field day, study tour etc. on different technologies viz. Formation of Small farmers group saving schemes, Fruit plant management and top-working, Soil conservation etc.

Integrated Plant Nutrient System (IPNS)

The research activities are concentrated and designed to address the problems stated by the farmers earlier during the problem diagnostic survey and other exercises like Farm household categorisation, special emphasis to the poor category farm household and feed back presentation of CBNRM activities conducted in the Lingmuteychhu watershed during the due course of time.

Activities on integrated plant nutrient system conducted during the year 2001-2002 were establishing low cost and effective soil erosion control measure like establish maize trashline lines which was very popular and 50% of the dry land farming communities adopted this technology. Also Farmers Field School approach was tested with farmers on application of balance chemical fertilizers.

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Integrated Pest Management

The IPM sector provides need-based technical plant protection services to the client Dzongkhags through field visits, disease-pest verification, surveillance and monitoring. IPM research for 2001-2002 emphasized on *Shochum* Control Campaign, Chilli Blight disease management through use of recommended raised bed method combined with minimal use of selected fungicides, integrated disease management (IDM) of potato via farmer field school (FFS) approach, *Parthenium* weed Control Campaign, citrus fruit fly control and literature reviews for *Parthenium* weed.

Agricultural Economics

The Agricultural economics unit undertook three major research activities in 2001-02. A winter crop budgeting survey of the selected winter crops (wheat, mustard and potato) was done in the Limutechu watershed. The main objective of the study was to determine costs of production and the profitability of growing these crops. The average production costs of wheat and mustard was found to be Nu. 20.28/kg and Nu. 33.21/kg respectively. Cost of potato production was Nu 2.28/kg. One important finding of the winter crop study in Limukha was that potato generates greater net returns to farmers land and Labour than competing crops (like wheat and mustard).

The main objective of the household income study was to provide data on household income and distribution, and sources of income. The emphasis of the survey is on agricultural production (includes livestock). Off-farm income, such as wages, remittances other services were also covered. Summary data for the five income sources show the importance of crop and livestock income to the households. On the average, crop and livestock together account for about 64 per cent of the total household income. The most important sources of income for the category 1 and 2 farmers is from crop while livestock is the most important source of income for the category 3 farmers.

The agricultural economics section conducted an economic exercise to determine ginger production cost in order to come up with price recommendation. Simple economic analysis was done to compute the cost of producing ginger in the area.

Results of the analysis showed that the total cost of producing ginger Nu. 31394 per acre or Nu 11.20 per kg. Marketing cost was estimated at Nu. 3.94/ kg. In total it cost a farmer about Nu 15.00 to produce a kg of ginger and bring it to the market to sell.

Water Management Research

The Water Management Research started in 1997 as a Water Management Research Project with a support form SNV and became part of the RNR Research System by 2000. In the initial years a good a progress has been made in the field of water management research. However, lately the WMR team is struggling to keep same momentum due to the staff shortage and at present RC Bajo has only staff only. Besides carrying out the mandated research activities WMR team is also given the task of civil engineering works which demands half of the WMR team's time and energy. Despite of many constraints, the research team is doing its best to keep some activities on-going.

WMR 2001-2002 annual report gives a full report on Stabilisation of Gully in Dompola while it give some highlights on the on the activities that are on-going. Full report will be given only when the activity is completed or terminated.

- The gully report gives some background to the irrigation system that has been existing since the time immemorial. The irrigation system, which was, built by the farmers in the distance past, has evolved to the present state and why gully stablisation work is important. How did the farmers benefit from this gully plugging works and the approached adopted for this work.
- Rainfall and stream gauging data collection activity has been started since 1998 to mainly to do water balance study in the watershed to access the water shortage scenario. In the long run it will be also possible to access the health of the watershed and how it varied over the time.
- Old MS Flumes needs replacement in most of the irrigation schemes in the watershed. Currently farmers are asking pipes for pipes to replace those old MS flumes. It is critical to replace those flumes in time else there is a high risk of soil erosion and landslides beside lowering the conveyance efficiency of the irrigation canals.
- Citrus irrigation scheduling trial has been established in Bichgoun in Tsirang, Gelephu and Dakpai in Shemgang to access the benefit of irrigation. First year result from Tsirang has been quite promising while there was no harvest data from other sites due to fruit drop problem in 2001.
- On-station direct seeding trial for rice has been started starting from 2002 season. The main objective of the trial is to study the advantages of direct seeding compared to delay transplanting due to irrigation water shortage problem. Irrigation water shortage is mainly caused by delayed rainfall and most of the irrigation water sources small stream or springs. These water sources needs to be recharged with rainfall. Farmers at the higher altitude are affected the most due to late rainfall during some years.

FIELD CROPS RESEARCH

1 FIELD CROPS

1.1 Variety Improvement

1.1.1 Advanced Evaluation Trial (AET)

In 2001, AET consisted of 16 test entries including local and standard check varieties. The objective of this trial was to identify suitable varieties with high yield potential, medium height, optimum maturity and resistance to prevailing pest and diseases for mid-altitude rice valleys.

The trial was laid out in a randomised complete block design with three replications. Seedlings were transplanted in 10 sqm plots at a spacing of 20 x 20 cm. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha with half the N as top dress at PI. To control the weed, Butachlor 5G was applied at the rate of 1.5 kg a.i./ha. Hand weeding was done whenever necessary. Irrigation was applied as and when required. Grain yield was estimated from a harvest area of 5.04 sqm and grain moisture content was standardised at 14%. Results are presented in Table 1.

Analysis of grain yield showed that the highest yielder were CNT 87040-33-1-1 and IR62467-B-R-B-24-1-B averaging 7.47 t/ha. The standard check Bajo Kaap2 produced 6.99 t/ha. Several other crossbred lines produced yields higher or comparable to IR 64. Local check Zakha yielded 2.22 t/ha. Occurrence of insect pests and diseases was negligible during the test season and hence no intervarietal rating was done. The best performers from this trial will be evaluated in the farmers' fields in the ensuing season.

Table 1 Yield and agronomic traits of entries in AET, 2001

Variety	Yield (t/ha)	P.ht (cm)	50% Flw (days)
Bajo Kaap 1	7.72	109	114
CNT 87040-33-1-1	7.52	109	119
IR62467-B-R-B-24-1-B	7.43	164	114
SPR 88090-30-1-2-4	7.36	102	119
IR65239-B-B-68-1-B	7.28	145	117
ST 8240-15-3P-21-11-21	7.04	103	118
IR62745-B-R-B-20-1-B	7.02	141	115
Bajo Kaap2	6.99	107	118
Bajo Maap2	6.89	122	102
IR 62467-B-R-B-F60-1-B	6.79	151	105
IR62467-B-R-B-8-B	6.78	151	105
ZHONGYO 5	6.37	110	118
Bajo Maap 1	6.29	112	114
IR 64	6.22	101	117
IR62467-B-R-B-10-B	5.97	147	112
Local Zakha	2.99	143	114
CV%	10.7	2.5	1.2
S.E.D.	0.58	3.0	1.0

1.1.2 Initial Evaluation Trial (IET)

IET consisted mainly of introductions and breeding lines intended for identification of promising materials in terms of grain and straw yields, maturity, height and resistance/tolerance to biotic and abiotic stresses.

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

Analysis of variance showed that several test varieties produced significantly higher grain yields than the check varieties Zakha, IR 64 and Bajo Maap 1. Days to 50% flowering ranged from 105-130 days. No significant damage due to insects and diseases occurred precluding a differential rating among the entries. The elite selection from this trial will be further evaluated in the following season.

Table 2 Grain yield and characters of entries in IET 2001

Variety	Yield (t/ha)	P.ht (cm)	50% Flw (days)
GUOJING 4	8.38	109	119
IR 64683-87-2-2-3-3	8.14	108	118
SPR 87036-7-1-1-2	7.94	122	119
CNAX 4506-3-2-2-1-B	7.75	102	119
UPR 84-21	7.72	104	118
IET 13245	7.66	99	105
B2983B-SR-85-3-2-4	7.12	115	134
IR 56383-77-1-1	7.11	106	105
IET 13711	6.96	99	118
BR5513-38-1-3-2	6.71	106	119
IET 12884	6.47	101	117
IHH 351-19CX-7CX-2CX	6.27	107	125
TOX 3098-2-2-1-2-1	6.25	107	131
IR 72102-3-115-1-3-2	5.97	99	118
TOX3241-31-2-1-3-1	5.93	94	126
RP 2233-10-16-9	5.90	109	120
RP1667-301-1196-1562	5.78	103	119
IR 64	5.65	97	118
Bajo Maap 1	5.41	107	118
RHH 33025-CX-3CX-024	5.38	111	130
Local Zakha	5.0	135	118
M 88	4.36	114	119
IR 68535-35-3-3-2-2-1-2	3.39	96	96
DR 92	2.68	107	117
CV%	5.4	3.9	3.1
S.E.D.	0.47	3.39	3.04

1.1.3 Observation Nursery I

This nursery consisted of introductions from the IRRI-INGER program where the entries were evaluated in single plots of 10 sqm for yield, maturity period, pest resistance and plant height. Seedlings were transplanted at 20 x 20 cm in late June. Inorganic fertilisers were applied at the rate of 70: 40: 20 NPK kg/ha. Butachlor was applied at the rate of 1.5 kg a.i./ha to control weeds.

The observed yield ranged from 2.77-7.39 t/ha. The yields (Table 3) of most of the entries were higher than the local check variety Zakha. Days to 50% flowering ranged from 95-130 days, while the plant height ranged from 86-126 cm. No notable insect pests and diseases were observed in the trial. The selected entries will be further evaluated in replicated yield trials.

Table 3 Agronomic traits of entries in Observation Nursery 2001

Varieties	50% Flw (days)	**P. height** (cm)	Grain yield (t/ha)
TOX 3055-10-1-1-1-2	125	99	6.59
WAB 340-B-B-10-112	97	126	5.61
IR 68445-62-1-3-1	113	95	6.69
CNAX 4354-2-3-1-2-B	130	100	5.81
IR 65621-299-3-2-3-3	120	89	4.26
IR 68077-33-1-3-3-3	119	95	6.86
PNA 1010-F4-23-1-1	116	95	3.47
IR71606-2-1-1-1-3-3-1-2	116	92	5.25
CH 5	125	128	4.11
BR 5969-3-2	119	116	5.28
IRGA 318-11-6-9-2-A3	113	99	5.71
CT 9737-5-2-1-2-4P-M	113	100	6.75
IRGA 440-22-3-4-1F-1	119	107	5.61
IR 71604-4-4-3-7-2-2-3-3	119	102	2.77
M 91	120	143	5.12
MK 9-87	130	107	4.12
IR 63896	119	99	7.39
IR 73887	119	91	3.98
C 74	131	116	4.72
PSBRC –2	129	90	3.83
CT 6163-8-9	119	102	4.35
IR 73887	119	86	7.19
BR 4676	125	96	5.66
93F106	119	94	2.87
RHS 392	125	113	5.24
VN 93-1	119	111	6.76
CT 9846-1	130	98	5.33
CNTBR 82075	119	107	5.95
P 4	125	110	5.83
WAB 337	105	113	3.90
WAB 224-16-HB	95	108	5.68
IR 68059-73	119	91	5.66
IR 68077	119	97	7.33
UPR 990	130	98	3.95
Bajo Maap 1	111	105	4.83
Bajo Kaap1	113	103	5.05
IR 64	119	101	6.67
Local Zakha	119	135	1.39

1.1.4 Observation Nursery II (IIRON)

It consisted of 112 varieties and breeding lines from the International Irrigated Rice Observation Nursery (IIRON) of IRRI, as part of the collaborative exchange of elite lines and varieties from the worlds' rice improvement program and the initial evaluation under a wide range of irrigated rice environments. Thirty day-old seedlings were transplanted at a spacing of 20 x 20 cm in mid-June. Inorganic fertilisers were applied at the rate of 70: 40: 20 NPK kg/ha. Butachlor was applied at the rate of 1.5 kg a.i./ha to control weeds.

Estimated grain yield ranged from 2.75-11.26 t/ha; plant height from 80-143 cm and days to 50% flowering from 85-144. No notable insect pests and diseases were observed among the genotypes. Selected entries, based on selection criteria such as maturity, plant vigour and height, panicle and grain types and general performance, will be further assessed.

1.1.5 Yield Evaluation trial 2001

Four lines were tested and compared for their yield performance with the standard checks IR 64 and local Zakha.

The trial was laid out in a randomised complete block design with three replications. Seedlings were transplanted in 10 sq.m plots. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha, with half the N top dressed at PI. Butachlor 5G was applied at the rate of 1.5kg ai/ha to control weed pressure. Hand weeding and irrigation was done whenever necessary. Grain yield was obtained from a harvest area of 5.04 sqm.

ANOVA was used to analyse the data and the results are presented in Table 4. Khumal 4 gave the highest yield of 6.44 t/ha followed by P. Masino with an average yield of 5.18 t/ha. Analysis showed that Milky and Khumal 2 yielded significantly higher than local Zakha.

Table 4 Yield Evaluation On-station trial 2001

Varieties	Grain yield (t/ha)	50% Flw (days)	Plant height (cm)
Khumal 4	6.44	116	144
P. Masino	5.18	126	162
IR 64	5.01	116	93
Milky	4.66	87	93
Khumal 2	4.52	112	141
Zakha	3.56	116	141
CV%	2.3	0.5	0.6
SED	1.08	2.19	6.10

1.1.6 On-farm rice PRET

The trial consisted of four varieties evaluated at Thedsho geog of Wangdi district. The main objective of the trial was to assess the grain yield of varieties under farmers' management condition.

Khumal 4 and Khumal 2 yielded significantly higher than the local varieties.

Table 5 Yield comparison of improved varieties with local varieties**.**

Variety	Yield t/ha	Local Yield t/ha
Milky	4.02	4.29
Khumal 4	7.36	4.76
Khumal 2	7.48	5.63
Pokhari Masino	5.13	5.08

1.1.7 High Altitude On-Farm Rice Trial 2001

Three improved high altitude varieties of rice (PP2(38-4), PP3(31-2-1) and PP4(8-1-1) were evaluated at various locations of Wangdue-Punakha valley. The objectives were to introduce high yielder of high altitude varieties and to assess their performance at farmers' management conditions. Local varieties Maap and Shenga Maap were used as the standard check. PP2 (38-4) and PP3 (31-2-1) out yielded local checks with an average yield of 4.57 t/ha.

Table 6 High altitude on-farm rice trial 2001

Variety	Bjena	Limbukha	L. Gaselu	U. Gaselu	Mean
PP2 (38-4)	5.16	5.78	5.13	4.10	5.04
PP4 (8-1-1)	3.40	-	-	4.39	3.89
PP3 (31-2-1)	3.48	4.25	-	4.60	4.11
Local (Maap, Shenga Maap)	3.5	4.06	3.66	3.97	3.79

1.1.8 Mid Altitude On-Farm Rice Trial 2001

Two improved mid-altitude varieties advanced from previous year (IR62467-B-R-B-F8-1-B and IR63332-B-B-B-26-B) were evaluated at different locations of Wangdue and Punakha valley. Varieties were evaluated for their yield performance under farmers' management conditions. IR 63332-B-B-B-26-B yielded higher (i.e. 5.86 t/ha) than local cultivars used as standard checks (Table 7).

Table 7 Mid-altitude on-farm rice trial 2001

Variety	**Bjena**	**Phyangyul**	**Reupaisa**	**Guma**	**Omteykha**	**Mean**
IR 62467-B – R –B-F8-1-B	5.39	6.17	3.81	-	4.15	4.88
IR 63332-B-B-B-26-B	-	5.6	4.39	7.58	-	5.86
Local (Maap, Apadago, Tan Tshering)	5.10	4.77	5.62	4.18	-	4.92

1.1.9 Mid-altitude on farm rice trial 2001 (Tsirang)

Two improved varieties of mid altitude rice (IR 62467-B – R –B-4-1 and IR 62467-B-R-B-B-1-1-B) were evaluated at various locations of Chirang district. The main objectives were to introduce improved varieties in that region and to assess farmers' preferences. Results of the trial are given in Table 8. Farmers' field day was organised during the harvest of trial at Tshokana geog where participants from other geogs shared their views on introduced rice varieties. Although there was not much difference in production, improved varieties were preferred to local Attey variety owing to lodging tolerance and early maturity of the former. As suggested by farmers varieties will be further evaluated in the following year at on-farm level.

Table 8 Mid-altitude on-farm rice trial 2001

Variety	Mindrel-gang	Dungle-gang	Chanau-tre	Goze-ling	Tshoka-na	Mean
IR 62467-B – R – B-4-1	1.80	1.42	1.95	-	3.37	2.13
IR 62467-B-R-B-B-1-1-B	-	1.56	3.72	4.00	3.11	3.10
Local (Attey, Choty)	2.40	3.46	3.77	2.00	1.74	2.67

1.2 Collection and Conservation of local rice germplasm

Collection, characterisation, preservation, and rejuvenation of rice germplasm are considered as important activities in varietal development for higher yield and as sources of resistance to abiotic and biotic stresses. Germplasm are also an invaluable resource for sustainable food production in the future. In 2001 a total of 31 local rice varieties from different altitudes were rejuvenated and characterised at the station.

1.3 Crop Production Management

1.3.1 Nature Farming using EM technology

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

The major objective of nature farming using EM technology is to improve the productivity and efficiency of resources use, with the least detriment to the natural environment on which the production is based. It is a farming method without the use of synthetic agrochemical.

The Nature Farm roughly measures 4000 sqm. It is intended as a long-term study in a rice-based system. Crops included are rice followed by wheat or mustard. Maize is also grown under upland conditions. Grain legumes are grown on rice bunds and fruit and forest trees are planted at the fringes of the terraces.

For all crops inorganic fertilizer and pesticides are not applied. All crop residues are incorporated into the soil along with 5 t/ha of FYM and 7 t/ha of Bokashi at the time of land preparation. EM solution prepared at the ratio of 1:1:100 (EM, molasses, and water) is sprayed. Other management practices are followed as per normal practice for each individual crop. EM5 is sprayed twice a week if there is any pest or disease problem.

Table 9 Cropping calendar and varieties grown in 1999-2001.

Crop	Variety	Date sown/planted	Harvest date
Rice	IR 64	3rd wk June	3rd wk Oct
Wheat	BK 2	3wk Nov	2nd wk May
Mustard	M-27	3rd wk Nov	2nd wk Apr
Maize	Yangtsipa	4th wk May	3rd wk Aug
Pear	Local	1995	2000 fruiting started
Banana	Improved	1995	fruiting not started
	Local	2000	fruiting not started
Guava	Local	2000	No fruiting yet
Tree tomato	Local	1999	2000 fruiting started

For fruit and forest trees EM bokashi and FYM is applied twice a year around the basin. EM solution is also sprayed at the foliage. Forest tree species include *Melia azedarach, Eriolobus indica* and *Ficus religiousa.* Crop yields from 1995-2001 are presented in the table below.

Table 10 Grain yields (t/ha) of various crops from 1995-2001**.**

Crop	Year					
	95-96	96-97	97-98	98-99	99-2000	2000-01
Rice	8.7	4.4	5.05	6.26	6.5	6.80
Wheat	0.766	1.25	1.058	1.2	1.9	1.5
Mustard	0.26	0.27	0.406	0.485	0.49	0.26
Maize	6.37	5.82	6.84	7.7	5.0	5.25

The yields as presented in the table and figure above 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. The yield for wheat for 1999-00 was good (1.9t/ha) and has stabilised at 1.5 t/ha. The yield of maize has decreased in the year 1999-2000 as compared to the previous year because of the change in plot. Due to improvement of soil fertility over a year the yield has increased to 5.25 t/ha in 2000-2001.

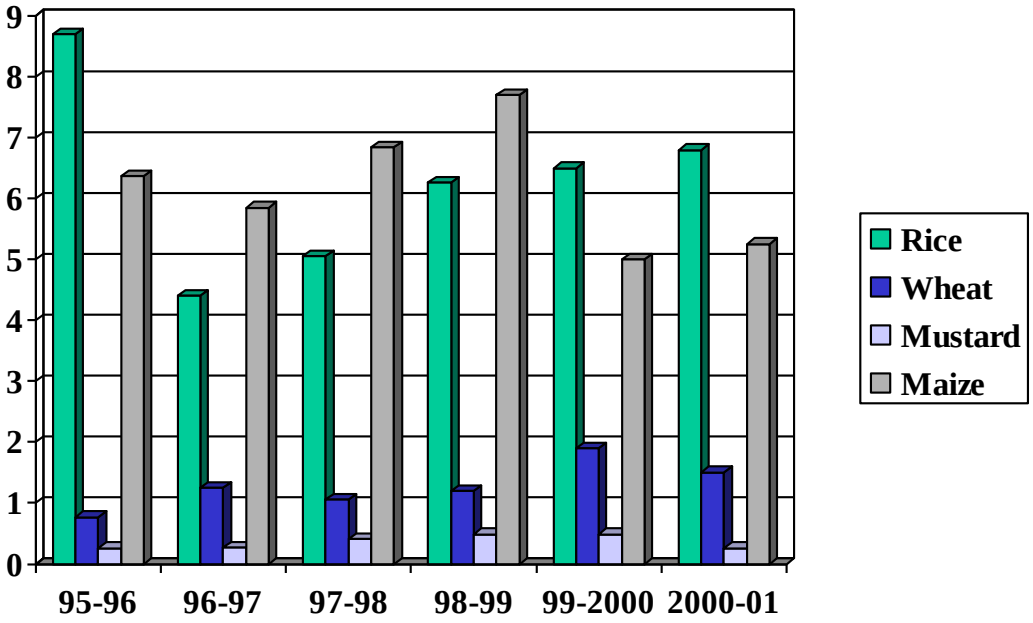


Figure 1 Crop yields (t/ha) from 1995-2001

As Nature Farming involves long-term investment, it does take time to improve soil texture, weed management and fertility of the soil. Data on the number of weeding and the time taken to weed rice show that it takes a number of years to suppress weed population. For winter crops it is much easier to manage. Unlike rice there is no weed problem and if the soil moisture is adequate, which is important for establishment, yields are generally high.

Soil analyses in the beginning and in between are also done. Besides yield, pest and diseases problems are also monitored and recorded. Nature Farming uses only organic matter, which favours insects and pests, both beneficial and harmful. The most common is mole cricket. It is believed to be beneficial since it helps in soil aeration but it also creates problems since it makes tunnels in rice bunds, draining out irrigation water. This calls for extra work to plaster bunds and seal off the escape holes.

Agriculture in Bhutan is basically organic. The six-year experience tells us that we can encourage organic farming. Provided that optimum organic matters are available and used, crop yields comparable to using chemical fertilizers can be obtained. However, production economics will largely influence the acceptability of this method.

1.4 Grain Legumes

1.4.1 Ground nut On-farm Trial 2001

Two promising lines of groundnuts (Kadiri, ICGV-87921) were evaluated at Limbu geog of Punakha district and Gaselo geog of Wangdi district. Total of 8 trial sets was given to farmers with objectives to introduce the crop varieties in that locality

and to assess farmers' preference for the crop. Moreover, if grown over large scale, groundnut could be a very good source of income for farmers in future.

Seeds were sown at the rate of 100 kg/ha with 50 x 15 sq.m row-plant spacing. Grain yields were obtained from harvest area of 6 sq.m. ICGV-87921 gave an average yield of – and Kadiri yielded-.

Table 11 Yield (t/ha) of Ground nut on-farm trial 2001

Varieties	**Nabji**	**Khemphey Jichu**	**Gaselo**	**Mean**
Kadiri	2.53	1.38	2.50	2.14
ICGV-87921	3.36	1.73	3.33	2.81

Farmers' feed back

Being cultivated for the first time Nabji farmers were very much interested in trying out the new crop. They would like to continue cultivating the crop in future. Hence they need technical assistance from researchers with regards to spacing, inter culture operations, plant protection measures, esp. against red ants, etc. Encouragingly more farmers wanted to try groundnut next year, for which seeds will be made available to interested farmers.

HORTICULTURE RESEARCH

2 HORTICULTURE RESEARCH PROGRAM

The main objective of horticulture research in RNRRC-Bajo involves in improving quality and yield of vegetables, nut crops and subtropical fruits through introduction and diversification of these crops with emphasis on high value crops that would meet both nutritional and cash income requirements of the farmers. These objectives can be realized through the introduction and evaluation of exotic 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 would also be given adequate research attention.

Setting priorities and outlining clear strategies have been the essential elements of the horticulture research in the West Central region for accelerated horticulture industry development. Research was focused on diversification of fruits, nuts and vegetable crops with emphasis on high value crops that would meet both nutritional and cash income requirements of farmers. Depending upon the ecological feasibility and distance from the market outlet the RNR-RC Bajo has focused 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. Besides collection of germplasm for screening outstanding cultivars and establishment of orchards for demonstration and training purposes in the research Centres, emphasis was also given to on-farm research.

The activities for the sector have been developed in line with the 9FYP document, ongoing activities, collaborative activities with regional Dzongkhags and major work as vegetable and subtropical fruits research and as coordinating centre for walnut and other nuts crops research and development. The highlights on the research and developmental activities being carried out by this centre in the field of horticulture are as follows.

2.1 Subtropical fruits, nuts and low chilled temperate fruits and Nuts

2.1.1 Varietal Improvement

2.1.1.1 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. The peach cultivars were introduced from Solan, Himachal Pradesh, India. The objective of the trial was to select the suitable peach cultivars for dry sub-tropical ecological zones.

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. The tree was pruned with open-centre system. The plants were 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 manure and fertilizers were applied as mentioned in Table 12. The parameters considered for evaluation were time of fruit maturity, crop yield and above all fruit qualities and consumers acceptance.

Table 12 Manure and fertilizer application

Age of tree	FYM (kg)	N (g)	P_2O_5 (g)	K_2O (g)
1 year	10	50	25	50
2	15	100	50	100
3	20	150	75	150
4	25	200	100	200
5	30	250	125	250
6	35	300	150	300
7	40	350	175	350
8	45	400	200	400
9	50	450	225	450
10 & above	50	500	250	500

Grafted peach fruited in 3 years after planting. Fruits mature in 90 to 120 days after flowering depending upon the cultivars**.** The peach performance was very good under dry sub-tropical condition with good tree canopy, trunk and less pests and diseases problems. Of the three pear cultivars, Flordason was the best considering the fruits quality, time of fruit maturity and ease of marketing. Yield was higher for San-I-Punjab all over the period of evaluation but the consumers acceptance and fruit quality is not as good as Flordasun. In fruit size there was not much difference with average fruit diameter of 5.1cm and length of 5.9cm. Tree trunks also were of similar size. Flordasun is the earliest flowering, fruiting and maturing among the peach cultivars evaluated. Further, it was observed that is the first appearing fruits in the market and fetches good price. We had proposed to the Variety Release Committee (VRC), Ministry of Agriculture for release of Flordasun for general cultivation under mid altitude regions (1300 – 1500 m) since research was done only under Bajo condition. Dry and warm temperate zone to low hills and valleys are suitable for its cultivation. It is also a preferred cultivar in India, Australia and USA. Feed back from Gokha (Royal) and farmers are excellent. The proposal for the release of peach cultivar was accepted and it was released as Bajokham-1 on April 2001. The morphological features (Table 13), fruit quality and characteristics (Table 14) and average yield performance of five trees (Table 15) of the peach cultivars evaluated were given below.

Table 13: Morphological characteristics of peach cultivars

Cultivars	Tree appearence	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 14: 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 heavy pubescence	medium	yellow	Acidic sweet	10%

Table 15: Average yield (kg/tree) trends of peach cultivars

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

The trial is terminated and RNRRC-Bajo is responsible for maintaining its germplasm (mother plant) and we have maintained 5 mother plants in the centre.

2.1.1.2 Apricot Variety Evaluation

Bajo Khamchung-1

Apricot is one stone fruit which has huge potential for commercial cultivation but it is still not cultivated at the same scale as other stone fruits like peach and plum. The trial was established in 1995 with the support of IHDP-I, Ministry of Agriculture. The objective of this trial therefore is to identify superior apricot cultivars which are adaptable to dry sub-tropic and low chill areas in the region. The parameters considered for selection are time of harvest, fruit size, quality and yield. The treatment consists of two cultivars with five replications (one tree per replication). The plants are planted in a spacing of 5m row to row and 4m within a row. All management aspects especially fertilizer application are carried out during the season as per standard practice.

Grafted apricot fruits in 3-5 years after planting. Fruits mature in 80 to 90 days after flowering. New Castle (see picture) performance was excellent under Bajo condition but the cultivar Kaisha (fruit drops) didn't do well.

New Castle is suitable for low chill-warm temperate and dry sub-tropical areas. The crop could be harvested in mid May, which is one of the earliest

appearing fruits in the market. The cultivar New Castle has small fruit size compared to the cultivar Kasiha. The mean yield of New Castle is significantly (P = 0.01) higher than Kaisha. It could be because there was no fruit dropping problem in New castle which is very severe in Kaisha. The TSS % for Kaisha is slightly higher than that of New Castle, though both the cultivars are extremely sweet cultivars. As it has high sugar content there is a potential risk of destruction by birds and wasps as evident from this trial. The variety New Castle has been submitted to His Majesty the King, MOA and panel tested by the researchers, we received positive feed back for this cultivar. We have proposed this cultivar to be released as Bajokhamchung-1 to the VRC, MOA and they did so for the general cultivation. Bajokhamchung-1 is recommended to cultivate in altitude between 1200 to 2000mals and for further detail refer "leaflet on Apricot production"-ready to be published by RNRRC-Bajo. The morphological features (Table 16), fruit quality and characteristics (Table 17) and average yield performance(Table 18) of the Apricot cultivars evaluated were given below.

Table 16: Distinguishing morphological characteristics

Cultivars	**Tree appearance**	**Plant height (m)**	**Bloom time**	**Harvest time**	**Productivity**
New Castle	Semi-vigorous and spreading	2.6	Early (end of February)	Early (mid of May)	Medium to high
Kaisha	Vigorous	3.1	Early (1st week of Jan.)	Early June	Low

Table 17: Fruits characteristics

Cutivars	**Shape**	**Colour**	**Size**	**Barium colour**	**Stone**	**Taste**	**TSS**
New Castle	Round /globular	Yellow	medium	yellow	free	sweet & juicy	18%
Kaisha	Roundish	Yellow with red blush	medium	yellow	free	sweet	19%

Table 18 Average yield (kg/tree)

Cultivar	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
New Castle	6	12	13.5	10	18	35.4
Kaisha	00	00	0.5	00	1.3	00

The trial is terminated and RNRRC-Bajo is responsible for maintaining mother plants and we have maintained five mother plants in our centre.

2.1.1.3 Variety Evaluation of Sub-tropical apple

The subtropical apple cultivars-Anna was introduced as a scion material from Israel through John Goelet foundation in 1997. The anna was grafted on apple

root stock-M111. The observation trial with 15 plants was established in RNRRC-Bajo in 1997. The objective of the trial was to investigate its suitability and performance under dry subtropical areas.

It has started fruiting from second year but the fruit shape, size and quality was not good. The fruit were mis-shaped and protruded. The fruit ripens in 160 days after flowering. The fruit can be harvested very early (early to mid July) compared to apple in the temperate region. In 2000 the pollenizer (Einchimeir) was introduced and frame-worked with some of the trees of sub-tropical apple cultivar. There was huge improvement in the uniformity of fruit size, shape and quality (Fig.2). Its fruits quality is good and similar to that of Red delicious (temperate apple cultivar) which is popularly grown in the country. The average yield of 5 years old apple tree was 20kg/tree and yield of any fruits tree increases over the year and get stabilized only at or above 10 years after planting. The fruits were submitted to the His Majesty the King of Bhutan, Council of Ministers, Ministry of Agriculture, and panel tested by the researchers and some of the cooperating farmers of its demonstration orchards for feed and evaluation of the apple cultivars. Some of the feed we received are:

Picture: Unbelievable but true you can grow apple in sub-tropic and lowland areas with Bajo apple-Subtropical apple cultivar

- Fruit quality and colour were good
- Good for off-season production in low valleys
- Fetches good price in the market (Nu. 70/kg as per the cooperating farmer).

The major pests infesting sub-tropical are birds and wasps. We believe the birds and wasps attacking subtropical apple is due to limited fruits growing in the area and as the area of its production expands the nuisance of these pests will be minimized.

We are convinced that subtropical apple has good potential for extending apple production season and area since at this point of time we have only temperate apple cultivars and apple production is limited to temperate zones only. Now with sub-tropical apple, we can extend the apple production in other parts of the country enhancing the income and nutritional standard of rural people. Therefore, we have decided and proposed to the Variety Release Committee, Ministry of Agriculture for its release for general cultivation and they consented to our proposal and the sub-tropical apple cultivar was released as *Bajo-apple*. *Bajo-Apple* is recommended to grow in mid altitude regions (1200 – 2000 m) of Dry sub-tropical areas (Leaflets on sub-tropical apple production will be soon produced). The on-station trial is terminated and the mother plant of Bajo apple will be maintained by RNRRC-Bajo as

mandated. The morphological and fruits characteristics of Bajo apple are in given in Table 19 and Table 20.

Table 19: Morphological features of *Bajo apple*

Cultivar	Tree appearence	Bloom time	Self-compatibility	Harvest time	Productivity
Bajo-apple	Semi-vigorous and upright	Early (mid February)	incompatible	Early to mid July	Medium to high

Table 20: Fruits characteristics

Cutivars	Shape	Large (mm)	Long (mm)	TSS (%)	Taste	Colour
Bajo apple	oblong	75	100	14	Sweet	Red with golden blush

2.1.1.4 Other Fruits and nuts germplasm collection and evaluation

Table 21: On-going fruits and nuts varieties evaluation

Crop	Cultivars	Remarks
Orange	Valencia Olinda Navel Lane's late	Good potential for extension of citrus production season since they are late maturing cultivars.
Mandarin	Freemont Clementine Nules	Preference of His Majesty Not yet fruiting
Tangelo	Minneola	
Grape fruit	Rio Red Star Ruby	Not yet fruiting ''
Lime	Bearss	High potential and be release soon.
Lemon	Limoniera Meyer	
Pumello	Oro Blanco	Not yet fruiting
Rootstocks	Rangpur lime Cleopatra mandarin Carrizo citrange Troyer citrange	High potential ''
Satsuma mandarin	Ichifumi wase Miyagawa wase Okitsu wase Matsuda unshu	Promising Promising
Mandarin	Ootaponkan Kishu Encore	Promising Promising
Mandarin Hybrids	Murcott Miya uchi Iyo Seminole	} Not very promising

Almonds	DrakeKagzi Texas Pathak Wonda Debor Badam	Promising
Mango	Himsagar Dasheri Langra Amrapalli	Promising
Pecan	Kiowa Western Schley Diserable Witicha Nellis Mahan	Promising -cont-
Avocado	Bacon Hass Fuerte Zutano Pinkerton	Promising
Chestnut	Autumn bounty Niels special Manjimup mahogany Morena	Promising
Walnut	Broad view Chandler Chico Vina Howard Payne	Not yet fruited
Grapes	8 table cv 9 wine cv	Perlite and Pinot blanc are promising cultivars

2.1.2 Production management

2.1.2.1 Citrus Survey in Punakha Dzongkhag

There have been many reports in the past by growers and various organizations on the citrus problems in Punakha Wangdue valley. Citrus decline seems to show the symptoms of general deteriorating process exhibiting loss of vigour, yellowing, death of twigs and branches, reducing yields and ultimate death. The field visit reports on these claims were neither conclusive nor consistent. A number of causal factors were reported which differed from one location to other. Given these possible uncertain factors, it was difficult to provide corrective or preventive measures on the citrus problems.

A citrus survey was carried out in all nine geogs under Punakha covering 60% of the orchard under each geog in collaboration with the NSSC & NPPC-Semtokha, IHDP-Thimphu and Punakha Dzongkhag. The objectives of the survey were:

- What are the current management practices adopted by the farmers in producing mandarin in the valley?
- What is the influence of elevation/temperature on the yield and quality of mandarin fruits
- Is yellowing/die back of trees the most important problems for mandarin growers? What is its distribution pattern?
- What is the soil fertility status of mandarin producing areas?

For detail see a survey report of June 2002 “Is citrus production declining in Punakha Dzongkhag?”

2.1.2.2 Training of farmers and extension agents on top-working of persimmon, pear and walnut and orchard management

Dzongkhag extension, Punakha and farmers from Nobgang reported poor quality of persimmon and having plenty of local pear and walnut. They requested support from RNRRC-Bajo to improve the existing orchard of persimmon and back yard orchards of pear and walnut. RNRRC-Bajo decided to train the farmers and extension agents in order the translate the research findings into practices and the training objectives were:

- extension on top-working technique of fruit crops
- To improve the existing poor quality, undesirable orchards

Picture : Farmers pear successfully top-worked

Budget for the training was arranged by the Dzongkhag Agricultural extension, Punakha and the technical support for the training was provided by the Horticulture Section, RNRRC-Bajo and JAICA expert placed in RNRRC-Wengkhar. JICA expert was instrumental in arranging the non-astringent persimmon scion wood and good quality pear scion wood. Walnut scion wood was arranged by RNRRC-Bajo. Training on top-working as well as orchard management along with practical demonstration was conducted for two days.

16 farmers from Nobgang and 5 extension personnel from Punakha Dzongkhag were trained in the technique of top-working of persimmon, pear, walnut and orchard management.

Top-working is termed as a process when comparatively older rootstocks are grafted or budded at the higher level (1m above the ground) in the production field (Fig 3). It is usually adopted for the conversion of wild large seedlings into production of commercial plants or inferior cultivars to improve ones or to provide pollenizer. A large numbers of the wild seedlings walnut trees (*J. regia*), local persimmon and pear are found in the farmers fields were top-worked with improved cultivars. Bark grafting was used for top-working in the

spring season (mid March). The dormant scionwood was selected from disease-free young trees and cut off from parent tree quite in advance and be stored in the refrigerator after proper packing. Frame-working or grafting of branches is desirable for top-working of grown up trees, for quicker healing of wounds, earlier production and higher yields.

Three to five branches with wide angles and the projection in all the directions are retained for this purpose removing the other branches. Using the top-working technique we have achieve graft success as high as 95% to 100% (Persimmon orchard at Nobgang top-worked, March, 2001 & 2002) and 100% (for walnut). Added advantages are, since the rootstock is already well established, the scions make rapid growth and commences bearing earlier (within a year or two after top-working) than the transplanted trees

Farmers and extension personnel were trained in orchard management and the top-working of persimmon, pear and walnut. Practical demonstration of orchard management particularly on basin making and weeding of orchards was done in Royal persimmon orchard as well as in the farmers' field. The top-working of pear (10 households), persimmon (6 households) and walnut (2 households) was done in the farmers field in Nobgang village beside other areas like in Limbukha, Nabjee etc. The other pear cultivars used for top-working were Yakumo and Atago (> 1kg fruits) in Nobgang farmers field but Hosui being the best cultivar in term of fruit quality. All the pear and Persimmon cultivars used for top-working are Japanese

2.1.2.3 Nursery management and plant propagation

The plant propagation techniques for various fruits and nuts tested successfully and training were provided to the farmers, DSC and Dzongkhag Agriculture extension. DSC has achieved about 95% graft success in walnut grafting this year in Paro after they had received walnut grafting training in March 2002 at RNRRC-Bajo. The nursery management and plant propagation techniques were developed for the following fruits and nuts:

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

Sl.No.	Crop	Grafting Technique	No. of planting materials produced	Remarks
1	Sub-tropical apple	Whip	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. organisation on request.
2	Different cultivars of citrus	T-budding	500	
3	Peach	Whip	100	
4.	Apricot	Whip	70	
5	Walnut	Whip	700	
6.	Pecan	Whip	100	
7.	Pomegranite	Cutting	60	
8	Guava	Air-layering	40	

9	Citrus rootstock	Different Rootstock	1200	All these rootstock will be used for propagating the promising cultivars for further research.
10	Walnut		1000	
11	Avocado		400	
12	Apple		500	
13	Peach		200	
14	Apricot		70	

2.1.2.4 On-farm Fruit and Nuts demonstration orchards

The promising cultivars of various fruits and nuts are taken to on-farm as serving the dual purposes of demonstrating the new crops and their management to farmers and for multilocation evaluation after the completion of preliminary adaptive trial in research station. We have established two demonstration orchards in each five Dzongkhags of West-central region.

2.1.3 Trainings of farmers and extensions personnel

The farmers, nursery growers and extension agents were trained as follows:

- 30 Farmers and five extension agents in Limbutechu watershed and Nobgang were trained in persimmon, pear and walnut top-working and orchard management.
- All the extension agents (7) in Zhemgang Dzongkhag and some of the plants nursery growers (5) are trained in walnut nursery management and propagation.

2.1.4 Translating research into communication materials

Some of the publications produced from our centre are as follows:

- Walnut grafting technique was published in kuensel issue 9th March 2002
- Participated RNR-Exhibitions in Changlingmethang and its leaflet produced.
- Technical information provided to IHDP for walnut production manual development.
- Leaflets on Apricot (newly release Bajokhamchung-1) Production developed and yet to be submitted to the Ministry for further action.

2.1.5 Technical support submitted to the policy makers in Ministry of Agriculture

- Technical recommendation for mango production in Bhutan was submitted to MOA as mandated.
- Nuts Variety Evaluation Guidelines and Release procedure
- Minimum planting materials standards for nuts and subtropical fruits

2.2 Vegetables

2.2.1 Integrated germplasm development

2.2.1.1 Release of various vegetable cultivars

After the extensive on-station and on-farm adaptive trial this year we have released one onion culitvar(Red Creole) as Bajogob-1, tomato cultivar(Ratan) as Bajolambenda-1 and a radish cultivar (Hongkong white) as Bajolaphu-1. Their characteristics and yield performance are presented in tables below.

Table 23: Bulb characteristics of onion cultivar Bajogob-1

Characteristics	**Data**
Bulb diameter (cm)	5.2
Bulb length (cm)	4.1
Bulb weight (gm)	115
Bulb colour	Dark red
Storability	Longer
Maturity (days)	180

Table 24: Yield of Bajogob-1 in different farmers fields.

Locations	**Bulb yield (t/ha)**
Bajo	11.50
Gubjee	24.28
Damche	11.66
Guma	28.57
Average	19.00

Table 25: Characteristics of radish variety Bajolaphu-1

Characteristics	**Summer crop**	**Autumn crop**
Plant canopy (cm)	40 x 40	50 x 45
plant height (cm)	50.17	59
root length (cm)	29.53	34.67
root dia (cm)	4.6	5.79
yield (t/ha)	102.60	75.0
Days to maturity	45 days	
Root colour	Clean white (Very less hair/ roots)	
Leaf colour	Light green (Smooth and hairless)	
Leaves	Not serrated and sag-like taste	

Table 26: Characteristics of tomato variety Bajolambenda-1

Characteristics	
Plant height Fruit diameter: Fruit length: Fruit-weight: Number of fruits/kg: Colour of fruit: Taste:	77cm 3.5 cm 5.7cm 35.7g 28 Yellowish red acidic sweet
Yield	23 to 30 t/ha
Reaction to pest and diseases	Moderately tolerant to early blight and powdery mildew

2.2.1.2 Cucumber varietal observation trial

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

Seeds of cucumber varieties Rampal, Bavipal and Norgoan were received from DRDS for testing in our locality for adaptability and other important characteristics. A popular local variety from Thinlaygang was included as the check. The seeds were sown in the seed sowing pots filled with a mixture of compost and soil, on 19 April 2001. The adaptability test was done in Thinlaygang and Kabji, popular cucumber growing areas since Bajo was found to be unsuitable for cucumber production. Transplanting was done on 14 May 2001.There were 2 rows per plot spaced at 100 cm in between and 50 cm between plants. Well rotten farmyard manure was applied at the time of land preparation. Hills were then filled with a handful of suphala and mixed before transplanting. Top dressing with nitrogen was done during fruit setting. Hoeing and other cultural practices were done manually.

Variety **Norgoan** was the earliest to flower and fruit. It matures about two weeks before the local variety. The fruit size was small, short, and very green and tender. The fruits turned dark brownish and round when matured with about three deep ridges. The fruit length is about 15 cm and breadth about 25 cm at full maturity. The fruit was sour and very juicy. This variety is most probably the small pickling type, where the fruits are picked when small and green. **Rampal** is the late maturing variety. It matures about thirteen days after the local variety. The fruits are large with length of about 16 cm and breadth of 4.5 cm. The fruits are juicy with higher water content. It was observed to have more seeds and less flesh. **Bavipal** has long dark green fruits and looks similar to the local Dhomi genchu. It matures later than the local variety but earlier than Rampal. The fruit length is about 29.5 cm and breadth is about 9 cm. It was observed to be highly susceptible to powdery mildew in the early growth stage. **Thinlaygang local** is the most popular variety grown by the farmers in the area. The fruits are light green and very juicy. The fruit length is about 15 cm and breadth is about 5-6 cm. The local variety was found to be more resistant to powdery mildew.

Since this was a preliminary observation trial detail yield data was not collected. The cooperator farmers feed back was that all the new varieties under testing had their own advantages. Norgoan the small type was less preferred due to the shape and its characteristic of maturing “too soon”. However, if the fruits are picked when still green and tender, it has high

potential of being accepted in the market as a “fruit” since it is suitable to be consumed by a person in the same manner as an apple or a pear.

The variety Rampal, being late maturing, has the potential of being an off-season variety. The fruit size and shape were both acceptable to the farmers. The variety Bavipal was highly accepted by the farmers due to its smooth dark green skin and soft flesh. However, infestation with powdery mildew at the early growth stage would require some fungicide sprays. There was no difference in the performance and fruits quality of different cumber cultivars tested at two difference sites. The farmers have collected the seeds for all the three new varieties and are planning to grow them at a larger scale next year. The research center will also conduct more detail observation in the next trial.

2.2.1.3 Tomato Variety evaluation

Tomato is a popular vegetable grown in the early spring summer in the mid altitude regions of Punakha and Wangdue Phodrang. There are two varieties available for cultivation by the farmers i.e Roma and newly released Bajolambenda-1, both are determinate type. Roma is still popular among both growers as well as the consumers, the yield was found to be decreasing over the years and the plants were found to become susceptible to many diseases and pests. It was therefore, necessary to find an alternative variety that would yield high, be tolerant to major pest and diseases and be acceptable to both growers and consumers. Eight cherry tomato lines were introduced from AVRDC, Thialand through IHDP in January 2001. The aim of the trial was to evaluate and assess the performance of the cultivars under Bajo condition.

The on-station preliminary evaluation of eight new tomato cultivars with roma as local check was carried out in 2002. The sowing was done in 19th February 2002 and transplanted on 12th April 2002. The plot size was of 5m^2 and design was RCB design with three replications. The spacing of 50cm plant to plant and row to row. Fertilisers were applied at the rate of 60:75:20 kg/ha NPK with 30t of FYM. A total of three hand weeding was done. Alternate day irrigation was done right after transplanting till proper establishment of the plants. After 15 days, flood irrigation was done at an interval of 15 days. Harvesting was done in mid-June.

All the cultivars are determinate type and came to harvest earlier than local check roma. Three pickings were done from 13th June to 8th July 2002. The earliest cultivars among the new entries are: CLN65-349135-2-0, BSS-99 and CL1131-0-013-0-6. Among the all entries and local check, BSS-99 found to perform well (Table 27) with high yield and less susceptible to pests and diseases.

Table 27. Average yield in the first evaluation trial 2002.

Variety	yield (t/ha)
Roma	44
CL5915-93D4-1-0-6-1	30
CLN65-349135-2-0	35.2
BSS-40	36.2
CL-5915-93D4-1-0-12	40.2
CLN 495 BCF2-265-9-0	40.2
BSS-99	53.1
CL 1131-0-0-13-0-6	33.1
CL 143-0-10-3-0-1-10	38.4
LSD (0.05)	6.8
CV%	24.5

In this trial BSS-99 yielded significantly (P = 0.05) higher than local check variety roma and all other new cultivars. This was an on-station preliminary variety trial and in next season it will be evaluated in multi-location. The fruits characteristics of the various cultivars are given in Table 28.

Table 28: Fruits characteristics (average of five fruits)

Variety	Fruit Size (cm) length	breadth	Fruit wall thickness (cm)	Fruit shape
Roma	3.5	4.5	0.8	Oval
CL5915-93D4-1-0-6-1	3.7	5.6	0.5	Globular &
CLN65-349135-2-0	3.9	3.5	0.5	ridge
BSS-40	3.0	5.3	0.5	Peach shape
CL-5915-93D4-1-0-12	5.0	4.9	0.5	Flat round
CLN 495 BCF2-265-9-0	4.0	3.5	0.5	Round
BSS-99	3.5	3.7	0.4	Peach shape
CL 1131-0-0-13-0-6	3.6	3.6	0.4	Globular
CL 143-0-10-3-0-1-10	4.0	4.2	0.4	Peach shape
				Peach shape

2.2.1.4 Local beans germplasm collection and evaluation

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

The trial design was CRBD with three replications. The treatments consisted of 9 beans cultivars. The plot size was $4m^2$ per treatment in a replication. The sowing was done on 18th February 2002 with spacing of 45cm plant to plant

and 50cm between the rows. The fertilizer were apply @ 25:50:40kg /ha with 40t/ha FYM. Three hands weeding were done. The data were analysed using Genstate and the mean yield is given in Table 29.

Table 29: Mean yield and type of beans cultivars

Cultivars	Mean Yield (t/ha)	Dwarf or pole
RNRRC Dwarf	14.3	Dwarf
Borlotto	12.7	Dwarf
Rajma	12.6	Dwarf
Nobgang black	13.3	Dwarf
Geobori	13.0	pole
Kanchi boni	9.3	pole
Tsirang local	14.3	pole
Punakha yellow	14.8	pole
Chitokha local	10.2	pole
LSD (0.05) CV%	4.8 32.6	

There was no significant difference in the yield performance of various beans cultivars except for the Kanchi boni which yielded significantly lower than most of the cultivars. Farmers reported that Geoboni, Borlotto, Tsirang local and Nobgang black are easily marketable. All of these varieties will be evaluated in multi-locations in on-farm during the next season for participatory evaluation and selections. The selected varieties will be proposed for release in the next VCR meeting.

2.2.1.5 Asparagus variety evaluation

Nine hybrid asparagus varieties were sown in the nursery in April 1994 and transplanted in July 1995. The trial was established to evaluate these nine hybrid varieties for yield, earliness in production and spear quality. The trial was laid out in a randomized complete block design with four replications. The plot size is 7 x 1 m^2. First harvest began in 1997 and thereafter-yearly harvest data were collected to assess the yielding ability of these varieties till 2001. A combined analysis over year was carried out for yield data from 1997-2001. There was a high significant ($P<0.001$) difference in variety, year and a significant effect of the interaction of variety and year. Now this trial as variety evaluation is terminated since we have identified the suitable cultivars with high yield and quality but seeds of these varieties are not available in the market. Since all of these cultivars are hybrids they have become obsolete. With the same trial we are carrying out the analysis of the cost benefit of asparagus production in the coming season.

2.2.1.6 On-going vegetable variety evaluation

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

- Water melon variety evaluation
- Vegetable soyabean variety evaluation

2.2.2 Production management

2.2.2.1 Observation trial of Potato weed control using Herbicide

Potato cultivation in Rice-based system is common in Lingmuteychhu Watershed, and the community there produces potato in commercial scale. Among 32 households in Limbukha village, 14 farmers cultivate potato as their major cash crop. In an average, a farmer grows about a langdo or more potato per season.
Labour shortage and weeds especially *Fagopyrum spp* were the major constraints in potato production in Limbukha. It was learned that due to shortage of farm labour, farmers conduct one hand weeding or none. Potato growing areas like Phobjikha, the farmer practices weed control in potato by means of chemical (Herbicide) spraying. Observation trial to evaluate the right concentration of herbicide and to up scale the chemical (***Metrobuzin***) method of weed control in potato production in the watershed was initiated by Horticulture sector in collaboration with CBNARM or on-farm sector.

The treatments consist of three concentrations of Metrobuzin (1g, 2g, 3g per litre of water) and a check (unsprayed potato plot). The plot was $10m^2$ for each of the four treatments and there was only one replication. The single post-emergent blanket spray of herbicide was done on 29th March 2002.

The effect of the herbicide (Metrobuzin) was observed only after three weeks of spraying. The herbicide concentration of 2g per litre of water was very effective in controlling all weeds excepting dock weed.
At the end of observation trial, farmers' field day was conducted and some of the comments by the farmers in the field day are:

- It will mitigate the problem of farm labour shortage
- It will reduce the cost of potato production
- The most of potato grower like to go for herbicide control of weeds in the coming season but they were also cautious about residual effect of the chemical on the subsequent paddy crop.

It is recommended to trained farmers on the amount and time of application, use and misuse of herbicide in the coming season. It is recommended to conduct detail observation in the coming season validating the feed of farmers in the field day.

2.2.2.2 Early chilli cost benefit analysis

Chili is the major vegetable crop, which is in demand all year round in the domestic market and fetches good price. In collaboration with agricultural economist of RNRRC-Bajo, an early chilli production trial under the polytunnel was carried out in this season with emphasis on the cost benefit analysis of early chilli production . The polytunnel used was the standard AMC structure. Detailed records of every activity, inputs, labour etc were kept till the trial was terminated. The seeds were sown in the nursery in the second week of November and transplanted after one month in the polytunnel. ie. 3rd week of January. The size of the standard polytunnel was 20m x 2.3m. Transplanting was done at a spacing of 30 cm RR and 30 cm PP. All necessary cultural

practices were carried out and recorded. The plastic has to be removed by early March, since then the ambient temperature is congenial for chilli production. Harvest was possible by the end of March. A total of four pickings were done. The total marketable yield was 52.2 kg. At a price of Nu.100-150 per kg for early chilli, the Gross Revenue earned was Nu. 5,220. The expenditure was broken down in several components. The inventory list was drawn on all tools, equipment and other infrastructure used. Depreciation calculated with the life span and price of the material was made and thus the cost of the material for the particular year was determined. The cost of early chilli production (Nu 67/kg), return to land, labour and capital were calculated (Please see annual of economic section of RNRRC-Bajo 2001-2002 for detailed report)

2.2.2.3 Maintenance of breeder seeds of released vegetable cultivars

The responsibility of maintenance of breeder seeds of released crops cultivars was transferred to RNRRCs from Druk Seed Corporation by the Ministry of Agriculture. RNRRCs are mandated to maintain the breeder seeds of the various crops released from their centre. In this regard, horticulture section of RNRRC-bajo has started maintaining the breeder seeds of various vegetable crops cultivars. The most of vegetable cultivars were released from RNRRC-bajo and maintaining all the cultivars of different vegetable are not possible in RNRRC-Bajo due to specific climatic requirement of various crops. It also demands one person full time working on vegetable breeder seeds maintenance works since there are more than 35 vegetable cultivars released from this centre. The vegetable breeder seeds produced and maintained so far in RNRRC-bajo are given in Table 30.

Table 30: Vegetable breeder seeds produced in RNRRC-Bajo.

Crop	Variety	Quantity
Japanese Green	Taisai	200g
Japanese Green	Mebuna	200g
Carrot	Early Nantes	300g
Onion	Bajogob-1	1kg
Brinjal	PP long	300g
Tomato	Ratan	200g
Tomato	CHT 160	200g
Tomato	Roma	200g
Bean	Borlotto	2 kg
Beans	RNR dwarf	2.0 kg
Beans	Punakha pole yellow	1.5 kg
Beans	Rajma dwarf purple	1.8 kg
Beans	Tsirang pole stripped Geobori	1.0 kg
Beans	Nobgang dwarf black	2.0 kg
Beans	Tsirang pole creamy	1.0 kg
Beans	Chitokha pole black	1.0 kg
Broccoli	Desico	200g
Okra	Pusa Kranti	300g
Cauliflower	White summer	200g
Radish	SPTN	300g
Radish	Bajolaphu-1	1.2kg
Radish	Minowase	200g
Lettuce	Iceburg	50g

2.2.3 Training of farmers and Translating research into practices

The activities undertaken are as follows:

- Demonstration of year round vegetable production in home garden done in the Limbuteychu watershed
- 14 farmers trained in early vegetable production in Jawa/Jarigang, Wangdue Dzongkhag on 14th to 15th June 2002
- All the extension agents (14) in Wangdue Dzongkhag were trained in asparagus production management during 24th –25th June 2002.
- Potato seed awareness campaign in Limbuteychu watershed was carried out where significant yield different was observed between the potato grown using farmers' own potato seed and the potato seeds supplied by the Druk Seed Corporation.
- New or potential vegetable cultivars ready for release and production technique of early vegetables are demonstrated in RNR-Exhibition held in Changlingmethang by the Ministry of Agriculture.

LIVESTOCK RESEARCH

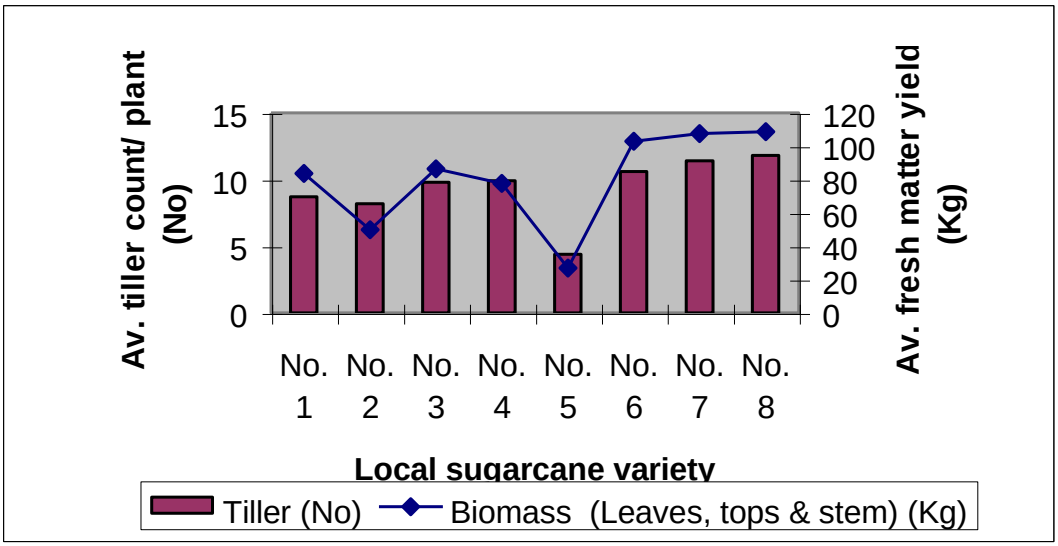
3 LIVESTOCK RESEARCH PROGRAM

3.1 Feed and Fodder Research

3.1.1 Sugarcane accessions and evaluation

The objective of this trial was to evaluate local/improved sugarcane varieties for adaptation to Bhutanese conditions, suitability for use as winter fodder and dry matter production. Initially, 8 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 the figure below.

Figure 2 Tillers and fresh matter yield of local sugarcane varieties



(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 data recorded for the last three years of on-station experiment revealed that all local collections are adaptable to Bajo's prevailing climatic and soil conditions though winter cold is bit intolerant. As suggested by the objectives, this experiment was to evaluate its suitability as fodder possibly in winter. Therefore, the performances assessment of these sugarcane varieties in winter is important. But, the trial result showed that the fodder yield in winter both in terms of quality and quantity was poor. Poor because the leaves become matured, hard and remain dry. Nonetheless, all 8 local collections showed satisfactory performance in terms of height growth. However, the fresh matter yield from Collection No. 8,7 and 6 was good which corresponded to highest number of tillers (see fig above). It has become clear that the biomass yield is dependent on the tillering capacity of plant or the genetic performances of different cultivars with in the same species.

Above data collected for the last three years also clearly indicated that biomass production is very much determined by the development of tillers and plant maturity. Production increased drastically in the subsequent years once the plants were well established which maintained the production stable. As a

trial implementer, the concluding remark is that sugarcane cannot make qualitative forage roughage for winter owing to its declining nutrient value (TDN and DCP) and poor re-growth under tropical conditions like ours. Normally, growing takes place during the monsoon month of June to September. Growth completes by October, after which the crop enters its ripening phase. The low temperature in winter retards ripening during December to mid March. Therefore, such trial needs to be studied more for its acceptance by the farmers with dual intention for promotion as fodder / feed (cattle and pig) and consumption / sale of stalks to generate cash income. Sugarcane has been already recommended as winter fodder / feed for livestock vide Extension Publication No. 52, October 1999 though most farmers are still unaware to its usages. Therefore, it may not warrant any further research on sugarcane as to study its winter fodder potential. The three years long on-station trial completed last year. However, the centre has maintained about 17 different collections of sugarcane on-station collected from various places.

3.1.2 Lucerne germplasm evaluation

The objective of the Lucerne germplasm evaluation is to select promising Lucerne entries.

Thirty-one varieties of Lucerne (*Medicago sativa*) were sown in a single plot design with the plot size of 1 m x 4 m. The trial has been set up at NRTI subject to Lucerne's soil requirement i.e. dry and infertile land. The trail was established on 31.7.2001. Data collected as per protocol is presented in the tables below.

Table 31: Plant density (no.) and fresh biomass of 31 entries

Variety	Density of plants in two rows counting all 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

Table 32: Fresh matter production (t/ha) recorded from 2 cuttings

Variety	Biomass production (t/ha) after		Total t/ha
	60 days	90 days	
L238	2.5	2.0	4.5
L330	4.0	3.5	7.5
L583	7.5	6.5	14.0
L603	9.0	6.0	15.0
L634	5.0	4.5	9.5
L635	8.5	7.5	16.0
L636	10.0	8.0	18.0
L754	9.0	7.5	16.5
L755	11.0	9.5	20.5
L792	11.0	8.5	19.5
L794	9.0	6.5	15.5
L813	7.5	5.0	12.5
SA 32087	5.0	4.5	9.5
SA 32088	3.5	1.5	5.0
SA 32089	3.5	2.5	6.0
SA 32090	2.0	10.0	12.0
SA 32091	5.0	2.5	7.5
SA 32092	6.0	4.5	10.5
SA 32138	6.0	3.5	9.5
SA 32140	8.5	4.75	13.25
SA 32147	8.5	3.75	12.25
SA 35067	7.5	4.0	11.5
SA 35068	5.5	2.5	8.0
SA 35088	6.0	4.0	10.0
Eureka	6.5	4.25	10.75
PL 34HQ	3.0	2.25	5.25
PL 55	7.5	5.0	12.5
Prime	11.0	8.0	19.0
Super 7	5.0	4.0	9.0
WL 414	4.5	3.0	7.5
15 L 756	3.0	5.0	8.0

The observation for the year 2001 revealed that the highest biomass production was from L755, followed by L792, Prime, L636, and L 635 from the 2 cuttings at 60 and 90 days of sowing. The observation of the trail will be continued till 2004.

3.1.3 Legumes in orange orchard

Objectives

- Optimise forage production with horticultural crops (especially with orange).
- 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.

As a nation-wide trial, in addition to the earlier two sites in Wangdue and Punakha dzongkhags 3 more are established at Tshokana, and Dagapela, under Tsirang and Dagana dzongkhags respectively with an aim to make more replicates in rest of the client dzongkhags to make the trials results comparable and realistic. GLD and *Arachis pintoii* are in use to compare with a control plot seperately. The records till date revealed that both of these legume species are doing well at all the levels of different altitude range where this trial has been set up. GLD is doing well only at the lower elevation below 1500 masl compared to *Arachis pintoi*. Since the growth of Arachis pintoi is slow at the moment and the co-orporaters already started complaining of its poor performances. They preferred GLD to *Pintoi* since GLD grows faster and yield more fodder under cut and carry system. However, in the orchard system, *Arachis pintoi* would perform better as a soil conservation strips and live mulch in the long run. Therefore, to arrive at the conclusion further study will be continued till the full period of five year is completed.

3.1.4 Assessments and Monitoring of Grassland Resources

Short-term objective:

- To describe the natural grassland, identification of grass & legume species and establishment of a herbarium

Long-term objective:

- Monitor trends in production, soil quality, population composition and nutritive quality.

This is a nationally co-ordinated trial. For this region it has been laid out in Laya under Gasa dzongkhag in July 2001. The following data is collected:
Soil samples collected and sent for analysis to the National soil-testing laboratory (SPAL), Simtokha, (result not received yet). Herbarium samples collected and most of the species identified.

In the first transit counting, about 36 types of grasses, 16 sedge, 75 different broadleaves, 4 Rhododendron, 4 Junipers, and 65 other different species

were recorded. However the recording was different during the second trip. Initially only 20 counting were done in a transit and one transit each per plot, but in the second trip 30 counting per transit with 12 transits per plot were done. However there was not much difference in plant composition. Table below shows the locations, and its description.

Table 33: Laya grassland monitoring site details

Site	Date of establishment	Locations	Altitude	GPS	Aspect	Slope	Vegetation
I	10/7/01	Kuchuyachey	4408 m	N=28°.04.744 E=89°41 .202	South/East	20-25	Juniper, Shrub, mixed grass
II	10/7/01	Kuchugo	4078m	N=28°04.255 E=89°41.063	South	25-30	Shrub, grass
III	11/7/01	Gochung	3708m	N=28o03.787 E=89o41.784	South/East	30-35	Spruse, shrub, Fern
IV	11/7/01	Tsheko	3582m	N=28o03.470 E=89o40.786	South/west	25-30	Silex, juniper, Spruce, shrub

3.1.5 Silvo-pastoral Trial

The objective of this trial was to measure tree growth, fodder dry matter production and economic benefits, and to study fodder and tree interaction.

Dawakha village in Punakha Dzongkhag has the oldest history of community forest plantation. Poor management of the trees has resulted to stunt growth of the trees, which prolong further the gestation period of tree crop to derive its early benefit or income. Therefore to boost the growth of the trees and derive early economic return in a form of milk, cheese and butter improve pasture has been developed within the plantation area. Joint effort was made by a team of EPO, Researchers (Forestry & Livestock) and the EAs with the community to bring the activity in progress by establishing improved pastures in the plantation area. The work started by second week of April with land preparation and sowing of pastures seeds May 2001. The improved pasture showed satisfactory growth and production, which impressed the community. About 2-3 harvests were made since the establishment last year. Whatever yield harvested were shared among the community at their own understanding. The development of improved pastures has not only improved the fodder resources but have eased weeding, improved soil fertility and boosted the growth of the trees. The community is happy with the achievement made within the short period of time.

3.2 Surveys and Studies

3.2.2 Cactus as animal feed

Objectives

- Develop an appropriate document to describe an alternative animal feed resource for livestock
- Correlate local cactus over improved variety in terms of livestock preference and farmers acceptance
- Study nutritive value that influences livestock production over other feed resources.

The centre has been mandated for feed and fodder development. Every possible efforts has been attempted to tackle the problem to solve the feed resource shortage. Inadequate land holding for pasture (Feed & Fodder) development is the major constraint in most of the dzongkhags in the region. However a survey was conducted on the use of cactus as animal feed and this has revealed that one possibility to reduce this pressure is to further study, do research on it. It is an age-old tradition that our farmers use cactus as one of the feed resources for the cattle and pigs in these cactus-growing areas as in the table.

Table 34: Cactus growing dzongkhags/geogs

	Dzongkhags	Gewog/Villages
1	Wangduephodrang	Thetsho, Rubisa, Upper Gaselo, Phangyul
2	Punakha	Zomi, Guma, Talo, Kabisa, Chubu, Limbukha
3.	Thimphu	Matalumchu

Table 35: Categories pf animals fed with cactus

Species	Type of animals fed to
Cattle	Milking cow, Pregnant cow, Draught bull Calves
Pigs	Suckling sow, pregnant, piglets, fatteners

Recommendations

It is important that cactus need to be officially recognized as potential animal feed resource. Study/research on cactus potentiality need to be included in the livestock research mainstream. Study on cactus may include socio-economic value, species identification, and monitor trends in production, population composition and nutritive value including changes in soil. Draw up judicious and appropriate management plan and strategy including legalizes ownership rights is also important.

3.2.3 Survey on local bees

Objectives:
- Explore possibilities of improving traditional bee keeping to
- Improve hive and management system.
- Document traditional practices.

The areas of two Dzongkhags namely Dagana and Tsirang where local bee keeping is popular have been selected and interviewed. Combined formal interviews using structured questionnaire and informal discussions were geared to obtain first hand field data.

Results and discussions

Traditional / bee keeping history

For several reasons the traditional beekeeping in Bhutan is limited to the south. The local bees *Apis cerana* are kept in the Log and Wall hive where their combs are built in natural way (traditional fixed combs hives).

Log hive:

It is a simple hive with a hollowed-out tree trunk without any frames and boxes. The open ends of log are sealed with a piece of tin, a wooden plank or a mixture of mud and cow dung. The entrance is made in the middle of wooden cylinder. The entrance hole for long and large logs normally ranges from 2-3 holes (see Pictures). The log hives in most of the surveyed areas were placed along the attics and cellar of their houses where few were still left unattended on the raised ground.

Picture: Log hive hung on wall

Picture : Log hives in Tsirang

The wall hives are usually rectangular in shape with square recess in the wall. The small hole is provided at the base, middle or top, as an entrance. The side walls are plastered with mud and cow dung and alike, and the roof and the bottom with wooden planks. The back of the recess towards the house is closed inside with a wooden plank that is temporarily fixed to the wall with mud and cow dung.

As revealed by the findings of survey, the common species of local bee are yellow & black. The black is bit bigger than the yellow in size, but both of them have same characteristics except for the black species, which tends to

eat away the whole honey of their combs especially during the inclined weather condition. No special methods as such are used in domesticating the bees. The hives are free and open to allow the bees to come and hive themselves. There are two common hiving systems; log hives and wall hive as already mentioned earlier.

The domestication of bees has been a century's legend and traditionally root down technology. Some do not have even definite record and findings as the bees have been kept since time immemorial and passed down from the hierarchical tradition. Even today instances show that traditional types of houses are constructed and the provisions of wall hives are kept either intact to the walls or above the attics of the houses or immediate dwellings.

According to one of the most experienced and progressive farmers, one of the methods of domesticating the wild bee is normally targeted for a roaming and dwindling bee around the humans' head. This bee is caught and put in the hive, so it brings all of its members to the hive gradually, which eventually forms a crowned colony. There is also a traditional legend that such bees, which encircle at and around human set-up, are actually seeking the help for protection and to locate good house/hive of their own.

Non of the bee keeping farmers have a fixed number of their bee colony, because every year the number of hives tends to change their habitat according to habit of usual migration practices and bee norms. Usually the bees used to come and settle on their own and the migration takes place during winter seasons. The bees mostly migrate during the month of January & February of the year. There are also some unconfirmed beliefs that the absconding generally occurs following physical human interventions and other disturbances from natural calamities

For all the farmers the beekeeping is only for the honey and hobby. None of them have understood the main benefit, the pollination that is enhancing the crop productivity and other outcome of the agricultural impact at large.

Production/output

Harvesting of honey is carried out bi-annually in a year (April/May) and (October/November), depending on the amount of honey accumulated. The production depends on the richness of flora during the season in the area producing 2-4 bottles of honey/hive/harvest. The accumulation of honey has been reported more from the yellow coloured honey bee than the black coloured one. There are also evidences that the honey production is bit more in autumn harvests. (Could be attributed to dry and foraging weather and more collection).

The honey is harvested manually by opening up the log/wall at one side with the help of a knife and breaking out and cutting the combs filled with honey. It is collected while pressing the combs through a strainer or a muslin cloth. During harvesting, the smoke is also used to pacify the guard bees. As a by-

product, wax is also obtained which is melted and purified. The quality of honey is good.

Marketing

The honey is sold only when there is excess production. One to two bottles are sold depending upon availability of market resource in the vicinity. Otherwise it is stored for their own consumption. With regard to the price, there is no fixed rate and ranges from Nu. 80/- to 120/- per bottle based on the quality (purity) and market resource. For the local customers and close relatives, it is sold at considerable rates.

However, the demand for the honey has increased over the years with increase in market resources. So far there has been no market problem with the present production level. The rate of indoor sale is taking its momentum and, yet there is very little hope for avenues for scope of future marketing.

Flora and Feeding

As revealed by the survey the commonly used bee flora are more contributed towards farmers cultivated crops, flowers of trees & shrubs. Even some weed flowers have also been useful as flora. Some of the common cultivated crops that is playing a vital source as bee flora are given the table below.

Table 36 Commonly cultivated crops as source of bee flora

Spring	Summer	Autumn	Winter
Orange	Paddy	Paddy	Mustard
Pear	Maize	Vegetables	Buckwheat
Peach	Vegetable	Maize	Oak flower

Among the seasonally cultivated crops, the mustard has been considered as best flora by most of the farmers. Most farmers use to believe that the bees survive on any flowering plants and they have sufficient flora throughout the year. Thus they have never done the feeding, although the bees might have been starving during some of the seasons of the year.

Pest, disease, predator and other disorders.

The most common rodents that usually harbour nuisance to the bee industry ranges from the most docile hornet, wild bees to giant squirrels. The most problem is created by the hornet/wasp, (the *Bachung* in *Lhotshamkha*). The preventive method used is simply driving away manually with the help of physical measures. No other pest or diseases have been noted so far.

Hive and swarm management.

The management practice is quite simple and traditional. People have not yet adopted any new and advanced management system except, the hives are kept in a proper place and entrance kept open, ready for the bees to come & hive and driving away of the enemies whenever they come and attack. As

was voiced somewhere in the foregoing report, the commonly used hives are log and wall hive. They have never tried any other methods of hiving. The swarming is happened at any time during the lean winter months.

Future of bee keeping.

Bee farmers lack adequate knowledge and idea in the proper management of bee keeping. The full time bee farming will largely depend upon their technical capacity and resource availability including other on-farm activities and future market remuneration.

As suggested and endorsed by some of the progressive farmers, farmers training programs to update their knowledge with basic bee keeping system may be inevitable if a sustainable bee industry is to be complemented.

Problem/constraints

Migration and absconding
It is the major problem in most of the areas. According to most of the respondents it occurs mostly during the month of January and February.

Pest and predator

Sometimes the pest and predators like hornet and giant squirrels plays an un-profound menace particularly during late summer and onset of autumn season.

Insufficient flora during winter

One of the reasons of their migration and absconding during winter could be due to lack of sufficient flora in the area.

Lack of knowledge in beekeeping

No feeding has been done even during the dearth periods/winter. People have given least botheration on beekeeping due to lack of knowledge.

Lack of time due to busy in farming work

Some people could hardly have access to attend for the proper management of bee farming given the time frame in their scheduled agricultural farming work. Alternative attention is given only when the harvesting time has really approached.

Conclusion/comments

The occurrence of high absconding rate can be minimised by applying the following methods through research trials and practices.

- Improving the local hives using/providing frames and bars in the local log and wall hive itself with some modifications. This will help reduce the

damaging of broods while harvesting the honey. Damaging broods and its combs could be one of the biggest reasons how absconding is happened.
- Keeping reserved sufficient feed in the hive when harvesting.
- Providing the feed during dearth periods.
- Reducing the entrances and providing the insulations during the severe cold periods of the winter, as the existing log hive system possess the big entrance and there is high chance of entering the enemies including predisposing factors.
- Imparting the knowledge on modern advanced technologies on beekeeping and its management practices through short-term trainings.

Other alternative scopes

Apis mellifera, Ligustica, can also be introduced as a pilot venture. Under normal conditions this race does not abscond, so it is much easier compared to *Apis cerana*. This advantage combined with suitable hive system called movable frames allows extracting the honey without spoiling the combs.

This species can be introduced through research trials and under pilot program basis through the selection of farmers in the potential areas.

3.3 Breed and management research

3.3.1 Apiculture research at Bajo

The on-going agricultural farming system with particular attention to cash crop farming posses new challenges in improving and maintaining crop productivity. Of these challenges crop failure due to lack of pollination has emerged as one of the major concerns in the development of any agricultural related activities. This work has revealed that pollination failure could be due to number of reasons.
- Scarcity of insect pollinators
- Continuous increases in the cultivation of self-incompatible crop varieties
- Lack of an appropriate pollination ratio
- Climatic factors and alike
- The scarcity of natural insect pollinator

The use of the hive bees, *Apis cerena* and *Apis mellifera* has been observed as a possible low-cost and farmer friendly method of managing crop pollination. Besides the pollination, the bees have played a lot of vital roles in generating cash income resources through sale of honey and wax products. Several legendry beliefs do illustrate of being fulfilled the olden mighty rulers and kings by honey and their end products complemented as tax that were being used as medicines including social obligations.

The objectives are to demonstrate beekeeping for adaptability, survivability and productivity; demonstrate honey production on pilot scheme basis to enhance cash income for farmers; and enhance crop production through pollination, particularly in orchards.

An apiary with three *Apis mellifera* colonies brought from Bee keeping Association in Bumthang has been set up in the centre in July 2001 and is under observation. At the end of the first season (2001) a total of 10 Kg honey was harvested to study the production feasibility and to test the quality of honey produced at Bajo. The harvest was necessary to create the space for developing bees as they had very limited space that time of the season. The product was distributed among the staff of the centre to taste the quality of the product. Colony development has been very effective and fast. By the start of the season we have already added an additional super to increase the colony strength and is doing well. However, attack by Wasp/Hornet has been noted as the major problem especially during summer till early autumn. The attack normally took place in the late morning and evenings. Large numbers of working bees were killed last season. Manual protection was only the feasible alternative. During the late October to early November one colony was also affected by lice, however by mid January it disappeared itself. It was suspected due to cold winter temperature.

FORESTRY RESEARCH

4 FORESTRY

4.1 Introduction

Although the centre's forestry sector's main focus is into social forestry research, the sector gave emphasis and initiatives into the mainstream research, collaborative research and other activities. The centre assisted the study on fir/mixed conifer forest ecology carried out by RNRRC, Jakar focal centre for conifer research. Other ad-hoc activities such as collection of wood discs from Rimchu FMU for stem ring analysis were being carried out and will also continue in the next fiscal year. Most of the activities of the centre in the Llingmuteychu watershed under the community forestry projects are long term. Further the community forestry plantations have been assessed both visually by participatory approach and taking measurements for height and form development.

Research needs in farmer oriented research as identified by the Dzongkhag forestry sectors during the fourth regional RNR review and planning workshop were attempted.

For the purpose of this report the activities of the sector have been divided into three namely On-station, Lingmueteychu watershed, and Territorial forest management units.

4.2 Activities at the centre

Activities on-station is being continued as usual i.e. evaluation of multi-purpose tree species (MPTS), evaluation of propagation techniques in the nursery and bamboo rhizome multiplication. Initiatives were being taken to study the germination percentage of the Local Tsenden (*Cupressus corneyana)* by mid of the fiscal year 2001-2002. And also a provenience trial of *Thysonalena latifolia* (Tsakusha Dz.) was established in the nursery. Proven rhizomes will be ultimately promoted in the community forestry plantations.

4.2 Activities in the Watershed

The major activity of the forestry sector in the Lingmutey Chu watershed are inline with community based natural management (CBNRM) research which the Centre had initiated since 1997. Other activities are either directly related to community forestry or else makes use of the existing activities, for instance the multi-purpose tree species assessment trial is super-imposed on the community plantation.

Participatory visual assessment on the performance and survival of different plant species was conducted in mid October 2001.

4.2.1 Participatory Visual Assessment of Community Forest Plantation (PVACFP)

Participatory visual assessment of community forest plantation (PVACFP) were carried out in three years plantations (i.e. 1998-2000) of both the communities Omteykha and Matalumchu, by a multidisciplinary team viz. Extension program office, forestry research, BG-SRDP staff and the User Group in a two days program. The objective behind the exercise was mainly to assess the performance of different species through a participatory approach. This also aimed at exchanging the views and opinions of different stakeholders and feedback on the future improvements and directions.

Results & discussion

Omtekha

Participatory Visual Assessment of community forest plantation was conducted on 18th. October 2001 with the User groups, of Omteykha. During the assessment we found about nine species that are doing well out of a total of twenty-two planted species (Table 37).

Table 37 List of species planted in community forest site.

No	species	Local/Common Name
1	*Cupressus cashmerieana*	Tshenden/Cypress
2	*Robina psedoacacia*	Locust
3	*Melia azedarach*	Jashing
4	*Leucaena leucocephala*	Ipil Ipil
5	*Dodanea anguistifolia*	
6	*Quercus lanata*	Gumshing
7	*Albizzia procera*	Siris
8	*Leucaena diversifolia*	
9	*Quercus gluca*	Thomshing
10	*Castanopsis spp.*	Sokay
11	*Morus indica*	Sano kimbu
12	*Albizzia lebbeck*	Kalo siris
13	*Alnus nepalensis*	Gamashing/alder
14	*Poplar spp.*	
15	*Spondias axillaris*	Lapshe
16	*Ailanthus excelsa*	
17	*Acrocarpus fraxinifolious*	
18	*Quercus griffithii*	Sisi-shing/Oak
19	*Salix babylonica*	Changmashing
20	*Jatophus curcus*	
21	*Erythrina spp.*	
22	*Eriolobus indica*	Tongshing

Choice of species by gender

Looking at the performance of the species planted the User groups were asked to give their choice for future plantation. The women group of Omteykha community gave top priority to *Quercus species*. The reason cited for the choice of species was mainly for leaf litters and for fuel-wood. Timber species such as C*upressus spp.* (Tsenden) and *Schima wallichii* (Puyamshing) were given the secondary choice. Table 38 indicates the choice of species by women. On contrary men's group gave high priority to timber and hardwood species, which can be used as agriculture implements. Table 39 indicates the choice of species by men.

Table 38 Priority tree species for women

No	Species	Local/common name	Purpose	Priority
1	*Quercus griffithii*	Sisi	Fuel-wood /leaf litters	1
2	*Quercus lanata*	Gum	Fuel wood	1
3	*Quercus gluaca*	Thom	Fuel wood	1
4	*Cupressus spp.*	Tshenden	Timber	2
5	*Schima wallichii*	Puyam	Timber	2

Table 39 Priority tree species for men

No	Species	Local/common name	Purpose
1	*Cupressus spp.*	Cypress/tshenden	Construction timber
2	*Pinus roxburghii*	Chir pine/tongphu	Construction timber/fuel-wood
3	*Quercus griffithii*	Oak/sisi shing	Agriculture tools & implements
4	*Quercus lanata*	Oak/gum shing	Agriculture tools & implements
5	*Quercus gluaca*	Oak/thom shing	Agriculture tools & implements
6	*Juglans regia*	Walnut/tago shing	Construction timber
7	*Schima wallichii*	Puyam shing	Construction timber

The User group expressed that the species, which have high mortality rate (low survival %), low timber value need exclusion in future plantation. They have pointed out that the following species in Table 40 are not performing well in terms of growth and survivability.

Table 40 Tree species with poor good growth form and survival rate

No	Species	Remarks
1	*Melia azedarach*	Top dying (leading shoot) and ultimately whole plant dies up.
2	*Leucaena leucocephala*	Slow growth, mainly it is being browsed by deer
3	*Albizzia spp.*	Slow growth with low survival %
4	*Poplar*	Slow growth with low survival %

Community forest plantation assessment at Matalumchu

On 19th October 2001 the Team conducted the same exercise with the User groups, of Matalumchu. During the assessment the team found species in Table 41 doing well in such a site that is characterised by heavy degradation and barren soil through soil erosion.

Table 41 Tree species with good growth form and survival rate

No	Species	Common/local name	Remarks/observation
1	*Quercus griffithii*	Sisi-shing	Good growth with very low mortality rate
2	*Quercus lanata*	Gum	Good growth with very low mortality rate
3	*Quercus gluaca*	Thom	Good growth with very low mortality rate
4	*Cupressus spp.*	Tshenden	Good growth with very low mortality rate
5	*Albizzia procera*	Semchung-shing	Good growth with very low mortality rate
6	*Alnus nepalensis*	Gama-shing	Good growth with very low mortality rate
7	*Syzigium cumini*	Nyasishing	Good growth with very low mortality rate
8	*Euclyptus spp.*	-	Survival and growth rate is good
9	*Dodonea anguistifolis*	-	Degraded ground cover improved
10	*Sun-hemp*	-	Degraded ground cover improved
11	*Clotrolirsa*	-	Degraded ground cover improved

Picture Left Lemon grass planted on the barren soil doing well. **Right** *Quercus griffithii* shoots up its growth within three years

Picture Left *Alnus nepalensis* suits well in the waterlogged areas of the lower community. **Right** Sunhemp - a hardy leguminous shrub that can be used as hedge rows for rehabilitation of degraded sites.

Choice of species

Unlike the user group of Omteykha, both men and women of Matalumchu expressed that they prefer Chir pine plantations in future. This is because they have seen Chir pine trees benefiting within twenty to thirty years after planting. Also the Chir pine plantation is easy to maintain and take care compared to other species, as both domestic and wild animals do not easily destroy it. Further, accidental forest fire can not destroy the plantation due its fire hardiness. Chir pine was traditionally used as timber, fuel-wood and leaf litters for production of farmyard manure. However, they would still like to continue with different oak species and the C*upressus* spp.

Recommendation

It is felt important to different stakeholders involved in the community forest plantation establishment to source out seed tree stand as preferred by the communities as well as for those species that are proving to grow well in the plantation sites.

It was also felt necessary to educate and involve the community forestry user's group members in the entire process like on identification of seed stand as well as in the seed collection process to make the community forestry program sustainable and economically viable in future.
The totally degraded and rocky sites need to be replanted after identifying the appropriate species suitable in such kind of environment, preferably chir pine which may suit well.

Conclusion

In general most species are performing well given the very adverse site conditions. The growth and the survival rate are reasonably good for most species. Among as many as twenty-two species that are planted oak species, *Cupressus*, *Syzigium* and *Alnus species* are performing well while other grasses and leguminous shrubs species are also growing well in totally degraded sites.

4.2.2 Community Forestry Nursery

The Community Forestry Nursery (CFN) could produce sufficient seedling for 2001 plantation. Matalumchu community extended the plantation by four hectares in the FY 2001-2002, but unfortunately Omteykha could do the plantation because they were engaged in the Rural Water Supply Works during the plantation season. However, their seedlings were used in beat-up plantations latter.

4.2.3 Community Forest Assessment

As continuation to the height growth and survival assessment carried out in 2000 the sector had conducted the second year's assessment to compare the growth and survival rate over time. The results of the two years assessment are analysed.

The mean total heights of all the test species have increased significantly except for *Melia azadaracht.* Mean total height *Quercus griffithii* had increased from 24cm in 2000 to 50cm in 2001, however, mean total height of *Melia azadarach* had dropped from 45cm in 200 to 23cm in 2001. The drop in the mean total height of the *Melia* is due to the dying back of the leading shoot during the late winter and early spring seasons.On the other hand there isn't much significant decrease in the survival percentage except for *Melia*. The total survival percentage of 2000 was 94.5% and in 2001 we have 83.7 % survival. Survival percent of *Melia* decreased from 91.9% to 49.6% in 2001. Therefore we would say that *Melia* does not do well on such soil and climatic conditions, but this is not a concrete conclusion itself.

4.3 Activities in the Territorial FMUs

With the aim to diversify into mainline forestry, two forest management units (FMU) under the Wangdue territorial division (viz. Rimchu FMU and Khotokha

FMU) were identified as possible sites of research during the second national forestry coordination workshop at Taba, Thimphu.

4.3.1 Khotokha FMU

Although we reported on the Blue pine Stand Stability Trial in the Annual report 2000-2001. But it gave only the over view on the objectives, layout and site information. This report would include the status of what has been done so far.

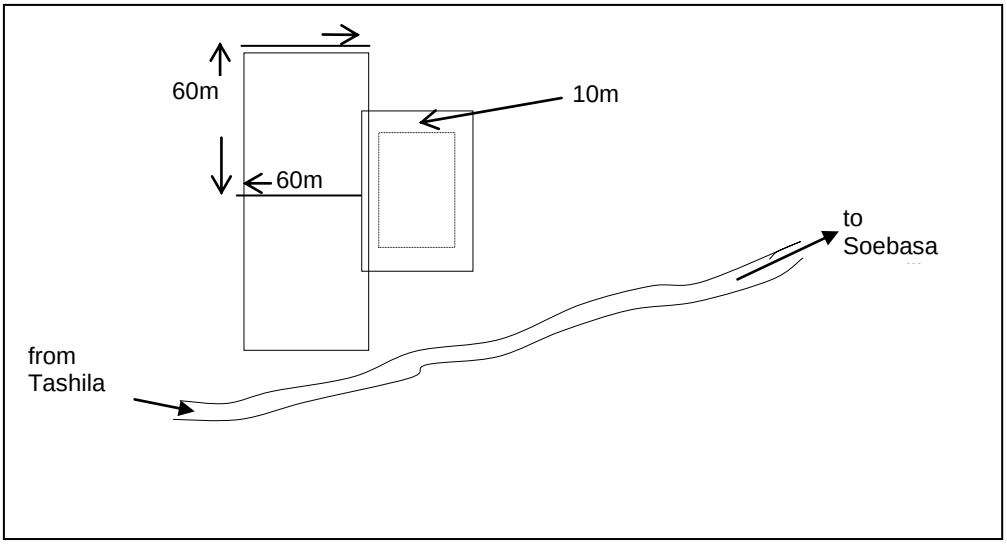
The Khotokha Forest Management Unit is situated in Bjena and Rubisa geogs of Wangdue Phodrang Dzongkhag. It covers an area of 9407 hectares and ranges from 2300m to 3785m in elevation. The dominant tree species in the FMU is Blue pine (*Pinus wallichaina*, A. B. Jackson) with only occasional oak (*Quercus semicarfolia*). Blue pine regenerated naturally here naad occupied the pastureland. Counting growth after felling at 45 cm above ground, the stand age was estimated to about 22 to 25 years. Tree growth is very good with an average stand height of 10 to 13 m. The forest stands are in some places very dense alternating with open areas with rose and *Barberis* bushes.

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).

Location and Site Description

The trail is located about 2-3 kilometers from Tashi La near the road leading to Soebasa sawmill at an altitude of 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. Figure 3 gives a rough sketch of the plot layout.

Figure 3 Diagrammatic representation of plot layout at Khotokha



Treatment and Design

Three permanent plots were established in the selected site. The size of the plots is 60 x 60 m (0.36ha) with an inner plot size of 40-x 40-m (0.16ha) and a buffer zone of 10 m around the plot. Plots were selected randomly for the three thinning treatments with varied thinning intensities as follows.

T1: Control; no thinning at all
T2: Moderate thinning; about 20.1% of the standing volume are to be removed.
T3: Heavy thinning; about 37.5 % of the standing volume are to be removed.

Actually the thinning intensities were hypothetically estimated to 25% and 35% for moderate and heavy thinning respectively, but the above mentioned percentages are obtained while implementing by following the criteria for thinning.

All trees above 10cm diameter in the inner plot were numbered and measured to calculate the standing volume before thinning, including the control plot to compare the changes in volume output with the treatment plots in the subsequent thinning. As an additional treatment the good oak trees were given space for development.

Thinning was carried out following the silvicultural aspects, which we did not only rely on the removal of weak and dead trees but also removed some elite trees looking at their social position, phenotype and genotype. In each plot with thinning treatments, we have selected 23 and 18 trees as “future trees” in plot 2 (moderate) and 3 (heavy) respectively, that was being done according to approximate estimate of 100 trees/ha (i.e. 16 to 20 trees per plot). Out of 41 trees which were left as future trees 20 trees were pruned (i.e. 10 trees in each treatment plot), leaving an approximate green crown length of 3-4m. Equal treatment was also given to the trees in the buffer area and some of the future trees were marked as well but these are not measured and numbered. In order not to get confused in the future numbering of the “future trees in the buffer area is deemed necessary though these trees won’t be assessed but will also be given the same treatment in the subsequent thinning.

Parameters recorded

The following variables will be measured for each tree before thinning:

- Tree number
- Tree species
- Diameter at breast height (dbh)
- Tree height
- Social position (phenotype and genotype)
- 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)
- Remarks (e.g. forest fires)

Trial duration

The trial is proposed to last for twenty-five years (2000 to 2025). The difference in the volume out put and the quality of stand will be measured every after two years, which means we would re-measure the trees in 2002. Depending upon the need of the stand in the treatment plots subsequent thinning will also be carried out for further improvement of the stand quality and growth vigor.

Trial establishment and Data Collection

Doley Tshering, Rinzin Dorji, Choley Namgyel and Ugyen Tshering carried out the trial establishment and initial measurements in November and December 2000. We got the technical assistance from Mr. Hansruedi Steirlin (Forestry research advisor) and Mr. Pema Wangda (ARO Forestry Yusipang). BG-SRDP (GTZ), Lobeysa also assisted us in terms of logistic support and manpower. We de-branched, debarked and removed all the thinned materials out of the plots to road head and handed them over to the territorial forestry personnel for further action. The stumps of the removed trees were debarked with the help of financial support from BG-SRDP, Lobeysa and this was carry out by Mr. Ugyen Tshering the unit in-charge. The data are compiled and stored in the computer for future comparison and reporting. Some of the preliminary results are as follows.

Preliminary Results

All the trees above 10cm dbh were measured/recorded and their volumes were calculated using local volume table. In the second round we marked future trees and the trees that were removed using ribbons of two different colors (yellow and red respectively). The tables below summarise our works and presents the results in hectare by extrapolating data from the plots (area of each plot is 0.16ha).

Table 42 No. of trees and volume per hectare before thinning

Plot No.	Treatment No.	No. of trees/ha before thinning	Volume/ha
1	Control (without thinning)	1063	97.2
2	Moderate (with 20% thinning)	1388	122.8
3	Heavy (with 37% thinning)	1106	103.3

Table 43 No of trees and total volume per hectare after thinning

Plot No.	Treatment No.	No. of trees/ha	Volume/ha	Actual no of trees/ha
1	Control	1063	97.2	170
2	Moderate	1056	98.1	169
3	Heavy	675	65.0	108

Table 44 Average dbh, height, volume and the total volume

Plot No.	No of trees/ plot	Avg. dbh (cm)	Avg. ht (m)	Avg. vol (cum)	Total Avg. vol (cum)
1	170	14.3	10.0	0.1	13.1
2	169	14.4	10.4	0.1	13.4
3	108	14.2	10.4	0.1	14.4

Table 45 Average dbh, height and volume of 10 future trees/plot

Plot No.	Avg. height (cm)	Avg. dbh (cm)	Avg Vol (cm)	Total Avg. Vol (cm)
2	12.0	15.4	0.1	19.1
3	12.2	15.5	0.1	20.1

Table 46 Average height, dbh and volume of pruned trees/plot

Plot No.	Avg. height	Avg. dbh	Avg Vol	Total Avg. Vol
2	11.5	15.6	0.1	19.6
3	12.2	15.2	0.1	19.4

Although it was mentioned in the protocol that the re-measurement will be done every after five years, but it is felt too long because the stand as estimated is 22-25 years and if we wait for five years, the subsequent would not have effect on the stand. Thus, we would assess the trial biannually and produce the comparative interim reports and recommend on the thinning regime.

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., and 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 Bhutan German Sustainable RNR Development Project, Lobeysa brought a consultant to study the regeneration dynamics of the broad leaf forest of Rimchu noting the acute research paucity. We have collected about 300 wood discs till date from the operated coupes and yet we would collect some more before the consultant arrives for the analysis.

A protocol on the establishment of permanent forest research area (PFRA) in Rimchu and Nahi was also developed by the same consultant and will also be implemented in the next fiscal year. The collaborators of the above research discussed on the implementation responsibilities.

Conclusion

The research program has been able to successfully monitor and continue with all on-going activities and conduct all planned activities. Besides the research program also collaborated with the CBNRM framework development team of the Department of Research and Development Services (DRDS) and conducted a bamboo and cane study as one of the required case studies.

SYSTEMS RESOURCE MANAGEMENT

5 SYSTEMS RESOURCE MANAGEMENT

5.1 Community Based Natural Resource Management(CBNRM)

5.1.1 On-farm Paddy Variety evaluation for Mid altitude

Two lines of mid altitude rice seeds were tested at Omteykha village. The lines were IR62467-B-R-B-F_8-1-B and IR63332-B-B-B-26-B. The average yield of IR62467-B-R-B-F_8-1-B was 4.15 t/ha and farmers feedback included: good tillering and grain formation, milling recovery of 50%. no broken rice, but threshing bit harder compared to IR64 and other improved white varieties. The other line was damaged by wild animals and data could not be gathered.

5.1.2 BUCAP Activities

Plant genetics and conservation activities were also conducted in the watershed in Thanju village in collaboration with National Bio-diversity Centre to conserve the diversity of rice plants genetics from genetic erosion. To this the following activities were done with the community:

5.1.3 Rice Plant Genetic Resources Baseline Survey

The objectives of this survey was: 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, 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 and to help farmers to identify their breeding and crop improvement objectives. A total of 15 farmers were gathered for the survey and with them using PRA tools like Time line for rice varieties cultivated in the area, Matrix ranking for farmers' criteria for selecting rice varieties and Matrix scoring for different rice varieties, information was gathered and documented.

5.1.4 Farmers Training on Rice seed selection

After the baseline survey, a farmers training on Rice seed selection was done to the same 15 farmers with the objectives 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 selection and storing for the next season and to involve farmers through all stages of BUCAP activities. During the training, the farmers were briefed on the Farmer Field School approach steps and also key points on rice seed selection as mentioned below were briefed to them.

- Importance of good seeds
- Ways and means of seed mixture and deterioration
- How good seeds should be?
- Ways to improve seed quality
- Steps involved in improving the seed quality

Also field practical on seed selection was done with the farmers on their field and seeds of four local varieties in the area were collected.

5.1.5 Demonstration Orchard

Monitoring the performance of the improved varieties of fruit plants in farmer field and which also serves as a demonstration plot was continued. This year an additional 5 number mango seedlings were planted adding up to total of 103 fruit plants of different sub-tropical varieties. Routine fertilisation and chemical spray was done. The varieties tested in the orchard are all performing well except few citrus plants (3 Oota pomkin, 1 Valancia, 1 Encore, 1 Okitsuwashi and 1 Itchefumi) which have retarded growth and needs replacement. The major problem this year was the damage of fruit plants especially apple and apricot by deer which have effected in the production potential of the fruit trees. Because of this problem, this year the apple trees have borne less fruit compared to last year. The data on this year harvest will be reflected in next year report.

5.1.6 Improvement of fruit plant back yard

During June 2000, based on the household categorisation few households from three categories were distributed improved citrus plants in order to improve the existing fruit plant back yard as well to see the management differences between different farmers' categories. Till date the fruit plants distributed are surviving well besides there is not much differences in management practices between farmers' categories. Further to strengthen the farmers' capacity in horticulture farmers training programs were conducted and some of the training conducted was:

5.1.7 Farmers Training on Fruits propagation

A 3-day farmers training was organised to six interested and innovative farmers (one farmer from each community) of the Lingmuteychhu Watershed on Fruit Plant Nursery Raising. The objective of this training was to transfer technologies to the farmers so that they could in future establish/produce their own planting materials, besides this will also help them to generate additional income. The training was conducted at Research centre with a short lecture and mostly field practical in the Horticulture research plot. The farmers were trained on the following topics: Orchard Management, Plant propagation, Rootstock seed extraction, Seed stratification and seed bed preparation, Seed sowing and transplanting, and Budding and grafting techniques.

5.1.8 Hands on Training on Pruning and Top-working

During March 2002, four-day hands-on training on pruning and top working for farmers was organised at Nabchhey, Dompola and Limbukha communities, where a total of 71 farmers participated in the training. There was equal participation from both genders. The training mainly focused on practical training to farmers on pruning of fruit plants, top-working including grafting and budding, handling of pruning and grafting tools and implements, simple

management of fruits backyard like manuring, basin preparation and irrigation. As per the feedback received during the training from the farmers, through the training the farmers hope do some basic pruning and top working, simple grafting activities in their fruit backyard. They would like to practice them during next season also so that they do not forget. Monitoring to this trained farmers group will be continued.

5.1.9 Model Kitchen garden

With the objectives to make vegetable available throughout the year and to improve the nutritional intake in the daily diet of the people in a farm household, home gardening was started since 2000 at Dompola. Further continued monitoring and technical support was provided to farmer collaborators in order to built up capacity and be sustainable in future.
Another similar model kitchen garden was replicated at Nabchhey during the month of August 2001, where free seeds and technical support were provided to collaborator farmer and trained practically for bed preparation, nursery preparation, transplanting etc., field day will be conducted later.

5.1.10 Observation trial of Potato weed control using Herbicide

In Lingmuteychhu Watershed, Potato cultivation in rice-based system is common in Limbukha community owing to suitable climate, soil and less attack by pests. The community here produces potato in commercial scale for cash earning. Among 32 households in Limbukha village, 14 farmers cultivate potato as their major cash crop. In an average, a farmer grows about a langdo or more potato per season. RNRRC, Bajo has been doing potato trials. After the series of on-farm potato trial, it was understood that weed was a major problem in potato at Limbukha. Due to shortage of farm labour, farmers conduct one hand weeding or none. But elsewhere in other potato growing areas like Phobjikha, the farmers practice weed control in potato by means of chemical (Herbicide) spraying. Therefore, an observation trial to control weeds in the potato by spraying herbicide (***Metribuzin***) was initiated by the on-farm sector in collaboration with the Horticulture (vegetable) sector during March 2002.

Three plots of 5 square meter each was selected in the farmer field, three different treatments were used consisting of different chemical strengths as mentioned below and a blanket spray was done when the potato was germinated and was about 10-12 cm in height. The herbicide spray was done on 29th March 2002.

Treatment 1	1gm of Metrobuzin per liter of water
Treatment 2	2gm of Metrobuzin per liter of water
Treatment 3	3gm of Metrobuzin per liter of water

From the three treatments tested, treatment 2 plot (2gm Metrobuzin per liter of water) showed significant effect on the weed control compared to plot 1 and plot 3. The chemical controlled all kinds of weed except the duck weed. The dominant weed in the potato field was *Fagopyrum spp*., which was controlled.

A farmers field day was then conducted where the farmers were shown the effect of weedicide in controlling potato weeds. Crop-cut was also done but there was not much differences in the yield. The farmers participants informed that although the weedicide is effective in controlling potato weeds but then since they practice rice-based potato production and transplant rice right after harvest of potato, they still need to look into the effect of weedicide on paddy production before accepting the application of weedicide.

5.1.11 Monitoring community managed breeding bull and Pasture

There is evidence that a lot of government supplied breeding bulls are not managed properly by the communities, whereby the bulls are transferred frequently within communities and do not have a proper permanent bull keeper. It leads to poor natural service performance by the breeding bull and at the end it is wastage of money and labour. But in Nabchhey community, after the placement of the bull in the community in the year 1999, unlike in other areas the farmers here formed a committee consisting of all 21 households and then had selected a volunteer permanent bull keeper. The committee has come up with an agreement that proper management of the bull and to work together for the welfare of the breeding bull, all households should help in construction of proper bull shed. The bull will be provided with a maintenance ration consisting of maize flour and a bottle of mustard oil per month on rotation basis, this practice is still followed and the community has a clear accountability. The committee have agreed upon to provide one man day labour from each households per year to the Bull Keeper and exempted from other *woolas* (labour contribution) as a compensation to him for the management of the bull.

The breeding bull is in good condition and has 9 progenies (2 female and 7 male) born till date. The committee has also discussed that for sustainability on a long run, they would like to render the breeding services to other neighbouring communities on payment where they will charge upon the progenies born.

Besides management of bull, the extended pasture is also growing well, there is a balance mixture of grasses and legumes. There is a need to demonstrate to the farmers on the fodder conservation techniques especially in preparing hay for feeding bull during winter.

5.1.12 Farm household categorisation of Dompola and Matalungchu villages

Out of a total of six villages in the Lingmutey chhu watershed, farm household categorisation exercise was conducted in four villages: Wanjokha, Omteykha, Nabchhey and Limbukha in the year 1999. The findings of the exercise were documented and the farm households of the villages were categorised based on the access to resources (‘resource endowments’). But then the farm households of the remaining two villages: Dompola and Matalungchu were not categorised during that time. Therefore, as recommended in the documentation it was useful to conduct the exercise in the remaining two

villages in order to obtain a complete understanding on the household wealth status in the Lingmuteychhu watershed. The objectives of the study were similar to the one conducted in the year 1999 to:

- Together with the village community members in the watershed, categorise farm households based on difference in access to resources ('resource endowments') and identify 'typical farms' or the 'range of resources' within each category.
- Identify locally reverent wealth indicators that allow for easy identification of household categories.
- To help access implications of socio-economic differences among households in terms of RNR-Rc Bajo's technology development work.
- To test further develop a wealth ranking method, for further application by RNR-RC Bajo and others in Bhutan.

Method

The exercise was conducted in two days time, in which the farmer group was asked to divide all the households in their villages, based on the resource endowments that influence farming. The farmers were given small cards with household name written on it to facilitate this task. The farmers were asked the reasons for the divisions and identify attributes, which distinguish each group. The farmers divided themselves into 3 groups. The attributes were noted and also a checklist of pre-identified wealth indicators was used to describe or quantify these indicators for each category in each village as done during earlier exercise. The method use was similar to the one done earlier. The farmers group was also asked about the 'social mobility' of the farm household between the categories and the reasons for the changes were also noted.

Results

The farmers from the both communities grouped into three different categories "Rab" "Ding" and "Tha". The factors the farmers used to divide the households at Dompola village were land holdings, food self-sufficiency, household labour and household relatives working in government firm or private enterprises whereas in Matalungchu village land size and food self-sufficiency were the two major factors. The data enable to compare the two villages for the food self-sufficiency and farm size.

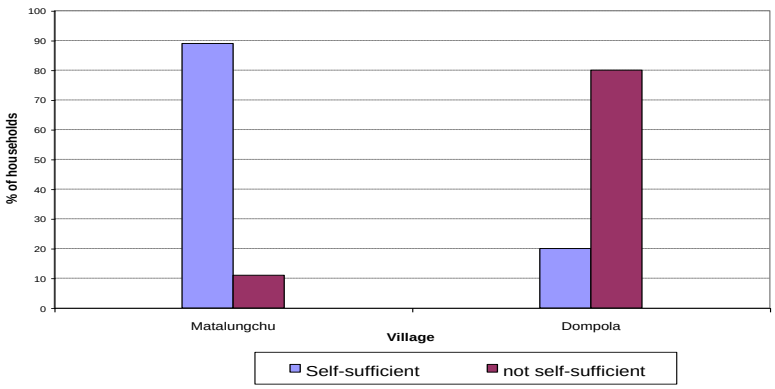


Figure 4 %age of household per vilage that are food self-sufficient

Food self-sufficiency level is high in Matalungchu, where 89% of household is self-sufficient in rice compared to Dompola where it is only 20%. 80% of Dompola households are food deficit for a period of 3-4 months during which they buy rice from the market through the sales proceeds of vegetables. Land holding also differs between villages and farmers categories. In Dompola village Category 1 farmers have an average of 5 acres land (range 2-8), whereas category 2 farmers have an average of 2.5 acres (range 2-3), category 3 households have a maximum of 2 acres, besides there are two household land-less in Dompola (average holding 1 acre). In Matalungchu category 1 farmers have a maximum of 11 acres land but on an average this category owns 6 acres of land whereby category 2 farmers have 3 acres land and the category 3 farmers owns 1 acre or less land (range 1-4 langdos). The amount of household labour availability is also different among categories, the richer category have more labour availability in the household than that of the poorer category.

Table 47 Household labour availability per category in Dompola and Matalungchu

Wealth category	Dompola	Matalungchu
Category 1	2-5	4
Category 2	2	2
Category 3	1-2	2

Ownership of cattle is not an important wealth indicator in these two communities since all the household rear cattle for FYM production. Ownership of machinery is an important wealth indicator and there is a considerable difference in the ownership of machinery between villages. In Dompola there are 6 power tillers available (5 in category 1 and 1 in category 2) where as in Matalungchu there are none. Rice mills are common in both the villages Dompola have 9 rice mills in total (5 in Category 1 and 4 in category 2), Matalungchu also has 11 rice mills (9 in category 1 and 2 in category 2). Pedal thresher is much common in Matalungchu than in Dompola, although almost all of the rich farmers in Dompola have pedal thresher still they prefer to do threshing with their hand since it is much easier, requiring less labour and time. In Matalungchu almost all the household have pedal thresher except one household of category 3.

Use of chemical fertilizer differs among farmer category in Dompola, where the category 1and 2 farmers apply it in their field where as the category 3 farmers could not afford to purchase it. In Matalungchu there is not much differences in application of chemical fertilizers between farmer category. Type and size of house is another wealth indicator for the people. In Matalungchu mostly category 1 and 2 household have three-storied house with CGI roofs whereas category 3 farmers have two-storied house and usually roofer with shingles. In Dompola also category 1 and 2 houses are CGI roofed house and they are bigger in size than the category 3 farmers where they have used shingles for roofing.

Conclusion and Recommendation

In conclusion through this exercise now we have a complete understanding of the farm household wealth status in different communities. Based on the categorisation we can now define and disseminate what kinds of activities can a household undertake depending upon the household capacity in terms of wealth, labour, land etc. Through this exercise, we can also design and recommend appropriate agriculture technologies for the poor farmers to increase their livelihood considering and taking care of their major constraints. Similar kind of exercises may also be replicated in other areas before planning and implementing activities, so as to understand the farmers capacity to undertake the activities.

5.2 Integrated Plant Nutrient System Research

The IPNS activities covered mostly the FFS approach on balance fertilizer application in Omteykha and soil conservation measures. During the year 2001 – 2002, simple changes were made in the FFS program with respect to the number of trial plots in the area. During the previous year, trials were established for each individual farmer on his/her field. This method of having trial on each participating farmer's field has some advantages as well as some disadvantages. The advantage of the method is that, the precision of an experiment increases with the increase in the number of replications in a area. Fields are never similar in their soil type and it is very important to cover all soil types to come out with a reliable fertiliser recommendation for the area. However the disadvantage is, it is very difficult to get all the crop cuts taken during the season given the existing manpower in the centre working on the same subject. And some times trials are harvested before the crop cut is done and one season's efforts and resources are wasted. So, given this justification, the number of trials in the area has decreased to one. During the last meeting for the first season, farmers selected a representative field as a common learning field for the program. However, there was no change in treatments and other related field operations.

5.2.1 FFS approach in the second season (2001)

Some of the steps of the first season were repeated like presentation of the objectives, principles and procedures of the approach, agreement on the length and frequency of school meetings and agreements on school start and end dates.

Second season – 1st meeting

1. Review of the previous season's activities and the out come
2. Identifying a common learning plot for the program
3. Agree on date for the trail establishment
4. Agree on dates for the subsequent meetings
5. Agree on the number of meeting for the season
6. Discuss on what is expected from the farmers during the following meetings
7. Summary of the day's progress and closure

Second season – 2nd meeting
1. Field visit, observations, data collection and farmer feed back on the trial
2. Presentation from the field owner on how he establish the trial, crop variety he planted and which one is which treatment
3. Soil nutrient cycling
4. Agree on the date for the next meeting
5. Identify topics to be covered during the next meeting
6. Summary of the day's progress and closure

Second season – 3rd meeting
1. Field practical – trial crop cut and yield assessment
2. Farmer feed back on the yield differences
3. Summary of the season's activities
4. Summary of the day's activities
5. Presentation of the farmers' opinion on what they want to test more in relation to soil Nutrient Management.

The yield data from the second season are presented in the table below.

Table 48 Crop cut result of 2001, 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%
S.E.D	0.35

5.2.2 5.2.2 Soil conservation

During the year not much activities have been conducted on soil conservation, the farmers in Nabchhey village have already adopted the maize trash line as a measure to control the soil run off during monsoon. The number of farmer applying this technology is still nine but these farmers would like to increase more trashline counters in their field. Besides developing trashline, other technologies like sowing and transplanting hedgerow, legumes and fodder plants were done to further stabilise the trashline.

5.3 Agricultural Economics

5.3.1 Economics of Winter Crop Production in Watershed

Areas cultivated to wheat and mustard crops are low in the Punakha-Wangdue valley as compared to rice. Their yields are also quite low mainly because of the limited inputs used. Nevertheless, wheat and mustard are considered the main winter crops in the valley and is grown by almost all the households. In addition potato is also grown by many farmers and is an important cash crop. A crop budgeting study of the selected winter crops was done in the Limutechu watershed. The objectives of this study are to:

- quantify such as labour and material inputs for growing the selected crops;
- determine costs of production of these crops;
- determine the profitability of growing these crops, by assessing their returns to land and labour and comparing these with available alternatives;
- test and further develop a method for assessing costs and returns of crops in larger areas with large sample sizes.

Farmer Selection

Wheat and Mustard: A total of twenty four farmers (six from each village) from Limukha, Dompala, Nabche and Wangjokha were selected for the these winter crop survey.

Potato: Limukha was the only village selected for the Potato survey as farmers in this village grow potato as a winter crop. Four farmers growing potato were selected for this survey.

Some households were taken from each of the different 'soil fertility management' categories that had been developed earlier. This was done to ensure a fair representation of the households in the study areas.

Data Collection

Data was collected through farmers' recall using interviews with selected individual farmers. Two separate interviews were conducted To minimise recall error, the data gathering was done through separate interviews conducted just after a particular set of activities was completed: one interview was done just after land preparation and planting was completed and one after harvesting. Their actual labour and other inputs, as well as outputs of growing the different crops from each of these fields were asked. Farmers were able to recall the amount of FYM applied in most cases. But where they cannot remember, they were asked about the person days used for FYM carrying to the fields and the number of rounds each labor could do in a day. This way the FYM quantities were estimated. Care was also taken in recording the field sizes. Farmer's field sizes in langdos or seed rate could not be relied on especially for a survey covering a small sample. For this reason actual field measurements were carried out using measuring tapes and compasses. Crop price data were taken from market surveys at the Wangdue Sunday market.

Results

The most important findings of the winter crop survey are presented in the following section. The figures below show proportions of total costs in wheat, mustard and potato production. For wheat and mustard, labour inputs was the main cost component while in potato it was the material inputs. Total labour days used for growing the crops are as follows:
Wheat: 122 labour days/ha (sd 82)
Mustard: 99 labour days/ha (sd 67)
Potato: 429 labour days/ha (sd 269)

Fig 5: Proportion of Total Wheat Production Costs, Limuteychu, 2001

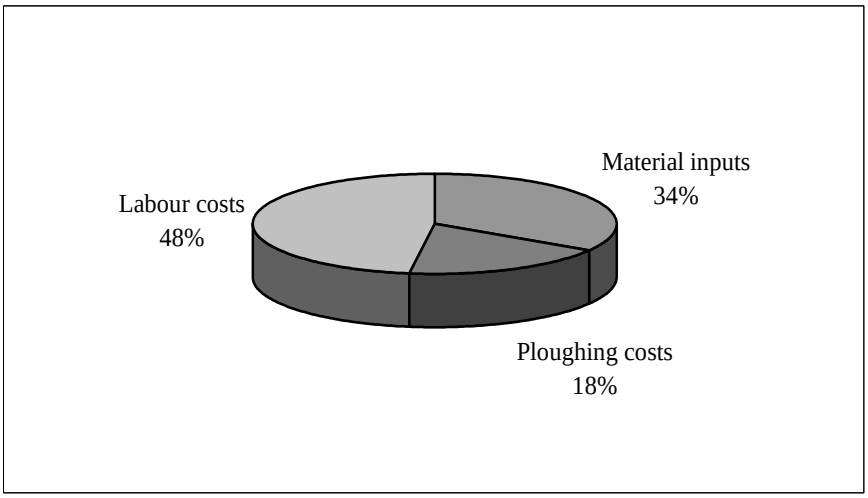


Fig 6: Proportion of Total Mustard Production Costs, Limuteychu, 2000-01

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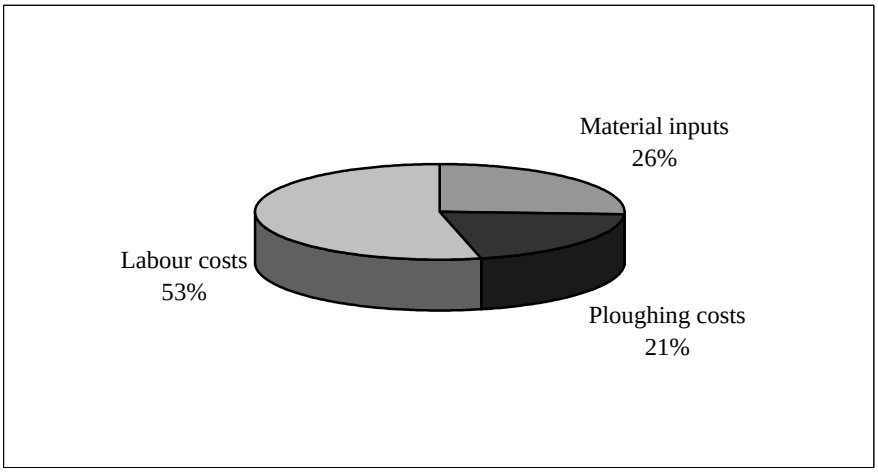
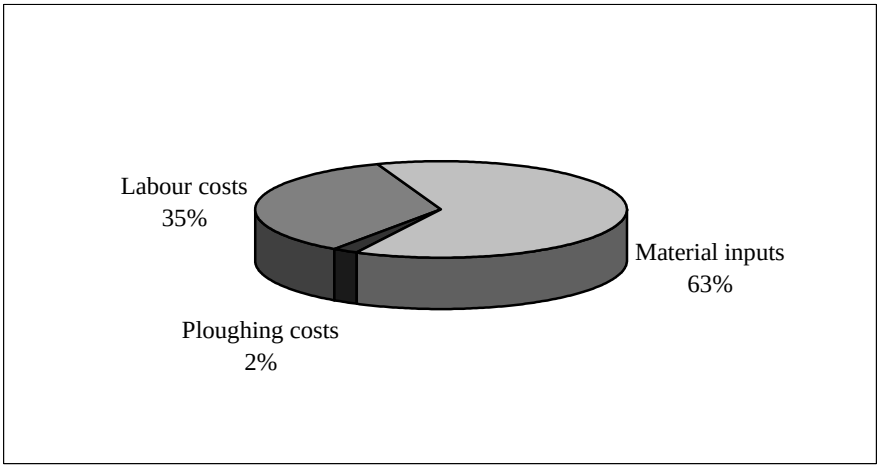


Fig 7: Proportion of Total Potato Production Costs, Limuteychu, 2000.



Yields, Production Costs and Returns

Wheat and mustard yields were quite low. Farmers pointed out that low yield was due to lack of irrigation water and damage of crops by animals (both wild and domestic animals). But as shown in table 49, use of low inputs could also be attributed for low yields.

Table 49: Winter Crops by Average Yields, Limuteychu Watershed, 2000-01

CROP YIELD	**CROP**		
	Wheat	**Mustard**	**Potato**
Average yield (kg/ha)	859	438	22659
Std deviation	*497*	*252*	*8275*

The average costs of production of the crops are given in the table below. Standard deviation for the wheat and mustard are bit high indicating high variability of the cost of production among farmers. The 95% confidence interval of the cost of production for the crops are also shown. For example 95% CI of wheat was 3.24. This means that there is 95% probability that the cost of wheat production in Limuteychu Watershed lies within the range of Nu. 20.28 minus 3.24 to Nu. 20.28 plus 3.24.

Table 50: Production Costs of Winter Crops, Limuteychu Watershed, 2000-01

COSTS (Nu/kg)	**CROP**		
	Wheat	**Mustard**	**Potato**
Production Costs	20.28	33.21	2.28
Std. Deviation	*6.82*	*19.04*	*0.48*
95% CI	*3.24*	*10.77*	*0.47*

Analysis to returns to land and returns to labour are useful parameters. Both are relevant for farmers in the area because both arable land and labour are scarce factors. Returns to land and Labour for wheat was –1147 and mustard, Nu. 7050 per hectare, showing very low (even negative for wheat) net returns to land. This low return was also reflected in net returns to labour. Both wheat and mustard showed negative returns to Labour of Nu. 68 and Nu 97 per day respectively. However, for potato the net returns to land Nu 72528/ha. Its net returns to labour was computed at Nu. 181/day which was above the prevailing wage rate. Standard deviation of net returns to land for potato was also high, indicating high variability among farmers growing potato in Limukha. The average return to labour is Nu.143 per day, which is above the prevailing wage rate. However, the returns to labour highly varied among farmers for wheat and mustard (s.d. = Nu 100 and 371/ labour-day).

Table 51: Net Returns from Winter Crops, Limuteychu Watershed, 2000-01

RETURNS	**CROP**		
	Wheat	**Mustard**	**Potato**
Net Returns to Land (Nu/ha)	-1147	7050	72528
Std deviation	*5293*	*9214*	*30096*
Net Returns to Labour (Nu/day)	-68	-97	181
Std deviation	*100*	*371*	*88*

Sensitivity Analysis

A sensitivity analysis was conducted to assess the effect of a change in some parameters on the outcome. These parameters are Labour costs, yield and opportunity costs of land. In the analysis conducted we have changed these parameters to determine what corresponding effects they have on the outcomes such as production costs, returns to land and labour.

Table 52: Sensitivity analysis showing costs of production and returns to land and labour for wheat production in Limuteychu watershed under different assumptions

5.3 Assumptions ↓	**Prod'n costs (Nu/kg)**	**% change**	**Net returns to land**	**% change**	**Net returns to labour**	**% change**
Actual (computed)→	20.28		-3633		-115	
Labour valued at 100% of hired cost	28.08	38%	-10132	179%	-115	0%
Labour valued at 50% of hired cost	16.38	-19%	-383	-89%	-93	-19%
Yield increased by 100%	11.74	-42%	6688	-284%	-79	-31%
Yield increased by 50%	14.74	-27%	1527	-142%	-132	15%
Opportunity cost of land increased by Nu 10000	20.28	0%	-3633	0%	-184	60%

Table 53: Sensitivity analysis showing cost of production and returns to land and labour for mustard production in Limuteychu watershed under different assumptions

Assumptions ↓	**Production costs**	**% change**	**Net returns to land**	**% change**	**Net returns to labour**	**% change**
Actual (computed)→	**33**		**1837**		**-307**	
Labour valued at 100% higher hired cost	50	52%	-3431	-287%	-307	0%
Labour valued at 50% of hired cost	25	-24%	4471	143%	-307	0%
Yield increased by 100%	17	-48%	16038	773%	-103	-66%
Yield increased by 50%	22	-33%	9493	417%	-202	-34%
Opp.cost of land increased by 10000	33	0%	1837	0%	-456	49%

Table 54: Sensitivity analysis showing cost of production and returns to land and labour in Limuteychu watershed under different assumptions

Assumptions ↓	**Prodn costs**	**% change**	**Net returns to land**	**% change**	**Net returns to labour**	**% change**
Actual (computed)→	2.28		72528		181	
Labour valued at 100% higher hired cost	3.1	36%	41226	-43%	175	-3%
Labour valued at 50% of hired cost	1.5	-34%	79224	9%	175	-3%
Yield increased by 100%	1.02	-55%	179855	148%	502	177%
Yield increased by 50%	1.35	-41%	123207	70%	339	87%
Opp.cost of land increased by 10000	2.03	-11%	66558	-8%	143	-21%

Conclusions and Recommendations

Wheat: The market price of wheat in 2000 was Nu. 16/kg and the average production costs of wheat in that year was found to be Nu. 20.28/kg. This shows that production of local wheat is not economical (a net difference of Nu.

–5.28/kg) in the study area. This was mainly due to low yield of the crop (859kg/ha or about 350kg/acre).

Mustard: The difference in farmers cost of mustard production and the price of mustard was very small. Cost of mustard production was calculated at Nu. 33.21/kg where as its market price was Nu. 36.5/kg (a net difference of Nu 3.00/kg. As mustard is not available for sale in grain form in the markets, price of market was taken from the extension diary 2002.

Potato: Comparing the cost of potato production to its prevailing market price it can be concluded that for Limukha farmers growing potato is very profitable. Potato requires high Labour and material inputs. Consequently, gross returns (outputs) were also equally high. One important finding of the winter crop study in Limukha was that potato generates greater net returns to farmers land and Labour than competing crops (like wheat and mustard)

In general low yields of wheat and mustard in the Limuteychu watershed suggests that there is considerable room for increasing yield at the farm level using currently available technologies. Crop management practices for wheat and mustard are seem to be lacking. There is also a need to improve the process by which improved wheat and mustard production technologies are transferred to farmers. For wheat sonalika variety was quite popular among farmers due to its higher yield but the adoption rate was not very impressive especially in the upland areas. A diagnostic survey would be required to understand the issues and constraints farmers are facing in wheat and mustard production.

Lastly, it must be noted given that the sample size is fairly small covering only four villages, the results from this study cannot be generalised for the farmers in the valley, particularly because there was high variability of the results among farmers. A more extensive study of this kind in the near future would be required to give a clearer and more conclusive picture of economics of winter crop production in the valley. Nevertheless, the results of this study are thought to provide some useful information and indications of the important issues

5.3.2 Rural household income and its distribution

Introduction

Rural development programs seek to uplift living standard of the households through improving their incomes. But unless the changes are quantified and monitored the success (or failure) of these development programs and policies cannot be assessed and evaluated. For example economic opportunities for the households in the Limuteychu villages were enhanced with the construction of the community road. The selection of this community as a watershed is also expected to greatly benefit the households in the area. But to actually measure the effects of development activities, it is essential to develop some basic economic indicators. Therefore, a Household Survey in the Limuteychhu Watershed was undertaken to determine households'

income level and distribution. It should be noted from the outset that this is not a household income survey in its strict sense because household comprehensive income surveys seemed to be beyond the scope of a Research Centre. With the limited resources and time availability it was thought that limiting the survey to collecting some new but basic income data would be the best option.

The main objective of the study is to provide data on household income and distribution, and sources of income. Such data are potentially useful to the Research Centre because they help the bio-physical researchers to focus crop research priorities and assess implications of new technologies. Moreover, as Limuteychu (the study area) is the watershed, number of on-farm research activities are underway, it is important to understand the income distribution and sources of income for the different household categories.

Methodology

The key source of income for the farmers is agricultural activity. That is why the emphasis of the survey is on agricultural production (includes livestock). There are also off-farm income, such as wages, remittances other services. It is noted that as many are subsistence and semi-subsistence farmers mainly engaged in meeting basis needs, farm incomes can be best measured from total farm consumption and from the sale of products and services (MoA, 1993). With this in mind we have attempted to determine the household income survey in the study area. The data collected were entered in spreadsheet (Excel). Analysis was done using some simple statistical tools such as summations, means and percentages.

Data set

The data for this study were collected from 41 households in the Limuteychu watershed which constitute 25 percent of the total of about 165 households in the study area. These households were selected using stratified simple random sampling. A wealth ranking exercise conducted earlier by the Centre identified households into separate wealth ranking categories. Based on the households wealth rank proportionate numbers of households were selected from each category. There were 15 households each from Category 1 and Category 2, and 11 households from Category 3. The survey covered all the six villages in the Limuteychu, namely Wangjokha, Matalumchu, Omtekha, Dompala, Nabche and Limukha.

Two Research Assistants from the Research Centre conducted the interviews. They visited the selected households and collected data using structured questionnaires. The data collection was completed in a month’s time, ie. from February-March 2002.

Landholdings

Before going to the main discussion on household incomes it is worthwhile to discuss about landholdings per household in different categories. Because land being an important factor of production, income level of household may depend largely on it. The figures below show the average wetland and dryland holdings of the households in different categories. The figures confirm that both wetland and dryland holdings follow the wealth categories of the households. Average wetland holding per household in Category 1, Category 2 and Category 3 were 3.8, 2.5 and 0.6 acres respectively. Wetland holding here refers to own land operated and those shared-out to others. As for dryland holdings average household in category 1 owns 1.2 acres, category 2 has 0.6 acres and 0.9 acres for average category 3 households.

Figure 8: Average wetland holding by category, Limuteychu watershed, 2002

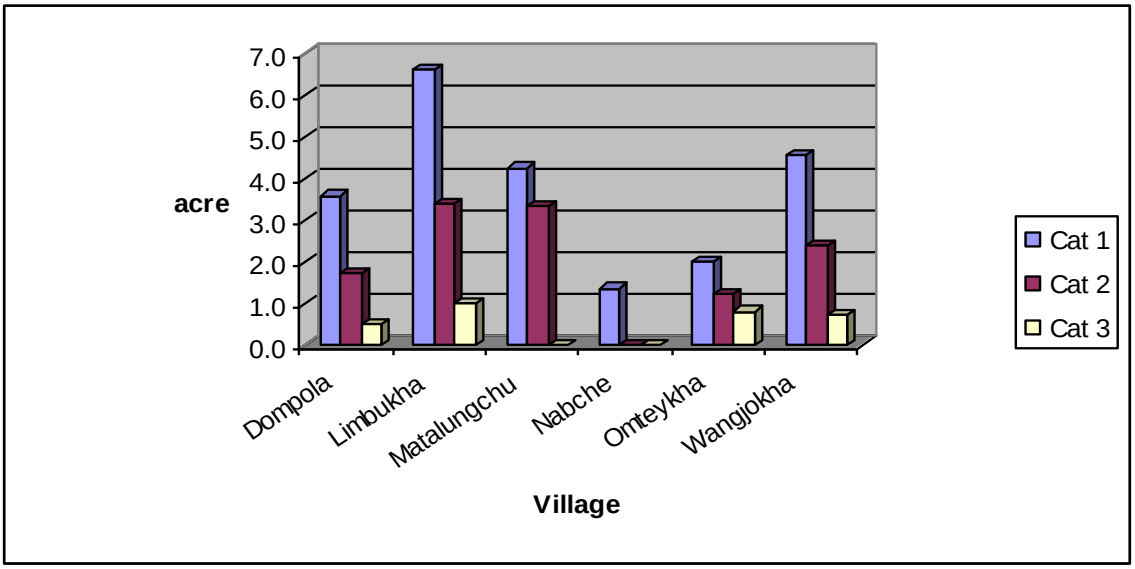
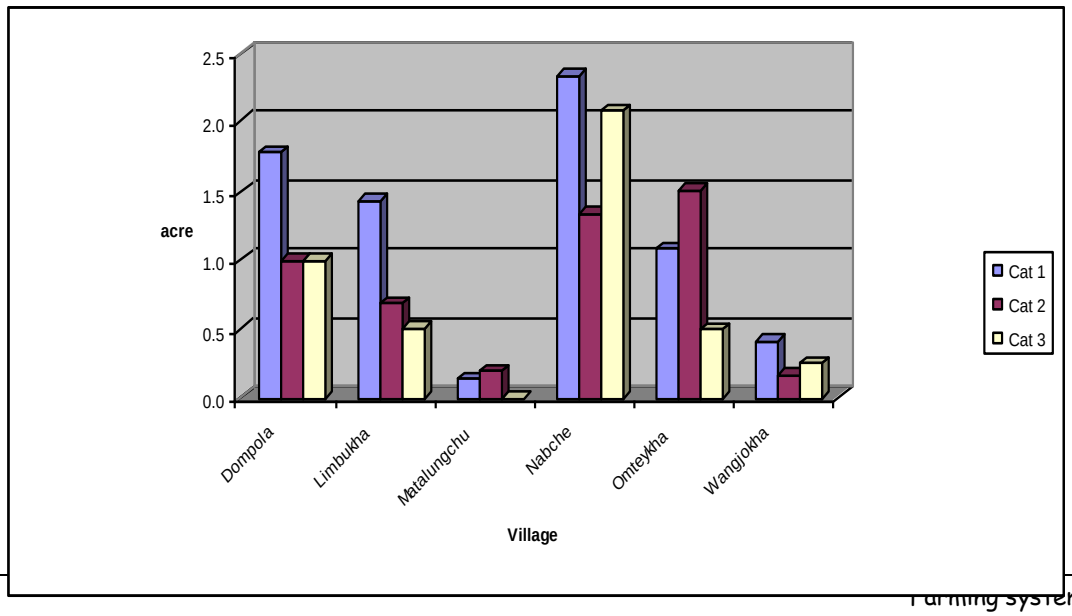


Figure 9: Average dryland holding by category, Limuteychu watershed, 2002



Land ownership/tenancy

Wetland

Category 3 farmers heavily depend on the wetland shared-in from households belonging to higher categories. Of the total 2.2 acres that average category 3 households cultivate 77 per cent of it is shared-in from other households. Only 23 per cent of the wetland the average category 3 farmers cultivate is their own land. Evidently wetland shared-out from these households was nil. On the other hand average wetland shared-out by category 1 households was about 33 per cent of their total wetland. Table 55 below gives a summary of the average wetland per household by ownership and tenancy.

Table 55: Average wetland per household by ownership/tenancy

CATEGORY	AVERAGE WETLAND PER HOUSEHOLD (ACRES)			
	Own Land Operated	Land Shared -out	Land Shared-in	Own Land Left Fallow
1	2.4	1.2	0.1	0.3
2	1.7	0.6	0.5	0.2
3	0.5	0.0	1.7	0.1
ALL CATEGORY	1.6	0.6	0.1	0.2

Dryland

Average dryland holding based on ownership/tenancy and belonging to different category households is presented in Table 56. From this table it can be concluded that dryland is distributed more equally among the categories. But this also indicates that poorer households depend on drylands since they do not own enough wetlands. The results clearly shows that households in any category do not share-in or share-out any drylands. Perhaps there is not much need for additional dryland, since households do not grow commercial crops on a large scale.

Table 56: Average dryland per household by ownership/tenancy and by category, Limuteychu watershed, 2002.

CATEGORY	AVERAGE DRYLAND PER HOUSEHOLD (ACRES)			
	Own Land Operated	Land Shared -out	Land Shared-in	Own Land Left Fallow
1	0.9	0.0	0.0	0.3
2	0.5	0.0	0.0	0.1
3	0.9	0.0	0.0	0.1
All CATEGORY	0.7	0.0	0.0	0.2

5.3.3 Livestock

Summary data on the mean number of animals owned by households in each category are presented in Table 57. Four types of animal dominate: cattle, horses, pigs and chickens. Number of cattle and horses seem to be related to

a households wealth rank, wealthier the household, higher the number of cattle and horses. But this does not hold true for pigs and chickens. As not much investment is required to buy these animals, households in the lower wealth rank category keep these animals to augment their income.

Table 57: Distribution of animals among households by category

Household category	Average number of animals per household			
	Cattle	Horses	Pigs	Chickens
1	8.6	2.1	0.8	1.9
2	6.9	1.7	2.1	1.7
3	3.5	1.1	1.2	2.3
All category	4.75	1.23	1.03	1.48

Household Income

Income sources

The five sources of income include the following kinds of income:

1. *Crop income* includes gross income from all crop production. Crop is broken down into field crops (ceraels), vegetables and fruits.
2. *Livestock income* includes returns from sale of live animals sold (cattle, horses and pigs), meats and dairy products.
3. *Transfer income* includes mainly internal remittances from family members/relatives.
4. *Rental* income includes rents received from ownership of farm machinery (power tillers, pedal threshers, rice mills etc)
5. *Non-farm income* includes wage earnings from non-farm labour plus incomes from non farm enterprises.

The computation of these was done in a straightforward way. It just calculated the gross incomes. This means that no input costs data collection was done and therefore does not show net income. In the surveys, detailed questions were asked on area cultivated, production, and quantity sold cash/kind received. Market prices were used for crops sold as well as those that were used for home consumption.

Income from different sources

Summary data for the five income sources show the importance of crop and livestock income to the households (Table 58). On the average, crop and livestock together account for about 64 per cent of the total household income. Distinguishing these two sources of income reveal crop is the most important sources of income for the category 1 and 2 farmers while livestock is the most important source of income for the category 3 farmers. This explains the fact that the land holding (wetland) is unequally distributed in favour of the rich farmers. This resulted to lower income from crop to the poor farmers and confirms the argument that unequal land ownership represents a key determinant of rural income inequality.

After crops and livestock, transfer income is important for all categories. Transfer income comes from remittances. These remittances are received by the households from their family members or relatives working outside of their communities, either in government or private sectors. Remittances account for about 1/5 or 20 per cent of the total income.

Non farm sector provides an important source of income for the households. Non-farm income is divided into earnings from non-farm Labour plus income from non farm enterprises. Such enterprises comprise of shops that were usually owned by the rich households. Then there are wages earned by households especially category three farmers. Surprisingly these incomes from wages and services also constitute significant proportion of the total income. Perhaps this is due to the fact that the study site is located near the urban centre where the high demand for manual Labour is high. Farmers reported using their Labour in logging and contract business for wages during months when Labour requirements on the farm is less.

Lastly rental income share to total household income is the lowest. Rental income here refers to farm machinery such as power tillers, pedal threshers and maize crashers. Data shows that rental income to category three farmers is nil and negligible (1 per cent of the total income). For category 1 households also, rental incomes comprise only 4 per cent of the income. Whatever, the result of the rental income analysis showed that all farm machinery in the study areas owned by the rich farmers.

Table 58: Summary of income data by income source

Source of income	Income per household from each source (Nu)		
	Category 1	Category 2	Category 3
Crops	26278	24592	9139
Livestock	15121	18973	10210
Rent and interest	2726	687	0
Non farm income	11033	2730	6818
Remittance	12633	11300	8591
All sources	67892	58282	34758

Cash Income

Household income, as already defined is the total value of total farm consumption and the sale of products and services. The report dealt with household income in the earlier section. Now in the following section we have attempted to analyse the later separately in order to understand the cash income of the households. The tables below show in detail the cash incomes to the households from different sources. Crops (rice) is by far the largest source of cash income for the category 1 and category 2 households (43% each of total cash income). On the other hand, remittances followed by livestock gives highest proportions of cash income to the category 3 households (33% and 23% respectively). Remittance also constitutes second most important source of cash income to category 1 and category 2 farmers.

Table 59: Cash income of different household categories by sources of income, Limuteychu watershed, 2001-02

SOURCES	HOUSEHOLD CATEGORY						ALL CATEGORIES	
	Category 1		Category 2		Category 3			
	Sale value	% of total sale value	Sale value	% of total sale value	Sale value	% of total sale value	Sale value	% of total sale value
Crops	20903.8	42%	15958.7	45%	5059.4	19%	13973	35%
Livestock	2627	5%	4712	13%	5961	23%	4433	14%
Non-farm (Services and wages)	11133	22%	2730	8%	6818	26%	6893	19%
Rental (Rent and interest)	2726	5%	687	2%	0	0%	1137	2%
Remittance (transfer income)	12633	25%	11300	32%	8591	33%	10841	30%
ALL SOURCES	50023	100%	35387	100%	26430	100%	37278	100%

CONCLUSIONS

The report shows that the incomes (both gross and cash income) among the households of different wealth categories are not so wide. Except for crop, income from other sources is fairly distributed. The households that falls into the poorest category have low wetland holding. For this reason income accrued to those households from crop production, especially rice is quite low. Their cash income from rice sale is also comparatively low. Increasing land productivity through improved agricultural inputs of the category 3 households will boost their agricultural income.

However, income from livestock seems to benefit the poor households greatly as it (livestock) is an important source of income for the poor. The poor households depend so much on local cows while the rich households keep some cross breed cows and mithuns. Therefore, the dependence of poor on source of income such as livestock must be recognised. Upgrading the productivity of the local cows through cross-breeding schemes and veterinary programs must be given greater attention.

Lastly, remittance is an important source of income for the households in all categories. Internal remittance that these households receive from their family members and relatives working outside of their communities is quite important and also does not vary much among the households. This suggests that urban dwellers have much of their roots in agriculture and therefore continues to support their folks in the rural areas.

5.3.4 Cost of Ginger Production in Daga-Uma

Introduction

As part of its promotional program the Dzongkhag Agriculture Office had given150 kg of free ginger rhizome seeds to each of the selected thirteen farmers from Uma village under Daga geog of Wangdue Dzongkhag in 2001. As a result, the farmers had a bumper harvest – reportedly 12 MT of ginger. Ginger production therefore, can provide an important boost to farm income and intensification of land use in the area. But considering that ginger is a cash crop for these farmers the marketing aspect is a concern. There are already indications of serious marketing constraints and inefficiencies that hamper further development of this marketing system. The farmers growing ginger from this area complain of having lack of demand from the local wholesalers/retailers. The reason according to the District Agriculture Officer, Wangdue is that price farmers' set for their produce (ginger) is quite high and therefore cannot compete with cheap imports from India.

In view of this, a team comprising of officials from the Dzongkhag Agriculture Office and RC-Bajo held a meeting with the 13 farmers on January 7, 2002 at Kamichu. A group interview with the farmers was conducted by the RC Bajo Agricultural Economics Sector. Farmers were asked about yields obtained and cost incurred from growing the crop**.** Simple economic analysis was done to compute the cost of producing ginger in the area.

Findings

Ginger yields and Production Costs

1. Ginger Yields: Average yield of ginger production was 950 kg per langdo or 2803 kg/acre.

2. Costs: The following information was gathered to compute the costs:
   - Inputs used to grow the crop
   - Quantity of each input
   - Price of each input

Costs fall in two categories - labour cost and material costs.

Labour Cost

Farmers used only household Labour for ginger production. The opportunity cost of household Labour was valued at 75 percent of hired Labour cost. As cost of hiring Labour is Nu. 60 cash per day plus cost of foods and refreshments (Nu. 40), hired Labour cost is therefore Nu. 100 per day. Hence, the opportunity cost of household Labour is Nu. 75 per day.

Table 60: Labour cost computation for ginger production, Daga-Uma, 2001

Sl. No.	Activity	Person-days	Rate (Nu/day)	Amount
1	Ploughing & Digging	1	75.00	75.00
2	FYM transport and spreading	3	75.00	225.00
3	Planting	7	75.00	525.00
4	Fencing	3	75.00	225.00
5	Bund making	5	75.00	375.00
6	Irrigation	2	75.00	150.00
7	Weeding	8	75.00	600.00
8	Harvesting	5	75.00	375.00
	Total	**34**	**75.00**	**2550.00**

Material Cost

Table 2 shows the material inputs used and the costs incurred. Although farmers got their seeds for free, it was included in the material costs since. This is because in the coming years they will be either using their own seeds or may even have to buy it. FYM, valued at Nu 0.50/kg is from a research report on the Economics of FYM production, Limuteychu Watershed.

Table 61: Material inputs costs computation for ginger production, Daga-Uma, 2001

Sl.No	Materials	Quantity	Unit	Price/ Unit	Cost
1	Seed	150	kg	45.00	6750.00
2	FYM	1200	Kg	0.50	600.00
3	Suphula	25	kg	9.00	225.00
4	Oxen plough	0.5	day	300.00	150.00
5	PP Chemical	100	ml		85.00
	Total				**7810.00**

Cost of Production

Adding the Labour inputs costs and material inputs costs gives the total cost of production, which was Nu. 10,360 per langdo or Nu. 31394 per acre. Therefore, average cost of ginger production (Nu/kg) per kg was calculated as: Ginger production cost (Nu./kg) = total cost of production(Nu/acre)/Qty of ginger produced(kg/acre), which is Nu. 31393.94/2803 = Nu. 11.20/kg

Cost of Marketing

Marketing cost was also computed. Here, costs mainly consist of Labour charge and vehicle fee for transportation. Labour is needed for carrying the produce from farm to the road head from where it is transported to the market in vehicle. Marketing cost was therefore, estimated at Nu. 3.94/ kg.

Conclusion and Recommendation

The farmers presently sell their product at the rate of Nu 30-40 per kg in the market. As shown above we found that their cost of production was Nu. 11.20 and marketing cost was Nu. 3.95. In total it cost a farmer about Nu 15.00 to produce a kg of ginger and bring it to the market to sell. Looking at the difference between the production cost plus marketing cost and the farmers selling price, it may be assumed that for these farmers ginger is a profitable crop. However, such an assumption can hold true if farmers could dispose all their marketable ginger at their present selling price. But considering that there are cheap gingers coming from India, farmers must be price competitive to be able to get enough demand for their produce (ginger). Hence, the farmers groups were informed on their actual cost of ginger production and marketing. It was also recommended to adjust their selling price accordingly. Even few post harvest methods to preserve the rhizome for longer period was

briefed to the farmers group so that they can market their ginger during off-seasons and fetch good price.

Also, discussions and information were gathered from vegetable retailers in Wangdue market to find out the possibilities for marketing the ginger in the local market at a reasonable price of Nu. 20 per kg. But it was understood that since the local vendors bring the goods from India in a smaller quantity of approximately 10 kgs per week at the cheaper price of Nu. 8-15 per kg and always keep the fixed market price of Nu. 35-40 per kg during this peak season, this is because to avoid the fluctuation of the ginger price from the supplier and also to adjust the loss from drying and rotting. Besides, the retailer here are not able to purchase ginger in bulk and store here although they have the post harvest and storing ideas but they lack facilities to store the products in their godown.

As a result, the District Agriculture Officer has discussed with the Druk Seed Corporation, and they have agreed to purchase all the ginger products at a fixed price of Nu. 20 per kg for this year from the road head. Therefore, in future to market the products, a pre hand market survey is foreseen, the Dzongkhag Agriculture sector in consultation with the Agriculture Marketing Unit of Ministry of Agriculture should lead in the exercise.

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 [8FYP] with a support SNV. WMRP has originated from the need felt within the Ministry of Agriculture for an integrated sustained national research effort to study the relations between water management practices, soil and crop water production. As a result WMR policy objectives stemmed from the then called Irrigation Section's and Renewable Natural Resources [RNR] Research overall policy framework for the 8FYP. The main objectives were to raise the productivity of existing rice-based irrigation schemes through improvements in water delivery. To increase rural incomes by diversifying the range of irrigated crops on wetland as well as on dry land and rationalise the irrigation assistance program with a view to increase the role of water users and the private sector and to reduce recurrent government investments in irrigation schemes. Most of the initial On-farm activities were implemented in Lingmuteychu Watershed in conjunction with CBNRM Project activities. By 2000 SNV withdraw its support and WMR was institutionalised as part of the research system under DRDS.

The report attempts to highlight the WMR activities in Lingmuteychu Watershed for 2001-2002 financial year only. Activities are at various stages like some are being continued from previous years, some are new activities initiated during the year and some completed during the year. Those activities that are completed before 2001 July will not be featured in this report.

5.4.1 Traditional Sharing System and the Changes

A comprehensive information on traditional water sharing, distribution and management practices in water dominated resource management system from Lingmuteychhu Watershed has been documented in the past annual reports of RC Bajo. However, the sharing system under Dompola Irrigation Scheme has always been dynamic and sharing system changes from year to year.

Dompola Irrigation Scheme was built by the farmers in the distance past. It is about 5 km long and its intake lies in the middle of the Limbukha Paddy Field. Its has a maximum conveyance capacity of 80 lit/s benefits about 25 farmers. The channel irrigates about 160 langdos (16 ha or 40 acres) of wetland. Dompola community received government assistance for irrigation channel renovation in 1999 where in some sections of the channel was lined to control seepage and drop structures were constructed wherever required. The renovation was done in the main channels only.

Before the renovation water users were divided into *Thruelpa*, *Chhep* and *Chatho* with one household receiving the full share, 5 households receiving half the share and 10 household receiving the quarter share. But the existing traditional system of sharing was changed after the renovation. The new sharing system was based on landholding size and accordingly rotation period were reduced from five days to four days by forming four groups of farmers [6,5,10 &8]. Each group has 40 langdos of wetland. Within a group water is shared based on the size of landholding on rotation basis. Accordingly labour contribution for renovation and maintenance work is also based on landholding size. However, the main disadvantage of this system of sharing was that the farmer with less land gets his next round of share only about one to two weeks later. Therefore, farmers with less land wanted to revert back to old system of sharing and the case was put up in their Dzonkhag Court in 2001 rice season.

As the intake of Dompola irrigation channel lies in the middle of the Limbukha paddy field, Limbukha farmers release water only after the 10th Day of the 5th Bhutanese Month as per their agreement in the past. Starting from this 50% of the flow in the stream is diverted into the Dompola Irrigation Channel, but Limbukha farmers still use this 50% of the flow to irrigation the fields below this channel. However, by this time about 90% of the paddy transplantation in Limbukha is completed, while Dompola farmers start to gets their first share of their water. This delays their transplanting season resulting in decline of paddy yield.

5.4.2 Gully Erosion Control

In a hill irrigation system with difficult terrain, most of the distributory irrigation channels or laterals run down the slope. In such scenario there is a high risk for soil erosion, landslides and gully formation especially in areas where the soil is loose and sandy. This situation has been further aggravated by absence of any form of drop structures be it framer or government constructed

irrigation schemes. Generally in the past main channels has been the only area that has been technically designed and the major investment has been made. A little thought has been given to distributory channels, yet it poses greater challenge towards the sustainability of the system. Land degradation due to soil erosion, slides and gully formation as a result of distributory channels will undermine the livelihoods of farming communities in areas where the soil is not stable.

Gully formation has affected the farmers benefiting from Dompola Irrigation Scheme the most compared to other schemes in the watershed. Gully formation has both short and long term affect to the farmers. It affects in the following ways:-

- Lost land to gully formation as the gully size increases over the time
- Sediments get deposited on part of the channel where the bed slope is low and fills it and water starts to overflow. This cause soil erosion and land slides down the slope.
- The sediments have to be removed before the water is applied to the field. Sediments not only reduce the yield of the crop but also reduce the water retaining capacity of the bunds.
- When a filed is irrigate at least one person has to be employed to remove sediments from the channel where the bed slope is low and the sedimentation tanks constructed before the water is diverted to the field.

Topography of the command area, soil type, kind of irrigation infrastructure and design features of the irrigation scheme are the main factors, which lead to the formation of gullies. The above factors are very apparent in case of Dompola Irrigation Scheme, as it has very difficult terrain where most of the distributory canals run down the slope and the soil is loose. Drop structures are absent in all the distributory canals. As a result there are gullies wherever there is drop in the canal mainly alone the distributory canals. Although the most of the gullies are stabilised over the time due to natural vegetative regeneration few remains active and growing in size that need human intervention.

Objectives

Gully formation results in many adverse effects, which ultimately affects the livelihood of the farmers. To minimise such affects the vegetative stabilisation were done with following objective:-

- To minimise/control soil erosion due distributory irrigation channel running down the slope
- To minimise land degradation due to gully formation and deposition of sediments in the rice fields down stream of the gully.
- To demonstrate, create awareness and built the capacity of farmers to carry out the vegetative stabilisation.

Materials & Technical Support

Punakha Dzongkhag and Research Centre Bajo supported both material and technical support for the gully stabilisation works as specified in the following table.

Table 62 Material and technical support provided

Institution	Shachamo Gullies :G1&G2	Kuneyzingkha Gully:G3
Punakha Dzongkhag		Technical support Material support ▪ Cement
Research Centre: Bajo	Technical support Materials Support ▪ Napier [*Pennisetum purpureum*] ▪ Vetiver ▪ 80m used old PVC pipes	Technical support Materials Support ▪ Napier [*Pennisetum purpureum*] ▪ Vetiver
Community	Local Materials for Live Post ▪ Chhatsheshing [*Erythrina indica*] ▪ Langmashing	

Methodology

Vegetative stabilisation of gullies was done in three sites, which were selected by the farmers based on severity of the problem and its impact to them. Community participation, making use of local materials wherever possible and blinding of indigenous know-how with the modern technology are the major features of the methodology adopted during the process of gully stabilisation works.

Community Participation – Social Capacity Building

The farmers made free labour contributions for all stabilisation works while RC Bajo and Punakha Dzongkhag provided the technical and material support. Besides labour contribution farmers were also made aware of the importance of community participation in solving such kind of problems, different techniques of gully stabilisation works and it both short and long term benefits. Indigenous knowledge and local resource base were given the first preferences in mitigating their problems.

Types of Gully Stabilisation Methods

Depending on the type of gully, soil and technical support/input provided, two different stabilisation works were adopted namely lined bed and pipe-check dam methods.

1. *Lined Bed Method*: In this method the gully bed was lined with cement so that the further deepening and widening of gully will be minimised. The

slopes of the sidewalls were reduced before lining the bed. This was done to avoid collapsing in future and to allow the vegetation to regenerate.

2. *Pipe-Check Dam Method*: In this case pipes were use to initially stop scouring of bed and steps of check dams were built out of live post that were locally available. By the time the life span of the pipe is over a network of root system will be formed to hold the soil particle together thus minimising the soil loss. The soils cut from sidewalls were use to fill the check dams.

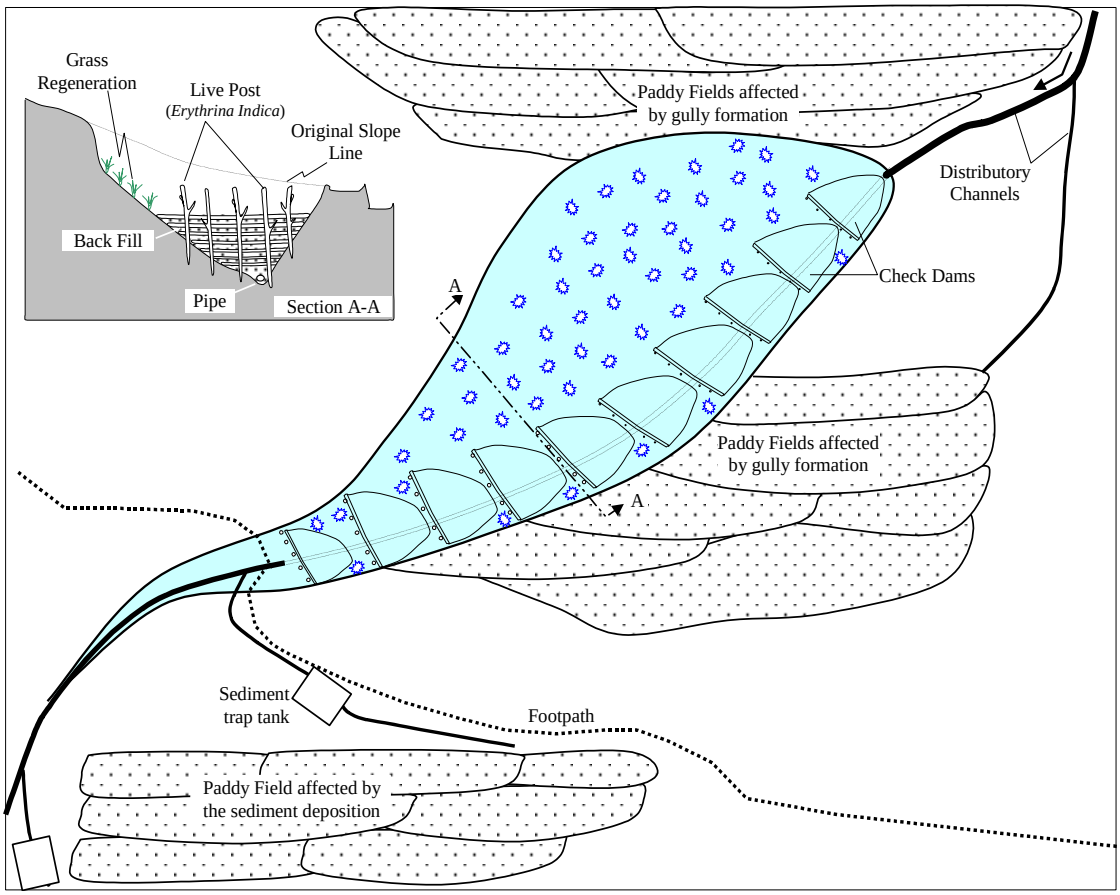
Gully walls were planted with fast growing grass species in both methods. Wherever require the gullies has been fenced to prevent the animals grazing in the gullies and to control tempering with foot so that rapid regeneration of vegetation takes place.

Lined Bed: Kuneyzingkha Gully G3

Kuneyzingkha Gully G3 lies on the main canal, which conveys water to paddy fields in Tongcheykha. The gully drops by about 50-100m within 20m of horizontal distance. In the past water was let to rundown the natural slopes and slowly gully started to form over the time. According to one farmer the gully started to grow at a faster rate during the last ten years. Since the gully was growing at an alarming rate farmers seek the support of the Punakha Dzongkhag and RC Bajo to stabilise the gully. At one stage it was decided to bypass the gully but later on realised it might create the same problem if drop structures were not provided. Hence Punakha Dzongkhag provide cement while RC Bajo provided planting materials like fast growing grass species.

Since the upper half of the gully is actively growing in size compared to the lower parts, a line-bed method was adopted to prevent any further collapsing of head wall. Fast growing grasses species like Napier [*Pennisetum purpureum*] and Vetiver were planted on the sidewalls. These grass species adapts well in less nutritious soils. In the past farmers used wooden flumes instead of lining with cement. But stabilisation with vegetation was not practised.

Figure 10 Sketch of gully stabilisation work in Shachamo, G1



Picture: Shachamo gully. Picture A-After one year of stabilisation work and picture B- after two years of stabilisation work

Results & Discussion

Vegetative regeneration of natural as well as planted grass species takes place seen within a year while it takes couple of years to achieve a good coverage of vegetation. Among the two fast growing grass species Napier does better than the Vetiver.

In all three sites active gully formation has been controlled as result of stable bed and walls. This has resulted in the loss of wetland to gully formation especially in case of gully site G1. Sediment load in the irrigation water has been reduced as the soil has been conserved. As a result farmers don't have to construct sedimentation tanks and employ a person to remove sediments from the tank unlike in the past. Dredging of irrigation canals has become less frequent compared to the past thereby saving time and labour. Farmer feel that paddy yield not affected any more by deposition of sediments. The water holding capacity of the rice terraces has been improved too.

Since the farmers were involved in the process of gully stabilisation work right from the beginning their capacity to do such kind of work has been developed. In the future should they face similar problems they are have the capacity to amend such kind of problem by themselves.

In general farmers express their feeling of satisfaction of the gully stabilisation work and the benefit in terms of labour saving, yield stabilisation and control of land loss to gully formation.

Conclusion

In general land degradation can be minimised if not completely controlled if the problems of land degradation is identified and appropriate solutions are adapted. Such kind of strategy will go long way in a paving the road for the so-called "The Sustainable Development ". Building the social capital to manage and solve their own problems based on the locally available resources is of utmost importance to realise the objectives of sustainable development. This has been stressed throughout the whole processes of gully stabilisation.

5.4.3 Rainfall and Stream Gauging Data Collection

Before 2000 rainfall and stream gauging data was collected manually by employing local people. However the data collected are unreliable and it was decided that automatic data logger is to be used instead (table below).

Table 63 Summary of rainfall and stream gauging data collection activities

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*
		Matalung chu	Thalimedes	January 2001	

Alternative/Replacement of Old MS Flumes

In the past the government provided MS flumes which are used for conveying irrigation water over a deep gully or a steep unstable slopes where the normal means of conveying is impossible. Wooden flumes/chutes are also used where possible for instance where the gully is narrow and use of timber is feasible. Farmers have benefited lots from the use of MS flumes as it has the life span of 15-20 years compared to 3-5 years for wooden ones. Hence wooden flumes needs to be replaces with new flumes every after four to five years.

MS Flumes though has a longer life span is very difficult for farmers to buy and replace with new flumes as framers do not have sufficient money. On the other hand it has become equally difficult for farmers to replace the wooden flumes due to the receding resource base and stick conservation laws. In the Lingmuteychu Watershed most of the MS Flumes needs to be replaced by next three to four years. Water conveyance efficiency become low as the flumes gets older year by year. As result of this leakage there is a high risk of soil erosions and slides. This has already happened below Kuneyzingkha village in under Dompola Irrigation scheme. Farmers have started asking for pipes from RC-Bajo. Used HDP pipes were provided for immediate use only.

5.4.4 Citrus Irrigation Scheduling Trial

Citrus irrigation trial was established at Bichgoun in Tsirang, Gelephu and Dakpai in Shemgang following the soil moisture regime monitoring for the last three years. Irrgation scheduling is based on the soil moisture regime under normal rainfall condition. The main objective of the study is to see the yield benefit of irrigating the citrus and to demonstrated the technology to the farmers. Below is the first year result for Tsirang. But there was harvest for for Gelephu and Dakpai due to the fruit drop problem.

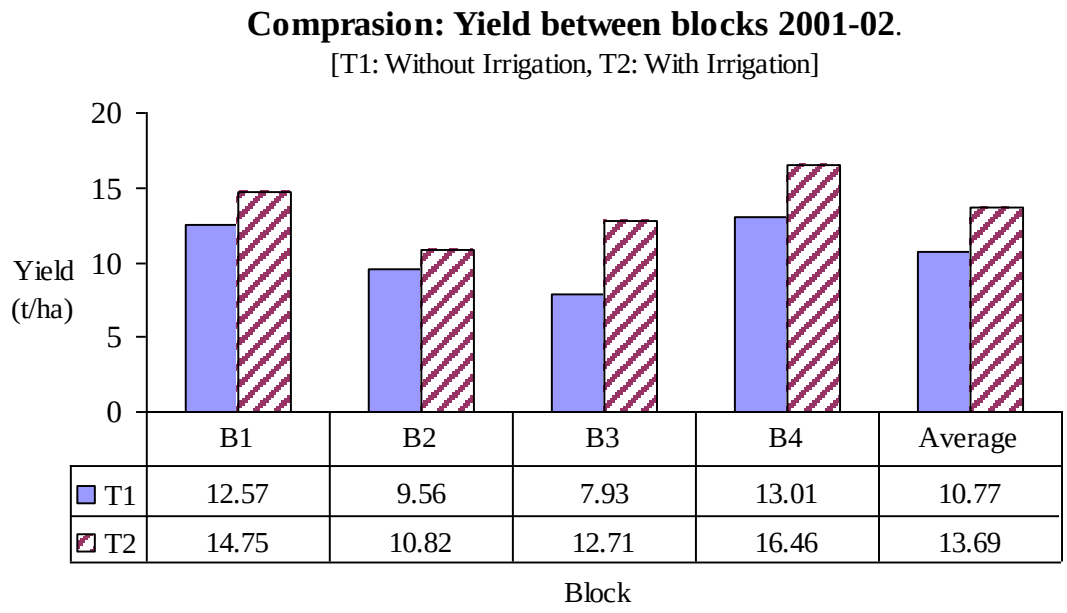


Figure 11 Comparison of yield (kg/tree) between farmer's practice [T1:without irrigation] and with irrigation[T2] for different block within one orchard.

Direct Seeding of Rice

On-station direct seeding trial for rice has been started from 2002 season (results not yet available). The main objective of the trial is to study the advantages of direct seeding compared to delay transplanting due to irrigation water shortage problem. Irrigation water shortage is mainly caused by delayed rainfall and most of the irrigation water sources small stream or springs. These water sources needs to be recharged with rainfall. Farmers at the higher altitude are affected the most due to late rainfall during some years.

5.5 INTEGRATED PEST MANAGEMENT

The IPM sector provides need-based technical plant protection services to the client Dzongkhags through field visits, disease-pest verification, surveillance and monitoring. IPM research for 2001-2002 emphasized on *Shochum* Control Campaign, Chilli Blight disease management through use of recommended raised bed method combined with minimal use of selected fungicides, integrated disease management (IDM) of potato via farmer field school (FFS) approach, *Parthenium* weed Control Campaign, citrus fruit fly control and literature reviews for *Parthenium* weed.

Potamogeton distinctus (Shochum) is a noxious perennial aquatic weed infesting wetlands. To promote intensive weeding and awareness amongst the farmers a Shochum control campaign was conducted in collaboration with extension staff of Wangdue. Two sites – one in Gaselo and one in Lingmuteychu watershed were selected and three intensive weedings done. At harvest, field days were conducted and crop cuts were done jointly with

extension agents and the collaborating farmers. The collaborating were those farmers who had participated in the study tour to Paro on the control of Shochum control campaign a year earlier. This was reinforced to increase the awareness of Punakha- Wangdue valley farmers on the control aspects of Shochum and to demonstrate that intensive weeding can eradicate this noxious weed in due time.

Realizing the fact that parthenium (*Parthenium hysterophorus*), an exotic weed, introduced via India probably as seed contaminants can cause more of health hazards than agricultural nuisance intensive parthenium weed management and awareness campaigns were conducted in and around the Wangdue valley. While the centre conducted the weeding campaign in the farm area other institutions were also informed and encouraged to mobilize similar activity in their areas. It has become a routine exercise for the centre to take the initiative in the control of the weed.

Chilli blight *(Phytophthora capsici)* has threatened cultivation of traditional Bhutanese chilli in major chilli growing areas of the country since late 80s. Trials conducted in pilot villages the past had indicated positive results in reducing the disease via use of raised bed, good drainage and optimum plant density in concurrence with the use of other improved cultural practices. However Wangdue farmers are of the opinion that the use of raised bed method is not effective in controlling the disease. To assess whether farmers do strictly follow the recommended raised bed method a trial using selected systemic fungicide in combination with the recommended packages was established in farmers' field in Chegina, Kazhi which is on of the major chilli growing areas in Wangdue.

On the citrus fruit fly control, the proper timing of bait splashing still remains doubtful as the emergence of the adult flies differs across agro ecological zones. In keeping with the objective to develop a viable control method for the fruit flies that cause citrus fruit drop, a trial was conducted in Tsirang to determine the efficacy of different liquid lures and emergence period of adult flies. Since the trial is on-going, with the exception of raw data collected so far, the terminal report will be prepared jointly with NPPC at Semtokha towards the end of 2002.

On the cash crop front, potatoes constitute one of the major cash crops in Bhutan. Late Blight disease is the most threatening constraint in its production. Although integrated control measures are available for the major diseases, they need to be further fine-tuned. A new approach that is commonly and successfully used in South East Asia called the FFS is implemented in ten potato-growing areas of Phobjikha. This approach involves and educates the farmers through out the crop production process. It not only deals with a particular disease, but also emphasizes on crop sanitation to help minimize other problems as well.

With regard to citrus fruit fly control, the proper timing of bait splashing still remains doubtful as the emergence of the adult flies differs across agro ecological zones. In keeping with the objective to develop a viable control

method for the fruit flies that cause citrus fruit drop, a trial was conducted in Tsirang to determine the efficacy of different liquid lures and emergence period of adult flies. Since the trial is on-going, with the exception of raw data collected so far, the complete results and conclusions will be prepared jointly with NPPC at Semtokha at the end of 2002.

5.5.1 Shochum Control campaign

Shochum (Potamogeton distinctus) is a major weed problem in Punakha-Wangdue valley. Farmers practice only one hand weeding and cannot afford chemical control owing to the prohibitive price (Nu. 590+/kg SANBIRD) of the chemical. Therefore, to control the weed problem in the flooded wetland, *Shochum* a control campaign through intensive hand weeding was initiated by the center in two locations - Limbukha and Omteykha villages and two locations in Gaselo (upper and lower). Those farmers who had participated in the study tour to Paro on this weed control were selected to participate in the campaign in addition to their interest; the farmers were briefed to do intensive hand weeding 3 times at 2, 4 and 6 weeks after transplanting (WAP). The field size varied upon the cooperator the crop cut results of which are given. The intensive hand weeding will be continue for 3 years to check any yield differences vis-à-vis weed pressure. So it will be further continued and monitored.

Table 64: Crop cut results from Lingmuteychu Watershed *Shochum* Control Campaign (2001)

No.	Village	Average Yield (Kg per Acre)		Yield difference (Kg)
		Weeded (3 weeding)	Farmers' Practice (1 weeding)	
1.	Limbukha	2640	1600	1040.00
2.	Omteykha	1640	1520	120.00
3.	Wangjokha	2320	2160	160.00
4.	Thangu	2640	1360	1280.00

Table 64 shows the rice yield difference in fields where intensive hand weeding was implemented against the farmers' practice of one weeding per cropping season. The highest yield difference was recorded in Thangu (1.3 t/acre) followed by Limbukha (1.0 t/acre) and the lowest yield difference was in Omteykha (0.1 t/acre). Considering that the control campaign is on-going the results are convincing to boost the farmers' morale that additional 2 weedings at 4 and 6 weeks after transplanting will prevent yield loss to Shochum. The awareness campaign is expected to continue for a few more years in both the locations.

In Gaselo, 2 farmers (1 from Gase Tshogom & 1 from Gase Tshowom) were involved in the awareness campaign. Taking into one of the objectives, a few students of Gaselo Junior High School were also involved in the weeding campaign. Prior to the weeding activity, the students and Agriculture Focal Teacher were briefed on the economic importance of *Shochum* to the

Bhutanese rice production. The students participated in all the 3 weeding and also during the field day wherein the neighbouring farmers were also invited headed by the concerned *Gup* and *Tshogpa*. A joint crop cut with Dzongkhag Extension officials, students and farmers was done. Three crop cut for each treatment was done from an area of 6 m^2. The difference between yield from each trial plots were exhibited to the participants who attributed the yield difference to timely weeding.

Table 65 Crop cut results from Gaselo *Shochum* Control Campaign (2001)

No.	Village	Average Yield (Kg per Acre)		Yield difference (Kg)
		Weeded (3 weeding)	Farmers' Practice (1 weeding)	
1.	Changkha	1717.82	1748.00	30.18
2.	Drapchekha	1820.00	1860.00	40.00

5.5.2 Farmer Field School (FFS) Experience in Phobjikha

Introduction

Since the inception of FFS in 1999, the integrated disease management (IDM) of potato via the FFS approach is currently in its third year, in Phobjikha under Wangdue Phodrang Dzongkhag. One of the major potato diseases affecting potato production is late blight (LB) caused by fungus *Phytopthora infestans* in the chief potato producing areas such as Phobjikha, Bumthang, Chapcha and some parts in eastern Bhutan. Although Bhutan currently grows about 5654 hectares of potato in the temperate regions with yield ranges of 15-25 tha^{-1} (Nidup, 1999), potential to increase the yield does seem possible provided proper disease management is carried out in combination with recommended management practices. Sharing experiences from other countries in potato production recommendations have been made available on how to contain major pest and diseases. Yet our farmers have not completely adopted these recommendations. Hence to let the farmers have a first hand experience, the FFS approach which has been successfully executed in South East Asian countries was continued in Phobjikha with seven new farmers in addition to three farmers who had participated in the 1999 potato growing season.

Objectives

The short-term objectives are:

- ✓ Assess the constraints in potato production;
- ✓ Induce the farmers in implementation of the best available IDM packages through FFS approach;
- ✓ Develop and test FFS curriculum on potato IDM;
- ✓ And to determine the out come effect and impact of IDM through FFS.

The long-term objective is:

- ✓ Guide the farmers in discovering Integrated Pest Management (IPM) methods and build their skills and decision-making capacity in the control of potato pests and diseases.

Methodology

The FFS was carried out in Damchulakha (2820m), Tsokopangna (2840m), Yuesa (2890m), Tabading (2865m), Mole (2850m) and Dangsa (2840) villages under Phobji geog. These villages have reported incidences of late blight problems and among others soil borne diseases such as common scab.

Farmer and Site selection

The IPM research team from RNRRC Bajo visited Phobjikha during the first week of March 2001 and convened an informal meeting with the Phobji and Gangtey extension agents (EAs), Phobji Gup, Tshogpa and pre-identified farmers from the said geog. The three farmers who had participated in the FFS activity last season were present during the meeting who helped facilitate the discussion by relating their own experiences to the new farmers. During and after the meeting the farmers were briefed on the objectives and procedures of the study and stressed on their participation and cooperation throughout the potato season. In all, more than 15 farmers had volunteered for the activity but a few of them could not assure the team of their participation throughout the season in view of labour shortage. The team in consultation with the concerned EA and village representatives agreed on 10 farmers including 3 who had participated in the last 2 cropping seasons to be involved in the current FFS curriculum.

For the selection of FFS learning plots, the researchers and EAs in consultation with the concerned farmers visited the respective potato fields in each village and agreed on the site that was nearer to their residence. This was done as the farmers felt that it would be easier to monitor and guard against wild animals especially wild boars.

Learning plot design, treatments and planting activity

The EAs of Phobji and Gangtey geogs helped the concerned farmers to design the layout of the learning plots. However the farmers were encouraged in the making the layout on their own. In each village, 3 learning plots – each plot measuring 50 m^2- was laid out with the following treatments:

1. Good quality seed, recommended late blight control
2. Farmer seed, farmer management
3. Farmer seed, recommended late blight control

In each learning plot, potato variety *Desiree* was planted in the 3rd week of March 2000 as per the given treatments. Standard potato production practices were followed in all the learning plots.The farmers were also instructed on how to recognize and differentiate early blight from late blight symptoms in

addition to the time and method of spraying fungicides such as Mancozeb and Copper Oxychloride in recommended doses. Among others they were also informed on the benefits of rouging volunteer plants during earthing-up and following proper plant spacing. However they were reminded that these factors would be compared against the farmers' management practice during harvest. Besides, the farmers were also provided hands-on training on the various aspects of potato production in addition to plant protection guidance throughout the cropping season. Sessions for different activity stages were also finalized with the collaborating farmers and procedures implemented as in Table 66, which also highlights what the researchers, and farmers learned at the end of the FF curriculum.

Results

The LB incidence was very low. Except in isolated cases LB occurrence was not very significant. Using the CIP scale, the LB scores were 1 in all the treatments (1=mild, 9=severe) at 60, 70, 80 and 90 days after planting (DAP). The yield from the treated plots did not vary significantly from the farmers' practice. The experiences gained at the end of the FFS curriculum is given in table 66

Table 66: Implementation plan and out put at the end of FFS activity

Session	Activity	Goal	What farmers learned	What researchers learned
Planting	Fertilization Planting space Seed selection Good quality seed	Farmers learn the importance of seed size use and its economic importance and planting space	Proper seed size selection and to avoid high density planting	Farmers use a combination of SSP, suphala and urea during planting. A handful of the mixture is applied for every *domgang* (approximately 2m) of rows. Some use only suphala preceded by farmyard manure (FYM) during land preparation.
Earthing up	Hilling up Roguing LB control	Farmers learn proper hilling and roguing and its importance	Proper hilling technology and roguing to remove volunteer plants. They understood that volunteer serve as source of inoculum for soil/tuber borne disease.	Most farmers do not practise roguing as they use volunteer tubers as vegetable during off-season.
Flower-ing	About LB and its control Roguing Virus diseases and other pests	Farmers learn about LB and its recommend ed control. They also learn about virus disease and other insect pests.	Learned to recognize LB symptoms in the field and how to control cutworm problems.	The farmers had been relying on toxic chemical such as furadan to control insect pests in the past, which has been banned now.

After flowering	Continuation about LB and its control Virus diseases	Farmers learn about LB and its recommended control. They also learn about virus disease and other insect pests.	Farmers learned when to spray mancozeb in addition to proper techniques of handling chemicals and equipment. They also understood that LB spores can overwinter in soil and that infected tubers serve as source of inoculum.	Farmers spend sleepless night guarding their crops from wild animals especially wild boar that come to feed on potatoes.
Harvesting	Result Tuber diseases Storage Data analysis Evaluation Planning	Evaluation and interpretation Plan for the next cropping season.	Farmers learned proper harvesting and handling techniques. They also learned the concept of crop cut and make comparative yield study.	Farmers preference for *Desiree* varieties as they fetch high prices compared to *Yusikap* and *Kufri Jyoti.*

Conclusions

Though FFS approach has been successful in other countries especially in South East Asian countries, its success in Bhutan still remains to be seen. The following suggestions to popularize this diagnostic tool seem timely.

To spearhead this curriculum, a need for an in-country training for the FFS trainers by a TA specialist is felt necessary in view of the current researchers who have no formal knowledge on the subject.

In order to produce impact-oriented results the trained trainers should create greater understanding on the part of the EAs and farmers in particular through group discussions, hands on training and demonstrations.

Farmers in Phobji geog and surrounding villages have shown keen interest in continuing this activity. As such allowance for new farmers joining the curriculum have been prioritized.

5.5.3 Parthenium Weed Control Campaigns

The Plant Protection Sector has been coordinating Parthenium Weed Control campaign in the west-central region especially in Wangdue and Punakha Dzongkhags. A brief write-up (see below) on the weed was distributed among organizations within and outside Wangdue to conduct timely control campaigns on the weed. On average, the centre has been conducting campaigns on a monthly basis starting June through September 2001. Concurrently the Centre has been engaging staff and labourers in the Parthenium weed control campaign within the research farm area. So far the emphasis has been on hoeing or pulling up of the weeds before they germinate rather than on slashing.

***Parthenium hysterophorus* L.**

Local Names: Congress grass/weed or Parthenium weed (English)

Characteristics: Annual or biennial, erect to 1m. Foliage dull grey-green, rather like *Artemisia* in seedling stage but not aromatic. Flowers are many in diffuse panicles, about 2 mm across with white disc-florets (no ray-florets).

Propagation: Being a prolific seed producer it is extensively spread because the seeds are light, armed with pappus that facilitates its dispersal through natural agencies such as wind, water, animals including humans.

Distribution: This is mainly a weed of roadsides and waste places but can occur in perennial crops. It was introduced in India from Central America and most probably introduced in Bhutan via India. This is a dryland weed at lower altitudes, mainly below 1200m, but occasionally to 1700m. In Bhutan it is found along roadsides and on wastelands in Trashigang, Monggar, Trongsa, Zhemgang, Punakha, Wangdue Phodrang and Thimphu. In Wangdue Phodrang it was first observed near the Sunday market. Today it has spread rapidly from there to the surroundings of RNRRC-Bajo and as far as Nechenthang (Waklay Tar) in the south. It can also be seen along the Lobesa roadsides.

Potential danger: A noxious weed in parts of India where it causes severe allergic illness in adult males, including those whose only contact is with pollen. It has been shown to be allelopathic and appears in places to be replacing *Artemisia* spp. And other weeds on roadsides.

Control/Management: It may be pulled or hoed at least thrice a year before it flowers, but contact with skin should be minimized, which can be done using hand gloves. Biological management methods are being introduced in some parts of the world. In India the National Research Centre for Weed Science at Maharajpur, Madhya Pradesh have found *Zygogramma bicolorata* a defoliating beetle, spraying of pathogen *Gliocladium virens* qith 5% neem oil, Marigold plant at 1:2 and 1:4 (Parthenium:Marigold) ratio to be effectively suppressing the growth and spread of *Parthenium* weed. Chemical control of this weed is achieved with the use of Glyphosate but its use over large areas can be uneconomical, non-sustainable and environmentally undesirable.

5.5.4 Chilli Blight Management Trial

Table 67 Chilli yield, fruits per plant and plant stand

Treatment	Means		
	Yield (Kg/plot)	No. of Fruits/Plant	Plant stand/plot
T1	4.96	254	59.3
T2	5.99	256	18
T3	2.96	212	15
T4	6.23	305	17
T5	5.26	245	64.3
CV%	16.6	16.5	26.8
LSD	1.631	81.2	16.96

Table 67 shows that T4 yielded better than T1; the highest yield was recorded in T4 and the lowest in T3. Blight incidences were recorded in all treatments in varying degrees. In terms of blight incidence, T2 and T4 did not vary significantly. On average 2 plants in T2 and 3 in T4 were affected by blight at fruiting stage.

In terms of number of fruits per plant, T4 performed very well considering only 17 plants survived. T3 had the lowest number of fruits per plant even though it was raised using the recommended package. T1 and T6 produced fewer number of fruits per plant though the average plant stand per plot ranged from 59-64. In addition, the fruits harvested from these plots were varied in shape and hence most of them were not market able where as the fruits from T4, T3 and T2 were of marketable shapes as per farmers' feedback.

The mortality rate for farmers' practice was significantly higher than the raised bed method. The trial plots (10 m^2) accommodated 70-110 chilli plants when planted via farmers' method while the raised bed hold 20 plants only. The average plant mortality rate for the raised bed method was 10-25% and 22-29% for farmers' practice. Considering the large number of seedlings used in farmers' practice the mortality rate is high which means high disease incidence.

5.5.5 Fruit Fly Research

Citrus fruit drop is one of the major impediments to citrus production in Bhutan. Though substantial works on the fruit fly (*Bactrocera minax)* control have been attempted in the past the emergence of this insect in different agro ecological zones still remains doubtful. Until the exact emergence period of this insect pest is realized across different agro ecological zones the citrus production in Bhutan seems to remain stagnant. As such in an attempt to contain this insect pest NPPC in Semtokha and RNRRC, Bajo initiated a joint collaborative research with the primary objective of determining the emergence period of adult flies and efficacy of different protein baits. With TA inputs from ACIAR, Australia a trial was conducted in Tsirang for which a site was selected jointly by the Entomology Unit, NPPC and RNRRC, Bajo in consultation with DAO (District Agriculture Officer), Tsirang.

Currently data for the year 2000 and 2001 have been placed on record from which the following deductions can be made: Peak catches of both males and females occurred in May. After the end of July the number of flies caught in lures decreased. The peak attraction to protein hydrolysate lures occurred at the time when the females were approaching sexual maturity. The response to protein lures then seemed to decline markedly once the females had matured their first batch of eggs. This indicates that protein bait sprays would be most effective against the adult population in the orchard when applied in early to mid-June.

The pheromone dry trap trial using methyl eugenol and cue lure was also carried out concurrently. The fruit flies caught in each traps were collected on

weekly basis and sent to NPPC for dissection to determine the oviposition period. According to Dr. Brian Fletcher, Fruit fly consultant we do not know the peak and duration of oviposition in mandarin fruits but it would appear to be somewhere between late June and early September. He has prioritized bagging and subsequent exposure of fruit experiment to determine and quantify the oviposition period for the next season (2001).

6. EXTENSION PROGRAM

6.1 General

1. Regular visits to Dzongkhags/Geogs to monitor and evaluate planned activities could not be undertaken due to logistic problems. There has been hardly any visit made during the year.

2. Attended Dzongkhag meetings, trainings, workshops, seminar, conference on need basis and whenever the Dzonkhag asked us. Most of the attendance to such workshops and meetings is restricted to Wangdue Dzongkhag only. This is mainly due to geographical proximity thereby obliterating the need for transportation means. Visit to other Dzongkhags in the region is almost nil.

   AEPO attended a month long training program on Microsoft Access at PPD, MoA, Thimphu. Facilitated Agricultural Sector, Wangdue to conduct a three-day farmer's training on formation of small farmer group for Daga Uma ginger growers based on Dompola model. However, follow-up is needed.

3. Met and discussed with Wangdue and Punakha Dzongkhag RNR Sector Heads and with some EAs on maintaining geog database and information system and its subsequent institutionalization process at geog level. Geog extension information collection formats for agriculture, livestock and forestry was designed and sent to relevant agencies for suggestions and comments. After incorporating the necessary comments, these formats are presently being field tested in Limuteychu watershed area. Once it is fine tuned, the formats will be made available in form of a booklet for distribution to extension centers in the region.

4. Co-coordinated various farmers study tour groups from other Dzongkhags visiting centre. During this financial year a total of 4 farmer groups comprising 90 farmers visited the centre. The various farmer study tour groups were from Thimphu, Bumthang, Zemgang and Chukha Dzongkhags. A student group from Zhemgang high school also visited the centre.

5. Attended a number of veterinary emergency outcalls and provided expert services to both Punakha and Wangdue Phophodrang Dzongkhags whenever requested and asked for.

6.2 Research/Extension Collaborative Activities

1. Facilitated/Assisted in coordinating the annual (8th) Regional Review and Planning Workshop. This office was involved in rapporteuring and then subsequent compilation of Workshop Resolutions and proceedings. This office is also expected to do follow up on joint Research Extension Collaborative Activities. However, this job is proving to be a very tricky and difficult one. We are asked to do follow-up by sitting in the office alone. Field visits for verification purposes are not supported or entertained.

2. Had series of informal discussion with senior Researchers, Dzongkhag Sector Heads on initiating, designing and developing relevant extension leaflets, brochures, posters, etc in consultation with ICS. Most of the sectors have their materials ready for publication. Only thing remaining to finalize the leaflet outlay and design and then send them for printing.

3. As a follow up to Dawakha Community pasture development, which was initiated in April 2001, a new batch of pasture seeds and fertilizers was procured from Bumthang with the financial assistance from GTZ, Lobeysa and supplied to the community for replanting during the period. The pasture could not establish that well with the previous input. It has come quite well in few pockets in the plantation area. Hence, there was a need for the reseeding this year. However, there was a visible improvement in the growth of the plantation trees. Those trees, which were stunted before, were also able to grow mainly as result of application of inorganic fertilizers during the planting of pasture and also due to soil enrichment from leguminous pasture crops.

6.3 Others

The following activities were implemented with financial assistance from RNR ESP.

1. Organized and conducted a one day field day in October 2001 for progressive farmers of the region. There were 35 farmer participants, 14 researchers and research assistants covering different disciplines like field crops, horticulture including both fruits and vegetables, feed and fodder, and forestry. The main idea was to create awareness among farmers on available or forthcoming technologies.

2. Formation of Saving group in Dompola. A three-day training was given on formation of small farmer group in Dompola village in Limuteychu watershed. Twenty-eight farmers from the village were given training on group formation, group cooperation, group savings, basic book keeping and writing of group constitution and by-laws. From the total of 28 farmers 21 of them formed a savings group. They wrote their own constitution and by-laws to help in the smooth functioning of the

savings group. They have chosen their own management committee. After a formal opening ceremony, each group member has started saving Nu. 60 monthly. The collective savings is kept in an iron safe in the local temple. Once the savings has reached its take off value or critical mass, the members can start availing loan and credit facilities for various purposes as enshrined in their group constitution.

3. Conducted a regional agricultural input supply co-ordination workshop for the west central region basically aiming at strengthening the linkages between different agricultural input suppliers and other stakeholders like Commission Agents, AMC, DSC, District Credit Office, area development projects including the main stakeholder- the farmers. The main objective was to come up with strategies and mechanisms as to how to improve the co-ordination between different stakeholders in future. This activity is also reflected in the RNR ESP work plan for the period.

4. A three-day Farmer-led Technical Forum was organized and conducted by this office. There were 48 participants including 30 farmers from different Dzongkhags in the region. There were altogether 5 observers from RNR RC, Yusipang and ICS,Thimphu. The main objective of the workshop was to provide a platform to farmers where they can come together along with researchers and extension staffs to discuss issues pertaining to agricultural development especially with regard to appropriate technology generation. The other important objective was to get a direct feedback from the farmers on the success or failure of various RNR technologies that were generated and extended so far by the research system. And also to come up with some suggestions for improvement with regard to some of these technologies. It provided the perfect opportunity for the researchers to see where their strengthens and weakness are in terms of technology generation aspects and where they might to have to make improvements in order to serve the needs of the people better. This is also reflected in RNR ESP work plan.
5. EPO along with Wangdue Dzongkhag Livestock sector staff visited Beldrok under Kahsi geog under Wangdue, a remote place where yak herders live. Participated in anthrax vaccination and sterilization campaign. Also conducted surgery on a yak calf to repair its torn and lacerated rumen due to wild animal attack. Based on the group recommendations, the herdsmen of Beldrok have already started growing improved pasture in front of their settlement to start with or to experiment with. Later on they would like to leave it there or take up in greater proportions depending upon the success or failure of the present project. Though the group has also recommended for introducing vegetable production in the village, it was not taken by agricultural sector for some reasons. However, the sector has already given their words that they are going to conduct vegetable production training and conduct promotional program during the coming season on a priority basis.

6.4 Some Important Planned Activities that could not be implemented

1. Could not conduct Farmer-to-Farmer Extension training on Cardamom management in collaboration with Dagana Dzongkhag. It was planned during the month of June 2002. However, this month is when office vehicle movements are severely restricted due to non-availability of budget for fuel allowance. Moreover, we were informed that the DAO was out of station for some training abroad.

2. Extension Co-ordination meeting for Dzongkhag Sector heads and selected EAs of the region could not take place a day prior to start of the 8th regional review and planning workshop.

3. Networking and linkage with other sister RNR RCs. We could promote better networking and inter institutional linkages and interactions with other RNR RC staff through visit.

4. Could not conduct training on proper handling of seeds and seedlings as reflected in RNR ESP work plan. This is mainly due to lack of clear understanding as to what sort of training is to be given and to whom.

7 APPENDICES

7.1 Details of Wealth Ranking in Domploa and Matalungchu

Dompola

In total all the farmers of the community participated in the exercise consisting of 17 female and 13 male participants. Rinzin Dorji facilitated the discussion while Aita Kumar did the recording. Although similar exercises were conducted earlier also during the wheat adoption survey by a team from this Research centre, still the farmers were explained on the objective of the exercise. The participants discussed among themselves and separated into three groups Rab (category 1) Ding (category 2) and Tha (category 3).

Results and Discussion

Land holding, Food self-sufficiency, Household labour availability and Relatives working in government organisation or private firm outside village that supports household are the main indicator used to divide the household categories in Dompola. Only 20% of the household are self-sufficient where 80% of the household are food deficit for a period of 3-5 months. But unlike other communities here the poor households do not have debts from other, yet they meet their food requirement during food deficit period by buying rice from market through the sales proceeds of vegetable especially Radish, Beans and Sag.

Table A1. Value of main wealth indicators used by participants in Dompola to categorise households

Wealth Indicator Number of HHs	Category I (Rab) 6	Category II (Ding) 6	Category III (Tha) 18
1. Rice self-sufficiency	12 months	9 months	7 months
2. Farm Size (Wet land) (Dry land)	2-8 acres 0.5-5 acres	2-3 acres 1-2 acres	0-2 acres 1-2 langdos
3. Household labour	2-5	2	1-2
4. No. of cattle owned	3-13	7	0-4

Share cropping of land is not much common practice in Dompola due to shortage of irrigation water during transplanting time, only few farmers from category 3 share in land but not from rich farmers but from the monastic bodies (rabdeys) of the community. Water right and water-sharing system is not appropriate in Dompola and usually there is conflict within community for water.

Other wealth indicators that appeared to be different between categories in Dompola were ownership of power tiller, ownership of grain mills, type of house and application of chemical fertilizers.

Table A2. Value of all wealth indicators per household category in Dompola

Wealth Indicators No. of households	Category 1 (Rab) 6	Category 2 (Ding) 6	Category 3 (Tha) 18
1. Farm size (Wet land)	1.5 – 8 acres	1.5 – 3 acres	0-2 acres (two HHs do not own land)
2. Farm size (Dry land)	1-2 langdos	1-2 langdos	1-2 langdos
3. Sharing in and sharing out land	Neither share in nor share out	Neither share in nor share out	Maximum of 1 acre from Rabdeys
4. Water rights and sharing	Traditional Water sharing system from Limbukha, water not proportional to land size which causes water conflicts		
5. Rice self sufficiency	12 months	7-9 months	5-7 months
6. Number of household members	8-25	Average 12	3-6
7. HH members residing inside village	8-9	5-6	4-5
8. HH members residing outside village	4-10	more than 5	1-7 (mostly school going children and monks)
9. Amount of household labour	2-5	2-3	1-2
10. Off-farm income	No differences between three categories		
11. Number of local cattle owned	3-13	7	0-4
12. Number of improved cattle owned	1-2	2	0
13. Number of horses owned	1-4	2	1-3
14. Planting of cash crops such as vegetable & potato	No differences between three categories		
15. Regular use of chemical fertilizer	Yes, (some use more suphula than urea)	Yes, mostly urea	No, due to high cost of fertilizer
16. Regular use of weedicide	No differences between three categories		
17. Have enough FYM	Yes	Yes	No (less No. of cattle and also have to apply in dry land)

18. Cheese and butter sale	They sell cheese when they have milking cow and buy when don't have.		
19. Growing oats	No differences between three categories		
20. Access to sokshing and its size	Yes in small size	Around 1 acre	Around 1-2 langdos
21. Ownership of power-tiller	All, except 1 h/h	Only 1 h/h	None
22. Ownership of paddle thrasher	All, except 1 h/h	3 h/h	None, (people prefer hand thrashing)
23. Ownership of grain mill	All, except 1 h/h	4 h/h	None
24. Outsider & Extension Visit	No differences between three categories		
25. Influential h/h members	Yes	Yes	none
26. No. of school going children	No differences between three categories (Nearness to school)		
27. Length of h/h puja	2 days	2 days	1 day
28. Contribution to community puja	No differences between three categories		
29. Participation in agriculture development	No differences between three categories		
30. Purchase of oil cake	No differences between three categories (buys when they have milking cows)		
31. Improved rice/maize variety	No differences between three categories		
32. Quantity of fire wood use	Same in three category (as per forest law, 2 trees per year)		
33. Distance of field from house	No differences between three categories, depends on location of field		
34. Debts	None	None	None

Social Mobility

A simple trend analysis on social mobility was done to see the shift in household category during the last 20 years. It was found that 1 household have moved from category 3 to category 1, this is because earlier the people has to pay heavy land tax. Now the tax has reduced and besides that children have grown up, have good co-operation with the community, diversified agriculture activities and has a good business.

Another household also has switched over from category 3 to category 2 and the reason for this change is due to hard work done in agriculture activities.

Table A3. Individual households belonging to each category in Dompola.

Sl. No	Category I	Category II	Category III
1	Namgay	Dawa	Namgay Bidha (Dompola)
2	Wangdi	(Tongchekha)	Sangay mo (Dompola)
3	(Dompola)	Namgay	Kencho mo (Dompola)
4	Ap Zeko	Tshering	Nidup Wangdi (Dompola)
5	(Dompola)	(T/chekha)	Tshering pemo (Dompola)
6	Ap Bago	Tshewang	Chagay (Dompola)
7	(Dompola)	Dem	Yanka Bidha (Dompola)
8	Passang	(Kunizingkha)	Sonam Wangchuk (Sachamo)
9	(Tongchekh	Thinley Dem	Kezang mo (Kunizingkha)
10	a)	(Sachamo)	Kinga mo (Kunizingkha)
11	Karma	Kencho	Pem Choden (Sachakarmo)
12	Tshering	Bidha	Sonam Wangmo (S/karmo)
13	(T/chekha)	(Dompola)	Wangmo (Tongchekha)
14	Kencho	Dorji	Peka Dema(Tongchekha)
15	Zam	Gyeltshen	Sonam (Tongchekha)
16	(Sachamo)	(Dompola)	Kinley Wangmo (T/chekha)
17			Kencho pem (Kunizingkha)
18			Kuchum (Kunizingkha)

Matalungchu

Process

The wealth ranking exercise in Matalungchu was conducted to 19 farmers. Out of which, nine participants were female and ten were male. Rinzin Dorji explained the objectives of the exrecise and facilitated the discussion while Aita Kumar and Tanka Maya took notes and made observations on the involvement of the group members in the discussion.

Although the farmers participated actively, but they were quite reluctant to categorise the household considering that all the households are of equal status. However, with some facilitation and informing and making farmers understand the reasons for planning relevant activities. Finally, the farmers categorised by making sure the household categories are agreed upon by all participants and formed into three groups – Rab (Rich), Dring (Medium) and Tha (Poor).

Results and Discussion

The main indicator used by the participants to categories farm household in Matalungchu are the land holding size, household food grain availability and level of food self sufficiency. Other indicators were also identified which are presented in the table below. There are not many differences in the wealth categories in the community, actually only two households are in third category whereas the other are almost equal in the wealth status.

In Matalungchu, 90% of the household are self-sufficient and only 10% are deficit in food for a period of 2-4 months. The food deficit households manage

the shortage by buying grains through the sale of vegetables. Vegetable cultivation especially sag is the grown here in large scale beside others like chili, beans and other are also cultivated. Only 1 household in category 3 have debts in kind to the category 1 household which they lend in interest amounting to every 20 dreys of paddy they pay 3 dreys as interest.

The rich household have an average of 6 acres land (two household have upto 11 acres), followed by the category 2 farmers have on an average of 2-3 acres and the category 3 households have an average of a acre land. None of the households owns power-tiller. 9 out of 11 households in category 1 has grain mill whereas only 2 households out of 6 in category 2 owns and none in category 3.

Table A4. Value of main wealth indicators used by participants in Matalungchu to categorise households

Wealth Indicator	Category I (Rab)	Category II (Ding)	Category III (Tha)
Number of households	11	6	2
Land holdings (wetland)	6 acres (ava)	2-3 acres	0.5-1 acre
Food self-sufficiency	12 months + some surplus	12 months	8 –10 months
Number of horses owned	2-3	2	none
Type of house	3 storied	same as cat 1	2 storied
Debts	None	None	only 1 household

Social mobility

Earlier only 2 household (Ap Gasep and Ap Sangay Kahandu) were in category 1, rest of the category 1 farmers have ascended form category 2 or below through intensive and diversifying agriculture activities. These farmers shared in land and did marketing of agriculture products especially vegetables. The two households in category 3 still remain poor due to division of land among family and small land holdings. The individual households belonging to each category are presented in Table A6.

Table A5**. Value of all wealth indicators per household category in Matalungchu**

Wealth Indicators Number of households	Category I (Rab) **11**	Category II (Ding) **6**	Category III (Tha) **2**
1. Farm Size	Average 6 acres (2 HHs have 11 acres)	2-3 acres	0.5 – 1 acre
2. Sharing-in and sharing-out wetland	2 HH share out wetland rest do themselves	Some share in, some share out depends upon labour availability	Share in wetland
3. Water rights, sharing in and out	Same in all categories, all the Households have equal rights over water.		

4. Number of months per year self-sufficient in staple food	12 months and excess	12 months	8-10 months
5. Number of household members	Max – 17 heads Min – 5 heads	Max – 9 heads Min – 5 heads	Max –10 Min - 6
6 Amount of household labour	1-3	1-2	2-3
7 Off-farm income	No difference between categories,		
8 Number of local cattle owned	Average of 5-6 in all categories		
9 Number of improved cattle owned	1-2 heads of Mithun cross breed	1-2 heads of Mithun cross breed	Nil
10 Number of draught bull owned	4-5 heads in all categories since they don't own power-tiller		
11 Number of horses owned	1-3	1-3	none
12 Planting of cash crops	No differences between categories		
13 Regular use of fertilizer	No difference between categories		
14 Regular use of weedicide	No difference between categories		
15 Quantity of FYM available	No difference between categories		
16 Butter and Cheese sale	Subsistence for household consumption		
17 Growing Oats for fodder	No difference between categories		
18 Access and use of Sokshing	No difference between categories		
19 Ownership of power-tiller	-do-, None of the household owns one.		
20 Ownership of thresher	All	All	1 HH do not have
21 Ownership of grain mill	9 households	2 households	None
22 Extension and Outsider visit	No difference between categories		
23 Length of household puja	2 days	2 days	1hh for 1 day
24 Contribution to community puja	No difference between categories, equal distribution due to equal water right		
25 No. of influential h/h member	No difference between categories		
26 No. of school going children	Average of 2 children in all categories		
27 Type of house	Big and 3 storied	Same as cat 1	2 storied
28 Purchase of oil cake for cattle	No difference between categories, only home produce do not buy		
29 Improved Rice/Maize variety	No difference between categories		

30 Firewood usage	No difference between categories, as per Forestry rule		
31 Debts	None	None	1 h/h in kind

Table A6. Household according to category in Matalungchu

Sl. No	Category I	Category II	Category III
1	Sangay Dorji	Kadho	Sangay Dorji
2	Namgay	Saga	Tsagay
3	Nim Dorji	Lotey	
4	Tawchu	Bagom	
5	Gyeltshen	Zekho	
6	Gupdrep Saga	Tenzin	
7	Saga Chungwa		
8	Gasep		
9	Sangay Tshering		
10	Ugyen		
11	Rinchen		

7.2 Training/Workshop/Study tours

Name of staff	Dates	Purpose
D.D Chettri	2 July –9 July 2001	Attend SAVERNET Final Workshop in Bangkok, Thailand.
Tanka Maya Pulami	July 9 – 29 Sep 01	Attend senior-level Certificate Course in Agricultural Statistics and Computing
Sangay Duba	21-27 Aug 01	Participate in the Watershed Network Meeting held in Lima, Peru
Thinley Gyamtsho Kezang Jamtsho	2– 22 Sep 01	Undertake study tour on Water Management and Watershed Management in Nepal
Rinzin Dorji	24 Sept– 14 Oct 01	Attend Participatory Research and Development training course at CIP Office, Los Banos, Philippines.
Tsheten Lhendup	5 Nov – 16 Dec 01	Attend hands-on training on Citrus Management at Keri Horticulture Research Station, New Zealand.
Karma Tshewang	17 Nov– 18 Dec 01	Attend Finance Management Accounting & Project Monitoring in Pune, India.
Sangay Wangdi Neelam Pradhan Mumta Chhetri Namgay Wangdi Cheku Dukpa	19 Nov – 6 Dec 01	Participate in a study tour to various research institutes in Nepal, to cultivate institutional and individual links, exchange of genetic materials etc.
Aita Kumar Bhujel	23 Nov - 14 Dec 01	Community based integrated watershed management, IIRR, Silang, carity, Philippines
Dawa L Sherpa	18 Aug 01 - 18 June 02	Attend Tropical Animal Production course in the Netherlands.

7.3 Consultancies

Two consultancies were fielded during the reporting period. One of the consultants was Dr. Glenn Gregorio, Rice Breeder of IRRI, to review rice varietal improvements program in Bhutan and provide focus and direction to programs for the future, and to explore possible areas of assistance and collaboration with IRRI on the proposed National Rice Production Program in the 9th five-year.

The second consultant was Dr. Sadiq Bhuiyan from IRRI-Dhaka Office, Bangladesh to review on-going water management research program based on the 9th FYP proposal on water management; explore and recommend new areas of focus on water management research against the background of present management practices, existing resource base and the comparative advantages of horticulture crop production; review, examine and recommend water management practices based on experiences from outside which may be relevant to Bhutanese conditions; and examine and review the present water management extension services to be given by the Agriculture Extension and recommend possible adjustments required.

7.4 Visitors to the Centre

Name/Address	Date	Purpose
Dr. John Graham, IDRC, Tonie and Heneke (consultants/ resource persons)	16-25/7/01	Visit watershed/project sites; as resource persons for the training on Livelihood Analysis
Officials of the Revenue & Customs Department, RGoB	4-7/01	Conduct PIT/BIT/CIT Training and awareness workshop
UNDP, UNIDO/SNV delegates	15/02/02	Familiarisation visit; mission visit
Thai Delegation, GATC Dr. Adisar Sreesunpagit, Deputy Permanent Secretary Miss Chaneewan Leowijisk, Director, Foreign Affairs Mr. Mr Uthai Noproonwong, Director Mr. Sarapong Suttisa, Technical Director Mr. Sawastdee Boonchee, Senior Agronomist Miss Chalernwan Dechachart	3/9/2001	Familiarization visit
10th Batch NRTI Trainees led by R.B. Chettri, Senior Lecturer	28-30/11/01	Study and learning visit
Dr. Sadiqul Bhuiyan, IRRI Office, Bangladesh	18-24/11/01	As consultant on water management research to the Centre
Dieter Zuercher Johanes Patten Nerner Christen Samdu Chhetri Saemi Moser Malia Kaezing	12/9/01	Goodwill visit
Dr. J.G Campbell Director General of ICIMOD, Katmandu	31/8/01	Discuss on collaboration and linkages
Board of Governors and Support Group (ICIMOD) - 55 Members	2/12/02	Familiarisation/learning visit
Progressive farmers from Lhuntshe Dzongkhag (28 Farmers)	22/2/02	Study Visit
Dr. P.N Bahl, Consultant, FAO and Kailash Pradhan, DRDS	1/04/02	Discussions on grain legumes in the country
Javed Mucharraf, Country Portfolio Manager, IFAD	6/4/02	To prepare for field visit of delegates after IFAD Workshop
Ginna G. Geal, Consultant and Horticulture Extension Specialist	16/4/02	Discussions and exchange of vegetable breeder seeds
Tae Hyung Kim, Management Director, Hugo J. Hoerndli, Managing Director.	20/4/02	To explore possibility of marketing Bhutanese processed products to Thailand

7.5 Expenditure statement for financial year 2001-2002

RGOB contribution:

01.01	Pay & Allowance	3051326.00
02.01	Other personal Emolument	983350.00
11.01	Travel	1590875.00
12.01	Utilities Telephone	56857.95
12.02	Utilities Fax, W/T Postage	32382.00
12.03	Utilities Electricity	45934.43
14.01	S & M Office Supplies	43202.30
14.03	S & M fertilizer Manure	25812.00
14.06	S & M Uniform Ext. Kits	26066.00
14.07	S & M Text book & Jonals	20452.00
14.08	S & M Supply & Consumable	47248.06
15.01	MoP Building	92486.17
15.02	MoP Vehicles	393147.32
15.05	MoP Equipment	87084.51
15.06	MoP Agro forestry	7390.00
15.07	MoP Computers	14584.00
17.03	Opt. Exps. Transportation	9500.00
17.05	Opt. Exps. Energy	2292.00
24.03	Contribution Provident fund	173520.00
25.01	Retirement benefit	58829.00
45.01	Traning	41507.00
54.01	Furniture	294470.00
	Total	**7098315.74**

EPINARM Project contribution

SDC

12.01	Utilities Telephone	17457.00
14.08	S & M Others	81444.10
15.08	MoP others	18811.21
17.07	Opt. Expence others	88582.40
45.02	Training others	21580.50
52.05	P & E Agri. Machinaries	424579.55
52.08	P & E General tools & Instrument	18800.00
55.01	Professional Services	41085.00
	Total	**712339.76**

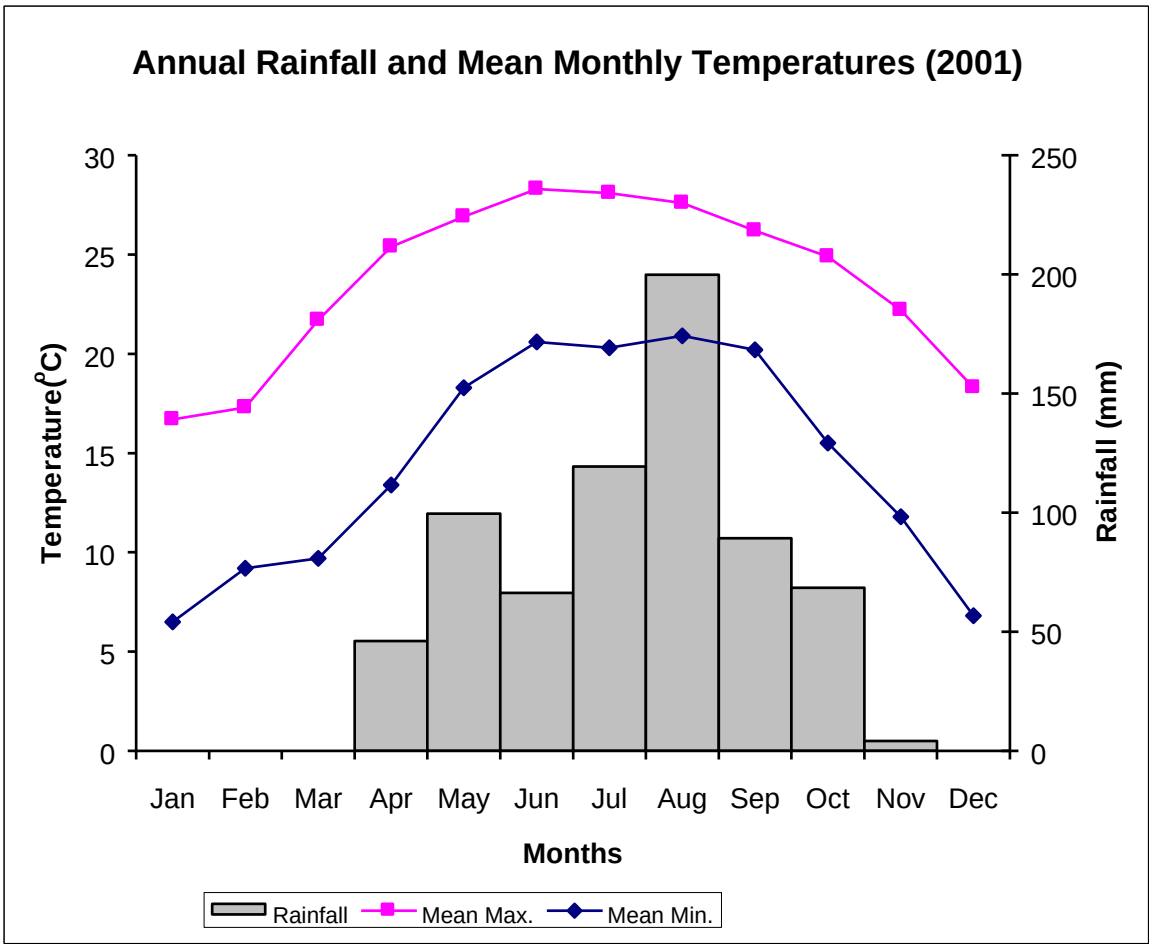
IDRC

11.01	Travel In country	3000.00
12.01	Utilities Telephone	14105.00
14.01	S & M office supplies	95573.60
14.07	S & M Textbook stationeries	20150.00
15.07	MoP Computer	17768.00
52.08	P & E Gerneral tools & Instrument	116000.00
55.01	Professional services	414634.80
45.01	Training	429523.73
	Total	**1110755.13**
	Grand Total (RGOB + EPINARM)	**8921410.63**

7.6 Annual Weather summary

January – December 2001

Months	Air Temperature (°C)		Humidity (%)	Rainfall (mm)	Evaporation (mm)
	Mean Max.	Mean Min.	Average		
Jan	16.7	6.5	84.8	00	2.6
Feb	17.3	9.2	81.4	00	3.9
March	21.7	9.7	69.2	00	5.6
April	25.4	13.4	71.6	46.1	6.1
May	26.9	18.3	79.3	99.5	5.0
Jun	28.3	20.6	78.9	66.3	5.2
July	28.1	20.3	80.4	119.3	8.8
Aug	27.6	20.9	83.1	199.9	4.3
Sept	26.2	20.2	84.3	89.2	3.7
Oct	24.9	15.5	81.2	68.5	3.9
Nov	22.2	11.8	83	4.2	3.6
Dec	18.3	6.8	85.8	00	3.0
Annual Average	22.8	14.2	80.3	57.8 (693)	4.7


Annual Rainfall and Mean Monthly Temperatures (2001)
Temperature(°C)
Rainfall (mm)
30
25
20
15
10
5
0
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months
Rainfall
Mean Max.
Mean Min.