ABOUT THIS REPORT

This is the sixteenth 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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Deo R Pradhan	-	Hilux Driver
Bago	-	Office Peon
Thinlay	-	Night Guard

* transferred/retired

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 other minor crops), oilseeds (mustard) and grain legumes in the long run. The short-term objectives are to identify, adapt or develop appropriate and affordable technologies/varieties for optimising the production of field crops.

Rice

Research on rice attempts to improve rice production using appropriate varieties and production management techniques. The general aim of variety trials is to identify suitable varieties with high yield potential, medium height, optimum maturity and resistance to prevailing pest and diseases. In AET, 15 entries were tested. Statistical analysis of grain yield showed that IR63322-B-B-B-26-B and IR62467-B-R-B-F8-1-B were the top yielders averaging 6.89 t/ha. Several other crossbred lines also performed well. Local check Zakha yielded 4.89 t/ha. The IET was composed mainly of breeding lines aimed to identify suitable varieties for further evaluation. Analysis showed that several test varieties produced significantly higher grain yields than Zakha. The elite selection from this trial will be further evaluated in the following season.

In the Observation Nursery, grain yields ranged from 2.60-10.40 t/ha. The yields of most of the entries were higher than the local check variety Zakha. Days to 50% flowering ranged from 99-132 days, while the plant height ranged from 65-109 cm. No notable insect pests and diseases were observed in the trial. The second set consisted of 115 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 world's rice improvement program and the initial evaluation under a wide range of irrigated rice environments.

Crop Management Research

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 EM in cereals (rice, wheat, mustard and maize) showed that moderate yields could be obtained without chemical fertilisers. Improvements in the physical and nutritive qualities of the soil are also becoming evident. However, detailed analytical and economic assessments remain to be done.

HORTICULTURE

Subtropical Fruits

During the period July 2000 to June 2001 the fruits research made a good progress especially in establishing on-farm demonstration orchards and backyard fruit cultivation. It also reaped few new results in previously-initiated on-station trials viz. varietal evaluation of pecan and almond and walnut propagation trials.

The season also saw the introduction of five new cultivars of table grapes through the auspices of JG.AG Foundation of Mr.John Goelet. The new grape cultivars came in the form of cuttings and are being planted in cutting beds for rooting and further growth to obtain sufficient materials for establishing an adaptability trial of their own.

In addition to the research results reported in the 99-2000 report, new results have been generated in pecan, almond and some citrus. On-farm evaluation of the promising cultivars have been further strengthened with the establishment of three demonstration orchards at three elevations in two dzongkhags. All the above promising cultivars have been planted in these orchards and monitoring is done at regular intervals. Three more demo orchards are in the process of establishment in two other Dzongkhags, Gasa and Punakha shall be established during this season, bringing the total number of established demo orchards to eleven ultimately. The on-going trial to ascertain if poor management is the cause of the declining citrus orchard at the Phuntsho Pelri Palace orchard is discontinued following a change in the management team. New areas of work in on-farm trial include persimmon budding trial at Nobgang, lime top-working at Shengana, cardamom varietal and drying trials at Tsirang.

Propagation of new materials and promising cultivars received maximum attention, to bolster speed and quantity, to enhance the process of establishing the materials soon in trials and demo orchards. New methods have been generated in walnut grafting- banana-grafting and tongue grafting in March has been deduced as the most reliable form of field propagation for walnut. Avocado and mango grafting, however, suffered a setback due to lack of mature scion-woods.

Equal efforts have also been put in collecting the local indigenous wild germplasm to evaluate their use in further development. A good collection of the local wild avocado, wild kiwi and wild grapes has been established in the nursery, which are available for trial use as rootstocks for the improved cultivars. Steady progress has been made in propagating the superior strains of our local mandarin from different parts of the country and sufficient materials have been sent out to all the established demo orchards for evaluation. Efforts are also made to collect other local germplasm.

Vegetables

Based on the Regional Research Program Profile for the 8th FYP, the main objective of vegetable research involves in the diversification of vegetable crops with emphasis on high value crops that would meet both nutritional and cash income requirements of the farmers. Efforts will be made to increase local off-season production to replace imports. These objectives can be realised through the introduction and evaluation of exotic species besides the evaluation and improvement of local germplasm. Production management (crop establishment, pest control, nutrient management – organically grown) crop rotation, intercropping and kitchen gardening would also be given adequate research attention.

The workplan was prepared keeping in mind the above objectives. This report covers all the planned activities starting July 2000 until June 2001. The trials were broadly categorized into different outputs. Output 1 includes those activities that are germplasm evaluation, screening, and seed production, which will eventually lead to the recommendation for the release of the promising varieties. Output 2 includes those activities that are carried out to develop improved crop management practices. Output 3 includes those activities that are tested in farmers fields and different on-farm locations. Output 4 includes those activities that are tested for off-season production. Output 5 includes the activities that are carried out in the Lingmutey-chu watershed areas.

The main activities were germplasm introduction and screening. Vegetable soybean was tested for the first time in the station. Seed production of the promising varieties is under progress for further trials. Local beans germplasm collection and characterization was done and sufficient amount of seeds were produced for further testing. With an attempt to understand the most suitable crop production and management techniques, trials were carried out to find out the suitable irrigation regime in potato and effect of age of seedling in onion. Testing of eggplant (brinjal) varieties for resistance to fruit and shoot borer was also carried out.

Model gardens were established, one in the station and one in a farmers field to demonstrate the importance of year round production of vegetables for home consumption. Potato varieties that were found promising in the previous trials were tested in farmers conditions for participatory evaluation and selection of the desirable varieties. Seed multiplication of different vegetable varieties was done for further testing and trials.

Livestock

Of the total livestock population in the country, the west central region has 13% large ruminants, 13% small ruminants and 15% pig. The ratio of large ruminants to total grazing land available is the lowest per household. Due to small land holdings, the development of permanent improved pasture in general has limited scope. Winter fodder development is an alternative solution to alleviate fodder crisis during lean periods. The present report summarises the results of the completed activities and highlights status of the on-going activities. Major emphasis has been on the feed and fodder trials, both on-farm and on-station.
During the year, the livestock sector undertook 11 activities. Of these, three activities had been completed and results reported. In consultation with RNRRC Jakar, the introduction nursery on legume tree species had been terminated in January 2001 due to the death of most of the entries. Assessment and monitoring of grassland resources, started about a year ago, are being continued.

FORESTRY

Besides the usual focus on social forestry much empahasis was given to other activities. The thinning treatments of the stand stability trial in Khotokha forest management unit were applied and a bamboo and cane study of the Punakha

and Wangdue valley was carried out. Most of the activities of the centre in the Lingmutey Chu watershed under the community forestry projects are long term. Further the multi-purpose tree species trail and the community forestry plantations have been assessed for height, diameter and form development. Research needs in farmer oriented research as identified by the Dzongkhag forestry sectors during the regional RNR workshops are jointly implemented with the Dzongkhag forestry sector.

At the station, the sector continued with the activities such as the introduction and evaluation of multipurpose tree species (MPTS), development of vegetative techniques for promising species, comparison of the various methods of bamboo propagation techniques and performance evaluation of some exotic leguminous species. Similarly the activities in the Lingmutey Chu watershed were continued.

SYSTEMS RESOURCES MANAGEMENT

This sector comprises of the CBNRM activities in the pilot Lingmuteychhu watershed, IPNS, IPM, WMR and Agricultural Economics. CBNRM activities were a continuation of the work started in 1997 with additional emphasis on new crop varieties, awareness and weed control campaigns on shochum, promotion of fruits through demonstration orchards, promotion of vegetable production and consumption through model kitchen gardens. In IPNS, major research areas were soil fertility management, soil conservation and diagnostic studies. FFS approach was used to implement activities with the farmers. Among the diagnostic studies, an adoption survey of wheat varieties and the situation analysis study of farm labour shortage were carried out.

The IPM sector mostly provides need-based technical plant protection services to the client Dzongkhags through field visits, disease-pest verification, surveillance and monitoring. IPM research for 2000-2001 was focussed on *Shochum* Control Awareness Campaign, Integrated Disease Management (IDM) of potato through the Farmer Field School (FFS) approach, *Parthenium* weed Control Campaign, citrus fruit fly control and literature reviews for *Parthenium* weed. Research on WMR concentrated mainly on the improved water management in rice. The study found that there is no significant yield difference between the improved method and farmers' practice while there is a significant improvement in water use efficiency of 34% with the improved method. With the adoption of the improved water management practices, there is no additional management requirement if fact it saves labour by having to irrigate less times. It controls aquatic weeds like shochum. The Agricultural Economics section worked mainly on the analysis of the vegetable marketing channels in Punakha-Wangdue valley, winter crop budgeting of wheat, mustard and potato, and the economics of FYM production.

1 FIELD CROPS

The principal goal of this research program is to increase and sustain the productivity of cereals (rice, maize, wheat, and other minor crops), oilseeds (rapeseed-mustard) and grain legumes (mungbean, soybean). The major focus of the program is on integrated germplasm development and the production management of the major crops. The short and medium-term objectives are to identify, adapt or develop appropriate technologies or management strategies in field crops for optimising the integrated production processes while maintaining a sound resource and ecological base.

1.1 Integrated Germplasm Development (IGD)

The main focus of the IGD is to develop improved germplasm with high yield potential, superior grain quality, multiple resistance to major diseases and insects, and short to medium growth duration. IGD includes research activities on cereals (rice, wheat, maize, minor cereals), oilseeds, and grain legumes.

1.1.1 Rice

Attempts to improve Bhutanese rice germplasm date back to the late sixties. However, systematic and institutionalised efforts started only in 1982. The following are the major objectives of this project:

* to introduce, evaluate and recommend high yielding, improved rice varieties suitable under low to moderate input levels and at the same time responsive to higher inputs
* to improve the traditional rice varieties through breeding and selection
* to test and identify varieties suitable for different cropping patterns and for different agroecological zones.

The general methodology of assessing the performance of either introduced or locally bred varieties ensures that the entries are subject to moderate fertiliser and cultural management systems reflecting the farmers' actual practices. Seedlings are raised following semi-dry nurseries. Fields are cultivated using tractor-drawn spring tine harrow, and puddled with power tiller and levelled by planking. Seedlings are transplanted at 20 x 20cm spacing except for breeding lines where 30 x 30cm is used. Fertilisers applied are 70-40-20 kg NPK/ha, with half the N topdressed at PI. Weeds are controlled using Butachlor and spot handweeding as necessary. Harvest and post-harvest operations are done manually to avoid seed contamination.

1.1.1.1 Advanced Evaluation Trial (AET)

In 2000, AET consisted of 15 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 yielders were IR63322-B-B-B-26-B and IR62467-B-R-B-F8-1-B averaging 6.84 t/ha. The standard check Bajo Kaap2 produced 6.71 t/ha. Several other crossbred lines produced yields higher or comparable to IR 64. Local check Zakha yielded 4.89 t/ha. Occurrence of insect pests and diseases was negligible during the test season and hence no intervarietl 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, 2000

Variety	Yield (t/ha)	P.ht (cm)	50% Flw (days)
IR 63322-B-B-B-26-B	6.84	104	108
IR62467-B-R-B-F8-1-B	6.83	130	110
Bajo Kaap 2	6.71	100	117
IR62467-B-R-B-24-1-B	6.68	144	110
IR65239-B-B-68-1-B	6.25	131	114
IR62745-B-R-B-20-1-B	6.24	119	108
IR62467-B-R-B-F10-1-B	5.90	130	108
IR62467-B-R-B-8-B	5.81	133	107
IR62467-B-R-B-10-B	5.51	126	108
IR64	5.45	95	113
IR62473-B-R-B-24-2-B	5.05	124	113
IR62745-B-R-B-5-1-B	5.03	122	111
LOCAL ZAKHA	4.89	120	112
IR65239-B-B-7-1-B	4.68	125	113
IR62745-B-R-B-5-1-B	4.41	120	111
CV%	14.6	5.3	2.2
S.E.D.	0.68	5.2	2

1.1.1.2 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 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 2.

Analysis of variance showed that several test varieties produced significantly higher grain yields than the check varieties Zakha and IR 64. However, none of

the entries could yield significantly higher than Bajo Kaap 2. Days to 50% flowering ranged from 105-125 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

Variety	Yield (t/ha)	P.ht (cm)	50% Flw (days)
CNT 87040-33-1-1	7.10	97	118
SPR 88090-30-1-2-4	7.10	86	121
Bajo Kaap2	6.60	98	118
ZHONGYU 5	6.33	95	118
CT 8240-15-3P-21-11-21	5.90	91	112
IR64	5.87	91	114
M 88	5.40	99	117
RP 1667-301-1196-1562	4.97	93	112
RHS 330 25-CX-3CX-4CX-02A	4.50	95	125
DR 92	4.37	89	121
ZAKHA	4.23	118	115
DELLA	4.20	114	105
SR 6014-ZHONSH14	4.20	90	113
PK 3161	3.87	113	109
IR66229-45-3-2	3.33	95	108
IR66696-49-1-2	3.23	85	105
IR67013-58-1-2	3.20	87	107
IR66232-75-5-1-2	2.40	89	107
IR66231-262-1-3	2.23	88	106
CV%	16.3	6.0	3.5
S.E.D.	0.62	4.6	3.2

1.1.1.3 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 a spacing of 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 performance of selected entries is presented in Table 3. The observed yield ranged from 2.60-10.40 t/ha. The yields of most of the entries were higher than the local check variety Zakha. Days to 50% flowering ranged from 99-132 days, while the plant height ranged from 65-109 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

Varieties	50% Flw (days)	Plant height (cm)	Grain yield (t/ha)
BR 5513-38-1-3-2	122	97	6.00
WAB 95-B-B-14-HB	101	85	2.60
TOX 3098-2-2-1-2-1	132	91	6.20
UPR 1329-1-6-1	111	92	6.00
RP 2233-10-16-9	119	98	6.50
IET 13711	119	90	5.70
B2983B-SR-85-3-2-4	110	103	5.90
CNAX 4506-3-2-2-1-B	120	87	6.10
UPR 1230-9-2	101	82	5.20
IR 64680-81-2-2-1-3	109	65	5.00
SPR 88090-30-1-2-2	122	81	5.50
TOX 3241-31-2-1-3-1	122	93	6.30
IR62141-114-3-2-2-2	110	91	6.10
SPR 87036-7-1-1-2	122	106	7.00
GUOJING 4	122	97	6.90
IR62243-41-1-3-3	109	85	4.80
CT 6163-8-9-5-2-M-134-M	119	92	4.70
BR(BE) 6157-R1-9	129	97	5.10
IET 13245	104	91	6.80
IR 68535-35-3-3-2-2-1-2	99	75	10.40
IET 12884	112	91	6.80
IR 56383-77-1-1	102	87	5.77
RHS 351-19CX-7CX-2CX-	125	95	5.90
FUJIANG 4	103	88	5.50
GIZA 178	110	79	6.20
UPR 84-21	111	91	6.30
IR 64683-87-2-2-3-3	116	90	6.35
IR72102-3-115-1-3-2	112	88	6.70
ICNAX 4354-5-1-1-3-B	103	83	5.10
Bajo KaaP 2	119	90	6.10
IR 64	116	86	5.50
ZAKHA	119	109	4.19

1.1.1.4 Observation Nursery II (IIRON)

It consisted of 115 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 world's 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 (**Table 4**) ranged from 0.84-12.0 t/ha; plant height from 71-131 cm and days to 50% flowering from 101-143. No notable insect pests and diseases were observed among the genotypes. Selected entires, based on selection criteria such as maturity, plant vigour and height, panicle and grain types and general performance, will be further assessed.

Table 4 Performance of entries in IIRON 2000

Designation	50% FLW days	Plant Ht cm	Grain yield t/ha
101. 86945-1	113	80	4.40
102. IR 64	115	80	4.80
103. ITA344	126	77	5.20
104. KARJAT	-	-	-
105. IR68068-99-1-3-3-3	132	72	4.3
106. ITA 402	127	80	6.3
107. IR 50	103	75	4.9
108. TOX3055-10-1-1-1-2	127	88	6.6
109. IR72102-3-1O7-1-1-2	112	83	5.3
110. TOX3162-11-1-2-1-1	127	83	4.8
111. IR721O1-4-159-1-3-3	112	83	5.4
112. PSB RC 2	127	76	4.0
113. WAB340-B-B-10-112	104	110	3.8
114. IR68445-62-1-3-1	101	89	4.2
115. CNAX4354-2-3-1-2-B	127	87	3.6
116. MR 183	145	73	4.3
117. ZAKHA	115	105	4.9
118. IR65621-299-3-2-3-3	122	84	3.7
119. IR68077-33-1-3-3-3	127	89	4.2
120. PNA1010-F4-23-1-1	119	91	5.4
121. IR71606-2-1-1-1-3-3-1-2	117	89	5.5
122. IR72	89	83	5.6
123. CH5	120	104	5.5
201. CT9852-3-2-1-2-4P-M	113	83	
202. ZAKHA	115	112	5.0
203. BR5969-3-2	114	92	4.3
204. C122CU83-SMCU-16CU-5CU	136	81	4.9
205. IRGA 318-11-6-9-2-A3	113	86	4.7
206. CT9737-5-2-1-2-4P-M	115	87	4.2
207.IR64	113	86	5.1
208. IRGA440-22-3-4-1F-1	116	95	5.5
209. IR73888-1-2-7	115	82	6.1
210. IR71604-4-4-3-7-2-2-3-3	116	92	7.0
211. CT9868-14-3-1-4-3P-M	127	77	4.8
212. IR50	111	73	5.4
213. Q34	145	99	1.6
214. M91	115	116	6.4
215. MK9-87	125	90	5.6
216. IR63896	116	88	6.6
217. IR72	116	78	7.0
218. IR72102	111	84	7.1
219. IR73887	113	86	7.4
220. C74	127	110	4.1
221. IR68444-18-1-3-3	114	83	6.9
222. PSB RC-2	127	86	5.9
223. D3	111	84	6.5
301. WAB368	94	78	6.3
302. ZAKHA	116	116	6.2
303. CT6163-8-9	118	88	4.8
304.IR73887	116	87	7.4
305. BR4676	127	91	7.2
306. C15	122	84	7.1
307. IR 64	112	81	5.6

308. UPR1137	110	75	6.0
309. GUIXIANG	106	83	4.1
310. IR69710	113	78	4.1
311. 93F106	116	87	4.2
312. PSB RC2	127	80	4.8
313. TOX3241	129	76	4.9
314. RHS392	122	93	4.9
315. SPR87028	122	93	4.9
316. IR71606	114	76	3.9
317. IR50	106	71	3.9
318. IR69715	118	71	3.8
319. WEI YOU 989	110	79	5.3
320. IR71604	111	82	4.4
321. CT9685	127	77	3.8
322. IR 72	116	79	4.6
323 18447	116	75	4.5
401. IR68078	131	73	4.5
402. ZAKHA	108	107	2.8
403. VN93-1	120	95	4.4
404. IR67406	112	84	4.3
405. HB94061	107	66	2.9
406. N28	127	77	5.7
407. IR72	122	67	5.7
408. CT9506-12	107	80	4.2
409. IR68059-76	125	81	4.3
410. TOX3084	-	-	-
411. IR69713	121	73	5.3
412. PSB RC2	125	70	4.0
413. CT9807-3	119	80	4.2
414. CT9846-1	127	88	4.8
415. CNTBR82075	115	91	4.1
416. P4	128	94	6.0
417. IR 64	109	82	5.0
418. WAB337	106	102	2.6
419. IRGA 411	98	80	3.3
420. IR69710-85	122	73	4.4
421. WAB224-16-HB	107	90	2.7
422. IR50	101	73	3.9
423. CT9682-2	-	-	-
501. IR68059-73	122	84	6.6
502. IR72	107	72	4.9
503. CNAX 4356	105	84	4.4
504. IR68077	121	86	6.5
505. JIANG-XI	107	75	3.3
506. IR69707	122	69	3.4
507. ZAKHA	113	107	3.5
508. IR68440-61	134	74	3.3
509. BR6158	99	71	3.6
510. UPR 990.	125	92	5.6
511. IR69749	125	82	7.4
512. PSB RC 2	125	76	5.3
513. IR68440-36	125	79	5.1
514. CNAX 4364	103	80	4.9
515. CT8285	114	75	3.8
516. CHETUMAL A 86	127	82	3.7
517. IR 64	102	88	5.5
518. 87314-4	85	76	4.7
519. LU HONG ZAO 1	114	59	1.9

520. IR71606	116	80	4.1
521. XUAN SO 5	136	75	4.2
522. IR 50	110	69	3.9
523. TOX3107	131	58	3.6

1.1.1.5 Seed Increase for Research

To make seeds readily available for research purposes, both on-station and on-farm, the Centre routinely multiplies seeds of released varieties as well as the emerging new varieties. Nucleus seeds of released and promising varieties are also being maintained. Varieties and their quantity of seeds multiplied are presented in Table 5.

Table 5 Rice seed maintenance and production, 2000

Variety	Quantity (Kg)	Nucleus Seed
No 11	100	
IR 64	450	
Bajo Maap 2	500	
Bajo Maap 1	1000	
Bajo Kaap 2	650	
Barket	41	
Bajo kaap 1	550	
IR 62467-B-R-B-B-1-1-B	270	
IR 56346-1-1-R-1-9-1-1	160	
IR 63332-B-B-B-26-B	160	-
K. B	50	-
Chumro	70	-

1.1.1.6 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 2000 a total of 161 local rice varieties from different altitudes were rejuvenated and characterised at the station (Appendix 1).

1.2 Crop Production Management

1.2.1 Effective Micro-Organism (EM)

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.

Nature Farming using EM technology

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 agrochemicals.

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 6 Cropping calendar and varieties grown in 2000-2001

Crop	Variety	Date sown/planted	Harvest date	Remarks
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	-	
Guava	Local	2000	-	
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 1995-2000 are presented in the table below.

Table 7 Grain yield (t/ha) of various crops from 2000-2001

Crop	95-96	96-97	97-98	98-99	99-00	00-01	Average
Rice	8.70	4.40	5.05	6.26	6.50	6.80	6.29
Wheat	0.77	1.25	1.06	1.20	1.90	1.50	1.28
Mustard	0.26	0.27	0.41	0.49	0.49	0.26	0.36
Maize	6.37	5.82	6.84	7.70	5.00	5.25	6.16

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. From the following year the yield

dipped down and has gradually stabilised at about 6 t/ha. The yield for wheat for 1999-00 was good (1.9t/ha) and on the rise. The yield of maize has decreased as compared to the last year because of the change in plot. The new plot will take some time to improve soil fertility.

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 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.

2 HORTICULTURE

2.1 Subtropical Fruits

Introduction

The period July 2000 to June 2001 was one in which fruits research saw gradual progress in previousely-initiated work viz. varietal evaluation and propagation programme. Evaluation of the existing germplasm, both on-station and on-farm, continued with renewed vigour. Efforts also continued in sourcing, introducing and establishing new germplasm to increase the number of collections for evaluation. The season also saw the introduction of six new cultivars of table grapes through the auspices of JG.AG Foundation. The new grape cultivars came in the form of cuttings and are being planted in cutting beds for rooting and further growth to obtain sufficient planting materials for establishing an adaptability trial of their own. New result has been generated on pecan, almond and citrus evaluation.

2.1.1 Integrated germplasm collection and development

2.1.1.1 Varietal evaluation of pecan cultivars

Pecan is a sub-tropical fruit whose cultivation in Bhutan is limited to a few trees in a few backyards across the country. These few trees are old trees which have been probably introduced from India. Indigenous pecan plants are not found even in the wild. It has a huge potential for cultivation in the country in that it is similar to walnut in properties, but has added advantage of being sub-tropical in habitat and has softer shells than walnut. This trial was conducted with the objective to evaluate adaptability and performance of different improved cultivars of pecan. Four cultivars of pecan with five plants each were planted in the trial orchard in 1994 at a spacing of 7mx7m row to row and plant to plant. The parameters considered for evaluation were tree growth, bearing habits and fruit qualities. All recommended management practices are carried out annually during the season. The trees are into seventh year growth and the first harvest was reaped in the seventh year this September.

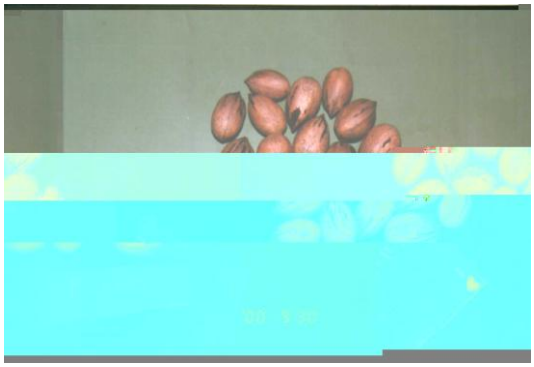
Table 8 Performance of pecan varieties

Cultivar	Yield / no. of fruits/tree	Av. fruit size Dia(cm)	length(cm)	Harvest time	Average trunk size(cm)
Nellis	8	2.5	3.9	28/9/2000	58
Western Schley	257	2.1	3.5	-do-	52
Mahan	184	2.0	3.1	-do-	57
Burkett	88	2.1	3.1	-do-	63

The overall performance of the trees look very encouraging, with good tree canopy, trunk and reasonably good first year fruiting. Of the four cultivars yield

was highest with Western Schley followed by Mahan. In fruit size there was not much difference with average fruit diameter of 2.1cm and length of 3.4cm. Tree trunks also were of similar size. Harvest was done at the same time for all the cultivars. Further observation needs to be carried out in the next two seasons to determine the ultimate promises of this crop.

Figure 1 A and B: Pecan nut ready for harvest (1A). Nuts of cultivar Western Schley 1B)



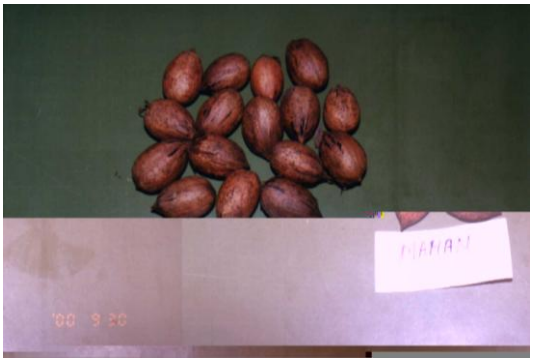


Figure 2 C and D: Nuts of cvs Burkett and Mahan.

2.1.1.2 Varietal evaluation of different citrus cultivars

To diversify the production base of our citrus industry it is necessary to introduce and evaluate different types of citrus cultivars. This trial is a step in this direction - to expedite the process of diversification of citrus cultivation. Twelve cultivars of different citrus with 3 plants per cultivar were introduced through the auspices of the IHDP phase I in 1994, and the Citrus Improvement Project,JG.AG, and planted in the evaluation orchard at a spacing of 4m in row and 5m between rows, with the objective to evaluate adaptability and performance of the cultivars.

The performance parameters considered for selection are fruit quality – size, colour, juiciness and taste. The trial is completed by this year as the trees have come to into full bearing. Of the citrus collection these have reached sixth-year bearing and results are presented below.

Table 9 Yield and other fruit characteristics of 14 citrus cultivars

Variety	Fruit shape	Seediness	Harvest	Av. fruits/tree	TSS %
Ichifume	Large flat	Seedless	Late Sept.	52	13
Miyagawa	Large round	Seedless	Mid October	37	14
Okitsu wase	Round	Seedless	Early Oct.	85	9
Matsuda	Round	Few Seed	Mid Nov.	18	13
Oota Ponkan	Round	Few seed	Late Dec.	115	10
Encore	Small Flat	Few seed	January	163	11
Seminole	Round	Few seed	January	140	8
Iyo	Large round	Normal	January	10	8
M.Iyo	Large round	Normal	November	41	9
Freemont	Small round	Normal	November	57	14
Clementine	Normal Round	Few seed	November	69	13
Bearss	Egg-shaped	Seedless	November	123	-
Limoneira	Oblong	Normal	December	42	-
Lane late	Large round	Few seed	December	9	16

Of the four cultivars of satsuma mandarins Ichifumi Wase matures 7-10 days earlier than the other satsuma cultivars Okitsu wase and Miyagawa wase. The first harvest of Miyagawa was done in October this year and is sweeter than Ichifumi, though Ichifumi has been reported the most sweet among the satsumas in the last report. Okitsu wase on the other hand has firm fruits. Oota Ponkan(normal mandarin) is similar to our local mandarin but matures about a week early. Seminole is highly acidic and juicy. Sample testing for juice extraction sent to Agro Industries, Wangchutaba has reported that Seminole has a potential for future juice production. Miyauchi-Iyo and Iyo are both tangors (hybrids of tangerine and sweet orange), which bear large fruits and highly juicy. Miyauchi Iyo seems to be a regular bearer. Encore (hybrid mandarin) is a late maturing cultivar with good fruit quality. All the lime/ lemon cultivars have good fruit qualities and are superior to the existing local lime/ lemon.

Based on this year's result Ichifumi, Okitsu, Oota Ponkan, Miyagawa wase, Minneola, Miyauchi Iyo, Freemont, Clementine, Valencia, Bearss, Meyer and Limoniera are being tested in the farmers' field at different agro-ecological zones for further tests of preference and acceptability.

2.1.1.3 Varietal evaluation of cardamom

In the past, cardamom cultivars were planted by the farmers without due consideration being given to their suitability to various egro-ecological factors, resulting in poor growth and yield and in most cases severe incidence of wilt disease. Thus, a need was felt to carry out a study to develop a database on cardamom husbandry as done under Bhutanese conditions, to study the

suitability, productivity and pest/disease tolerance of different cultivars across different agro-ecological zones and develop recommendations based on long term observation. A collaborative trial, coordinated by RNRRC Bjakar, is underway with four cultivars- Bharlanghe, Dzongu Golsey, Ramsey and Sawney, of large cardamom purchased from Sibsoo dungkhag and planted in lower Tshokhana geog, Tsirang. The trial design is RCBD with 3 replicates per cultivar, planted at a spacing of 1.5x1.5m with two pseudo-stems in each pit. Monitoring and data collection shall start from coming spring.

2.1.2 Propagation Trials

2.1.2.1 Persimmon budding

Most of the existing persimmon plant in the country are either traditional Bhutanese cultivars or Indian cultivars which are of the stringent type, which has limitations in marketing. A trial has been initiated in an orchard at Nobgang, Punakha last summer to bud the astringent Japanese cultivar onto young plants of Indian cultivars. The objective of the trial was to find out the possibility of top-working established young plants of Indian persimmon with Japanese cutlivar through summer budding. Two methods of budding – chip and T-budding, were carried out. In total 15 buds were budded, out of which 2 buds did not take. An important observation was made in the first lot of budding in the timing of plastic removal. Unlike in budding other fruit crops where budding plastic is removed in the fourth week after budding, in persimmon plastic removal should be delayed till spring. It was observed that the persimmon bud tends to take longer duration to take. Final bud take can be deduced only in the coming spring.

2.1.2.2 Lime top-working

Increasing interest is shown by the growers in growing lime plants both at the backyard and plantation scale. A trial was initiated at Shengana, Punakha June this season to top-work established Assam lemon plants with improved lime cultivar- Bearss, with the objective of ascertaining the possibility of top-working lime on lemon and explore future scope of scaling up this activity. A total of 45 lemon plants were de-topped and budded with buds of Bearss using T-budding technique. Bud take success has been 90% and so far the buds are in good condition. Plastic has been removed four weeks after budding. It remains to be seen how the buds shoot out in the coming spring.

2.1.2.3 Top-working of apricot cultivar on plum rootstock

Till now in the history of plant propagation in Bhutan, the most commonly used rootstock for the stone fruits have been the seedlings of the local peach (small peach). More recently there has been an effort to use the improved almond-peach hybrid called GF677, however its use is constrained by its difficulty in propagation. This activity was initiated to explore the possibility of using plum as both a rootstock as well as an interstock for budding apricot. 15 six-year-old plum trees were top-worked with two cultivars of apricot in March 2000. The percentage graft success was about 80 %, which was more than expected.

2.1.3 Production Management

2.1.3.1 Compatibility of local mandarin cultivar with improved rootstocks

Traditionally, and even now, the method of propagation of the local mandarin is done through seeds, which has many disadvantages among which the variation of the seedlings, extended period of juvenility and uncontrolled vigor of the plants result in future management and economic constraints. The standard vegetative method of propagation is still not practised by the suppliers of planting materials and the growers. In order to encourage planting vegetatively-propagated materials it was felt necessary to find the best rootstock suitable to the local mandarin. This trial was thus initiated with the objective to determine the best rootstock for the local mandarin. However, the trial is still in its initials phase of multiplying sufficient materials for planting. A few trees on three different rootstocks have been planted for initial observation, which are growing well. The trial will be properly designed and conducted in the coming year.

2.1.4 On-farm Demonstration orchards

This season has seen increased momentum in the sector's drive to push every tested and promising materials into on-farm trials. Eight demonstration orchards, housing all the promising cultivars of different sub-tropical fruits have been established in the region, and evaluation of sub-tropical fruit trees under farmers' management level continues vigorously. Three additional demo orchards are in the pipeline, expecting establishment in the coming season.

2.1.5 Backyard fruit cultivation

Another approach to test adapatability at different locations and acceptability of the new germplasm is being carried out through backyard planting. In addition to the peach, pomegranate and satsuma mandarins sent out in the past, other citrus cultivars have been distributed to 34 farmers in the Watershed area this year thus making the total number of farmers under this trial to 74. Apart from the demo and backyard orchards, other on-farm activities inclde a cardamom varietal evaluation and a dryer evaluation at Tsirang, in collaboration with RNRRC Bjakar.

2.1.6 Germplasm introduction during the year

Crop/Variety	Source
Table Grapes	JG.AG Foundation
Flame seedless	
Centennial seedless	
Blush seedless	
Merbein seedless	
Marro seedless	
Red globe	

2.2 Vegetables

2.2.1 Screening and Evaluation of Vegetable Germplasm

2.2.1.1 Asparagus varietal 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.
There is a gradual increase in yield over the years in all the varieties. High yield (8-9 t/ha) was observed in varieties Carlim, FIUC, Gijlim and Thelim. The other varieties did not do yield very well in comparison to these varieties. The lowest yielder was Larak and De Argentinal with a total yield of about 6t/ha.

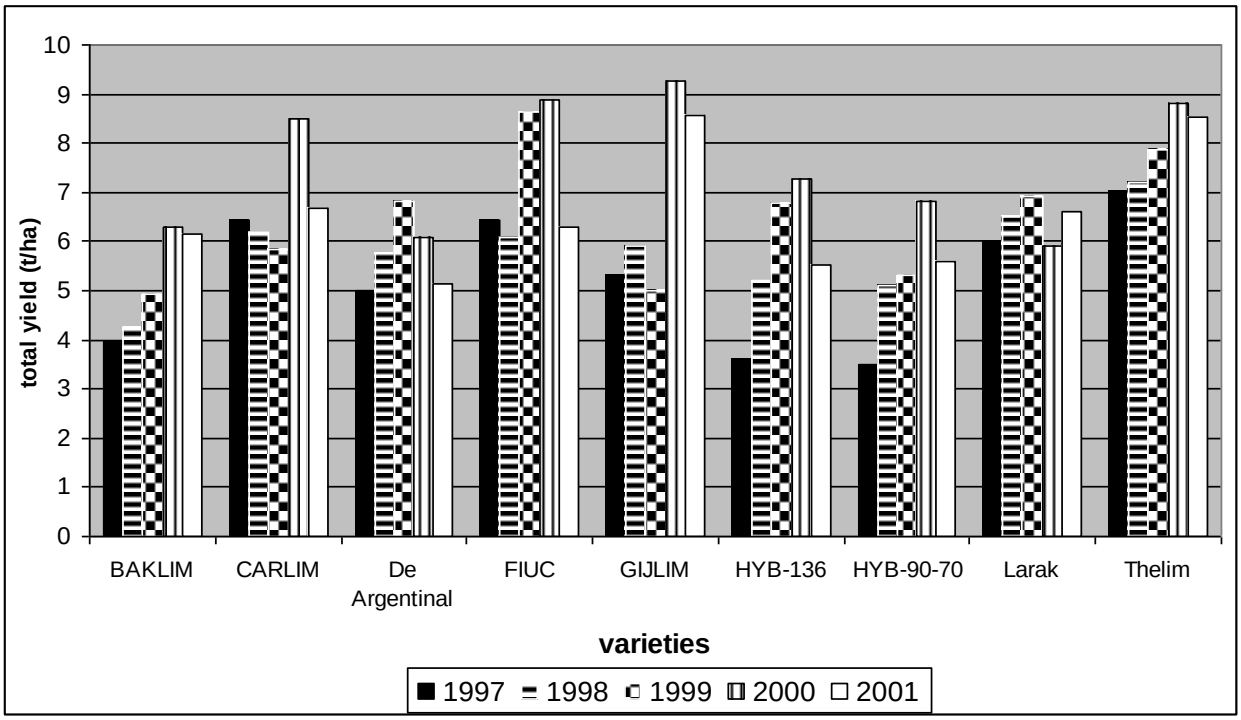


Figure 3. Total yield of 9 asparagus varieties, 1997-2001.

A general decline in the yield was observed in all the varieties in 2001. The highest yielder continues to be Gijlim and Thelim (8-9 t/ha). F1UC, Carlim and Larak yielded about 6-7 t/ha. The white varieties HYB-136 and HYB-90-70 produced low yield as usual. These varieties are probably for higher altitude areas. A highly significant difference was observed ($P<0.001$, s.e.d 0.83, cv% 15.7)
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. Since asparagus is a perennial crop, the yield is expected to increase upto a certain number of

years and then remain constant. It is therefore, not surprising to see a significant effect of year in the analysis. We do not expect any of the varieties to show a stable yield over the years.

Table 10. Average yield of nine asparagus hybrid varieties from 1997-2001.

Variety	Total yield (t/ha)
BAKLIM	5.55
CARLIM	7.05
De Argentinal	5.76
FIUC	8.20
GIJLIM	7.78
HYB-136	5.80
HYB-90-70	5.52
Larak	6.98
Thelim	8.59
CV%	21.0

Averaged over years, varieties Thelim, F1UC, Carlim and Gijlim produced the highest yield. The similar trend followed right from year one. It can be seen that these varieties produce higher yield in all the years and is therefore stable in their production patterns.

2.2.1.2 Vegetable soybean varieties

Legumes in general and soybeans in particular provide high levels of protein for nutrition. Soybean is also a good source of both protein concentrates and vegetable oil. Soybean cultivation is increasing worldwide, with soybean products used for human and animal consumption. Soybean belongs to the family Fabaceae, and botanically called *Glycine max* L. It originated in China and the domestication dates back to 5000 years ago. This trial was conducted to evaluate 19 soybean germplasm from AVRDC for agronomic characteristics, yield, and yield components. The trial was not replicated but laid out as an observation trial. Sowing was done on 6 June 2000. The plant-to-plant spacing was maintained at 15 cm and row to row at 50 cm. Each bed contained two rows. All the practices for growing beans were followed.

There were varieties that matured in 72 days till 97 days. The early varieties have a chance in diversifying the cropping system. The sowing was done in June and harvested by mid August. It will be worth trying to fit into the rice based system. The green pod yield ranged from 10t/ha to 30 t/ha. Most entries produced yield between 15 and 25 t/ha. Since this was the first observational trial, statistical analysis of the results were not possible. Seeds of the entries have been multiplied and will be further tested in replicated trials.

Table 11. Yield and agronomic characteristics of vegetable soybean varieties

Entries	DM	BNP	PHM	NNP	100SW	PL	PW	500PN	GPY
SS 86030-16-6-1	80	4.2	73.4	15.4	75	4.9	1.4	171	28.61
SS 86042-22-2-3	80	6.3	69.6	45.3	42.5	5.0	1.2	305	30.28
GC 87036-2-3	80	7.6	69.9	45.5	40	42.	1	305	30.56
SS 87040-2-1	95	-	-	39.4	35	4.6	1.1	305	26.67
SS 87008-1-1	95	5.5	66.4	19.6	47.5	4.5	1	263	15.28
159M-1	78	3.9	55.3	31	37.5	4.6	1	303	19.44
329P-3	78	3.8	61.3	40.6	40	5	1	253	17.22
373-1	78	5.6	67.8	25	50	4.5	1	256	16.94
373-5	78	3.8	53.5	36.3	125	5.3	1.5	150	16.67
475BC(F4)-1	97	4.3	66	22.5	40	4.2	0.9	352	16.39
AGS 292	72	3.8	46.8	27.3	75	5.7	1.3	140	19.44
AGS 333	80	6.8	59.6	24.3	75	5.6	1.5	168	21.11
AGS 334	78	5.9	65.2	38.2	87.5	5.7	1.5	149	15.28
AGS 335	78	8.5	67.5	38.6	125	6	1.6	127	33.61
AGS 351	97	5.7	92.5		85	6	1.4	147	23.89
AGS 329	72	-	-	35.3	85	4.8	1	198	17.78
AGS 340	80	5.8	70.3		100	5.7	1.4	149	28.61
AGS 354	72	-	-	43.5	87.5	5.3	1.8	135	11.11
AGS 349	97	6.3	76.6		75	5.7	1.2	171	9.72

DM= days to maturity, BNP=number of branches per plant, PHM=plant height at maturity (cm), NNP=number of nodes per plant, 100SW=100-seed weight (gm), PL=pod length (cm), PW=pod width (cm), 500PN=number of pods in 500 gms, GPY=green pod yield (t/ha).

2.2.1.3 Local beans germplasm collection and characterization

The collection and characterization of local beans germplasm was done 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.

1. Bajo dwarf

PLACE	BAJO
PLANT: DWARF/POLE	DWARF
SEED COLOUR	DARK BROWN
SOWING DATE	MID AUGUST
HARVESTING DATE PODS	16 OCT
DAYS TO MATURITY (POD)	58
PLANT SIZE (CM)	52 (l), 35 (w)
POD LENGTH (CM)	15
POD WIDTH (CM)	1
POD COLOUR	LIGHT GREEN
POD QUALITY Waxy/string	WAXY
HARVESTING DATE SEEDS	1 Nov
DAYS TO SEED MATURITY	80
NO OF PODS/KG	140
POD YIELD (T/HA)	2.67
SEED YIELD (T/HA)	1.5
PEST/ DISEASE	RUST
Soil type	SANDY LOAM
Other remarks	Pods very waxy and soft, even when mature.

2. Nobgang dwarf

PLACE	NOBGANG
PLANT: DWARF/POLE	DWARF
SEED COLOUR	BLACK
SOWING DATE	MID AUGUST
HARVESTING DATE PODS	16 OCT
DAYS TO MATURITY(POD)	58
PLANT SIZE (CM)	58(l), 35 (w)
POD LENGTH (CM)	11.5
POD WIDTH (CM)	1
POD COLOUR	YELLOWISH GREEN
POD QUALITY Waxy/string	STRINGY
HARVESTING DATE SEEDS	1 Nov
DAYS TO SEED MATURITY	80
NO OF PODS/KG	117
POD YIELD (T/HA)	4
SEED YIELD (T/HA)	2.5
FLOWER COLOUR	LIGHT PINK
PEST/ DISEASE	None
Soil type	SANDY LOAM
Other remarks	FLATISH PODS

3. Chitokha pole

PLACE	CHITOKHA
PLANT: DWARF/POLE	POLE
SEED COLOUR	PURPLISH BLACK
SOWING DATE	MID AUGUST
HARVESTING DATE PODS	16 OCT
DAYS TO MATURITY(POD)	95
PLANT SIZE (M)	2.39
POD LENGTH (CM)	12
POD WIDTH (CM)	1
POD COLOUR	PURPLISH GREEN
POD QUALITY Waxy/string	WAXY
HARVESTING DATE SEEDS	15 Nov
NO SEEDS/POD	7
DAYS TO SEED MATURITY	95
NO OF PODS/KG	160
POD YIELD (T/HA)	5.67
SEED YIELD (T/HA)	2.13
FLOWER COLOUR	PINK
PEST/ DISEASE	NONE
Soil type	SANDY LOAM
Other remarks	ROUND PODS, RED STEM VIENS, LESS AFFECTED BY RUST

4. Tsirang pole

PLACE	TSIRANG
PLANT: DWARF/POLE	POLE
SEED COLOUR	YELLOW
SOWING DATE	MID AUGUST
HARVESTING DATE PODS	16 OCT
DAYS TO MATURITY(POD)	58
PLANT SIZE (M)	2.33
POD LENGTH (CM)	13
POD WIDTH (CM)	0.8
POD COLOUR	GREEN
POD QUALITY Waxy/string	STRINGY
NO SEEDS/POD	5
HARVESTING DATE SEEDS	1 Nov
DAYS TO SEED MATURITY	80
NO OF PODS/KG	111
POD YIELD (T/HA)	6
SEED YIELD (T/HA)	2.4
FLOWER COLOUR	White
PEST/ DISEASE	None
Soil type	SANDY LOAM
Other remarks	FLATISH pods

5. Punakha pole

PLACE	PUNAKHA
PLANT: DWARF/POLE	POLE
SEED COLOUR	YELLOW
SOWING DATE	MID AUGUST
HARVESTING DATE PODS	16 OCT
DAYS TO MATURITY(POD)	58
PLANT SIZE (M)	3
POD LENGTH (CM)	16
POD WIDTH (CM)	1
POD COLOUR	LIGHT PALE GREEN
POD QUALITY Waxy/string	WAXY, SIDE STRINGS
NO SEEDS/POD	7
HARVESTING DATE SEEDS	I Nov
DAYS TO SEED MATURITY	81
NO OF PODS/KG	75
POD YIELD (T/HA)	8
SEED YIELD (T/HA)	2.9
FLOWER COLOUR	PALE PINK
PEST/ DISEASE	None
Other remarks	BIG FLESHY PODS COMMONLY GROWN IN KABJI PUNAKHA

6. Local pole stripped

PLACE	LOCAL PUNAKHA-WANGDUE)
PLANT: DWARF/POLE	POLE
SEED COLOUR	YELLOW WITH RED STREAKS
SOWING DATE	MID AUGUST
HARVESTING DATE PODS	16 OCT
DAYS TO MATURITY(POD)	58
PLANT SIZE (M)	3
POD LENGTH (CM)	
POD WIDTH (CM)	
POD COLOUR	GREEN WITH RED STREAKS
POD QUALITY Waxy/string	WAXY
NO SEEDS/POD	5
HARVESTING DATE SEEDS	15 Nov
DAYS TO SEED MATURITY	95
NO OF PODS/KG	127
POD YIELD (T/HA)	4
SEED YIELD (T/HA)	1.47
FLOWER COLOUR	PALE PINK
PEST/ DISEASE	none
Soil type	SANDY LOAM
Other remarks	FLATISH PODS LIKE BORLOTTO, CALLED GEU BORI, BUTTERY, OILY

7. Bajo dwarf

PLACE	BAJO
PLANT: DWARF/POLE	DWARF
SEED COLOUR	LIGHT YELLOW
SOWING DATE	MID AUGUST
HARVESTING DATE PODS	16 OCT
DAYS TO MATURITY(POD)	58
PLANT SIZE (CM)	53.6(l), 48(w)
POD LENGTH (CM)	13
POD WIDTH (CM)	0.7
POD COLOUR	LIGHT YELLOWISH GREEN
POD QUALITY Waxy/string	WAXY, SOFT
NO SEEDS/POD	5
HARVESTING DATE SEEDS	1 Nov
DAYS TO SEED MATURITY	81
NO OF PODS/KG	149
POD YIELD (T/HA)	3.7
SEED YIELD (T/HA)	1.6
FLOWER COLOUR	
PEST/ DISEASE	None
Soil type	SANDY LOAM
Other remarks	ROUNDISH FILLED

2.2.1.4 Seed production for further research

Crop	Variety	Quantity
Tomato	Ratan	100 gm
Tomato	CHT 160	110 gm
Tomato	Roma	110 gm
Tomato	CHT 176	10 gm
Beans	RNR dwarf	2.8 kg
Beans	Punakha pole yellow	4.5 kg
Beans	Rajma dwarf purple	2.8 kg
Beans	Tsirang pole stripped Geobori	4.6 kg
Beans	Nobgang dwarf black	1.6 kg
Beans	Tsirang pole creamy	1.6 kg
Beans	Chitokha pole black	1 kg
Broccoli	Desico	100gm
Saag	Mibuna	10 gm

2.2.2 Development of Appropriate Crop Management Practices

2.2.2.1 Eggplant fruit and shoot borer resistance study

Eggplant fruit and shoot borer *Leucinodes orbonalis* is a destructive pest of eggplant in almost all countries in South Asia. The caterpillars of this pest feed inside tender shoots resulting in wilting of that plant part and subsequent reduction in flower and fruit production. When fruits are present, the caterpillars bore into the fruit, which makes such fruits unfit for human consumption. Farmers tend to use a lot of insecticides for the control of this pest.
Asian Vegetable Research and Development Centre (AVRDC) have found that one cultivated eggplant accession EG058 is highly resistant to eggplant fruit and shoot borer, *Leucinodes orbonalis*. EG075 has been found to be susceptible
The purpose of this trial was to find out if the resistance can hold at other locations, under the Bhutanese environmental conditions.

Seedlings of EG058, EG075 and one local check (PP Long) were raised in a greenhouse in fine soil and well-decomposed compost mixture. For field planting, beds of size 1.5 m wide were raised. The plants were maintained at 50 cm plant-to-plant distance in each row. A distance of 2-3 m was maintained between two adjacent plots to avoid possible attraction of Leucinodes adults by EG075 away from EG058. A randomized complete block design was used with four replications per treatment.
The crop was grown by normal cultural practices such as weeding, irrigation, fertilizer applications etc. No spray was done against any insects. Each plant was observed once a week for Leucinodes damage in shoot and recorded the number of plants showing damage in shoots.
When the shoot damage in EG075 reached 50% of the plants, damaged shoots were cut from all plants after each weekly observation to make observations easier. By allowing the plant damage in the most susceptible accession to reach 50%, we allowed the pest population build up to avoid escapes and get more reliable data.

When the fruits were ready for harvest, the marketable size fruits were plucked, were immediately observed, and recorded the number of damaged and healthy fruits weekly. There were 8-9 harvests and the harvest season lasted from mid July to early September. The data were analyzed using GENSTAT statistical package.

Table 12. Yield and % damage done by fruit and shoot borers

	Yield (t/ha)			% Damage		
Variety	**Total**	**Mkt**	**Non-Mkt**	**Fruits**	**Shoots**	**Remarks**
Local	28.8	22.6	6.3	21.5	4.4	Fruit long and purple
058	11.2	5.8	5.5	49.3	10.6	Fruit small round and green
075	20.9	6.9	13.9	66.9	65.3	Fruit long but green
CV(%)	12.9	21.6	13.5	12.6	24.0	
$LSD_{0.05}$	4.5	4.4	2.00	10.04	57.57	

Total and marketable yield was highest in the local check. Non-marketable yield was found to be highest in the susceptible check 075, due to heavy fruit borer damage. The resistant check yielded low probably due to its small round fruit characteristic. The highest damage both in shoots and fruits were observed in the susceptible check 075. Damage in fruits was higher in the resistant check than in the local variety PP Long. The local variety showed least damage in both shoots and fruits, however, there was more damage in fruits than in the shoots. The resistant check 058 showed higher damaged fruits than in the shoots. Since the experiment shows that our local variety is tolerant to the Leucinodes damage and yielded higher than the other test varieties, it would be appropriate to continue growing this variety.

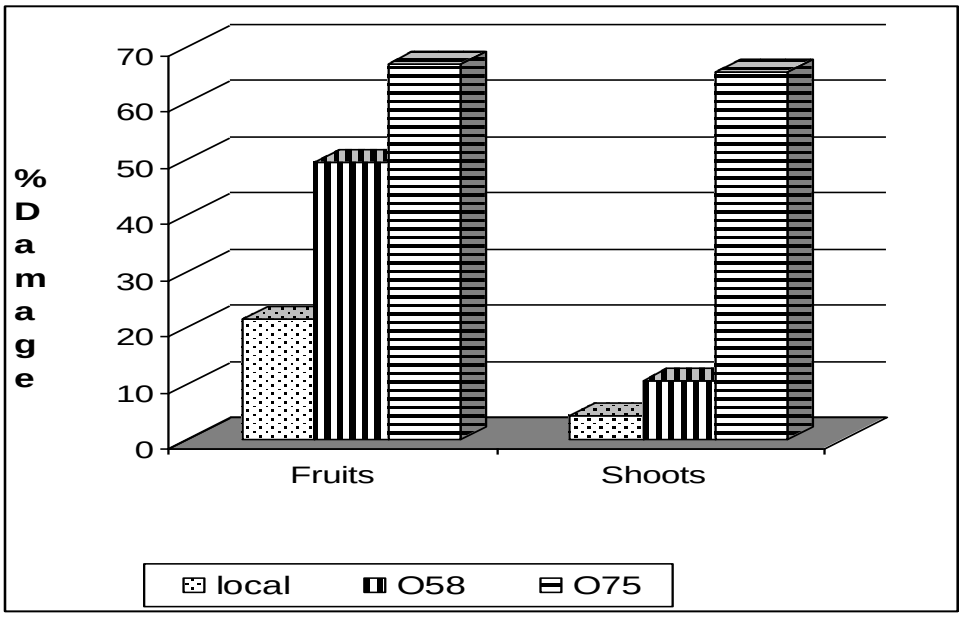


Figure 4. Percent damage in fruits and shoots by Leucinodes

Observing proper field sanitation and other integrated pest management measures would largely reduce the damage in fruits. Fruit characteristics of both the test varieties were not acceptable to local consumers. The resistant check 058 is round

and greenish white in colour and tasted bitter. The susceptible check 075 had long fruits but the colour of the fruits is green. However, the resistant check 058 can be used in future breeding programmes.
Since the local popular variety PP Long had the lowest incidence of damage in both fruit and shoots, it can be continued to be grown. However, for reducing the damage, use of an insecticide at the early stage should help. Maintaining proper field sanitation and picking and destruction of the pest will also keep the build up of the pests down. It has been confirmed that 058 has a higher degree of resistance to Eggplant fruit and shoot borer *Leucinodes orbonalis* as compared to 075. However, the resistant check can be explored for use in future breeding programmes.

2.2.2.2 Study irrigation regime for potato production in the rice based system

The potato crop grown after harvesting paddy is generally not irrigated. Farmers have often asked us for a suitable irrigation interval or regime. In line with this, a study was made to find out the effect of irrigation interval on the emergence and yield of potato. Two popular varieties, Yusikap and Desiree were tested against the different irrigation regimes i.e. irrigation 15 days after sowing and thereafter, 30 days after sowing and thereafter and one control without no irrigation at all. Irrigation was applied by flooding the plots. The sowing was done on 3rd Feb 2001. Plot sizes were 3 x 3 m, with plant-to-plant spacing of 25 cm and row-to-row spacing of 60 cm. Each plot contained five rows with 13 plants per row. The plots were separated from each other by 2m to avoid the effect of irrigation water seepage. Data were collected from the two center rows. The whole experiment was randomized and replicated thrice.
There were no significant effect of the varieties and their interaction with the irrigation treatment, so the variety effect was removed from the analysis. There was a clear effect of irrigation on the emergence of the plants. Emergence count after 30 days after sowing showed highly significant effect of irrigation. The treatment with 15 days interval had the highest emergence (51 plants out of 65) followed by 30 days interval (24 out of 65). There were no significant differences in the treatments with 30 days interval and the control plots.
The crop maturity thereof, was also different. The treatment with 15 days irrigation interval matured in 115 days after sowing and 30 days interval at 149 days after sowing. The plots with no irrigation matured 155 days after sowing. Maturity was said to have attained when all the foliage were brown and fallen to the ground. There was about 40 days difference in maturity when irrigation was applied 15 days after sowing and no irrigation at all. There was only 6 days difference in the maturity of the plants that were irrigated 30 days after sowing and no irrigation.
A significant difference in the total yield was also observed. The plants provided with irrigation 15 days after sowing produced an average yield of 16.65 t/ha, which is significantly higher than 12.36 t/ha produced by those plants provided with irrigation 30 days after sowing. However, there were no statistically significant differences in the total yield of those plants provided with irrigation at 30 days after sowing and no irrigation at all.

Table 13. Effect of irrigation frequency on potato total yield and emergence

Irrigation treatments	Emergence 30 DAS	Total Yield (t/ha)
15 DAS	51.33	16.65
30 DAS	24.66	12.36
CONTROL	20.50	11.39
Significance	<.001	0.01
s.e.d	4.51	1.59
$LSD_{0.05}$	10.06	3.44
CV%	24.3	20.5

It was evident from the study that irrigating the potato crop soon after sowing produced a higher yield and matured earlier than those that were not irrigated or irrigated only after one month. It also showed that there are no significant improvements in the emergence and yield when irrigation was applied 30 days after sowing. It was as good as not irrigating the crop at all.
However, the drawback of the trial was that it had not looked into the economics of the treatments. Irrigation would take up some resources like labour and the actual cost of irrigating for example the cost of running the water pump etc. Without having studied these details, it would still be early indication that irrigation of potato soon after sowing is profitable or not.
However, as a general guideline to our farmers, we can still recommend irrigation of the potato crop soon after sowing (not later than 15 days after sowing).

2.2.2.3 Effect of the age of seedling of onion on the plant establishment, earliness, yield and bulb quality

Onion is among the major vegetable crops grown and consumed all over the world. Onion production has become popular among the Bhutanese farmers owing to its suitability in the rice based cropping systems and comparatively less disease and pest incidence. However, one of the main problems faced by the onion growers seems to be poor seedling establishment after transplanting. Most growers transplant 4-5 week old seedling. Due to the poor survival rate of the transplants, the growers often have to sow large quantity of seeds than what they actually require. Since onion seedlings are very delicate to handle when tender, a trial to determine the most suitable stage of seedling handling is required. The main objective of this trial is to study the growth and yield of onion as affected by seedling age at transplanting.
The seeds were sown in the nursery at different intervals. The seedlings were 8,7,5 and 4 week old respectively at the time of transplanting. Transplanting was done on 9 November 2000. The plot size was 1.6 m^2 each. Each plot had four rows with 16 plants per row and 64 plants per plot. The variety Bombay Red was used.
The plant stand per plot was recorded after 2 months and % of plant survival was calculated. All necessary cultural practices were followed as per recommendations. A huge amount of bolting was observed. The numbers of plants bolted were counted as per treatment and the % of bolting was calculated. The bulbs were harvested when the leaves had turned brown and fallen to the ground. Harvesting was done on 30th May 2001.
All the data was analysed using GENSTAT statistical package.

Table 14. Effect of age of seedling on the yield and bolting in onion

Age of seedling	% survival	% bolting	Total yield (t/ha)
8 weeks	70.31	93.45	22.91
7 weeks	64.58	61.21	22.91
5 weeks	51.04	55.16	17.70
4 weeks	31.77	49.19	19.58
s.e.d	8.13	31.78	7.33
CV%	18.3	60.1	43.2
F.pr	0.013	0.007	0.86

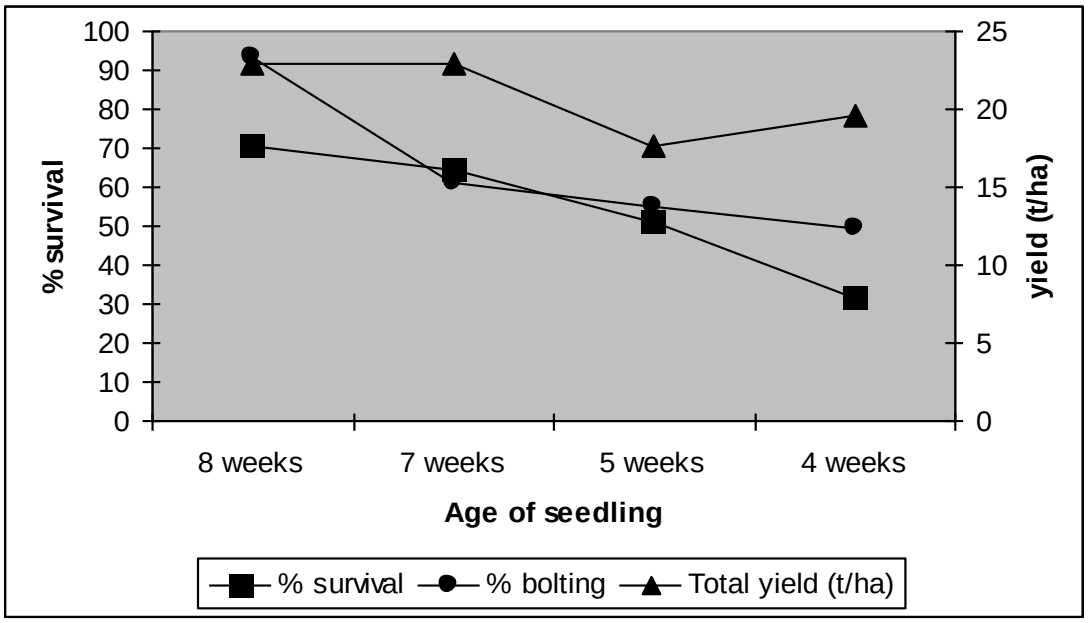


Figure 5. The effect of the age of seedling on the yield, survival rate and bolting of onion cv. Bombay Red.

It was observed that the age of seedling had an effect on the survival of the seedlings after transplanting. The survival percentage decreased as the age of seedling decreased. A similar trend was also observed in the case of bolting. Highest bolting was observed in the oldest seedling. The significance level of these parameters were $P<0.05$.

In terms of yield, there were no differences in the yield of those seedlings that were 8 and 7 weeks old. The younger seedlings produced a slightly lower yield. There were no significant differences in the yield between the treatments. However, looking at the statistical analysis, the experiment was not well replicated. The cv% was high. A similar trial with an increased number of replication and treatment would provide more meaningful results. It can however, be said that there is no effect of the age of seedlings on the yield of onion. There is a higher level of survival of the seedlings after transplanting as the age of seedling increased but there is also a higher incidence of bolting. It was also observed that the bolting did not affect the total yield of onion.

2.2.2.4 Design and demonstrate suitable rotation to be followed for a model kitchen and herb garden

Figure 6 Model kitchen garden for year round production

A model garden was established to showcase the year round vegetable production for the farmers and other visitors in the center. Techniques of crop rotation, relay cropping, mixed cropping anf inter cropping are displayed. A number of fruit trees, herbs and vegetables are grown. Details of crops grown, harvested and timing is being recorded to further develop a standard.

2.2.3 Demonstrations and On-farm Trials

2.2.3.1 Potato PET for mid altitude rice based system

The trial was conducted to screen lines for early maturity and tuber yield and characteristics for potato production in the low and mid altitude regions. The main emphasis was given to short duration lines that would mature earlier than the local check Desiree.

The seeds were obtained from RNRRC Yusipang and planted in Kabji, Punakha a popular rice-potato growing area. Sowing was done on 21 December 2000. The trial was laid out in a RCBD with three replications. The plot sizes were 2.4 m x 3 m, each containing 4 rows and 12 tubers per row. Fertilizer was applied at the recommended rate of 100:80:30 N: P: K kg/ha, whole P, K and 80 Kg N applied at planting. Remaining N was top dressed 45 days after planting. The harvesting was carried out in early May.

A field day was organized during the peak growing stage for late blight assessment with the potato-growing farmers in the area. About 16 farmers and 6 including Dzongkhags agriculture staff and researchers participated for the day. Extension Officer of the Punakha Dzongkhag briefly explained the objectives of the field day and introduced research staff to the farmers. The farmers were thoroughly explained and briefed how to identify disease-affected plants; how does it look like and where

does it appear. After the full instruction farmers were divided into four groups, each guided with a resource person as a facilitator.
A simple PRA tool of matrix ranking was used to score the disease severity. After visiting one replication, farmers were advised to place the bean seed in the readily prepared box (1 for severe and 10 for no blight).

Procedure followed
Around 70-90 days after planting, invite 15 farmers and 5 Researchers and including Dzongkhag Agri Officials to the trial field.
Divide the farmers into sub-groups of 6-8. Give each group a number eg. SG1,SG2.
After that assign one facilitator to each group of farmers.
Inform the farmer that they are to visit the variety plots and will then be requested to score the varieties for freedom from blight. Scoring from 10(no visible blight) to 1 (Severe blight). O represents " don't know"
Let the farmers visit the trial site (Plot).
Ask each group to agree on and give a score from 10 to 1 for each variety, by placing stone or maize or bean seeds(10= no blight symptoms; 1= severe blight symptoms) on the matrix.
The facilitators transfer the groups' score to the summary – scoring format, and calculate the overall variety mean score (measured across all groups to the nearest whole number from 0-10) for each variety.
Report back the mean score to all farmers for joint review and discussion.
Any relevant comments are added eg. Foliage differences due to different maturity dates; farmers observations: researchers observation etc.

Table 15. Summary sheet of the scoring exercise.

Sl No	Variety	Score (SG= score group)				SG average
		SG1	SG2	SG3	SG4	
1	676079	5	6	5	5	5.25
2	Desiree	1	4	3	2	2.5
3	720132	10	10	9	10	9.75
4	Yusikaap	3	7	3	4	4.25
5	Local	3	3	1	2	2.25
6	720053	3	1	2	4	2.5

After the scoring, the farmers were served refreshment and the facilitators analyzed the report. Immediately after tea, the results were presented to the farmers.
In the analysis, variety 720132 was found to be Blight resistant. After the short discussion farmers aging asked to go to trial field and observed the variety, which they like during the foliage, stage .It is the variety 720132 has been again selected by the farmers observing their plant growth and stems character. Some of the farmers had also confidently said that this variety will definitely produce more yield comparing to rest of the variety. After the field practical the lunch were distributed

Discussion during the day
Farmers reported that, through such program or practical Assessment of the disease will help he farmers in identifying the potato diseases.

Potato cultivation is increasing in the area due to good price since it comes as an off-season production. Through such knowledge, farmers can save their crop from blight disease and increase the production whereby they increase cash income.
They also added that they could share the knowledge with other farmers in the neighborhood.
Some farmers also asked the question that this program has helped them how to identify the blight disease in their potato crop. However, is there any such program on how to control and prevent the disease with chemical?
Farmers also showed their difficulties in getting good and healthy seeds. EA of the Geog has responded by saying that coordination of the seed requirement by quantity would now solve the problem by early placement of order in Druk Seed Corporation. He also informed that earlier demands were in small quantity and sporadic in nature which made it difficult for him to attend to.

A field day was also organised during the harvesting time. All the farmers who attended the previous field day on blight assessment were invited to now chose the best variety according to the criteria laid out by themselves.
The procedure was more or less the same. The farmers were divided into 3 score groups and were firstly asked to lay down the criteria for choosing a variety of their choice. Then they were asked to score according to their choice.
The most common criteria were total yield, large tuber yield, seed sized tuber yield, skin colour, maturity at harvest and blemish on skin. Flesh quality was also observed by slicing the potato in halves by a knife.
Women participants were more concerned with the skin colour, flesh colour and quality and yield. Men were concerned with total yield and skin colour.
Overall, the participants chose variety 720132 as their favourite variety in terms of yield, uniform tubers and resistance to blight. Their next favourite variety was 720053, in terms of tuber size and uniformity. They however, expressed the fact that both the varieties were white skinned. The farmers pointed out that varieties with red skin were easily marketable since most consumers like the red skinned varieties. The farmers own variety was also red skinned. None of the new test varieties was red skinned, except the already released variety Desiree. However, the farmers stressed the resistance to disease as being an important characteristic, and therefore choosing variety 720132 as the best.
The yield data were also collected and later analysed using GENSTAT.

Table 16 Yield and tuber characteristics of 6 potato varieties.

Variety	Yield (t/ha)			
	Small size	**Seed size**	**Large size**	**Total**
720132	4.12	9.81	18.14	32.08
720053	3.93	5.83	15.55	25.32
676079	3.61	10.55	13.61	27.77
Yusikap	3.24	11.48	11.99	26.71
Desiree	2.40	7.50	11.48	21.38
Farmer's	2.40	8.61	14.35	25.37
s.e.d	1.11	1.57	3.15	1.83
$L.S.D_{0.05}$	2.49	3.51	7.02	4.09
Significance	n.s	0.04	n.s	0.004
CV%	41	21.6	27.2	8.5

All the varieties performed well, the total yield ranging from 21 to 32 t/ha. The variety 720132 produced the highest total yield of 32.08 t/ha, followed by variety 676079 with 27.77 t/ha. The farmers own variety yielded at par with the test variety 720053 (25.37 and 25.32 t/ha).
The variety chosen by the farmers 720132 produced the highest total yield. This variety should now be proposed for release.

2.2.3.2 Potato PET for high altitude rice based system

The trial was conducted to screen lines for early maturity and tuber yield and characteristics for potato production in the low and mid altitude regions. The main emphasis was given to short duration lines that would mature earlier than the local check Desiree.
The seeds were obtained from RNRRC Yusipang and planted in Limbukha a popular potato growing area. Sowing was done on 10th Jan 2001. The trial was laid out in a RCBD with three replications. The plot sizes were 2.4 m x 3 m, each containing 4 rows and 12 tubers per row. Fertilizer was applied at the recommended rate of 100:80:30 N: P: K kg/ha, whole P, K and 80 Kg N applied at planting. Remaining N was top dressed 45 days after planting. The harvesting was carried out in the end of May.

Table 17. Tuber characteristics of potato varieties

Variety	Tuber quality
67079	Tubers not uniform, pale whitish skin, white flesh
720053	Roundish tubers
720132	Skin dark yellow, oval shaped, white flesh
Local	Red skin, yellow flesh, oval shaped and mostly large tubers

Table 18 Yield and tuber characteristics of 6 potato varieties.

Variety	Yield (t/ha)			
	Small size	Seed size	Large size	Total
720132	8.55	8.55	7.73	24.95
720053	3.19	6.08	12.87	22.87
676079	2.40	6.00	8.00	16.42
Yusikap	5.11	6.80	5.97	17.88
Desiree	1.80	5.50	9.00	16.31
Farmer's	4.21	4.53	9.35	18.10
s.e.d	1.08	1.46	1.65	2.82
L.S.D $_{0.05}$	2.41	3.25	3.68	6.28
Significance	0.001	n.s	n.s	0.05
CV%	31.4	28	23	17.8

The yield was comparatively lower in this location. Similar field days were carried out, once in the full growth stage and one at harvesting. Same procedures were followed for scoring and other observations.
The farmers identified the variety 720132 as the variety resistant to blight and this variety scored the highest during the harvest time.

There were statistically no significant differences in the total yield between the varieties. Highest total yield was produced by the variety 720132 (25 t/ha) followed by 720053 (23 t/ha). The other four varieties produced a total yield ranging from 16-18 t/ha. There was a highly significant (0.001) differences in the yield of the small sized tubers. Varieties Desiree, 676079 and 720053 produced less small sized tubers. The largest quantity of small sized tubers was produced by the variety 720132. However, it was observed that the highest yield of large sized tubers was produced by variety 720053. All the varieties were observed to mature at the same time.

2.2.4 Off season production

2.2.4.1 Off season chili

Chili is the major vegetable crop, which is in demand all year round. With an emphasis to develop a package for off-season production of chili for harvest by early May, an observation trial was carried out. The standard 5 x 20 m AMC polytunnel house was used.

Sowing was done December under polytunnel. Transplanting was done on 18th January 2001. 50% of the plants flowered on 10th March and 50% of the fruiting was started by 21 March. A super imposed spraying schedule was also carried out to see the effect of different fungicides on the blight disease. There was no disease and no effect of the spray schedule. The plastic was removed by early March.

The first harvest was carried out on 28th April. A total yield of 33 kgs was obtained from a tunnel of 20 x 5 m. Second harvest was done on 12 May.1.5 kg out of the total was non marketable. A total yield of 44 kgs was obtained from which 3 kgs were non marketable.

A total harvest of 70 kgs was obtained. Off-season chilies fetched a price of Nu.150-200 per kg in Thimphu market. However, since the detailed economics was not studied, it is not analysed economically whether it is profitable to grow off-season chilies under polytunnel

However, it is technically proven that chilies or any other crops can be produced for early market using the polytunnel provided by AMC. In Bajo conditions, there were no requirements for sophisticated equipments like heaters, thermostats etc. It can therefore, be said that those farmers who already own the polytunnel for use in rice nursery, can also use them for growing vegetable for off-season production.

2.2.5 Lingmutey Chu Watershed

2.2.5.1 Model kitchen gardens for year-round vegetable production

A model garden was established in Dompola to work and demonstrate to the farmers year-round vegetable cultivation techniques. Introduction of a systematic system of plot and bed preparation was done. Nursery raising techniques using plastic and nylon nets were demonstrated. Different types of crops were grown and therefore, it proved as a practical training ground for the farmers to learn the cultural techniques of vegetable cultivation. A field day was organized for other farmers in the community to see and adopt the method in their own gardens.

Figure 7. Model garden in Dompola

2.2.5.2 Potato seed quality demonstration trial

The main emphasis of this demonstration trial was to demonstrate the effect of new certified seeds on the yield and production of potato in Limbukha. Previous seed collection and verification tests indicated that seed potatoes from Limbukha were of the poorest quality. The demonstration was set up in one farmers field. A field day was organised at the time of sowing to all the potato growers in the area. Different aspects of potato seed quality and production were discussed with the farmers. The farmers were then shown the seed potatoes that are certified and the importance of the size and uniformity of the seed tubers. Sowing, spacing, and fertilizer application procedures were demonstrated.

The demonstration included one plot with the farmers own seed as a control.

A field day was organised at the full growth period to determine any pest and disease problem. Symptoms for late and early blight and viral diseases were explained to the farmers.

The last field day was organised at harvest. The farmers were asked to rate the performance of the different seed source by the important criteria that they decided.

Most important criteria were yield and uniformity in tuber size. Tuber shape and colour was also important, especially to the women farmers.
Comparison of the yield from the different plots measured a yield of 40.24 t/ha from certified seed and 23.4 t/ha from farmers own seed.
Most of the participants realised the importance of changing the seed stock and buying certified seeds.

2.2.6 Other activities

Other activities included providing technical assistance to client Dzongkhags whenever the need arose. Certain advisory services were also provided to DSC Bajo in terms of field visits and verification to their seed production problems.
Training on basic vegetable cultivation was provided to about 30 women from Wangdue Phodrang with financial assistance from IHDP.
Seeds of onion variety Red Creole and tomato variety Ratan were multiplied and distributed to interested farmers for promotion.

3 LIVESTOCK

3.1 Germplasm evaluation

3.1.1 Evaluation of sugarcane accessions

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 data of 2nd harvest are presented below.

Table 19 Performance parameters of sugarcane accessions

Local collection	Height 300 days (cm)	Biomass (leaves, tops & stem) (Kg)	Stem proportion		Tiller (No)
			Length (cm)	Girth (cm)	
AF Nursery	348	95.68	105.0	6.7	11.1
Ap Tandin Bajo	380	49.53	92.5	6.7	8.8
GC (kitchen garden)	341	102.95	125.0	6.7	11.2
Zingsay, White	347	82.00	107.5	6.5	11.6
Zingsay, Black	321	38.03	76.0	9.0	3.8
Bap, Wongjukha	350	126.35	120.0	7.6	11.3
MG (Kitchen garden)	340	143.63	115.0	9.4	14.0
Tshering, Lhaku	380	139.09	137.5	8.0	12.6

From the second harvest, the height measurement of the local collection Tandin and Tshering attained the maximum height of 3.8m each. MG produced highest biomass yield of 143.63 Kg at 300 days harvest followed by Tshering, Lhaku with and Wonjokha, Bap with 139.09 and 126.35 Kg respectively. The quantity of fresh yield of each variety directly corresponded to the capacity of tiller tillering. For example, MG produced 14 tillers and recorded highest biomass yield. Looking at its fodder yield, MG, Tshering, and Wonjokha, were tested and evaluated to be promising. The stems were also reasonably big and tasted sweet and if sold would fetch good cash.

3.1.2 Introduction nursery of legume tree species

This trial was established in July ’98 with an objective to introduce and evaluate legume tree species with potential for fodder, green manure, weed control and soil fertility management. Each plot of 100 x 50cm holds 12-20 trees in 2 rows and 2m space between entries. Weeding was done when necessary. Two measurements of plant height at 60 days interval after planting was taken of which results were presented in last report.

This trial had been terminated in December 2001 due to death of most of the entries of *Sesbania sesban*.

3.1.3 Winter Fodder Seed Production

The objective was to test appropriate forage species with potentials to produce higher biomass yield of green fodder and tolerate at least 2-3 cuttings per season. More importantly, trying out to bring best mixture combination of fodder grass and legume and at the same time produce seeds for multiplication and distribution. This season, the sector had produced around 300 Kg of Oat seed. Come season, oat in association with some compatible legume species will be tried.

3.1.4 Tree Fodder plantation / demonstrations

The objective was to observe their adaptability and fodder production capacity under the prevailing environment. In addition to the existing fodder tree planted, more than 500 cuttings of willow were planted around the fodder block. Maximum had survived.

3.1.5 Napier slips production and distribution

The Napier rootstock is propagated in an area of more than 1000m2. This serves as a perennial source of root slips for distribution to the Dzongkhags and to any interested and demanding farmers. During the year, the sector had supplied more than 10,000 root slips to various Dzongkhags in the region.

3.1.6 Legumes in orange orchard

The purpose of this trial was to optimise forage production with horticultural crops (especially orange orchard). Secondly, to study the comparative advantage of leguminous forages inter-cropped with orange in terms of input requirement, soil conservation and soil fertility management, and ground cover as cover crop with the traditional system of management and production of forages separately.
As a nation-wide trial, one site under Wangdue and other at Punakha was established in May 1997. GLD and Arachis were used to compare with a control plot. Arachis is found growing well but GLD had disappeared. The poor performances of the trial had resulted from the frequent change of the caretaker and negligence of the owner. Nonetheless, the two years observations revealed that both of these legumes could have done well in orchards if better care and added inputs like seeds and fertiliser were given timely. Similar trial replicates have been established in Tsirang with two farmers and at Punakha with one farmer during last summer. One more trial replicate was set in June 2001 in Dagana. This trial will continue for a period of five years.

3.1.7 Fodder herbarium

The sector had started small live herbarium of fodder plants. So far, there are only 26 grass and 18 legume species established. All these are doing well except few Stylo had died in winter due to cold. Will keep adding more species as when we get seeds of new species.

The objective this fodder herbarium is to showcase different grass and legume fodder species to any visiting guests and farmers. This fodder herbarium is also catering the source of slips (grass) and seeds for new trails in the watershed and in the Dzongkhags.

3.1.8 Participatory evaluation of oat

The objective was to increase awareness, evaluate adoption and acceptability of oat as a new potential winter fodder. 50 Kg each oat seed had been reached to Tsirang and Dagana for the said evaluation trial. However, there has been no data or any information received from the Dzongkhags as of now.

3.2 Surveys and studies

3.2.1 Economics of sheep production in Bhutan

3.2.1.1 Introduction

Sheep rearing has been a tradition among some sections of Bhutanese farmers. Next to yak, sheep makes best use of high altitude rangeland and provide supplementary source of income for the people living mostly in the temperate and alpine regions. Assessment of sheep husbandry as a whole is critical at this point in time. There is need to document current practices and economics to provide inputs for the planning of future interventions of sheep industry in Bhutan. Some key issues that need to be addressed include:
Can the present sheep breeding programs be sustained? What are the options and implications for changes or improvements?
Is the present level of wool production viable? It not, what is the future of sheep industry in Bhutan? Can we identify areas of interventions for improvement?
Can we change the production systems and aim for mutton industry for markets elsewhere?

In addition, there are some good local sheep populations, which are well adapted to the harsh and rugged environment of Bhutan. It will be therefore worthwhile to confirm the above breed descriptions through genetic analysis. This work has relevance especially from the perspective of the conservation of domestic animal diversity. In addition, it will provide further input for sheep genetic resources management plans in Bhutan.

The objectives were to;

- Describe traditional sheep production systems across Bhutan
- Characterise existing sheep populations (phenotype/genotype)
- Assess economics of sheep husbandry in Bhutan
- Assess impact of past sheep breeding programs at the farm household level
- Generate information for future directions of sheep industry in Bhutan

Overview of research methods
Interviewed the farmers and key informants using formal questionnaire and informal discussions. Actual measurements of body and live weight of 4-10 local sheep per flock using measuring tape and spring balance were done. Simultaneously, biological sample collection of hair follicles was also done.

Study areas
The study locations were selected based on the discussion with the management of the national sheep farm and district AH. Officers. However, some criteria for selection of the study site were as follows:
Localities with high sheep population and where sheep farming played an important role
Localities both accessible as well as inaccessible to motorable road were taken
Localities with both crossbred and local sheep were considered
Localities that had different indigenous sheep population
Taking the consensus of the Sheep Breeding Farm, following districts and geogs were chosen (Table below). However, the study areas and time of visits were finalised after making separate discussions with concerned DAHOs adjusting according to their plan of activities. Study locations in the West-Central region were:

Districts	Geogs	Study locations
1. Wangduephodrang	Phobji	Kingathang & Damcho Lhakhang
	Gangtey	Gogona
	Sephu	Busso, Dareloo, Longtey, Bumiloo & Rukubji
2. Tsirang	Beteney	Thangrey, Bhulkey
	Mendrelgang	Majhigang, Manidara, Mendrelgang

Data collection
Combined formal interviews using structure questionnaire and informal discussions were used to obtain field data.

3.2.1.2 Results & discussions

As revealed by the findings of the survey, there is a decreasing trend in sheep population in the Dzongkhag as a whole and even the number of sheep holding per household. For instance, the sheep population of Wangdue in 1990 was 3814 where as in 1995 it declined to 1818. Similarly, in Sephu geog, the sheep population in 1995 was 92 and 39 in 1998. There is a decrease of 53 sheep over three-year time. If the figure continues to fall drastically like this, what to expect of in another five years time. Possibly, there would be no sheep in Shephu. Sufficient evidence proved in all the three geogs that there has been fall in sheep population. The sheep owner themselves revealed that there is hardly any hard cash income derived from rearing sheep except their wool for home weave and dung as manure used in the field. Home weave garments made from wool could hardly be sold in the open market. The old members of the household do use these woollen products very occasionally. The younger generation consider these homemade garments as old fashioned as other foreign ready-made garments attract them.

Major problems in sheep rearing

All most all the sheep owners revealed health as a major problem in rearing sheep. Cent percent of the respondents from Phobji and Shephu geogs responded to this (Table 2). No less than 80 percent of farmers from Gangtey did also respond. Predation of sheep by the wild animals (like leopard, bear, and wild dog) emerged out as second priority problem for all the respondents from these three geogs.

Grazing and management practices

There were no pastures developed for the sheep as such. There are however some natural pastures, which are mainly in the forest areas. The type of grasses in these pastures varies from area to area on account of varying climatic conditions. The quality and type of pastures in these areas vary, depending upon their natural regeneration. It is the topography of these pastures and their carrying capacity, which determine the grazing routine of sheep flocks as well as their grazing behaviours. As said earlier, most of the sheep flocks are migratory and their area of migration vary from 1-8 days walking distance from their villages. There were hardly any flocks, which were considered stationary. However with reduced in flock size some flocks in Phobjikha are confined to homestead pasture (Tshadrog) belonging to a community. By and large, grazing hours of sheep is limited to availability of forages and wild predators. These conditions make our farmers migrate their flocks to long distances for food. The local sheep can walk and eat quite faster than exotic and their crosses that are accustomed to graze their pastures in peace. More deaths are also reported of cross breeds during migrations. The availability of pastures, which is seasonal, depended much on rainfall in different areas. Again, the rainfall is concentrated during few month of the year. Therefore the flocks of sheep migrate over extensive alpine pastures with yaks from summer grazing foothills and vice versa. Sheep are constantly in search of fresh pastures, which may sometimes be along the edges of the forestlands and sometimes scrubs along the verges of waterways. The hazards that the flock-owners have to face for taking their sheep for grazing from place to place determine their management practices as well as their social habits.

The non-migratory flocks that are comparatively stationary, grazing are supplemented with crop by-products and salt. All the respondents (flock owners) those who do not migrate their sheep have to depend on surrounding forested area and grasslands as grazing land for their sheep throughout the year. In winter, there is a bit of fodder shortage problem due to heavy snow that affects the growth and/or covers the browsable winter forages. Some of them resort to make hay out of either improved forages or native grasses and/or whatever is available at home like radish and turnip as supplement in feed-lean season.

The migratory herds normally leave for its summer pastures by the 4th month of the Bhutanese calendar. These flocks return only by the 8th month coinciding with the auspicious *Thrue* (The Blessed Rainy day) of the Bhutanese. The migratory flocks remain in the summer grazing land for a period of 6 months.

The existing system of migration exists in those village households, where labour shortage is a problem that avoids crop damages, as these months are the seasonally activity-peak season. More importantly, it is the tradition that was in practice that encourages the people to migrate their sheep. Normally, sheep migrate with the yak herd to high altitude alpine pastures by the yak herders. A single yak herder can handle large flocks of sheep of more then 1-5 households. In fact it saves family labour that has to be involved in herding the sheep throughout the year. For herding the sheep, the yak herders have to be paid for herding that varies from place to place. In Gogona, the owners give a *pouri gang*[*] of wool per sheep per year. While in Shephu, the farmers pay 1 *Drey*[•] of Wheat or Barley per sheep per year.

Wool shearing and wool preference

Normally, sheep are shorn twice a year in 2nd and 8th month. Sheep are shorn with hand-shear (penknife) by members of the household who is capable of shearing. It would take 15-30 minutes to shear a sheep manually. The improved type of shearing is not practicable as yet. Women in majority were found doing this job. A sheep would yield to 200-700gm of raw wool depending upon the body size, health, and time of shearing. They believe wool production is normally higher in winter than in summer.

Sheep owners prefer black wool to white. This is because black wool doesn't require dying as white wool. In the naturally pigmented wool like black, greys, and brown, the pigment is incorporated into the fibres during their formation inside the wool follicles in the skin. In white wool, the fibres acquire the colour after their formation and growth into the fleece. The dyed white wool that is light fugitive, fades on exposure to light. Consequently, the dyed products made from such wool lose their brightness after some use. Normally, the farmers find expensive to dye the white wool and comparatively time consuming, which undermines the value of white wool and dislike improved Marino and their cross breeds for wool production.

Reproduction parameters

The reproductive efficiency is an important economic factor, which determines the return from sheep-rearing operations. It is only when rate of fertility is high that sheep and lambs would become available for better and more wool, more lambs, suitability to particular environment, etc. On the other hand, low lambing percentage affects the building up of flock strength and retards improvement, which can be brought about by proper selection and judicious culling. The reproductive efficiency depends on breed, environment, mating, season, age and general management, including nutrition.

As revealed by the sheep owners through their years of experience in sheep rearing, the reproductive parameters didn't vary much over the period of time (Table 3). However, fluctuation in the plane of nutrition would make the difference in their

[*] local unit for estimating wool yield (3 *pouri* is equal to 1 kg)

[•] local unit for weighing cereals (1 Drey is equal to 1.5 kg)

performances. Whatsoever, the genetic factors governing their performance remained unchanged over the years. No much difference in the reproductive performances of improved and local sheep was noticed.

Management and performance of sheep a decade ago

As responded, there was not a big difference between the body size of the sheep years before and that of now. However, 58.3% of the respondents from Sephu responded that sheep ten years before were larger than that of today (Table 4). All the sheep owners from the three geogs responded that the lambing behaviour of the sheep did not change over the years. 42.48 and 33.3 % of the sheep owners from Phobji and Gangtey goeg responded that there was no difference in fleece production of sheep. However, 33.3% respondent each from Sephu goeg responded to both more fleece yield and no difference respectively (Table 4). Similarly, only the sheep owners from Sephu responded that occurrence of disease ten years before was more as compared to that of today. Quite surprisingly, the sheep owners from Phobji and Gangtey again responded that there was either less or no difference on occurrence of diseases. Significant percentage of respondents responded that there was either less or no change on the type of management given while rearing sheep.

Majority of the farmers either had very less improved pastures or there was no much difference at all since most of the herds were migratory in the past. Similarly the fodder conservation practice was not there for sheep particularly. In extreme cases, they provide the sheep with turnip and radish as supplement to grazing. The system of sheltering did not change as of today. For Phobji sheep owners alone, the migration system had been dropped as flock size per household had declined considerably. 43% of sheep owners from Phobji geog responded that they had larger flock size in the past as compared to that of today (Table 5). However, the Gangtey and Shephu flock sheep owners, migration system did not change much in practice. They cannot do away with migration. It is quite interesting to note that there is a balance of response of 33.3% from Sephu. One third of the respondent either had more or less or no difference of flock size over ten-year period. For Gangtey, there is a balance of 33.3% of flock owners responded to either less or no difference with only 16.6 % respondents responding to better herd size in the past (Table 5). Since Bhutanese have strong religious sentiments attached to killings, sheep owners from all three geogs firmly responded that culling is not a common practice among them.

Why rear sheep

For the farmers of Phobjikha, reasons for rearing sheep are mainly for wool and tradition (Table 6). Rearing sheep is an age-old tradition followed from the time of their grandparents still in practice. To briefly highlight on tradition: from the time of their grandparents, they used to perform offerings locally known as *Tenzoo.* To keep this practice alive, each household needs to offer a live sheep either male or female to the deity. For those households who do not rear sheep also do need to make this offering after buying a sheep from the neighbour. The farmers of Gangtey and Sephu follow this

system of worshipping *Tenzoo* too. However, this system is getting neglected by the younger generation. The farmers from Gangtey and Sephu consider wool as first priority commodity from sheep followed by manure, tradition and lastly meat. Saying meat should not mean that they rear for meat purposely but those sheep that die of old age and minor sickness is consumed.

Economics and marketing of wool and related products

Sheep were found maintained mainly for the production of wool in these areas. The major portion of the wool produced was used for weaving *melchas*, *Charkap*, *Gho*, *Kira*, *chooktuk,* etc. Besides, other subsidiary functions were manure and meat. Much of the materials woven never catch market to earn cash income unless demanded. More of these hand woven products were used at home. If at all need be, they bartered these for cereals or any other urgently required household items.

The female members that had time and capability did converting wool to woollen products at home predominantly. Obviously, this would allow them to use leisure their time fruitfully. Whilst, the manufacturers of these products were always left desperate for their inability to find market and sell it. With the introduction of readymade garments, blankets, quilts etc at a much cheaper price, people prefer to buy these rather than the traditionally made materials from across the border or from the nearby town. Even the synthetic wool for weaves is readily available in the market at cheaper rate as compared to local wool.

General opinion on flock size, future of wool production and market of related products

As revealed by survey findings, sheep farming does not have any significant contribution in the economy of the farm household. Economically, the overall contribution is below 25 percent. Due to the materials benefit they derive more form other farming activities; the diversity of benefits derived from sheep rearing operation particularly is very narrow among the Buddhist flock owners. This is because the hard cash they could derive from selling live sheep or mutton is not captured. Therefore, wool and manure remains priority commodity for them, which do not attempt to fetch cash income. These farmers do not conceive the idea on the expansion as a whole. Rather than reducing, increasing the flock size is a far cry. There is no burning desire or innovation among them on what changes they could do to make sheep farming operation more beneficial and attractive.

Rearing sheep solely for wool as single commodity did not benefit the farmers much. Rearing large flock of sheep for producing wool to the extent of commercial exploitation is not marketable. So, not think of marketing of hand woven woollen products that cannot compete synthetic woollen products in the market. Economically, the costs of production of these hand woven woollen materials are quite high where as ready-made woollen materials in the market are cheaper and attractive. Therefore, rearing few sheep just for wool and manure for domestic purpose might seem economically sustainable in the long run till further Govt. intervention.

3.2.1.3 Conclusion and recommendation

Despite the fact that suitable sheep rearing conditions exists in Bhutan, much has not been made owing to the continued adoption of primitive managerial practices in the maintenance of sheep flocks. Obviously believed, if not goat in the small ruminant group, sheep rearing operation should largely benefit marginal and sub-marginal wealth group farmers in the temperate areas of Bhutan. Of whatever the total population of sheep exists, sheep rearing is still in the hands of illiterate and weaker sections of people who need effective support and facilities to cope up with the pace with time for improvement. In Bhutan, more than 80% of the sheep population lies in the temperate areas and most flock comprises of local breeds kept for wool. Over the years, sheep population has been found altered a lot towards declination. Role of sheep rearing in improving the rural economy is not found well established. It is especially true with resource poor farmers in the event of failure to buy woollen materials from the market with cash the home-woven woollen products have served their purpose. It is foreseen that sheep rearing can be recommended as subsidiary occupation for these flock owners. Sheep can subsist on low set and sparse vegetation where other species of livestock struggle to thrive which is possible because of their inherent capacity to browse. Farmers believe that sheep manure excels cattle manure and penning of sheep in harvested field enhances soil fertility and increase crop yield. As revealed by these flock owners migration and grazing practices have profound effect on sheep farming. Survey findings did reveal that sheep population was subject to considerable fluctuations on account of diseases, wild animals, drought and unfavourable market situation for wool and related products. With the exception of some constraining factors, the main production aims include wool and manure in the order of priority. Therefore, to further improve and make sheep rearing operation profitable the followings are recommended:

Study and find out favourable market for wool and related products within Bhutan and elsewhere.
Adoption of appropriate modern techniques of breeding, improvement in the feed and fodder resources, better management practices and provision of health coverage, will promote sheep development and in turn improve the rural economy.

Open good profitable scope for exploitations of sheep farming through initiation of rural industry.

Explore possible means of rearing sheep for meat and milk/butter beside wool and manure. (People consider sheep's milk and butter have medicinal value)

Study the adaptation through selection of local breed like Gharpala and Bonpala of Tsirang in other parts of the country, which is prolific enough to produce two lambs per lambing twice in a year.

Table 20 Trends in sheep population under Wangdue dzongkhag.

Year	Sheep population		Total No.
	Local	Improved	
1990	3360	454	3814
1991	2583	422	3005
1992	2012	312	2324
1993	1505	473	1978
1994	1071	789	1860
1995	1430	388	1818

Table 21 Farmer's problems of rearing sheep.

Respondents	Health (%)	Predator (%)	Breeding (%)	Feed/Fodder (%)
Phobji geog (14hh)	100	3	7	
Gangtey (12hh)	3	33		8
Sephu (12hh)	100	67		25

Table 22 Reproduction efficiency of local and improved sheep.

Criteria	Local	Improved
Age at first lambing	2-4 years	2-4 years
Inter lambing period	1-2 years	1-2 years
Lambs/year	1 lamb/ year	1 lamb/ year
Life expectancy	5-15 years	5-12 years

Table 23 Change in physical traits of sheep of ten years before and today.

Performance	Respondents from Phobji (I), Gangtey (II) and Sephu (III) geogs in percentage								
	More/large			Small/less			No difference		
	I	II	III	I	II	III	I	II	III
Body size	35.7	16.6	58.3	7	16.6	8.3	35.7	41.6	16.6
Lambing	7	8.3	8.3				64.2	50	9
Fleece production	7	3	33.3	28.5	8.3	25	42.8	33.3	25
Disease resistant	3	3	33.3	21.4	8.3	33.3	42.8	33.3	16.6
Management	7	3		28.5	8.3	16.6	50	33.3	58.3

Table 24 Change in the management system of rearing sheep over ten-year time.

Management system	Respondents from Phobji (I), Gangtey (II) and Sephu (III) geogs in percentage								
	More/better			Less/poor			No difference		
	I	II	III	I	II	III	I	II	III
Improved pasture		8.3	8.3	8	16.6	41.6	21.4	41.6	41.6
Fodder conservation		8.3		42.8	3	16.6	28.5	33.3	75
Sheltering		8.3		14	8.3		71.4	58.3	84.6
Migration	50			7			28.5	8	83.3
Herd size	42.8	16.6	33.3	5	33.3	33.3		33.3	33.3
Culling							85.7	58.3	83.3

Table 25 Reasons for rearing sheep.

Respondents	Wool	Manure	Meat	Tradition
Phobjikha (14 households)	85 %	64%	28%	85%
Gangtey (12 households)	83%	75%	17%	41%
Sephu (12 households)	100%	58%	33%	33%

Table 26 Body weights (kg) and body configurations (cm) of local sheep.

Identification # / Name	Age (yrs)	Sex	W Ht	Bl	Hg	Pg	El	Fl	Fw	Hl	Hc	Cc	Tl	Bwt
F1 Phurba	4	fl	62	64	63	66	14	22	22	p	p	6.5	17	26
F2 Phurba	4	ml	67	69	67	67	13	22	10	23	14	7	17	26
F3 Wangda	4	fl	67	64	66	66	11	24	10	p	p	6.5	13	23.5
F4 Wangda	5	ml	63	70	73	78	11	24	11	43	11	7	15	30.5
F5 Wangda	2	fl	56	65	64	75	8	22	10	p	p	6	13	23.5
F6 Wangda	5	ml	67	67	74	82	12	24	11	35	14	7	17	37.5
F7 Mindu	4	fl	60	62	66	72	14	20	10	p	p	6	14	26.5
F8 Mindu	6	ml	66	74	75	83	13	24	11	23	12	11	16	35.5
F9 Kinley	3	fl	55	56	75	73	10	18	10	p	p	6	16	24
F10 Kinley	5	ml	62	69	72	83	8	18	11	38	17	6	13	36
F11 Kinley	4	fl	64	63	78	70	11	17	12	p	p	6	13	32
F12 Kinley	5	ml	59	65	75	76	11	17	12	22	13	7	13	36
F13 Dago	3	fl	58	67	70	74	13	23	10	p	p	6	15	27
F14 Dago	3 mo	fl	47	47	51	55	11	16	7	6	6	6	13	13
F15 Dago	10	ml	68	75	80	79	16	25	11	32	15	7	16	39
F16 Dago	10	ml	68	74	77	79	11	24	11	46	17	7	12	45
F17 Dago	2	fl	55	58	64	70	12	22	9	p	p	6	10	21
F18 Dago	3	ml	60	67	68	75	7	22	10	15	15	6	15	27
F19 Gangto	4	ml	58	56	75	74	7	20	13	30	15	6.5	14	31
F20 Gangto	3	fl	62	63	75	69	11	20	10	p	p	6	11	30
F21 Gangto	4	ml	70	67	74	73	10	21	10	33	17	6.5	12	34
F22 Gangto	5	fl	57	62	66	68	10	22	10	p	p	6	10	27
F23 Rinzin	3	ml	64	68	73	80	11	21	9	24	15	6.5	20	33
F24 Phurba	5	fl	73	85	96	85	1	14	13	p	P	9	12	
F25 Phurba	3	fl	66	86	78	77	8	22	12	p	P	7	13	
F26 Phurba	8	fl	66	85	87	91	10	22	12	P	p	9	13	
F27 Phurba	7	fl	66	84	81	76	4	23	10	p	P	7	16	

F28	Phurba	7	fl	65	85	82	83	5	22	13	p	P	9	14
F29	Phurba	4	fl	63	84	79	74	10	18	10	P	p	9	12
F30	Phurba	5	fx	63	83	80	89	10	13	12	15	7	7	13
F31	Phurba	6	fx	63	87	82	84	7	25	12	p	P	8	10
F32	Phurba	10	mx	65	76	86	92	10	18	14	36	14	8	20
F33	Phurba	6	fx	65	83	80	89	12	13	12	P	p	9	18
F34	Phurba	5	fx	55	70	72	72	10	20	11	p	P	6	13
F35	Phurba	5	fx	66	85	75	86	13	20	12	P	p	7	16
F36	Phurba	5	fx	65	80	82	84	12	22	12	p	P	7	15
F37	Phurba	4	fl	58	76	68	68	12	17	12	P	p	7	14
F38	P Lethro	4	fl	54	75	69	68	10	20	12	p	p	6	14
F39	P Lethro	10	ml	66	90	98	85	12	22	12	27	12	7	13
F40	P Lethro	8	ml	65	95	86	86	13	24	12	19	13	7	16
F41	P Lethro	8	fl	60	75	75	79	13	22	12	p	p	6	12
F42	P Lethro	11	ml	65	93	84	87	12	23	12	40	21	7	17
F43	P Lethro	12	ml	65	80	80	85	12	22	12	38	23	7	17
F44	P Lethro	6	fl	60	75	82	83	12	22	12	p	p	7	12
F45	P Lethro	6	ml	65	87	78	82	7	22	12	37	18	7	14
F46	P Lethro	9	fl	64	80	78	76	9	24	12	p	p	7	18
F47	P Lethro	10	ml	70	98	80	90	9	23	12	38	21	7	15
F48	P Lethro	2	mx	60	68	68	72	13	18	10	19	13	7	13
F49	P Lethro	2	mx	60	90	75	75	11	20	12	37	18	7	16
F49	P Lethro	2	fx	54	84	64	64	12	17	10	p	p	6	12
F50	P Lethro	3	fx	60	80	78	82	13	18	12	p	p	7	15
F51	Pem	2	mx	60	90	76	70	10	17	6	22	5	8	18
F52	Pem Rin	5	fl	56	82	80	71	10	24	10	p	p	8	11
F53	Pem	7	fx	57	90	83	84	7	16	6	p	p	6	15
F54	Tshering	5	ml	56	77	76	77	10	19	6	17	13	7	13
F55	Tshering	4	fl	59	70	78	79	7	18	6	p	p	7	14
F56	Phub T.	5	ml	65	90	86	86	10	23	8	47	19	8	16
F57	Zomba	3	ml	57	82	70	76	5	22	12	20	13	8	13
F58	Zomba	5	fx	57	80	84	83	11	19	6	p	p	7	20
F59	Zomba	5	fl	55	76	82	81	6	17	7	15	8	7	18
F60	Phub Zam	3	ml	54	74	72	72	10	21	6	29	17	8	13
F61	Phub Zam	4	fx	56	84	84	76	11	15	6	p	p	7	16
F62	Phub W.	7	mx	67	90	90	90	6	20	7	23	16	8	17
F63	Phub T.	3	fl	58	79	83	83	10	19	7	p	p	7	15
F64	Phub T.	1	mx	53	77	73	77	9	18	6	26	15	8	15
F65	Pem Rin	3	fl	57	90	70	70	11	21	9	p	p	9	14
F66	Sacha D.	4	ml	66	80	90	91	10	24	7	21	13	8	17

(p-polled; fl-female local; ml-male local; fx-female cross; mx-male cross)

3.2.2 Livestock Baseline Survey Findings of Watershed

Main objectives were to document role of livestock and its contribution to the farming community, and to develop database on livestock species, breeds, husbandry practices and feed / fodder productions.

Findings : Pasture and fodder production
Almost all the farmers in the watershed area did not have improved pasture developed in their land. The reasons were no land, labour, seeds, cattle, irrigation, barbed wire, and basic knowledge. Only some farmers from Limbu, Dompola, Nabche, Omteykha and Matalumche responded having land and wanted to develop improved pasture in the dry land area kept as fallow. The main problem is irrigation then.

Improved pasture
Farmers in the watershed did not have improved pasture developed. However, their opinion about the improved pasture was affirmative saying it would benefit if they could develop. But the limitation was land holding. So, the alternative left was to enhance winter fodder production in the paddy field left fallow.

Tree fodder
The type of fodder tree they planted are *Ficus roxburghii, Salix babylonica, Omshing*, etc. These fodder trees were found planted around the homestead area and field boundary. The tree fodder was fed from February till April.

Compound feed
Not a single farmer had fed compound feed. As understood, they were not aware and heard of compound feed ever existed and sold. Majority expressed that they cannot afford to buy and feed compound feed. They relied mostly on agricultural by-products and crop residues if needed available at home.

Local Feed resources

Table 27 Cereal crops used as fodder

Crops		Animal type	Feeding system
Summer	Winter		
Maize shoot	Wheat, Barley, Buckwheat	Milking, draft bulls, horses	Raw / green

Table 28 Crop residues

Crops	Animal type	Feeding system	When
Rice bran, hulls/husk,	Milking, draft bulls, pig	As a mixture/ wet feeding	As available
maize grits and flour, rice bran, hulls, alcoholic residues	Milking and draft bulls, pig	Raw, cook and feed as a mixture	As available
De-oiled cake	Milking and draft bulls	As a mixture/ wet feeding	As available

Table 29 Local feeds

Species	Summer	Winter
Pig	Hedo, Bjagahedo, Zingsay, bran, hulls, alcoholic residue	Rice hulls/husks, alcoholic residues, alcoholic residue
Poultry	Paddy, rice, food, maize grain	Paddy, rice, food, maize grain
Cattle	Rice bran, hulls, maize grits and flour, pumpkins	Rice bran, hulls, maize grits and flour, Radish, Turnip, Pumpkins

Fodder conservation for off-season use

Fodder shortage in winter appeared to be critical in the area starting January to April. They normally stack paddy straw for use as fodder during critical feed-lean season. They overcome this problem by feeding the animal with paddy straw, Radish and Turnip. They did not conserve hay or silage as fodder for off-season use.

Grazing management and feeding practices

Stall-feeding practice was not common. Neither was free grazing. The system in practice was grazing and housing at night. Cattle migration was not common except for few farmers of Limbukha and Omteykha. The draft bulls were left for grazing in the community pasture after the works was over and collected whenever there were works. Milking, dry and small calves remained at home. The animals kept at home were supplemented green fodder, straw, and crop residues in addition to day grazing. They cut and feed green wheat, barley, oats and young maize shoot in the morning and evening.

Community Pasture grazing (Tshadrog)

Limbukha, Nabche, Omteykha and Dompola have registered community pasture. Only the community hailing from the same village had access to grazing rights. The number of cattle did not matter much. Herding as well as grazing of animals from non-community group had no access to grazing rights. In the past, migration of cattle to these existing community pastures was common. However, there had been major shift from seasonal migration to day grazing with the reduced in cattle heads over the years due to change in farming practices from livestock farming to agriculture cropping. The pastures are still there but the animals graze and come back home for the night. If need be only the bulls were left in the pasture when there was no work to home reduce competition for feed and fodder with milking cows.

Cattle: Breeds and breeding

Local cattle breed dominated the cattle population. The Mithun and Jersey cross totalled to 9.8% and 7.9% respectively only from the whole seven villages out of the total 822 cattle heads in the watershed. Rest is local breed. Limbukha has a Jersey and Mithun breeding bull each. While Nabche has only one Mithun breeding bull that came to service just few months back. Rest of the villages depended on local *siri* bull available in

the neighbourhood. The local *siri* breeding bulls were not found genetically sound for breeding as they were meant more for drafting then breeding thus the production performance of these progeny borne were not to the expectation.

Table 30 Cattle breeds and population village-wise

Cattle breed	Limbu	Dompo	Nabche	Omtey	Mata/chu	Wonjo	Thango	Total
Local *(Bos indicus)*	81	81	119	138	152	29	76	676
Mithun Cross	32	13	18	7	7	-	4	81
Jersey Cross	20	18	08	5	2	4	8	65
Total	133	112	145	150	161	33	88	822
Non-rearing farmer	2	3	-	-	-	-	-	5

Cattle housing system

Few farmers did not have housing for their cattle. Cattle were kept outside in the open both during summer and winter. Most of the farmers have now built housing for their animals. On our observation alone most had designed simple housing for cattle separately. Few able farmers had constructed improved housing with strong mud walls, zinc sheet roofing, proper drainage, FYM pit to pile the droppings and bedding materials, watering and feed trough curved out of wood logs and space for providing fodder.

Draft and drafting bulls

Normally, *Jatsha* (Mithun Cross- F1) were preferred most due to the fact that the bulls are very strong, powerful and obedient (meaning can tolerate long hours of drafting). This breed of cattle normally loves to graze in forests and on the terrain topography. This made rearing this breed difficult where such grazing area was not available nearby. Because of the fact most of the farmers now keep *Yanku* (Mithun Cross-F2), local siri bull and even Jersey crosses for drafting purposes. These breeds of drafting bulls were found easier to manage compared to *Jatsha*. It was also reported by most of the farmers that the local bulls (Siri, Jersey Cross, Yangku) made good pair with *Jatsha* at times when they didn't have drafting bulls of same breed.

Animal products and marketing

Majority of the farmers in the watershed area was found rearing local and non-descript cattle breeds that produces little milk. Cheese and butter were the common marketing items but only if available in surplus. The findings revealed most farmers did not sell the produce but used it for household consumption. In fact many reported that they have to buy it from the Sunday market at Wangdue and Punakha. Rarely, some farmers did also sell meat (beef) when their cattle died of old age and minor illness.

Poultry: Poultry breeds and breeding

Nearly six local breeds of indigenous birds were recognised in the watershed area. Most of these breeds were non-descript and could be identified from their body colour only. Depending on their plumage colours the local breed can be categorised into six major verities. The golden yellow, dark black, black and white spotted, light red to dark red, white and golden and white. Among these, golden yellow, dark black, black and white spotted and light red to dark red are the most common varieties. Breeding within these local breeds take places unrestricted and uncontrolled. Few farmers reported crossbreeding between local male and improved females had been happening naturally. However, crossbred progeny was not reported available.

Table 31 Breeds and village-wise poultry numbers

Breed	Limbu	Dompola	Nabche	Omteykha	Matalumchu	Wonjo	Thango	Total
Local	23	37	84	59	69	47	33	352
Cross	-	-	-	-	-	-	-	-
Improved	1	-	-	-	2	-	2	5
Total	24	37	84	59	71	47	35	357
Non-rearing	12	9	2	7	3	1	6	40

Hatching and rearing

The laying capacity of the local birds ranges between 10-20 per month with rest period of 15-30 days or sometime even more per lay. Hatching for most farmers was reported uncommon. On need basis allow to hatch once every 2-3 years. The owner depending upon their need controlled hatching. Depending upon the body size and mothering ability of the broody hen the owner gave 6-15 eggs for hatching when time came for renewing his flock. The report revealed that the average hatchability percentage was around 70-100 %, which is quite a healthy achievement under farmer's conditions. Most of the farmers were found rearing 1-9 birds only. Rarely the number exceeded to 15 or more.

Housing and rearing system

The system of management is mostly semi-intensive. Few farmers had resorted to rear under total free-range conditions. Under semi-intensive conditions the birds were let loose during the day and lodge shelter during the night to protect them from inclement weather, and also to maintain production. The housing were simple designed to accommodate the poultry birds at night and protect from harsh weather conditions and nocturnal predators. There were neither run attached to it nor had the provision of feed and water trough and laying boxes. Just a simple shed. While birds kept under free-range or scavenging conditions look for safe shelter on the ceiling tops or inside the ground floor. Those birds were prone to attacks by predators and wilder in nature.

Food and feeding

The poultry birds depended mostly on whole maize grain, maize grits, whole paddy grains, cooked food that man eat. The birds reared under semi-intensive system were found fed twice daily. Few farmers reared poultry under complete free-range conditions. Those birds were left unfed and depended solely on scavenging conditions.

Marketing and other benefits

As revealed by most of the farmers their primary aim of rearing poultry was for eggs, and sold live for money when need for money was very urgent. Quite often than not, eggs were used for household consumption and sold if available on surplus. The other reason for rearing poultry was for crowing. It was noted during the survey that few farmers were found keeping only cock solely for crowing. Traditionally, in the villages the crowing of the cocks wakes up the family members to get ready early for their morning's works.

Pigs: Why rear pig?

Pigs were reared mainly for pork requirement of the household's annual ceremony locally known as "*Choko".* It was quite interesting to note that most farmers had at least reared one pig for annual *Choko*. Pig rearing was found closely associated with *Choko* as they consider pork was the desired meat of taste and choice for this celebration. Few farmers out of the fear of hurting the religious sentiments revealed that they rear it both for pork and cash income. Some farmers even produced piglets for sale and generate cash income.

Breeds and breeding

The local, improved and crosses were the three major pig breeds. Out of 234 pigs in the whole watershed, 137 were local, 72 crossbreed and 25 improved breeds. Pigs reared for breeding were very rare. Very few households reared both male and female for breeding and producing piglets. Once the piglets were littered the male was sterilised and kept for fattening. Keeping one or two piglets at home sold rest to neighbour or to anyone came for buying. Normally, breeding local X local and local X improved existed. The local and improved crossbred pigs were locally called as *Giba.* The *Giba* were larger in body size, faster in growth, higher in litter size compared to local pig and better pork quality then that of improved pig breed. Genetically, it possesses the phenotypic and genotype traits of their parents. There had been increasing in trends of rearing crossbreed pigs over the years as reported.

Table 32 Pig breeds and number per village

Cattle breed	Limbu	Dompola	Nabche	Omteykha	Matalumchu	Wonjo	Thango	
Local	13	5	23	13	54	8	21	137
Cross	8	13	21	8	8	1	13	72
Improved	1	1	7	4	6	-	6	25
Total	22	19	51	25	68	9	40	234
Non-rearing	8	13	2	10	4	3	4	44

Feeds and feeding

The pigs were found fed with whatever local feed resources available at home viz., crop residues, vegetable leaves, roots and tubers, and local summer grown weeds. The pigs were fed 2-3 times a day. The free roaming pigs when did not get food resorted to eat human faeces.

Housing and rearing

The pigs were kept in a simple raised wooden sty with a provision of roof to protect the pigs from direct sunlight and rain and floor for sleeping and resting. Wood logs were curved and made food and water trough. Few farmers at Libukha and Nabche reported have no house made for their pigs. The pigs were let loose with the cattle or tether under the tree or shade. The homeless pigs lodged shelter either inside the ground floor or outside in the open where direct rain and sunlight was obstructed or protected.

Horse: Why keep horses?

The reasons why farmers kept horses were mainly to transport FYM, collect firewood, collect paddy and paddy straw from the field, transport vegetables and rice for sale in the market and pick up salt and other household requirements from the market.

Horse breeds

There were in total 158 local horses and 10 mules in the whole watershed area. Matalumchu had the highest local horse population of 46 and Limbukha 38. There had been no report on availability of Haflinger crossbred.

Table 33 Horse breeds and number village-wise.

Breed	Limbu	Dompo	Nabche	Omtey	M/lumchu	Wonjo	Thango	Total
Local	38	25	14	22	46	1	12	158
Mule	3	2	1	1	1	-	2	10
Total	41	27	15	23	47	1	14	168
Non-horse keeper	-	8	10	-	3	6	4	31

Current status of livestock produces

Only a few farmers from Limbukha reported the sale of dairy products. Majority bought from the market. The produces were just sufficient for household consumption. Especially cheese, butter and beef were not available for commercial purpose. Exceptionally, egg and pork looked to be slightly stable as compared to dairy produce.

Constraints and priorities

The major constraints hindering the development of livestock and feed and fodder in the watershed according to priority were:

Winter fodder, hay and silage making

Shortage of fodder in winter starting from December to April was very critical. The farmers store paddy straw to overcome fodder crisis during this five months. Radish and turnip were also reported equally important fodder in winter. They chopped mixed rice bran/hull/husk and salt and cooked and fed it. Such system of feeding was meant for milking and draft bulls. Rests survive on whatever browsed during daytime and received few bundles of paddy straw if available. At present, most of the farmers grow oat to overcome winter fodder problem. Those non-oat growers fed green wheat to both cattle and horse. Also, most farmers reported green wheat was fed mostly to horse. However, oats have been becoming increasingly popular in the watershed and replacing wheat and other green cereal type winter fodder. More oat seeds in association with one or more legumes could be tried.

Livestock species, breeds and marketing

The livestock population in the watershed to be areas were dominated by the indigenous livestock species. The production potentials of these local livestock species are genetically poor though their adaptability to local conditions was good. This had resulted in deficit production especially milk and its related products at the household level. The cash income generated form the sale of livestock products were very little or nil as of now. Therefore, to have sufficient livestock produce for household consumption and for sale it would take another five years or so if maintained same pace of development in the field of livestock farming. There should be major shift in livestock rearing and farming pattern.

Taking cattle as one livestock species, as revealed by most of the farmers that they are happy with whatever is produced but their concern was manure and draft power. Keeping many heads of cattle only fulfils their requirement of manure and draft power. We felt keeping just 1-2 hybrid milking cows on stall-fed conditions and keeping a pair of bullock can achieve it. The number of milking cows could be increased depending upon ones own capacity to rear and the fodder resources available. This way, the household requirement for milk, cheese and butter would be fulfilled and left in surplus for sale and generate cash income.

Breeding bull / AI services

At the moment there was only one Govt. placed hybrid Jersey bulls at Limbukha. In addition to this, there was two-hybrid Mithun bull one at Limbukha itself and the other at Nabche. Rest of the villages neither had breeding bull nor artificial insemination services. This could be one reason that local cattle breed had dominated the improved and cross breed population. The general discussion generated that there is strong need of breeding bulls or artificial insemination services. In our observation too, artificial

insemination services could be introduced since all the villages are located at close proximity to the livestock extension service centre.

Veterinary Hospital

As discussion geared by the farmers of Wonjokha and Thango the former location of Veterinary hospital at Bajo deemed most appropriate. Relocation later at Pateykarpo quite at a distance and across the river had been causing lot of problems reported the farmers of Wonjo and Thango. As per the grievances shared by the Wanjo/Thango farmers a cow on heat has to be pulled all the way to Pateykarpoha for insemination. Quite often then not, the animal has to be dragged and pushed to cross the bridge with utmost difficulty and it is normally not easy for the women to do this. Again imagine the situation if the AI man is not available at the centre. The cow on heat has to be brought back the same way home full of stress and let the scrub bulls serve. Similarly, to get a medicine for a sick animal or to call the hospital staff for the treatment the owner has to walk up to that isolated location site of veterinary hospital leaving even urgent work aside to receive the medicine or bring home the man for treatment. Relocation of the veterinary hospital at the strategic site would help cater better services for the benefit of farmers.

Farmer's training, Field days, Study tours

Hardly one or two farmer form the whole watershed area was ever trained on fodder conservation and on animal husbandry practices. In general, majority of the farmers was demanding training on fodder conservation; pasture development including winter fodder, improved backyard (Dairy, Pig, and Poultry) farming, and farmer-to-farmer interaction through study tours and field days. This training they expressed would be very important as it covers and teaches basic knowledge required in day-to-day life for livestock farmers.

Future scope and development

A lot of room is seen open for livestock development in the watershed area. The population data clearly showed poor backyard uptake of improved backyard farming by the farmers in these areas as suggested by the type of livestock reared. The local species had dominated total livestock population. There was not much of crossbreeding done except in pigs. The leading factors limiting this poor uptake were fodder shortage, manpower, grazing lands and lack of knowledge on modern husbandry practices. The other good thing happening was the conservation of local livestock species by the farmers quite unknowingly. This is one of our national breeding policies goals. They depended largely on local livestock species though non-descript and low producing. By and large, the farmers expressed quite interestingly that cattle are reared primarily for manure and draft than milk and related products. High scopes of rearing few but productive cows under stall-feeding are foreseen.

4 FORESTRY

Besides the usual focus of the forestry sector of the centre into social forestry much empahasis have been given to other activities. The thinning treatments of the stand stability trial in Khotokha forest management unit have been applied and a bamboo and cane study of the Punakha and Wangdue valley has been carried out. Most of the activities of the centre in the Lingmutey Chu watershed under the community forestry projects are long term. Further the multi-purpose tree species trail and the community forestry plantations have been assessed for height, diameter and form development.

Research needs in farmer oriented research as identified by the Dzongkhag forestry sectors during the regional RNR workshops are jointly implemented with the Dzongkhag forestry sector.

For the purpose of this report the activities of the sector have been divided into four namely onstation, Lingmuetey chu watershed, territorial forest management units and other.

4.1 On-station activities

Activities on-station of the forestry sector include the evaluation of multi-purpose tree species (MPTS) and evaluation of propagation techniques in the nursery.

4.1.1 Introduction and evaluation of MPTS

Trees are very rarely used for a single purpose. Virtually all trees can be used for at least two purposes since they can be burned as well as used in solid form. Trees use include such as firewood, timber, fodder, medicinal and a host of other uses (Table 1). As populations increase, pressure on land becomes greater. Also more often than not most farmers are resource-poor with very limited land. A means to decrease this pressure and also help the resource poor farmer is to use the limited land more intensively by raising agricultural crops, domestic animals and trees on the same unit of land, either in intimate spatial mixture or in temporal sequence. These combinations are collectively called agroforestry (Hocking and Wangdi, 1999).

Table 34 Uses of few MPTS tested at Bajo

MPTS	Use				
	Fodder	Fuel	Fruit	Timber	Other
Syzygium cumini	✔	✔	✔	✔	Tannin, medicinal
Robina psuedacacia	✔	✔	-	✔	Paper, dye, medicinal
Azadirachta indica	✔	✔	✔	✔	Tannin, oil, medicinal
Albizza lebbeck	✔	✔	✔	✔	Tannin, gum, green manure
Populus spp.	✔	✔	-	✔	Manure, Pulp, soil stabilization
Dendrocalamus strictus	✔	✔	-	-	Paper, poles, rayan, pickles
Leucaena leucocephala	✔	✔	-	✔	Gas, pulp, medicinal
Melia azedarach	✔	✔	-	✔	Aromatic oil medicinal, whisky
Morus indica	✔	✔	-	✔	Medicinal, paper, basket
Gmelina arborea	✔	✔	-	✔	Pulp, medicinal

Source: Singh, S.P. (1995). *Favourite Agroforestry Trees*. Agrotech Pub. Academy, Udaipur, India.

There is tremendous demand for fodder, fuel, timber and many other tree products. Wood is the only source of energy in the rural areas and even in the urban areas of the country.

The aim of the activity is to evaluate such MPTS for growth in terms of height, diameter and form (based on a subjective form score of 1 (very poor) to 5 (very good). Results are given in table 2. Mean total heights and mean total diameter were significantly different ($p<0.01$). *Melia azedarch* (6.8 m) attained significantly larger mean total heights than all species assessed. It also achieved the largest mean total diameter (25.3 cm) than all test species except *Gmelina arborea* (16.0 cm). There were no significant differences between the mean total heights and mean total diameter of the other species. There were no significant differences between the mean form scores of the species, albeit *Acrocarpus* (4.3) and *Gmelina* (4.0) had larger form scores than the rest.

Table 35 Means of total heights, total diameter and form score of MPTS, on-station

Test species	Total height (m)		Total diameter (cm)		Form score+	
	Mean	s.e	Mean	s.e	Mean	s.e
Spondiax auxillaris	3.4	0.2	11.6	1.0	3.0	0.1
Robina psuedoacacia	3.4	0.3	9.5	1.1	2.9	0.1
Docynia indica	2.7	0.1	5.9	0.4	3.3	0.4
Albizzia procera	2.9	0.3	13.5	1.8	3,2	0.3
Acrocarpus fraxinifolius	3.1	0.3	13.5	2.1	4.3	0.2
Quercus griffithii	2.8	0.3	7.3	1.2	3.5	0.4
Leucaena diversifolia	4.0	0.3	12.2	1.2	2.3	0.2
Leucaena leucocephala	3.7	0.1	12.9	1.1	2.9	0.1
Melia azedarach	6.8	0.5	25.3	3.7	2.0	0.0
Morus indica	3.1	0.1	6.6	0.9	1.8	0.2
Poplar spp.	3.1	0.5	7.5	1.8	3.5	0.5
Gmelina arborea	3.4	0.1	16.0	1.2	4.0	0.0
Total	3.4	0.1	11.9	0.6	3.2	0.1
Significance level	**	-	**	-	NS	-

+ 1 lowest; 5 highest * = $p<0.05$ ** = $p<0.01$ NS = not signiificant

4.2 Vegetative Propagation of Bamboo

Seeds of bamboo species were sown in either polypots or raised beds. After germination two methods of vegetative propagation namely through rhizome and tillers for mass propagation were tried. The former method involved planting individual shoots with their rhizomes attached (fig 1) in polypots and left to form roots. This method proved very successful for mass propagation of, *Dendrocalamus hookerii, Bambusa nutans, Dendrocalamus hamiltonii,* and *Bambusa calvata* (results in table 3)

Propagation through the latter method entails separating tillers and small parts of rhizome with their nodes intact (fig. 2) and planting them into polypots filled with a specially prepared growing medium (rice husk mixed with manure and sandy soil in equal proportions) and are regularly watered. Sprouting and root formation takes place within 20-30 days, these can be ready for transplanting during the same season. In this way a large number of planting stock can be generated. Bamboo species with smaller culms are most amenable to this method.

Table 36 Bamboo propagation through Rhizomes

Species	Shoot (nos)		Dia Increment(cm)	
	1999	2000	1999	2000
1. Dendrocalamus hookerii	2	7	15	20
2. Bambusa nutans	1	2	10	13
3. Dendrocalamus hamiltonii	nil	2	10	15
4. Bambusa calvata	1	3	14	15
5. Yushania maling	Did not survive			

Figure 8: Separating shoots with rhizome **Figure 9 Separation of tillers**

4.3 Activities in the Lingmutey Chu Watershed

The major activity of the forestry sector in the Lingmutey Chu watershed in which RNRRC, Bajo has initiated community based natural management (CBNRM) research since 1997 is in community forestry. 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.

4.3.1 Community forestry (CF)

The Community Forestry Nursery (CFN) created (at Omtekha) in 1997 to identify and generate diverse tree species suitable for fodder, fuel, timber, community plantation is now fully functional and has a capacity of producing an average of 20000 seedlings per year.

Using seedlings generated in the nursery the communities and the forestry sector of the centre has jointly increased the area under plantation to about 20 hectares with a further 6 hectares planted in 2000.

In the summer of 2000, randomly selected plantations have been assessed for height growth and survival. Unfortunately diameter was not measured. Measurements of height, survival, diameter and form shall allow the assessment of growth in terms of total height, height increment, survival, total diameter and diameter increment and tree form. Results of the assessment are given in table 4 below.

Table 37 Mean total heights (cm) and survival (%) of MPTS in the CFP, Omtekha

Test Species	Mean total height (cm)	Standard error of mean	Survival %
Cupressus spp.	61.4	1.3	97.0
Quercus griffithii	25.1	0.8	92.7
Melia azedarach	51.3	1.6	93.7
Leucaena diversifolia	29.1	1.5	88.1
Albizza spp.	28.7	2.5	96.4
Syzygium cumini	55.6	3.2	97.1
Quercus lanata	16.0	1.1	94.1
Total	43.6	0.9	-
Significance level	**	-	NS

* = p<0.05 ** = p<0.01 NS = not significant

The mean total heights of test species assessed were significantly (p<0.01) different. Mean total heights of *Cupressus* species (61.4 cm) were significantly larger than mean total heights of all test species except *Syzygium cumini* (55.6 cm) while mean total height of *Syzygium cumini* were significantly smaller than the mean total heights of all species except those of *Melia* species.

Syzygium and *Cupressus* attained the highest survival rates of 97 percent each while *Leucaena diversifolia* (88 %) gave the lowest survival percentage.

4.3.2 Multi-purpose tree species (MPTS) assessment trial, Omtekha

The trial was established with the objective of identifying woody species that grow adequately on degraded land and provide timber/poles, fuelwood, fodder while at the same time conserve and stabilise soil. It was a randomized block design trial. Blocking was achieved by planting trees along the slope (and therefore fertility) gradient with ten seedlings of each species in a block. The trial was superimposed on poorly vegetated areas of the community forestry plantations at Omtekha. Results are presented in table 5.

Mean total heights and mean height increment were significantly different from each other ($p<0.05$). Mean total height of *Acacia arabica* (101.0 cm) and *Cupressus* spp (83.7 cm) were significantly larger than mean total heights of all other species while *Quercus lanata* (18.4 cm) had the smallest mean total diameter. *Acacia arabica* (49.8 cm) also achieved significantly larger mean height increment one year after planting while the next largest mean height increment was achieved by *Melia azedarach* (35.0 cm) obviously showing these two species as the fastest growing among the species tested. Significant differences in survival were found only between *Cupressus* spp. and populus spp. (40% each) and the other of the species. There were no significant differences between the survival percentages of rest of the species.

Table 38 First year results of the MPTS assessment trial at Omtekha

Species	Mean total height after 1 year (cm)	Mean height increment (cm)	Survival after 1 year (%)
Robina	41.2	23.0	90
Leucaena diversipholia	76.5	-5.4+	80
Acacia arabica	101.0	49.8	100
Mahel	63.7	28.1	70
Albizzia lebbeck	28.1	-7.9+	100
Lopshe	31.9	5.1	90
Albizzia stipulata	26.9	5.1	90
Acrocarpus fraxinofolia	26.9	-15.3+	100
Melia azedarach	52.8	35.0	100
Quercus lanata	18.4	11.3	100
Morus spp.	52.5	-2.1+	80
Ailanthus excelsa	29.8	6.3	40
Poplar spp.	30.8	-1.6+	40
Cupressus corneyana	83.7	10.9	90
Albizzia procera	25.9	-0.3+	70
Significance	*	*	*

+ negative as trees are browsed/dieback. * = $p<0.05$ ** = $p<0.01$ NS = not significant

4.4 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.

4.4.1 Khotokha FMU

The Khotokha Forest Management Unit is situated in Bjena and Rubisa geogs of Wangdue Phodrang Dzongkhag. It covers an area of 9407 hectares and ranges from 2300m to 3785m in elevation.

The dominant tree species in the FMU is blue pine (*Pinus wallichaina*, A. B. Jackson) It has many uses in Bhutan. Besides being the most important species for timber, poles, chams and firewood, blue pine forest are also used for collecting leaf litter for farmyard manure.

A stand stability trial with the objectives to: gain knowledge on the silvicultural treatment of young blue pine stands; quantify the effect of thinning on the natural regeneration on former pasture land; improve stand stability by stand treatment (thinning); and improve timer quality of the stand (thinning and pruning).

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

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

Research site has been identified and plots have been identified and demarcated Boundary plos and inner plots have been marked with yellow and red paints respectively and trees for felling, and pruning have been marked with coloured ribbons. The thinning treatments are (T1: Control; no thinning at all; T2: Moderate thinning; about 25 % of the standing volume are to be removed; T3: Heavy thinning; about 30 to 35 % of the standing volume are to be removed). Trees for felling and future trees have been selected and marked with coloured ribbons have been applied. The criteria for assessment for each tree before the treatments are: tree number; tree species; diameter at breast height (dbh); tree height; social position; tree broken (no; <1/10, 1/10 – ¼ , ¼ - ½ , > ½ , tree completely dead); damages, pest and diseases (bark damage by deer, bark beetles, fungi, etc.); remarks (e.g. forest fires). The thinning treatments have been applied and future trees have been pruned. The trial shall be visited every three years for assessment.

4.4.2 Rimchu FMU

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

A regeneration survey as part of a training workshop for territorial foresters in collaboration with NRTI and BG-SRDP has been carried out. Guidelines developed by the FRDD were used. Results are yet to be analyzed.

Noting the acute paucity of research in broadleaf forest and the general need to involve more forestry personnel in forestry research, it was decided during the 3rd national forestry research Coordination workshop, that research work in the broadleaf forest would be conducted collaboratively by RNRRC Yusipang and Bajo, the NRTI, the BG-SRDP and the territorial division of the DoFS. Accordingly in November 2000, BG-SRDP, organized a meeting of forestry personnel from these organizations at Lobeysa to identify research themes and work out a modalities of carrying out the collaborative research work at Rimchu.

4.5 Other Activities

The only other major activity conducted by the sector is a bamboo and cane study in the Punakha and Wangdue valley.

4.5.1 Bamboo and cane: CBNRM case study

As part of the framework development for CBNRM in the country coordinated by the Department of Research and Development Services, the sector also conducted a bamboo and cane study in the Punakha and Wangdue valley.

Results are available separately as a case study within the CBNRM framework. Three types of bamboo were encountered during the study: *Cephalostachyum latifolium* (local name – Munro); *Borinda grossa* (local name – Rhui baa); and *Chimonobambusa callosa*). Only two types of cane viz. *Plectocomia himalayana* (local name – Patsa) and *Calamus acanthopathos* (local name – Moo) were found.

Bamboos and canes are used extensively and intensively for a variety of purposes. They serve as building material, for making various types of baskets, mats, agricultural implements, handicrafts and young shoots are used as a vegetable. Subsistence uses include mats for drying, roofs for cattle sheds, baskets for storing grains, internal partitioning of houses and for making celings of rooms etc while commercial uses are mainly manufacture of large mats and baskets, the former used as roof of tree nursery sheds, fencing and scaffolding on a large scale while the latter is used for keeping fruits, vegetables and waste paper baskets. Use of bamboo in Sephu are carried out by the following communities: Rukubji, Langyi, Busa,

Wangjonpa, Lumbzaar, Jirii, Naksha, Sekta and Thangna. However only Sephubs use the resource extensively for commercial purposes.Besides the use in weaving baskets, bowls and rope making together with bamboo cane is sold in very small quantities a “patsa”, a bitter vegetable from Uma, Taksha, Adang and Rimchu areas.

Free grant of bamboo cutting for subsistence use is 100 culms. Commercial bamboo cutting is done by obtaining a permit (Nu. 8/100 culms). This royalty is either paid by the local people or the contractor depending on the arrangement. One man can cut and drag bamboo enough to make three standard size (6 * 4 m) of bamboo matsin a day. Splitting bamboo for bamboo mat takes about an hour per mat and weaving takes about quarter of a day per mat. While cane is used, wherever available, with bamboo to manufacture bamboo and cane products and sold as "patsa" a bitter vegetable, cutting cane is not permitted legally and no permits are allotted by the Range Office.However one man can cut 40-60 sticks of patsa (about a metre long) in a day and sell them for Nu. 10-15/stick. This serves as a very important supplementary source of income particularly for the poor households.

There are currently no management prescriptions for bamboo and cane. A permit system allows bamboo cutters to cut bamboo beyond the allowable free grant of 100 culms per household. Permits are given at Nu. 8.00 per 100 culms and in theory any number of culms can be harvested this way. The local forester can exercise his judgement to protect the resource by informing the forest range officer about the status of the resource and halting permits for areas where the resource is declining. However this becomes difficult in the field as not all bamboo are harvested legally with a permit. An estimation of the amount of bamboo cut by checking permit records would definitely give less than what is truly harvested.

Bamboo resources are perceived by local as susceptible to over-cutting, grazing and logging activities. The huge demand afforded by commercialization lead to over-cutting of bamboo whereby even young immature culms are harvested indiscriminately. Grazing is a serious problem particularly in relation to bamboo regeneration.

The following solutions for better management have been proposed by the farmers: restriction on harvest of young immature culms and control of grazing; Reduction in volume harvested for commercial purposes; Empowerment of local people to curb wanton cutting by outsiders; and Community Forestry.

4.6 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.

5 SYSTEMS RESOURCE MANAGEMENT

5.1 CBNRM in Lingmuteychhu Watershed

5.1.1 Crop Production and Management Research

5.1.1.1 On-farm Paddy variety for High altitude

The trial results till seedling vigour and cold tolerance were presented in 1999-2000 report, further continuation of the trial for its crop cut and other biophysical results are mentioned below in table below.

Table 39 Crop cut result of high altitude blast resistant rice variety

Variety	Plot Yield in Kg per Crop Cut and MC% Plot size = 10 sqm						Remarks
	Crop Cut 1		Crop Cut 2		Crop Cut 3		
	Yield	MC	Yield	MC	Yield	MC	
PP_2(38-4)	3.25	18.7	-	-	-	-	Had plants for one crop-cut only
$PP_3$22-1-2	-	-	-	-	-	-	Seeds did not germinate
PP_3-31-2-1	-	-	-	-	-	-	Seeds did not germinate
PP_4-8-1-1	5.5	18.5	5.0	18.2	6.0	18.8	

Among the four varieties tested, only one variety (PP_4-8-1-1) had good result. The farmers reported that this variety matures earlier besides having more yield than the local, but it is difficulty to thrash. The farmers preferred the variety and preserved seeds for the coming season to multiply.

5.1.1.2 Farmers evaluation on released paddy varieties

This trial was also in continuation to the last years report with the objective of continuing evaluating the production of released paddy varieties (Bajo Kaap & Maap I & II) at farmers' management condition. The earlier report covered till seedling germination and its vigour.

Farmers' feedback on the positive and negative aspects of the trial was collected from all the cooperators. Among the four released varieties tested on farm, the yield differences among the samples are shown in the figure and table beolw. The crop cut yield was taken from an area of 5 m^2 randomly. From the four samples tested Bajo Kaap II had the higher grain yield of 7.35 t/ha followed by Bajo Kaap I with 5.73 t/ha, Bajo Maap I with 4.83 t/ha and Bajo Maap II with 3.72 t/ha. The grain yield depends very much upon the management practices and inputs applied.

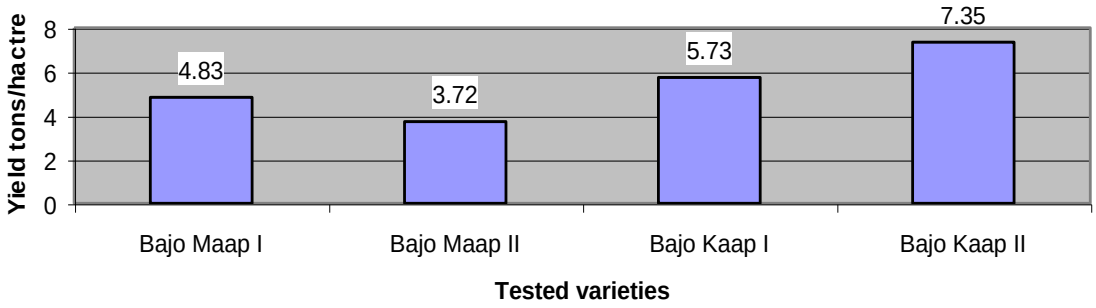


Figure 10 Average rice yield of 4 new varieties

Farmers feedback

Milling Recovery

The milling recovery rate of the tested varieties as mentioned by the farmers are:
Bajo Maap I : 6.5 dreys milled rice out of 10 dreys rough rice or 65%)
Bajo Maap II : 5.2 dreys out of 10 dreys or 52%)
Bajo Kaap I : 4.4 dreys out of 10 dreys or 44%)
Bajo Kaap II : 4.8 dreys out of 10 dreys or 48%)

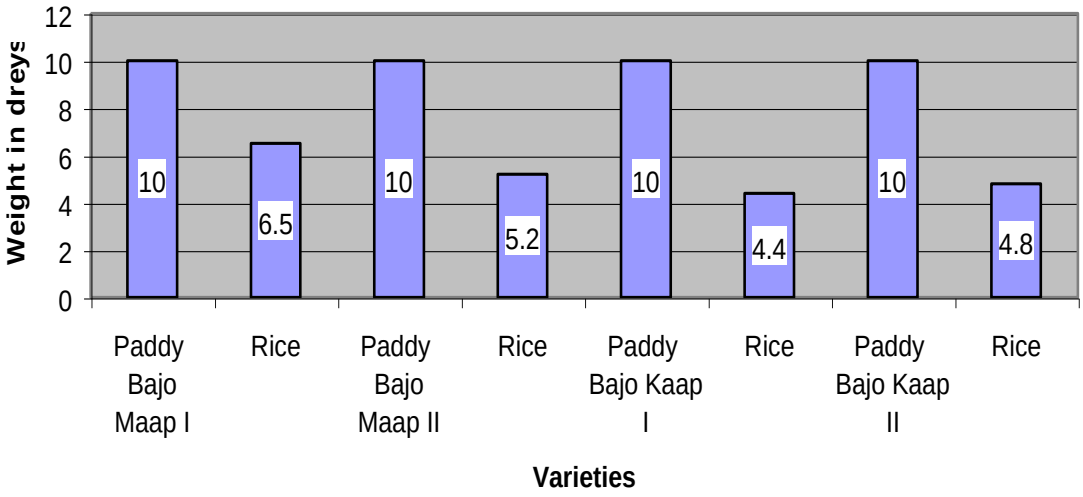


Figure 11 Milling recovery of new rice varieties

Threshing and Taste

From the tested varieties Bajo Maap II is reported to be harder to thresh in comparison to other varieties. But in taste Bajo Maap II is much preferred and is rated even better than the local variety. Overall the new varieties are good in taste and preferred by farmers.

Farmers preference

Among the four varieties tested, the farmers liked Bajo Maap I the most since this variety has average yield, good milling recovery, good taste and lastly it is red in colour. The farmers had high demand for more seed next season and they were informed on the seed source (Druk Seed Corporation) where it will be available.

5.1.1.3 Sochum weed control campaigns

Shochum (Potamogeton distinctus) is a noxious perennial weed infesting wet land rice field. This weed is also quite common in the Limbuteychhu Watershed, it cannot be controlled by the common weedicide. Therefore, in order to control the severity of the weed, seven farmers from the Watershed were taken on study tour to Paro to learn and interact with Paro farmers on the management of this weed where the Paro farmers control the weed intensity through intensive hand weeding. Similar trials or campaign was organised in the Watershed at one site and practice hand weeding upto three times to control this weed. The program will be continued for next two years and assessed with the following objective:
To demonstrate to farmers on the yield difference between intensive hand weeding and normal practice, and to control the weed in the farmers field.

One cooperator farmer was selected from Omteykha village upon his willingness to take up the activity and an area of 1 langdo was observed by doing intensive hand weeding for 3 times in first year. The weeding was conducted after 15 days of transplanting followed by 2nd and 3rd weeding at an interval of every 2 weeks where the weeds were uprooted and removed with its roots and disposed in one place.

Crop cut samples was taken during harvesting time from the intensive hand weeded field and normal practiced fields from an area of 6 square meters with 2 samples from each field. The findings of the crop cuts were as mentioned.

Table 40 Tield of rice as affected by weeding practice

	Weeded field		Normal Practice	
Variety	Local Maap		Local Maap	
	Yield (Kg)	MC %	Yield (Kg)	MC %
	3.250	11.7	3.125	11.1
	3.750	12.8	3.250	11.7
Average	3.500	12.2	3.18	11.4
Yield tons/ha	5.56		5.36	

There is not much differences in the yield in the first year but the farmers felt that the plants on the weeded field are more healthier than the unwed field and hope the yield will increase in the subsequent years.

5.1.2 Horticultural activities

5.1.2.1 Demonstration Orchard

In the second year of the establishment of demonstration orchard at Omteykha, more fruits plant varieties were planted. In the first year the total of 67 different fruit plants were planted, this year additional 31 fruit plants were added as mentioned below.

Fruit plants species	No. of plants	Date of planting	Remarks
Sub-tropical apple	13 nos	26/3/2001	Including 2 pollinizer
Local mandarin	13	26/3/2001	Including 3 rootstock
Walnut	5	26/3/2001	

Among the tested varieties in the demonstration orchard, it was observed that subtropical apple performed best among all the fruit plants. All the plants were applied with split dose of urea @ 20 gm per tree and timely spray of chemicals (Calyxcine and Cypermethrine) to control from pests. Within the second year of plantation it has started bearing fruits and during the first harvest on 10/7/2001, the following data were collected.

Table 41 Performance of subtropical apple

Tree No	Average fruit size (cm)	Average fruit weight	Total fruits per tree (No.)	Total fruit weight per tree (Kg)	Fruit TSS	Remarks
1	Large Height = 8 Girth = 7.8	Large 200 gm	21	3.4	10	
2			-	-		Pollinizer
3			39	5.5		
4	Medium Height = 7.6 Girth = 7.2	Medium 100gm	3	0.2		
5			24	3.9		
6			9	1.4		
7		Small 55gm	7	1		
8			8	1.4		
9			-	-		Pollinizer
10	Small Height = 6.6 Girth = 5.5		22	2.7		
11			32	5.9		
12			11	1.8		
Total			176	27.2		

Apple has problem of fruit drop and damage by beetles. Chestnut was also found promising in that altitude; it has started bearing fruits. Citrus shows slow progress with retarded growth but none of the plants have died till date. Further monitoring and evaluation will be done.

5.1.2.2 Intensification and Diversification of Backyard fruits

In order to meet the requirement of fruits in the household and to sell few surplus products to earn cash income, farmers of the Lingmuteychhu Watershed plant few fruit trees in their backyard. The fruit plants range from sub-tropical to temperate consisting of Guava, Orange, Pomegranate, Peach, Pear, Plum and Apple. Most of the fruits are of local varieties, which do not have good taste and so do not fetch reasonable market price. Earlier the research center has supplied few improved fruit plants (25 nos. citrus, 22 nos. Peach and 15 nos. Pomegranate) on trial basis in the Lingmuteychhu. Evaluating the performances of these fruit trees in terms of early fruiting and maturity and preferred taste, the farmers liked to plant few of these fruit

plants in their backyard since they do not have abundant land to develop as an orchard. Therefore, to develop/improve their existing fruit backyard into more productive and to meet the household demand, few promising citrus fruit plants was distributed to the farmers to see its potentials and also the management under farmers condition.

The fruit plants (citrus) for development of backyard was supplied to all the Communities of Lingmuteychhu Watershed during June 2000 based on the household categorisation as mentioned below in the table:

Table 42 Distribution details of citrus varieties

Village	Cat. 1	Cat. 2	Cat. 3	Varieties
Limbukha	3 farmers	2 farmers	3 farmers	Okitsu, Rio red, Navel, T. Mandarin, Oota, Bears, Orobalance, Itchifumi & Meyouche
Dompola	1 farmer			Okitsuwasi
Nabchhey	2 farmers	2 farmers	2 farmers	Itchifumi, Miyagawa, Okitsu, Itchefumi
Omteykha	2 farmers	2 farmers	2 farmers	Local Mandarin
Matalungchu	In total 6 farmers*			Local Mandarin
Wanjokha	2 farmers	2 farmers	2 farmers	Local Mandarin

*Farm household not categorised.

5.1.2.3 Asparagus promotion

31 farmers of watershed were supplied 25 nos. each Asparagus seedling last year by training them on the planting and management practices at different AEZ. In the second year, it was found during monitoring that all the plants were growing well and more farmers are interested to increase its cultivation, To this, the farmers were told to purchase the seedlings from Druk Seed Corporation.

5.1.2.4 Home gardening (Model Kitchen garden)

In order to encourage farmers to produce different type of vegetables year-round, a Model vegetable kitchen garden was established at Dompola in September 2000. In total 12 different varieties of vegetables viz. Local bean, local garlic, Peas Usui, M.green 'Hima beauty', Carrot 'E. Nantes', Radish '45 days', J.green 'Taisai', Coriander, Radish'SP Tokinashi', J.green 'Mibuna', Spinach 'all green' and Chinese cabbage 'Kyoto' were grown. Each entry was sown directly and or transplanted in a bed of 5 sqm. Seeds, fertilizers and technical support were given from the research centre. A field day was organised for around 60 farmers of Dompola, Nabchhey and Limbukha on 14th November 2000.

5.1.2.5 Pulses trial

Five varieties of local pulses/beans collected from Tsirang were tested in the watershed with 20 co-operator farmers. During harvest the yield and feedback collected from the farmers are as mentioned below:

Table 43 Performance details of pulses in the watershed

Household Name	Village	Variety of beans	Date of sowing	Date of harvest	Yield	Method of sowing	Remarks
Kuenga	Limbukha	Yellow dal	07/07/00	NA*	NA	Dry land	Damaged by wild animals
		Gheoo bodri	12/07/00	NA	NA	Dry land	
Ap Duku	Nabchhey	Gheoo bodri	08/07/00	Mid Nov.	1.8 kg	Dry land	
		Yellow bean	08/07/00	Mid Nov.	4.5 kg	Dry land	
Yuden	Nabchhey	Gheoo bodri	09/07/00	NA	NA	Dry land	Damaged by cattle
		Yellow bean	11/07/00	NA	NA	Dry land	
Ap Tobgay	Nabchhey	Gheoo bodri	08/07/00	Mid Oct.	1 kg	Intercrop with maize	Kept seeds for next season and consumed some at home.
		Yellow bean	09/07/00	Mid Oct.	0.5 kg	Intercrop with maize	
Tashi Chenzom	Nabchhey	Yellow bean	07/07/00	Mid. Nov.	1 kg	Dry land	
Ap Namgay	Nabchhey	Yellow bean	09/07/00	NA	NA	Dry land	Damaged by deer
Ugyen pelzom	Nabchhey	Yellow bean	09/07/00	NA	NA	Dry land	Damaged by pests
Am Jigme	Nabchhey	Yellow bean	08/07/00	10/11/00	3.5 kg	Dry land	Once attacked by pests but did cultural method to control it.
Ap Chala	Nabchhey	Gheoo bodri	14/07/00	December	2 kg	Dry land	Kept seeds for next season.
		Mixed bean	14/07/00	December	1 kg	Dry land	
		Yellow bean	14/07/00	December	3 kg	Dry land	

Kencho Dorji	Nabchhey	Yellow bean	08/07/00	Mid. Nov.	1 kg	Intercrop with maize	The yield is from 5 plants only since the farmer have to prepare land for winter crops could not harvest all.
Tashi	Nabchhey	Yellow bean	08/07/00	October	1.6 kg	Dry land	Damaged some by pests. Kept as seeds.
Kinley Dorji	Omteykha	Yellow dal	07/07/00	End Oct.	0.4 kg	Dry land	Damaged by deer. Kept as seeds.
Am Karma	Thangu	Mixed bean	14/07/00	NA	NA	Dry land	Eaten as vegetable when tender.
		Yellow dal	14/07/00	NA	NA	Rice bunds	Matured later than rice, so damaged by cattle
Ap Drawu	Thangu	Yellow bean	17/07/00	October	NA	Dry land	Damaged by cattle
		Yellow dal	12/07/00	NA	1 kg	Rice bunds	Damaged some by cattle.
		Mazhi bean	17/07/00	NA	NA	Dry land	Do not mature and damage by pests.
Kinley	Thangu	Yellow dal	12/07/00	October	6 kgs	Rice bunds	2 bunds destroyed by cattle.
		Gheoo bodri	-	-	-	-	Did not sow the seeds
		Mixed bean	-	-	-	-	Did not sow the seeds
Yanka	Thangu	Yellow dal	11/07/00	NA	NA	Rice bunds	Matured later than rice, so damaged by cattle
		Yellow bean	11/07/00	NA	NA	Dry land	Sold about a sack and eaten as vegetable when tender
Thinley Gyelmo	Thangu	Yellow dal	11/07/00	October	0.4 kg	Rice bunds	Destroyed most plants while cleaning the terrace and by cattle.

**** Not Available***

Farmers Preferences/feedback

1. Gheoo Bordi - The farmers of Nabchey village preferred most the Gheoo bordi than the other pulses since it can be consumed as vegetable when tender and can sell the dried beans in the market. However, the yield of this bean is quite less.

2. Yellow Beans - Although this bean grows well and yield better than other pulses, but only few farmers prefer it since the pods of this beans are harder and cannot be consumed as vegetable when tender. Farmers do not cook and consume the dried beans as dal.

3. Mazhi Beans - This is not preferred by the farmers since it is easily attacked by pests and do not mature on time. Beside it is difficult to sell in the market.

4. Yellow Dal - This dal grows well in the Omteykha and Thangu villages. The plants were also very vigorous and had many pods. Since the sowing was a bit late it did not mature on time and was grazed by cattle after the harvest of the paddy. Few plants were destroyed while cleaning the bunds by cutting the grasses.

5.1.3 Livestock (Feed and Fodder)

5.1.3.1 Community breeding bull management and pasture development

Monitoring of mithun bull was done for its community management, services performed and the progeny born from the bull. Two years after the placement of mithun bull at Nabchhey village, the bull had now started providing services. Till June 2001 nine services were recorded, but the progenies are not yet born. A permanent caretaker among the committee manages the bull. The community contributes maize flour and edible oil as a maintenance ration on rotation basis. Besides the community contributes a men day work to the caretaker as compensation.

This year the community has further increased an acre of pasture field for the bull. The researchers have supported them by supplying with pasture seeds, fertilisers and technical support. Besides the pasture development the community had also planted 60 nos. fodder trees *(Ficus roxbhurghii)* within the pasture field.

5.1.3.2 Fodder tree monitoring

Most of the fodder trees are old enough to harvest and feed the cattle during the fodder shortage seasons but then there is a persistent problem of leaf feeder, which eats up all the tender leaves before harvest. Some remedial measures have to be implemented from next season to control the attack of leaf feeder.

5.1.4 Special emphasis on poor households in the Lingmuteychhu Watershed

A wealth ranking exercise was conducted at Lingmuteychhu Watershed during September 1999 in four villages of Limbukha, Nabchhey, Omteykha and Wanjukha to categorise farm household based on differences in access to resources. Accordingly the farm households of the four villages were grouped into three categories “Rab”, “Ding” and “Tha” (wealthy, Rich and Poor). During the discussions

it was understood that the first categories farm household are quite self-sufficient in all the households requirements and have very less or no level of indebtedness. But the third category farm households are not self-sufficient having food deficit for almost half the year and also have higher level of indebtedness. After the categorisation of the farm household, a number of research activities (trials, free inputs supplies) were done to the poor farmers to increase the status of the farm household. To see the changes of the household status and social mobility after a period of two years a monitoring on the poor farm household was conducted.

The general aim was to assess the result of the CBNRM research intervention with the third category farm household in the Lingmuteychhu Watershed. Specific objectives were to find out numbers of third category farmers who participated in the CBNRM research activities; to understand how the research intervention had helped these farmers; and to identify area of interest for research intervention in future based on their problems. Individual house-to-house survey and discussions were done using a simple questionnaire. Findings are reported below.

5.1.4.1 Limbukha

In this village out of 35 households 8 households are in third category. Discussion was done with all the households and it was found that most households have similar problems as reported earlier. The households do not have enough labour and has food deficit for a period of 3 - 6 months, which they adjust through sale of potatoes during winter. The households also lend from first category farmers at the interest rate of 15%. Beside most of their crops are damaged by wild animals (boar and deer). From the 8 households in this category only 3 household have participated, the other five households could not participate because of labour problem.

Beside the third category farmers, other category farmers had also initiated in various activities and all the activities implemented have very good impacts like:
Fruit plants like peach, orange, apple were supplied through research center, which bears fruit early and also has a good taste.
Oat has solved their winter fodder problem to some extend, it does really good in their land.
Vegetables like asparagus has good potentials if managed properly.
Some farmers said that the WMR trial on intermediate irrigation has better yield than their normal practice.

Future potentials for development

Based upon the capacity of the households in terms of labour availability and land size, the third category household in order to improve their household situation in future would like to take part in the following activities as mentioned below in table:

Table 44 Farmers interest in future CBNRM activities

Activity	Why	No. hh interested
Vegetable cultivation (Pea, Cabbage, Carrot, Radish, Beans and Asparagus)	Land favourable for vegetable cultivation and also access to market	All 8 households
Winter crops (Wheat and Mustard)	For intensive cropping and to supplement food shortage and compare yield with local varieties	4 households
Backyard fruit trials (Apple, Peach, Walnut and Citrus)	Do not require much labour to manage and can be planted in household kitchen garden or the existing backyard	4 households

5.1.4.2 Nabchhey

This village has 10 households in third category, among them discussion was done with 8 households since 2 households have resettled some where outside the village. Until now only 6 households have participated in research activities. Since people of Nabchhey being dryland farmers, they grow mostly maize and cultivate wetland on share cropping in small scale (2-4 langdos) from Limbukha. The third category households still have food deficit problem ranging from 2-8 months. During off-season the farmers go for off-farm activities to earn cash and purchase food to meet the food shortage. They also borrow from rich farmers which they pay back in terms of labour. The third category farmers also grow winter crops like wheat and mustard but in small quantity only. They do not grow potato like in Limbukha as cash crop, because it is mostly damaged by red ants and are also not comparable to that of Limbukha. From the 8 households 2 households could not participate in research activities due to unavailability of inputs and labour shortage.

Farmers view on CBNRM activities

Since this community being the poorest in the Watershed and with the aim to increase the living standard of the community, most of the research activities are focused to this community. After four years of research intervention, the third category farmers' views on research activities are as follows:

Maize trashline preparation

After initiation of this activity by the researchers on the sloppy land, it has a very good impact over the control of soil and nutrient run-off. In comparison, the yield from the field with trashline is comparatively better than the one without trashline but few farmers felt that by establishing trashline it minimize their field size. Still then this technology is highly adopted and now most of the farmers have applied this technology. Some farmers regret for not able to apply this technology since their fields are in very steep land.

Mithun Breeding bull management and Pasture development

With intensive care and management for the last two years, the mithun breeding had started performing natural services. The farmers have high hopes that their cattle breeds and draught bull will improve for better production. Community pastures have also helped to feed the mithun bull during winter. The management of the breeding bull is done by a third category farmer as a permanent bull keeper, where he is provided one man day labour contribution from each households of the village and exempted from other labour contributions.

Land terracing

With the support from GTZ, farmers were provided with Agri. tools and implements to terrace their lands considering the steep land slope. The farmers feel that earlier their crops and vegetables planted were mostly washed during rainy season beside the manure applied laboriously use to become useless, now after terracing the field they could at least conserve some soil nutrient. Some four third category farmers were not provided with these tools and implements although that they had most sloppy land, so they could not terrace their land.

Future potentials for development at Nabchhe

The preceding table shows the area of interest that the third category farmers of Nabchhe are interested at in future.

Table 45 Feedback and interest for future CBNRM activities

Activity	Why	No. hh interested
Planting improved fruit plants	Does not require much labour and to earn cash	3 households
Vegetable cultivation (Beans, Asparagus, Cabbage, Cauliflower and Onion)	Good access to market and to earn cash	5 households
Fertilizer trials	Low yield from fields	1 household
Changing of maize seeds	Seeds get crossed and plant became tall again	All households
Upland (Chumro) rice seeds supply	Earlier trial results were good and also do not have wetland to cultivate paddy	2 households
Inter-cropping improved soya bean with maize	To improve soil quality and low yield from local soya bean	2 households
High yielding wheat seeds supply	Low yield from local wheat	4 households
Livestock farming	Infertile land and high income from Livestock farming	1 household
Pasture expansion, fencing and fodder tree plantation	For feeding Mithun breeding bull	All households
Land terracing if supplied with Agri. Tools	Crops washed away during monsoon	4 households

5.1.4.3 Omtekha

Omtekha has 12 household under third category from the total of 27 households. From the discussion, it emerged that after the help from research center for the last four years, 2 households stated that their level of food self-sufficiency has improved now because the households sell surplus rice to meet other household requirements. This improvement according to the farmers was due to high yielding varieties supplied through research and extension. Six households reported no changes and had remained same; they are food self-sufficient for 4-5 months. Two households reported that the situation has worsened since the households have now more small children at home and less number of people to work in the field.

Farmers' views on CBNRM activities are presented below.

Community Forestry plantation
The farmers feel proud while discussing community forestry activities, they think that it will benefit them and the future generation. Besides they could plant trees on the degraded barren land and control from the erosion.

Demonstration Orchard
According to the third category farmers, the demonstration orchard have very good result, although it was established last year only it has started fruiting and also the co-operator farmer has the benefit of fencing materials and has good potential to earn cash in future.

Improved Paddy Varieties
Most third category farmers were provided with the improved high yielding rice varieties on trial basis. Most farmers keep seeds for multiplication and use.

Future Potential at Omteykha
The third category farmers would like to continue with the on-going activities like community forestry plantation and Sochum intensive hand weeding, the other areas of interest that the poor farmers of Omteykha are interested in are reflected below.

Table 46 Interest of Omtekha farmers in future CBNRM activities

Activity	Why	No. hh interested
Vegetable cultivation (Sag, Cabbage, Carrot, cabbage and Asparagus)	For household consumption and to sell excess for cash earning	5 households
Winter crops (Wheat and Mustard)	Low yield from local varieties and also the yield of local declines with time	5 households
Backyard fruit trials (Guava, Apple, Peach, Walnut and Citrus)	For household consumption and for cash earning through sale of excess products.	6 households
High yielding rice trials	Low yield from local varieties	5 households

5.1.4.4 Wanjukha

This village has only 4 households out of 26 in the third category. Discussion was possible with three households only. It was reported that one household has improved its social status. The household has only two langdos of wetland but shares in 10 langdos. The sharing arrangement here is different from that of other areas; they have to pay back fixed amount of 1200 dreys (*Nitshu* three) of paddy to the land lord. Due to cultivation of high yielding varieties, they have more production and after repaying the fixed amount the remainder is large. The farmer has constructed a permanent house and also bought a power tiller and a rice huller. Among the other two households, the second household is also now self-sufficient in terms of food availability. This household has one langdo only but shares in 15 langdos. The household has surplus rice to sell for earn cash. The change in their social status is attributed to the help from the research centre (high yielding varieties). The third household has remained same; the household still has food shortage for four months. This household did not have idea on the inputs provided from research centre and had not participated in research activities.

Farmers' views on research activities:

Demonstration Orchard
One respondent stated that the Demonstration orchard at Omteykha has very good result although it was very recently established it has started bearing fruits and also the co-operator have other benefits provided with fencing and planting materials.

Fertilizer trials
This trial was very important since the farmers did not have clear idea on fertilizer application and its drawback so with the initiation of this trial the farmers have understood the yield differences through balance fertilizer application.

High yielding paddy Varieties
The respondents stated that, earlier when they used to cultivate the local varieties the yields were not so much as of now. With the use of improve high yielding paddy varieties the farmers now produce more and after sharing with the landlords, they still have certain amount remaining to sell and generate cash income.

Future potential for development of third category farmers of Wanjukha

The third category farmers of wanjukha have mentioned and shown interest in the following activities.

Table 47 Farmers interest in future CBNRM activities: Wonjokha

Activity	Why	No. hh interested
Winter Vegetable Production (Sag, Cabbage, Beans, Carrot, Tomato, Chhily and Asparagus)	Would like to cultivate in wetland since they don't have dry land. Besides, excess to market	2 households
Trial on red ant control on Potato	Potatoes are usually destroyed by red ants	1 household
Winter crops promotion (Mustard)	The local varieties yields low and are also not so good	1 household
High yielding paddy trials	For high yield and increase production	1 household
Sochum hand weeding	Try out as learned during study tour to Paro	1 household

Conclusions and Recommendations

As learned through the discussions, land and labour shortage are the most important factors that determine the living standard of poor category farmers, and based upon their interest and needs there is a need to improve their social status. To do so the following conclusions and recommendations are made:
Introduction of crop rotation practices and intensive cropping to increase production as the farmers have land shortage.
Introduction of crop varieties with short duration and having high yields, so that they could do more cropping per year.
More intensive vegetable production as it does not require much land, and providing basic knowledge on vegetable production
Acceleration of backyard fruit production for cash income
Information and awareness on the availability of improved seeds and seedling from Druk Seed Corporation and Commission Agents for their long term benefit and not by providing inputs continuously through research centre.

5.2 IPNS

Soil Fertility management, Soil Conservation and Diagnostic studies were the three major research areas under the IPNS research program over the last three and half years.

5.2.1 Soil Fertility Management

During the year 2000 – 2001, more emphasis was given to soil fertility management. Farmer Field School (FFS) Approach was used as a doing and learning tool for the farmers in Omtekha. A total of ten farmers participated in the program. Although it is a very new approach for them, yet the enthusiasm they showed towards the approach was very encouraging.

Participatory steps taken for the FFS approach were:

Review of existing soil fertility management practices
Identification of farmers with the same interest and /or problem
Presentation of the objectives, principles and procedures of the approach
Reaching agreement on a season-long participation in the program
Selecting the crop on which they want to do the trial
Agreement on the length and frequency of school meetings
Selection of learning plot for each farmer
Agreements on school start and end dates.

During the whole cropping cycle farmer participants met four times. First meeting during trial establishment, second meeting during trial top dressing, third meeting during crop dough stage and last meeting during trial harvesting. The whole school program was on balanced fertilization on rice.

First meeting agenda

Plant nutrients
Source of plant nutrients
Different types of plant nutrients
How nutrients are being lost from soil
Nutrient deficiencies
Identification of topics for discussion for the next meeting

Second meeting agenda

Balanced nutrition
Fertilizer types and nutrient content
Rates of fertilizer application
Efficient application of fertilizers
Identification of topics for discussion for the next meeting

Third meeting agenda

Side effect on soil and on crop yields with imbalanced fertilization in the long run
Crop cut result discussion
Farmer feed back (likes and dislikes about the approach)
Planning for the coming season.

Trials were established for every participant farmer on his/her field. Three treatments were used. Treatment 1 is farmer practices (FYM is used as basal with urea top dressing after 30 – 40 day of transplanting), treatment 2 is improved upon farmer practices (split the amount of urea that farmers use as top dressing into two doses, half as basal and half as top dressing at the normal time that farmers follow) and treatment 3 is recommended practices (70:40:20 NPK kg/ha). There were 10 replications (one farmer as one rep) with varying trial plot size. ANOVA was used to detect treatment differences using Genstat 4.1. Results are presented in Table 48. There were significant ($P<0.01$) differences in yield between the treatments.

Table 48 Balanced Fertilizer trial on rice crop cut results from Omtekha

Treatments	Grain yield (t/ha)
Farmer practices	3.47
Improved farmer practices	4.67
Recommended practices	5.37
CV%	13
S.E.D	0.30

Crop cut data from two farmers' fields was missing since crop was eaten by cattle and crop cuts were not done.

Balanced fertilizer trial crop cut results from out side watershed were presented in Table 49. Same treatments (Farmer practices, improved farmer practices and recommended practices) were used for 11 farmers. Grain yield differences between the treatments were very significant (P<0.01)

Table 49 Balanced Fertilizer trial on rice crop cut result from Lobesa

Treatment	Yield (t/ha)
Farmer practices	5.25
Improved farmer practices	5.71
Recommended	6.67
CV %	10
S.E.D	0.25

Results from both sites suggest that rice yields could substantially be increased either by improving farmer practices or using a higher does of balanced fertilizer (NPK) in the presence of adequate organic matter.

5.2.2 Soil Conservation

On the Soil Conservation side, in the summer 1998, a number of known technologies to control surface soil run-off were offered to the farmers of Nabchhe village, where dry land cropping system is the major practice and maize is the main crop. The technologies included terracing, hedgerow, maize trash lines and stone walls. From the options offered, one test farmer preferred to try maize trash lines to control surface soil run-off. By the end of the year 1998, there was quite an amount of topsoil accumulated behind the trash lines. Impressed by the held back soil and the difference in maize growth and yield in the fields with and without trash lines, another farmer took up the program in 1999. By the end of year 2000, the height of bunds raised by soil accumulated behind the trash lines was 0.5 – 0.6 meters. The number of farmer practicing trash lines has risen from one in 1998 to 9 in 2000. On seeing the interest of the farmers, a simple farmer training on A-frame construction and handling it in the field was felt necessary. A half day farmer training was organized where in farmers were introduced to 'how to make an A-frame and how to use it for contour lining'.

Farmers see maize trash line as a multipurpose technology, which disposes maize trashes in a better way than dumping or burning. They appreciated the technology as it is less expensive compared to terracing and does not have direct initial cost or maintenance later on. They commented that, it is not complicated to follow and hence it is 'farmer friendly'. Now more farmers are coming forward to participate in the program.

5.2.3 FYM Survey follow-up

A study on Management and Use of FYM in the Lingmutey Chhu watershed was started in May 1998 and completed at the end of summer 1999. This included only the field works. Rest office works like data compilation, data entry and data analyses were done during the 2000. Preliminary report is available. However, final report will be published very soon by the SSF & PNM Project office since this study was conducted in collaboration with the Project.

5.2.4 Other studies

Other major activities under taken as part of IPNS activities during the year were an 'Adoption study of Bajoka Wheat varieties in Punakha Wangdue Valley' and the findings were reported in a separate report as (RNRRC Bajo Technical Document No. 4, 2000) and 'Situation Analysis Study on Farm Household Labour Shortage' for the West Central Region. The findings were reported in another separate report as (RNRRC Bajo Technical Document No 6, 2001).

5.3 Integrated Pest Management

The IPM sector mostly provides need-based technical plant protection services to the client Dzongkhags through field visits, disease-pest verification, surveillance and monitoring. IPM research for 2000-2001 was concerted on *Shochum* Control Awareness Campaign, Integrated Disease Management (IDM) of potato through the Farmer Field School (FFS) approach, *Parthenium* weed Control Campaign, citrus fruit fly control and literature reviews for *Parthenium* weed. A trial on chilli blight (*Phytophthora capsici*) control by fungicide was also conducted in farmers field but the crop cut could not be done as cattle and deers had destroyed the chillies prior to harvest. Similar trials with proper fencing have been established in farmers' fields in March 2001 in 2 Dzongkhags – Punakha and Wangdue Phodrang. One replication of the chilli blight trial is maintained in the research farm to cross check the effects of altitude if any.

Potamogeton distinctus (Shochum) is a noxious perennial aquatic weed infesting wetlands. Mechanical weed control methods like hand weeding and rotary weeding are inefficient and expensive due to increased number of weedings. The use of herbicides however is effective. Trials conducted at RNRRC Bajo have proven that Sanbird (pyrazolate) is effective against Shochum and other weeds, but due to the unavailability and prohibitive prices of the herbicide (as high as Nu. 595.00 a kilogram) in the country other management aspects need to be explored. To create awareness amongst the farmers a Shochum control campaign was conducted in collaboration with extension staff of Wangdue Phodrang Dzongkhag. Two sites with history of Shochum infestation were selected – one in Gaselo and one in Lingmuteychu followed by three intensive weedings at recommended periods. During harvest, field days were conducted during which crop cuts were done jointly with Extension Agents (EAs) and the collaborating farmers. The collaborating farmers and a few other selected farmers were also given the opportunity to go on a 2-day tour to Paro where they could see the rice fields free of Shochum. This was done in order 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.

Among the cash crops, potatoes constitute one of the major cash crops in Bhutan. Late Blight disease caused by *Phytophthora infestans* 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 to suit the local Bhutanese agro-ecosystem. 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. The results for the school is currently in its third year and

Realizing the fact that parthenium weed (*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. *Potamogeton distinctus* (Shochum) is a noxious perennial aquatic weed infesting wetlands. Mechanical weed control methods like hand weeding and rotary weeding are inefficient and expensive due to increased number of weedings. The use of herbicides however is effective. Trials conducted at RNRRC Bajo have proven that Sanbird (pyrazolate) is effective against Shochum and other weeds, but due to the unavailability of the herbicide in the country other management aspects need to be explored. To create awareness amongst the farmers a Shochum control campaign was conducted in collaboration with extension staff of Wangdue Phodrang Dzongkhag. Two sites with history of Shochum infestation were selected – one in Gaselo and one in Lingmuteychu followed by three intensive weedings at recommended periods. During harvest, field days were conducted during which crop cuts were done jointly with extension agents and the collaborating farmers. The collaborating farmers and a few other selected were also given the opportunity to go on a 2-day tour to Paro where they could see the rice fields free of Shochum. This was done in order 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.

To promote national awareness, a one-day meeting on controlling parthenium weed was jointly organized by NPPC, Semtokha and RNRRC, Bajo on 24 August 2000 at RNRRC, Bajo. The staff from NPPC, Semtokha, RNRRC, Bajo and representatives from other institutions in Wangdue attended the meeting despite short notification for the meeting. Similar campaigns are conducted from time to time to keep the weed under check and create awareness on the ill effects of the weed to human health.

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. Data collected so far indicate that female fruit fly maximum catch is during early and mid May.

5.3.1 Farmer Field School (FFS) Experience in Phobjikha

Since the inception of FFS in 1999, the integrated disease management (IDM) of potato via the FFS approach is currently in its second year, in Phobjikha under Wangdue Phodrang Dzongkhag. One of the major potato diseases that affects potato production is late blight (LB) caused by fungus *Phytophthora infestans* which is still the number one constraint 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 to assess the constraints in potato production; to induce the farmers in implementation of the best available IDM packages through FFS approach; to 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 to 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

This year 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 2000 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 cropping season 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.

Figure 13: EA demonstrating plant spacing

Figure 12: EAs selecting seeds for planting

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 at the time of earthing-up and following proper plant spacing (figure 9a). 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.

Results

Like last year the incidence of LB was very low this year also. 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 1.

Figure 14 Farmers practising hilling up technology

Table 50: Implementataion 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.
Flowering	About LB and itscontrol Roguing Virus diseases and other pests	Farmers learn about LB and its recommended 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.

5.3.2 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 technical assistance (TA) inputs from ACIAR, Australia a trial was conducted in Tsirang for which a site was selected jointly by the Entomologist and researcher from RNRRC, Bajo in consultation with DAO of Tsirang.

Currently data for the year 2000 have been placed on record from which the following deductions can be made:
Peak catches of both males and females occurred in May (Figure 15). After the end of July the number of flies caught in lures decreased.

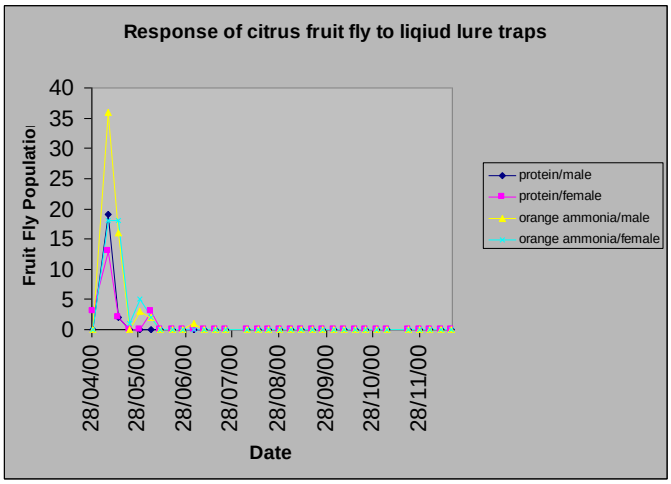


Figure 15: Citrus fruit fly caught in different liquid lure traps

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 2001season.

5.4 Water Management Research

5.4.1 Improved Water Management Trial for Paddy

The farmers' practice of paddy cultivation uses more water than is required. High water level at transplanting followed by deep standing water maintained in the terraces almost throughout the growing period result in low water use efficiency (WUE). The high water demand exerts pressure on the scarce water resource. To aggravate the situation, the peak rainfall and peak transplanting seasons are out of phase by a month. The mountain climate does not allow the shifting of the transplanting period to match the rainfall pattern.

Farmers report certain points favouring the present practice, like weed suppression and insurance against unreliable water supply. But water shortage has become the main and pressing issue, which justifies a research intervention. Two studies on improved water management for rice done in Bihar and Gujarat have generated encouraging results. The study in Bihar gave a yield improvement of 34% over the farmers' practice and significant increase in water use efficiency (state date). The Gujarat study showed 29% water saving and 55% higher yield per unit of water applied by adopting improved water management practices. The average yield increase in the study plot was 10.3% more than the control plot. The general indication from the studies is that rice crop does not require continuous flooding at the usual high water depths maintained by the farmers. Improved rice varieties with improved water management practices can substantially increase yield as well as WUE on farms with irrigation.

The main objectives of this research were to compare the water use efficiency between the traditional and the improved methods in terms of yield and the management requirement. If the same yields could be harvested with less water, water shortage problem would be addressed to a certain degree.

Method and Materials

The following materials were used in the research:
Wooden pegs with alternate rings of red and yellow;
WBC flume to measure quantity of irrigation water;
Plastic rain gauge to measure rainfall;
Stop watch, and
Weighing balance

The research was done on-station. There were two replications for the first year (1998) and ten replications for the subsequent years, comprising of three different treatments. Treatment 1 was control reflecting farmers' management practice. Treatment 2 was given 5 cm depth of water with one day stress period and Treatment 3 was given 7 cm depth of water with three days stress period. The water depth in Treatment 1 was always maintained at 5 -10 cm. The replications were adjacent to each other to ensure similarity in all aspects. The water level in the plots was monitored with the using wooden pegs with alternate rings of red and yellow. Each plot had 10 uniformly spread pegs. The stress period was counted when the soil under 8 of the 10 pegs had no standing water. The next irrigation in Treatments

2 and 3 was given after 1 day and 3 days' stress period, respectively. The control was irrigated whenever the water level dropped to approximately 5 cm.

The flow into the plots was measured with WBC flume and the depth of water to be applied was determined with the rings of the pegs. The plot size was approximately 18.35 m x 7.35 m (1998) and 7.10 m x 3.20 (1999, 2000). The total quantity of water given to all plots from transplanting to maturity was recorded. The quantity of water applied at each irrigation was determined as the product of discharge and the time taken to fill up the required depth.

Three crop-cut samples from each plot were assessed for yield. The weeds from all plots were collected and their dry weights recorded. All other management practices such as application of weedicides (butachlor) and fertilisers were the same in all the plots.

Results and Discussion

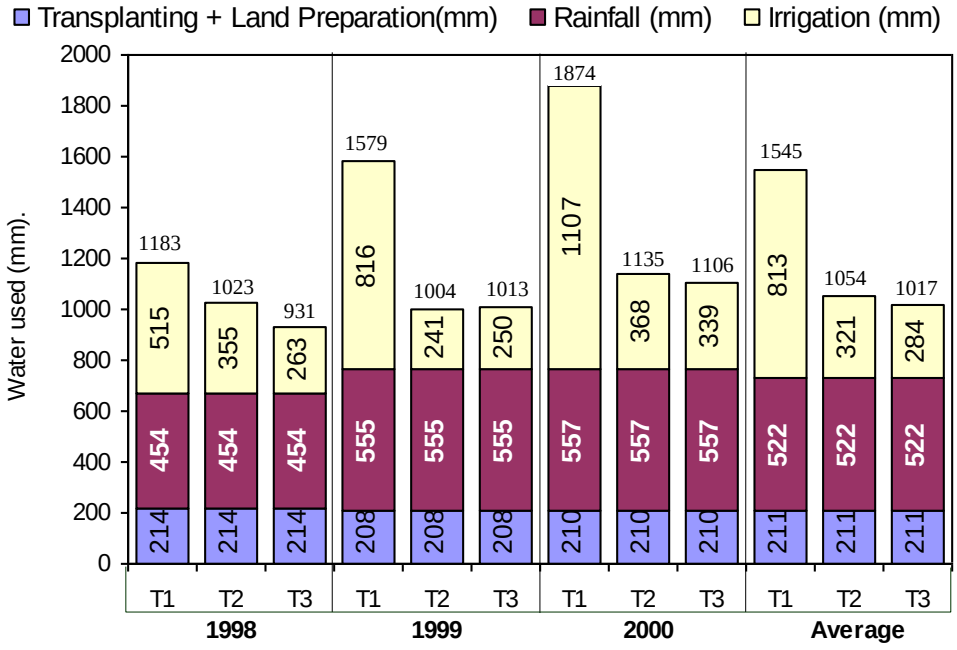
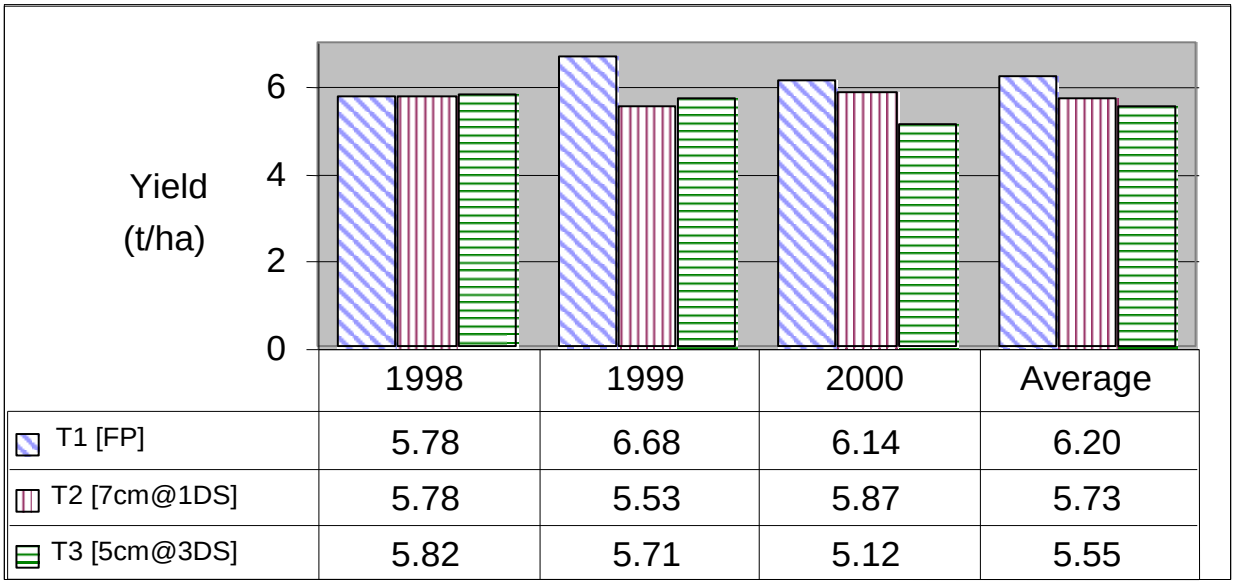


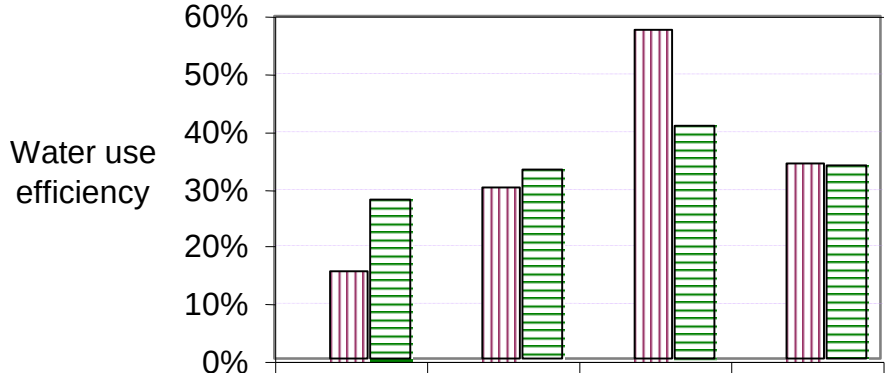
Figure 16 On-Station Water Management Trial on Paddy: Total quantity of water used for different treatment [*T1: Farmers' Practice, T2: 7cm Irrigation Gift with one day stress period and T3: 5cm II @ 3 D stress*]



	1998	1999	2000	Average
T1 [FP]	5.78	6.68	6.14	6.20
T2 [7cm@1DS]	5.78	5.53	5.87	5.73
T3 [5cm@3DS]	5.82	5.71	5.12	5.55

Figure 17 On-Station Water Management Trial on Paddy: Paddy yield for different treatments [*T1: Farmers' Practice, T2: 7cm Irrigation Gift with one day stress period and T3: 5cm IG @ 3 D stress*]

The total quantity of water applied in Treatment 1 was the highest with the average of 1545 mm (Three years average) while that in Treatment 3 was only 1017 mm which is the least.



	1998	1999	2000	Average
T1 [FP]	0%	0%	0%	0%
T2 [7cm@1DS]	16%	30%	58%	35%
T3 [5cm@3DS]	28%	33%	41%	34%

Figure 18 Water used efficiency for treatment T2 and T3 as compared to farmers' practice

The farmers' practice used 30% more water than Treatment 2 & 3. While there was a significant difference in the water used between the treatments, the yield difference was not significant (Figure 17). As a result there was an increase in water use efficiency of 30% between Treatments 1 and 3 (Figure 18). From this it can be inferred that paddy can be cultivated using less water compared to the traditional practice; for every three hectares, one more hectare could be cultivated with the same quantity of water.

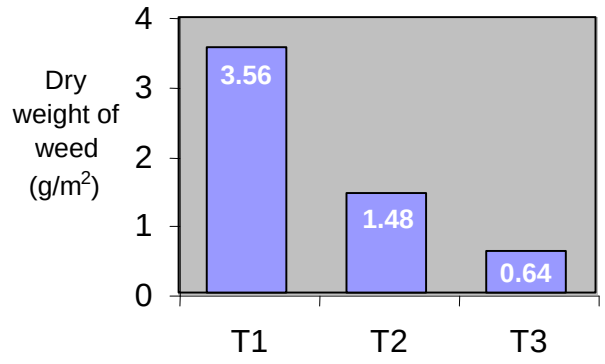


Figure 19 Dry weight of weed for different water management regime, 1998.

The farmers' practice (Treatment 1) recorded the highest dry weight of weeds of 3.56 g/m^2 while from Treatment 3 the dry weight recorded was 0.64 g/m^2. These results deny the farmers' notion of weed suppression by high depth of standing water. Standing water suppresses only non-aquatic weeds while aquatic weeds proliferate in more water. Major portion of the weeds in Treatment 1 was an aquatic weed (*monochoria vaginalis*) as a result of keeping standing water continuously.

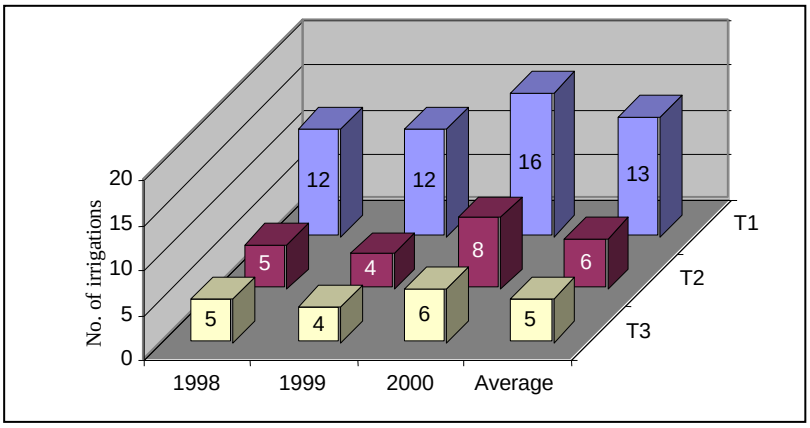


Figure 20 Number of irrigation done per season for three treatments.

Treatment 1 required average of 13 irrigation at an interval of seven days, Treatments 2 and 3 were irrigated only four to 5-6 times at an interval of 15 days each (Figure 20). This implies that the improved method requires less labour days for irrigation than the farmers' practice.

Conclusion

There is no significant yield difference between the improved method and farmers' practice while there is a significant improvement in water use efficiency of 34% with the improved method. With the adoption of the improved water management practices, there is no additional management requirement if fact it saves labour by having to irrigate less times. It controls aquatic weeds which can be an effective means of controlling SHOCHUM [P*otamogeton Distinctus*] which otherwise is very expensive to control chemically or labour extensive if physical weeding is done. If the improved management practice is adopted, the water shortage problem will be reduced if not solved.

Table 51 Summary of the results of 1998 to 2000

Year		1998	1999	2000	Average	Remark
Rainfall during the season (mm)		454	555	557	522	
Transplanting water gift (mm)		214	208	210	211	
Yield (t/ha)	T1	5.78	6.68	6.14	6.20	
	T2	5.78	5.71	5.87	5.79	
	T3	5.82	5.53	5.12	5.49	
Number of irrigation	T1	12	12	16	13	
	T2	5	4	8	6	
	T3	5	4	6	5	
Irrigation water gift (mm)	T1	515	816	1107	813	
	T2	355	241	368	321	
	T3	263	250	339	284	
Total water used (mm)	T1	1183	1579	1874	1545	
	T2	1023	1004	1135	1054	
	T3	931	1013	1106	1017	
Water productivity (gm/m^3)	T1	489	423	328	413	
	T2	565	569	517	550	
	T3	625	546	463	545	
Water use efficiency (%)	T1	-	-	-	-	
	T2	16%	34%	58%	36%	
	T3	28%	29%	41%	33%	

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Raman, S. & Desai, N. D. *On-farm Water Management Studies in Summer Rice*, Soil and Water Management Research Project, Gujarat Agricultural University, Navsari Campus, Navsari 396450, Gujarat, India, published in International Rice Research Notes Volume 22 Number 3, IRRI,1997.

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5.5 Agricultural Economics

5.5.1 Analysis of the Vegetable Marketing channel in Punakha-Wangdue Valley

The urbanization process, taking place in Bhutan has led to a growing demand from towns for agricultural produce. The Punakha-Wangdue valley provides an interesting example of a response to this. Farmers from this valley increasingly supply vegetables and fruits to Thimphu and other towns. However, there are indications of some serious marketing constraints and inefficiencies that hamper the further development of this system. Therefore, a rapid survey on the marketing system of the vegetables in Punakha-Wangdue valley was conducted in April and May 2000 in collaboration with Agriculture Marketing Section (AMS) of the Ministry of Agriculture.

Objectives

The study was conducted with the following objectives

Assess the supply of vegetables and fruits from the area, including their seasonality and prices.

Assess the performance of the different stages of the vegetable and fruits marketing chain.

Identify constraints and opportunities for each of the marketing activities.

Identify potential marketing support measures and suggest feasibility studies of such measures.

Test Rapid Market Appraisal as tool for marketing development in Bhutan.

Methodology

Data gathering had been done with help from NRTI lecturers and trainees. The survey was conducted within two weeks time, i.e. from 24/4/2000 to 29/4/2000 in Punakha Dzongkhag and 01/5/2000 to 07/5/2000 in Wangdue Dzonkhag. The team covered 6 geogs each in Punakha and Wangdue. These included Kabji Geog, Guma Geog, Zomi Geog, Shenga Geog, Tewang Geog and Limbu Geog under Punakha Dzongkhag and Nisho Geog, Bjena Geog, Thetsho Geog, Kazhi Geog and Rubi Geog under Wangdue Dzongkhag. Baap Geog under Thimphu Dzongkhag was also included. A list of villages in Punakha and Wangdue valley was selected with the help of Extension Agents (EAs). The weekend markets in Punakha and Wangdue were also covered.

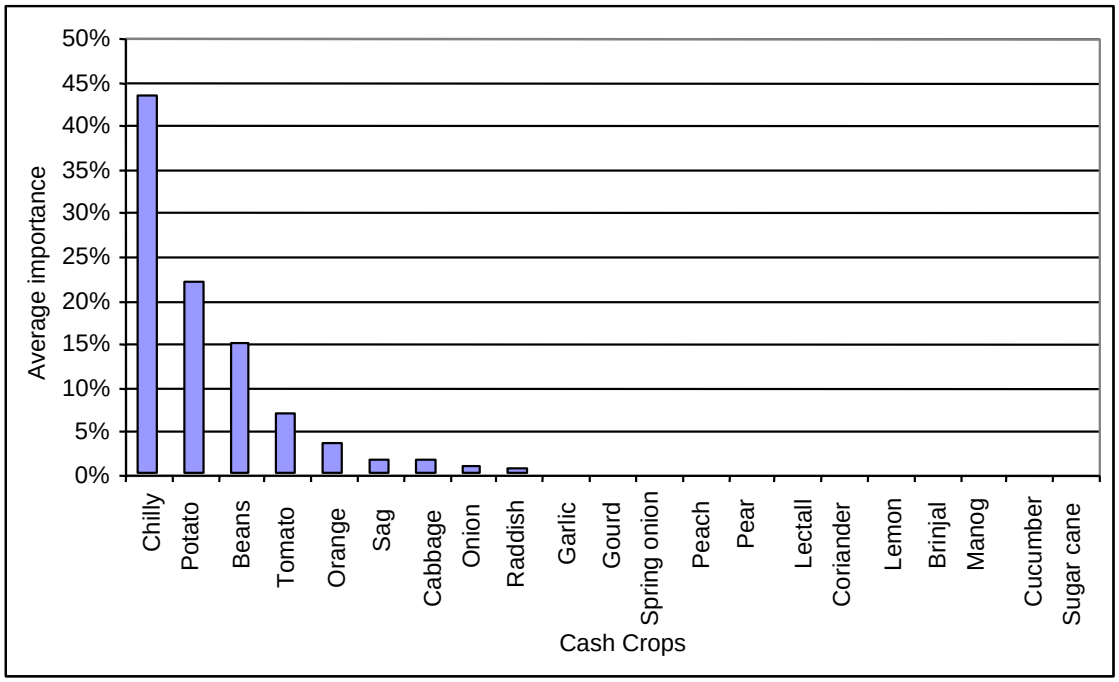
In general the different respondents for the survey were Extension Agents (EAs), Gups, Tshogpa, assemblers, wholesalers, retailers and farmers. A total of 46 farmers were interviewed individually and about 7 group discussions were conducted. Six different data collection modules were developed, each one covering a different aspect of the marketing system. Semi-structured interviews as well as number of PRA tools were used.

Results, Recommendations and conclusions

Although this survey covered all marketed vegetables and fruits in the valley, only five main cash crops were selected for the analysis. These cash crops were chilli, beans, potato, tomato and orange. Criteria for selection of these crops were

production volume, importance as source of income and marketability (eg. perishability, storability, etc.), see Fig. 1 below.

Figure 21 Average importance of the cash crops for the interviewed farmers



It is shown in table below that about half the produce is sold in local markets of the Punakha-Wangdue valley. Thimphu market is the largest single market outlet, Other market outlets are Phuntsholing, Paro and Haa.

Table 52 Market outlets of the major cash crops grown in Punakha-Wangdue Valley

Location of Outlets	Chilli	Potato	Beans	Tomato	Orange
Thimphu	40%	30%	47%	43%	40%
Wangdue	24%	40%	13%	57%	19%
Punakha	24%	20%	37%		31%
*Punakha – Wangdue Market**	*48%*	*60%*	*50%*	*57%*	*50%*
Phuntsholing	7%	10%			4%
Paro	5%				6%
Haa			3%		
Total	*100%*	*100%*	*100%*	*100%*	*100%*

*assumed as one socio-economic region

Marketing is mainly done by the farmers individually, incurring high marketing expenses per unit of produce. The marketing channel farmer-consumer for chilli was scored as most important and transformed into weight one as shown in table.

Table 53 Pre-defined marketing channels and scoring system used

Pre-defined marketing channel	Farmer to consumer	Farmer to Retailer to Consumer	Farmer to Wholesaler to Retailer to Consumer	Farmer to other Farmer
Scoring scale	1 most important	2 second most important	3 third most important	4 least important
Transformation key of scores into weights	1	0.75	0.5	0.25

Up to 50% or more of the gross sale value of the produce is often lost on marketing related costs. (The report provides a detailed analysis of marketing costs in various marketing channels). Despite the low post harvest losses of about 10%, transportation fare and marketing add up to a big share of the revenue.

Table 54 Marketing costs in % of the market price for the main cash crops grown by farmers of Punakha Wangdue Valley

Transport	Chilli	Beans	Potato	Tomato	Orange
By taxi	38%	36%	60%	54%	*

Arrangements among the producers such as assembling for joint marketing are not common in Punakha-Wangdue valley. Lack of trust appears to be the main reason.

Table 55 Opinions from interviewed farmers on assembling of produce

Different Assembling Practice	Reasons for assembling	Reasons for not assembling
Collecting produce and hire a truck.	Reduction of transportation costs	Mistrust
Farmers group themselves and hire a vehicle.	Small volume production	Lack of interest
Collect the produce from all households in the village. They share charge and profit.		Prefer to go individually to the market
		Better profit if done by farmer individually
		Small quantities

During the season, some areas in Punakha are frequented by wholesalers who arrive at the road head with their truck to buy directly from farmers. They then take their produce to Thimphu or elsewhere. In this marketing channel, marketing costs per unit of produce are substantially lower then when the produce is marketed individually by farmers. However, there are only a few wholesalers visiting the valley.

Marketing systems constraints and opportunities

Farmers were asked to unveil various constraints faced in marketing their produce and they were also asked to suggest solutions. Constraints along with the suggested solutions are presented dzongkhag-wise in the tables below. As already mentioned,

farmers regard transportation problems as the main obstacle for successful marketing. High costs, difficult road condition and lack of vehicles are main constraints. Therefore, farmers' first suggestion is the improvement of transportation facilities and services, mainly provided by the Government. Farmers also added lack of market access as a big problem. Lack of market information was also mentioned as a constraint not only by farmers, but also by wholesalers.

Tables presented below show the main marketing constraints faced by the farmers and their suggested solutions.

Table 56 Punakha farmers' main marketing constraints and their suggested solutions.

Marketing Constraints	Suggested Solutions
Transportation	
Lack of transportation	Truck services to take produce to Thimphu
High transportation costs	Government transport service
Poor road condition esp. during rainy season	Improvement of existing road network and motorable bridge over Pho Chhu
Prices	
Low price	Government to set floor price
Price competition	Control import from India
Market	
Khurthang market further away from farms	Weekend market near Punakha Dzong, bus and taxi stands
Labour	
Labour shortage for transporting	

Table 57 Wangdue farmers' main marketing constraints and their suggested solutions.

Marketing Constraints	Suggested Solutions
Transportation	
Lack of roads	Roads connecting villages to the urban centres
Poor condition of the feeder roads	Proper maintenance of the existing roads
Lack of efficient transportation services	Provision of transport services by the Government during peak season
Prices	
Low prices	Set floor price on domestic agri-products
Market	
Over supply in the market	Mini auction
Lack of demand	Sunday market whole day
No proper market facilities	Improvement of the market compound (roofings, for example)

Both producers and wholesalers mentioned that a seasonal mini-auction in, say, Punakha, would be very helpful measure. It would make the supply of produce more transparent, and thus encourage more wholesalers to buy in bulk from Punakha-

Wangdue valley. It would also increase the transparency of demand, as producers will be able to assess what produce is demanded by wholesalers and what prices are being paid. It should greatly enhance marketing efficiency. An investigation into this option is being recommended. An accurate and timely country-wide market information system would also be highly beneficial. Also, the formation of farmers' marketing association for joint marketing of produce should receive some attention.

Farmers are in constant competition with producers in India. Off-season production techniques being developed by RNR-RC Bajo will therefore be very important. Retailers claim consumers prefer local produce above imports because of quality, freshness etc. Promoting local produce emphasizing its (organic) quality might also be helpful, also for exports.

5.5.2 Winter crop Budgeting (Wheat, mustard and Potato)

Production costs data of winter crops like wheat, mustard and potato had been collected from Dompala, Wangjokha and Limbukha in 1999. To make the survey more representative of the farm households in the Watershed additional data had been collected this year from four farmers in Limbukha and six farmers in Nabji.

Even if there is a good input and output data on the production costs, one cannot expect a good result if the data on land area is not reliable. Areas reported by farmers in Langdo cannot be relied upon for use in developing such crop budgets. That was why fields of sample farmers (where winter crops were grown) had to be measured manually using measuring tapes and compasses. This was quite a tedious job, especially when measuring the wetlands.

Now that a complete data on the winter crop in the Lingmeyteycchu watershed had been gathered, analysis of it will soon follow. The final report on the winter crop budget will be ready by the end of the year.

5.5.3 Economics of FYM production

In 1998 a survey to understand the management and use of Farm Yard Manure in the Lingmutey Chhu Watershed was conducted by RNR-RC-Bajo in collaboration with the SSF-PNM Project, Semtokha. Using the labour data from this survey, a study on the economics of FYM production was also done with the main objective of determining cost incurred by farmers to producing and applying Farm Yard Manure to their fields. The results will then be compared with the cost of using fertilizer. In this way we will be able to understand which is cheaper for farmers to use-fertilizer or FYM? Recommendations can accordingly be made to the farmers.

However, such a study presents some problems. Not only the quantity of the output (FYM) is required for the analysis but also the quality. This means that the nutrient content (NPK) in, say kg of FYM must be found out and then the price for these contents must be determined too so as to be able to compare its usage to fertilizer.

Although the analysis has been completed a final report of this study is yet to be done. The table below is the result of the analysis.

Table 58 Cost of using FYM in Dompala-Wangjokha villages, 1998

FYM Production Costs 1998

sl. No	Village	Farmer name	TotLabour Days	Labour Cost/day	TotalprodCost	FYMquantity (kg)	ProdCost Nu/kg
1	Dompala	Karma Tshering	75	100	7475	20049	0.37
2	Dompala	Kinley Om	40	100	3963	3474	1.14
3	Dompala	Jakum	80	100	8025	13552	0.59
4	Dompala	Sangay Om	43	100	4275	3620	1.18
5	Dompala	Yanka Bidha	37	100	3688	2702	1.36
6	Dompala	Kencho Bidha	89	100	8925	11453	0.78
7	Dompala	Namgay Dolma	48	100	4825	13241	0.36
8	Dompala	Namgay Dem	33	100	3338	2755	1.21
9	Wangjokha	Zam	84	100	8450	11547	0.73
10	Wangjokha	Ugey	54	100	5463	9654	0.57
11	Wangjokha	Sangay	100	100	10050	12223	0.82
12	Wangjokha	Om	54	100	5450	19440	0.28
13	Wangjokha	Chencho Om	63	100	6381	4889	1.31
14	Wangjokha	Pem Gyaltshen	67	100	6788	8488	0.80
15	Wangjokha	Kencho Dorji	63	100	6313	5202	1.21
	Mean						**0.85**
	Standard deviation						**0.37**

As shown in the table above, the cost of using one kg of FYM produced at the farm is Nu. 0.85 with a standard deviation of Nu. 0.37. Here it must be noted all the labour used in FYM relevant activities such as leaf litter collection, FYM removal, transport of FYM to the fields and finally spreading FYM in the fields all together build up the costs.

Appendix 1 : List of local rice germplasm rejuvenated and characterized in 2000.

Acc. No.	Variety	50% FLW (days)	Height (cm)
2	Tan Tshering	111	122
8	Shengab	122	141
9	Janab	111	146
10	Jarey	111	113
11	Chumja	111	149
12	Shamap	86	100
13	Chumja	111	136
14	Tan Tshering	123	122
15		123	81
16	I- Zang	131	87
18	Kongko	104	83
19	Robtang Bara	96	120
20	Karmajam	121	98
21	BR 153	121	72
22	Sung Sung Bara	123	83
23	Brong kolapa	117	128
24	Yadu Bara	117	128
25	Yadu Bara	130	134
26	Sam Bara	128	78
27	Sung Sung Bara	112	118
28	Sam Bara	117	155
29	Pang Bara	113	112
30	Betpu Bara	108	114
31	Betpu Bara	110	-
32	Yurungpa Bara	106	167
33	Betpu Bara	114	134
34	Betpu Bara	106	130
35	Betpu Bara	105	142
36	Betpu Bara	107	136
37	Bara tshalu	107	180
38	Bara tshalu	112	172
39	Betpu Bara	96	119
40	Sam Bara	108	151
41	Sam Bara	108	148
42	Shilangpa	109	133
43	Khangpa	109	135
44	Sam bara	111	142
45	Assu	115	78
46	Wangdi karmo	123	127
47	Betpu Bara	106	115
48	Betpu bara	106	118
49	Betpu Bara	106	115
50	Betpu bara	108	128
51	Sam bara	110	143

55	Rey maap	116	137
58	Dumja	117	154
60	Dumja	115	152
73	Themja	107	130
101	Tan Tshering	115	121
102	Machum	123	137
103	Jaze	117	114
104	Kongtshe	127	162
105	Asha Dogo	125	128
106	Nabja	131	125
107	Kamnam	112	154
114	Zhuchum	111	80
124	Paijam	117	83
127	Bottay Dhan	117	164
130	Par Rottay	116	170
131	Tandin Tshering	123	169
132	Katha Metha	115	168
133	Dago Yekum	127	169
135	Zakha	111	121
136	Janam	109	170
139	Local maap	111	164
140	Local Yangkum	124	165
141	Ajey dogo	123	129
142	Local Zakha	115	110
144	Dasum	115	70
146	Tan Tshering	127	118
147	Local Kachum	114	75
149	Thaygom	133	172
153	Zakha	115	123
154	Local maap	127	175
155	Attay	140	152
156	Attay	132	111
157	BR 153	118	84
158	BR 153	127	84
159	BR 153	117	92
161	BR 153	127	83
163	BR 153	125	87
165	Asu Balingmo	123	107
166	BR 153	117	90
327	Guenja	117	142
350	Damja	117	156
351	Geuija	112	98
426	Pokchila	140	143
429	Sharchogpa	142	137
430	Korphogba	142	138
435	Rey kar	132	142
436	Bogarmo	111	160
437	Guenja	111	157

438	Dhenangmo	117	151
439	Mard	115	149
440	Chenangma	127	156
441	Jartshan	108	135
442	Nimshongpa	149	134
443	Kamthegorma	123	159
444	Shintey	117	161
445	Zangkar	117	121
446	Thrisarpa	123	142
447	Tenzin Bonday	143	139
448	Ngan mala	141	143
449	Dangphu Bonday	153	127
450	Bonday	150	112
451	Kungpongpa	117	146
452	Zangkhar	123	128
453	Mara	111	146
454	Noirala	124	153
455	Golingpa	109	137
456	Ngambrella	124	141
457	Lee	127	125
458	Sujami	108	132
459	Bullipa	123	141
460	Nigtala	111	91
461	Zintela	117	135
462	Panglang	125	125
463	Khartela	120	126
464	Rancham	117	104
465	Nuntela	117	159
466	Golingpa	141	126
467	Kesang	120	164
468	Japan	124	73
469	Kesang	122	156
470	Leey	122	155
471	Seeksemo	123	156
472	Bogarmo	123	158
473	Mraa	109	138
474	Zangkhar	120	154
475	Chakharpa	142	127
476	Yakpa chum	152	73
477	Golingpa	142	130
478	Bonday	151	126
479	Tenzin Bonday	143	158
480	Jarzan	111	140
481	Chakarpa	141	132
482	Bonday	150	125
483	Boktola	115	80
484	Karmatagpa	127	137
485	Ransham	124	135

486	Chiwala	124	84
487	Charkhar	143	112
488	Kamtakpa	141	131
489	Zochum	113	112
490	Janam	111	152
491	Jumsa	127	135
492	Chewala	123	121
493	Themzam	111	109
494	Jazam	123	149
495	Chhung Jinchila	117	92
496	Japan rice	125	81
497	Yepa Nonchila	141	115
498	Bangtarpa	141	84
499	Dakaling	121	93
500	Lee	143	122
501	Zhemgangpa	143	116
502	Beer	130	75
503	Jamtswola	130	80
504	Jinchila	152	70
118	Kartikay	153	115
119	Assamay	151	79

Appendix 2: Visitors during July 2000 to June 2001

Date	Visitors
28 July 2000	His Excellency Lyonpo Kinzang Dorji, Head AFD, Joint Director Research Division, DRDS, Head PPD, MoA
22 July 2000	Jacob John, Second Secretary, Mr Bhaskar Barua, Secretary of the Govt. of India, and Dr. R.S Paroda, Director General of ICAR, New Delhi
9 Sept 2000	Dr. Farooq Ahmed Partirn Roy, ICIMOD
10 Sept 2000	His Excellency Dr. Jacques Diouf, Director General of FAO & UNDP officials with Director, DRDS
13 September 2000	John M de Ruiter, Crop Physiologist, Dr. Savitri Abeyaskera and Ian Wilson, Reading University, UK.
28 October 2000	His Excellency Mr Michel Caillouet, Ambassador of EU
3 November 2000	D.Zuercher, Hansvuedi Steerlian, Johmus Proffen, S. Moser, Warmer Christen, Moria Keanzig of SDC/Helvetas
9 November 2000	Botschaffer, Dr. Walter Fust, Mr Paul Egger, Mr. Harry Sickle, delegates of round table donor meeting with Dasho Dzongda of Wangdue.
18 November 2000	Program Directors of 3 RNRRCs and Horticulture Officers for IPDP workshop.
19 November 2000	Program Directors and Research Officers for research management meeting.
15,17 & 20 November 2000	9th Batch NRTI trainees for the field visit with R. B Chettri (Lecturer)
10 January 2001	Shri Bhagal Singh, Additional Secretary MoA, Government of India Managing committee (ICTAB) and other delegates
19 January 2001	Her Majesty the Queen Ashi Dorji Wangmo Wangchuk, Director DRDS, DALS, DSC, Program Coordinator IHDP, Head Information Unit, DRDS
24 January 2001	A.C Elango Van, FAO Delegation with T.R Gurung
31 January 2001	Dr. Kazieto Shivata and Dr. Nagamine Tsukasa, National Institute of Agro biological Research, Japan.
1st March 2001	Lecturers and students, Banglore university, India
24 May 2001	Dr. MS Swaminathan and his family members
28 May 2001	A group of progressive farmers from Thimphu Dzongkhag
8th June 2001	Mr. John Goelet with other members
12 July 2001	A team from international Food Policy Research Institute (IFPRI)
16 July 2001	Dr. John Graham, Tonie, Heneke, for Livelihood Analysis training

Appendix 3: A summary of Annual Progress Report (July 2000- June 2001) of the Extension Program Office, RNRRC Bajo

Follow up visits to Dzongkhags on Extension Input database & compiling at Regional level

As proposed in the annual work plan, visits were made to all the five Regional Dzongkhags and forms were collected except from Dagana(yet to collect) and Punakha, it is instructed would be dealt directly by ESP since it is an ESP Pilot Village Project. However, compiling could not proceed since it was advised that an Information Management consultant will be fielded to install the programs. So it has been kept pending for the time being.

Routine visits to Dzongkhags/ Geogs centres to monitor planned activities-

This visits are being carried out on a regular basis in order to interact with Dzongkhag Sector Heads on the progress or lapses of the joint Research Extension Activities earmarked which are agreed between Researchers & Extensionists during the Annual Planning Workshop.

Assist Dzongkhags in farmers training, pest disease out break in crop/ livestock

During the reporting period the office facilitated/assisted in conducting training on citrus for staff of Punakha and farmers vegetable training for Wangdue Dzongkhag. Besides, out calls were attended to conduct post mortem in horses belonging to Army at Punakha. In this there is a need to attend Dzongkhag Sectoral Work Plan meetings so as to enable us to render effective support for any sort of training both in terms of resource persons or training materials.

Managing farmers study tour groups visiting Centre

A total of 194 farmers escorted by 15 RNR staff from Punakha, Bumthang, Haa, Samtse, Thimphu and Sarpang Dzongkhags visited the centre wherein they were shown around the various on going trials on Cereals, Vegetable, Fruits and Feed and Fodder. Farmers were really impressed on the new insights gained and the discussions they had with researchers were said to be very informative. Most farmer participants recommended such tours in future to fellow farmers with their respective Dzongkhag escorts.

Regional Review and Planning Workshop

Visit, discuss and Assist Dzongkhags in preparing their presentation paper for the annual workshop- Prior to the start of the workshop all the Dzongkhag's were visited and Sector Heads met and their views sought on how best the workshop could be conducted in the interest of Extension and their feed back on previous Workshops obtained.

Assist RC to conduct Annual Research Extension Review Planning Workshop

Assisted the Centre in conducting the Annual Workshop successfully and compilling of resolutions/ proceedings and sending the resolutions to relevant agencies after the workshop. Visits were also made to monitor the joint Research Extension Collaborative Activities spelt out during the workshop.

Collaborate with IPM Sector in successfully implementing Shochum (Potomogeton distinctus) noxious weed in paddy

A group of farmers selected by Dzongkhags of Punakha & Wangdue with severe infestation of this weed in their field were taken on a 2 days study tour to Paro which had a history of heavy Shochum in the past but almost eradicated it by now due to efforts of continued hand weeding rather than depending on expensive but unavailable weedicide. The tour was mainly focussed on farmer to farmer interaction which ESP is focussing on. It was funded by the RNR Extension Support Project of DRDS and a detailed report in relation to this tour is available in the centre. Participant farmers will carry out intensive hand weeding in small pockets of their field over a period of years and IPM and Extension will monitor and provide technical guidance from time to time.

Organised a one day Field Day to Extension Agents of the Region

A one day field day was organised to Extension Agents of the five Dzongkhags so as to enable them to have a first hand knowledge on what Research is doing in the various fields and what technologies it has on offer for extension and what are some of the emerging technologies for extension. The field staff had good interaction with the Senior Research Officers of the centre. Besides, they were shown around the fields like Fruits, Vegetable, Cereals etc. A highlight of the day was that all staff participated in a crop cut exercise guided by the Sector Head of the Field crop Sector.

Chily Blight Trial in collaboration with IPM

Chilly being a major cash crop for our farmers, our IPM Sector and EPO office in collaboration with Dzongkhag Extension initiated a blight trial at Kashi In Wangdue Dzongkhag and the trial is still on going.

Some ad- hoc activities carried in this reporting period

RNR Census - Extension participated in carrying out RNR Census within the Region with staff from the Ministry of Agriculture form January to March 2001 as instructed by Ministry

Geog Planning Exercise - Participated in conducting Geog Planning exercise in Tsirang, dagana and Sarpang dzongkhags as desired by MoA

Up dating RNR Staff Data - Compiled and up- dated data of RNR staff of the Region including data RC Bajo staff as instructed by DRDS.

Appendix 4: Financial report for financial year 2000-2001

Object Classification	Amount in Nu
Personal emoluments	4154233.74
Other Personal Emoluments	879046.00
Travel	2236817.00
Utilities – Telephone	143089.00
Utilities – Cable, tlx, fax,WT	51730.00
Utilities – Electricity	41292.64
S&M (Office Supplies)	125781.00
S&M (Fertilizers)	43085.00
S&M (Uniform, Ext.Kits)	69520.00
S&M (Textbooks and journals)	20924.01
S&M (Other supplies & consumables)	36813.00
MOP (Building)	49572.90
MOP (Vehicle)	616393.96
MOP (Equipments)	176410.25
MOP – Plantation	21517.50
Opt. Exp. (Transportation)	4840.00
Contribution – PF	294506.20
Retirement benefits	338750.00
Expenditure on structure – building	7116565.70
Furniture	19082.00
TOTAL	**16439969.90**