ANNUAL REPORT

1996-97

RENEWABLE NATURAL RESOURCES RESEARCH CENTRE

BAJO, WANGDUEPHODRANG

RESEARCH, EXTENSION & IRRIGATION DIVISION
ROYAL GOVERNMENT OF BHUTAN
MINISTRY OF AGRICULTURE

ABOUT THE REPORT

This is the twelfth 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 1996 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 report of 1995-96, wherein program by program presentation is followed.

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 THE 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 development 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 productivity and 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 system.

RNRRC Bajo receives technical support and improved germplasm from IRRI, AVRDC, CIMMTY, 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 the IRRI-Bhutan Rice Farming Systems Project, and other development projects of the region.

Mailing address:
Renewable Natural Resources Research Centre
Bajothang, Wangduephodrang, Bhutan

Phone : (PABX) : 81260/ 81209/81243/81362
Programme Coordinator : 81361
Fax: 81311

Research Personnel (1996-97)

Ganesh B. Chettri	MSc (Plant Breeding)	Program Coordinator
Mahesh Ghimiray	B.Sc Agri	Research Officer
Tayan Raj Gurung	BSc (Agri)	Research Officer
Sangay Duba	MSc (Agronomy)	Research Officer
Yuden Dorji	BSc Agri (Horti)	Asst. Research Officer
Kesang Jamtsho	MSc (Irrigation)	Research Offiecr, Water Management
Leo Van den Brand	MSC (Irri)	Research Advisor (WMR)
Sangay Dorji	Agri Diploma	Senior Research Assistant
Dhurba D. Chhetri	Agri. Diploma	Senior Research Inspector
Sib Charan Kujur	Agri. Diploma	Senior Research Inspector
Karchung	(Engg. Diploma)	Research Assistant
Leela Maya Dahal	Agri. Diploma	Research Assistant
Purna B. Gurung	Agri. Diploma	Research Assistant
Bindu Maya Tamang	Agri. Diploma	Research Assistant
Neelam Pradhan	Agri. Diploma	Research Assistant
Kesang Tashi	Agri. Diploma	Research Assistant
Nidup Tshering	Agri. Diploma	Research Assistant
Dawa Zangpo	Agri. Diploma	Research Assistant
Ugen Tshering	Agri. Diploma	Lab. Assistant
Chandra B. Tamang	Administrative Asstt	Administrative/support Staff
R.K.Chhetri	Account Clerk	
Sangay Gyaltshen	Store Incharge	
Sita Chettri	UDC Gr.1	
Kinley Zam	Typist	
Sonam Jamtsho	Tractor Driver	
Hemlal Kattel	Tractor Driver	
Desh B. Rai	Driver	
Ugyen Tashi	Driver	
Nidup	Driver	
National Work Force	30	Regular field labourers

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
Ht.	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
sqm.	Square meter
SSP	Single Super Phosphate
t or mt	metric tones (1000kg)
WMR	Water Management Research

EXECUTIVE SUMMARY

FIELD CROPS RESEARCH

Introduction

Field crops include rice, maize, wheat, barley, buckwheat, millet, oilseeds and grain legumes. In cereals, the Centre mainly works on rice and wheat. The principal objective of the program was to develop improved crop varieties and their management practices to enhance crop productivity. For the crop varietal improvement, the main focus is to develop improved germplasm with high yield potential, superior grain quality, multiple resistance to major pests and diseases, and medium growth duration. The short-term goal of the program is to identify, adapt or develop appropriate technologies or management strategies in field crops for optimising the integrated production processes within the entire RNR system while increasing production of field crops.

Rice

In 1996-97, a large number of varieties and breeding lines were tested in the research station as well as in the farmers' fields.

From among the genotypes assessed for yield in the Advanced Evaluation Trial (AET), grain yield showed that the test varieties IR61331-2-25-2-3-2-2 and IR61328-1-136-2-1-2-3 produced significantly higher yields (8.32 and 8.03 t/ha) than the local check variety Zakha (6.56 t/ha) and other test entries. The above two entries also yielded 11.7% higher than the standard check IR-64 (7.45 t/ha) though the increase was statistically not significant. The elite selection from this trial will be evaluated in the farmers' field in the ensuing season. Seventy-seven entries from 8 different populations tested under observation were evaluated for yield, maturity period and height. The highest yield was obtained from variety IR 60133-184-3-2-2 (9.10 t/ha) which was 55% higher than the local check Zakha (5.86 t/ha).

In farmers' fields at Pre-production Evaluation Trial, averaged across locations, the performance of varieties differed significantly in each location. The average yield across location showed IR61331-2-148 (5.84 t/ha), IR61328-1-1-136 (6.05 t/ha), and IR64 (standard check) to be better performers. The collaborating farmers for the trial, based on phenotype, identified and saved seeds of IR61331-2 and IR61328-1- for the next planting season. These two varieties will be further evaluated for wider farmer acceptance. In the Production Evaluation Trial to ascertain the yield and performance of two promising varieties under farmer's management levels, across varied growing environments in the Wangdue-Punakha Valley, variety IR62470-B-R-B-B yielded 6.48 t/ha while CARD21-10-1-1B yielded 5.91 t/ha.

Towards a sustainable strategy for improving local rice cultivars, a shuttle-breeding program was initiated in 1985 in collaboration with the International Rice Research Institute (IRRI) in the Philippines. The major objectives are to improve traditional rice of Bhutan by incorporating desirable genes from improved parents, and to develop varieties that are medium tall, resistant to major insects pest and diseases and high yielding under Bhutan's medium and high altitude rice environments. Out of the 463 pedigree lines from 8 different populations, 99 uniform progenies were bulk selected for further evaluation.

Aside from introduction and breeding works, seeds of 117 local rice germplasm collected from various rice growing Dzongkhags were rejuvenated and characterised for conservation.
In the Crop production Management aspect, Butachlor management in rice was studied It was observed that farmers apply Butachlor immediately before transplanting to avoid trampling of seedlings. The objective of this trial was to technically validate the farmers' practice and observation on Butachlor use.
The yield results indicated that there are no significant differences in yield among the treatments. The results, however, show a trend in incremental decline in yield, though not significant, as the application of Butachlor is effected much before transplanting. The results confirm the farmers' observations and therefore application could be made immediately before transplanting for practical reasons.

Wheat
The wheat research program continued with emphasis on varietal improvement and crop management. The volume of wheat research reduced markedly since the major wheat research will be done at RNRRC Jakar. The main objective of wheat research was to select lines having higher yield, suitable growth duration and resistance to rust diseases under normal conditions. During 1996-97, 44 entries were tested at the station in IET. Entry TAN/PEW/SARA CM88386-23M-OSY-OH-IY-4M-OM yielded the highest with 4.04 t/ha. Similarly, in AET, four test lines (3.99 t/ha) significantly out yielded all the check varieties. On an average, the out yielding test lines performed 76.5% higher than the average yields of the checks (2.26 t/ha). The test lines were taller than the checks; there were no significant differences in the days to maturity.
Wheat yield potential trial was also conducted with the objective to study the yield potential of released varieties of wheat under maximum fertilizer to obtain the highest yield. Variety Bajoka-1 and VL-728 yielded the highest with 4.9 t/ha and 4.4 t/ha respectively.
A cost benefit analysis of wheat production per hectare was also studied considering the average yield of 5 varieties (4.13t/ha). The yield as compared to the yield given by the normal recommended fertilizer is significantly higher, which means we can achieve higher yield by using the above dose of fertilizer.

Grain legumes
Grain legumes tested for performance were Mungbean and soybean. A set of the International Mungbean Nursery (AVRDC) was established to identify lines suitable for our local conditions. 17 long duration and 13 short duration entries were tested. Among the 17 long duration varieties, VC6173 B-14 yielded the highest (1.46 t/ha) followed by VC6375 41-13-6 (1.10 t/ha). Among the 13 entries of short duration varieties, VC 6370-92 was found to yield higher (1.28 t/ha) than all the entries. About 58% of the varieties were found to be susceptible to powdery mildew.
Six varieties of soybeans collected from various parts of the country were evaluated to identify varieties suitable for production in this valley. AGS 313 (2.56 t/ha) and AGS 286 (2.83 t/ha) yielded significantly higher than the rest of the entries. These varieties yielded 56.7% higher than the recommended variety Bragg.

HORTICULTURE RESEARCH

Sub-tropical fruits

The sub-tropical fruit research has gained momentum since it's establishment in 1994. A number of new materials were introduced for evaluation, which is still continuing. Different ways to vegetatively propagate the materials are being tested. Some promising materials are also being introduced into the farmers' fields for further evaluation.

In Grapes, three more wine varieties were included in 1996 planting season. The station also experienced high degree of weather fluctuations, which affected the grape trial. All the grape varieties were affected by Powdery Mildew resulting berry splitting and low yield. Perlette, an early variety, which usually escaped Powdery Mildew also, had mild infection.

Three peaches and two apricot varieties were introduced from India in 1994. All three varieties of peach and one variety apricot (New Castle) started fruiting. Among three peach cultivars, Shan-i-Punjab gave the highest fruit yield per tree. Shan-i-Punjab will be further tested in the farmers' field this coming season. Of the two Apricot varieties planted var. New Castle produced few fruits. Almond trees also started fruiting in 1996-97. Texas was the earliest maturing variety and gave the highest yield per tree.

To improve the citrus industry and extend the market season, different types of citrus have been introduced. The materials are still under evaluation and promising varieties yet to be identified.

Vegetables

The vegetable research in 1996-97 concentrated on varietal improvement through the introduction and evaluation of local and exotic species. Efforts were also made to look into possible summer crops for farmers to grow in the summer months.

Nine asparagus hybrid varieties under evaluation in the Centre since 1994 produced the first year yields in 1996. The variety Theilim (7.7 t/ha), F_1UC.157(7.5 t/ha), Gijlim (7.4 t/ha), Larak and Carlim yielded significantly higher than rest of the entries.

Out of the four varieties of bottle gourds tested for summer production, var. Midnapur Round gave the highest yield of 40.33 t/ ha. There were no significant differences amongst the three local varieties.

With an objective to introduce small to medium sized onion varieties with higher shelf life and better yield to replace the unpopular existing varieties like Shenshu red and Texas Yellow Grano, four varieties of Onion were tested. Texas Yellow Grano significantly gave the highest yield of 16.86 tons/ha followed by Red Creole and Shenshu Red. Improved Patna Red was the lowest yielder among the varieties tested with a yield of only 9.56 t/ ha. Improved Patna Red produced the smallest bulbs. The storability test showed that the varieties Texas Yellow Grano and Senshu red had very high storage loss as compared to the other two varieties. Variety Red Creole had the least storage loss.

In the tomato five varieties received through the South Asian Vegetable Research Network program, for autumn production under mid hill conditions. Variety Ratan gave a total yield of 23.71t/ ha.

LIVESTOCK RESEARCH

The main objective of this program is to develop more productive and sustainable livestock options for wetland farmers and to strengthen crop-livestock systems research creating synergistic effect on the crop production. Current emphasis is on feed and fodder development.
In 1996 - 97, a number of materials were introduced for possible summer Sub-tropical fodder species. Among legumes *Stylosanthes guianensis* had the best biomass yield. *Clitoria ternatea* CIAT 772 was the only species from which seeds could be harvested. Among grass species *Panicum maximum* (Gatton) recorded the highest biomass yield of 83 t/ha followed by *Digitaria milanyana* 61 t/ha in 3 harvests. Italian rye grass (*Lolium multiflorum)* was tested for potential to be a winter fodder for the sub-tropics. A demonstration/observation trial on grass species was also established in the center with Napier grass, *Seteria*, and *Signal*.
On-Farm testing of sub-tropical fodder species began in 1996 with an objective to select and identify the most suitable species over a range of biophysical conditions under farmers' management conditions. Out of 6 sown species, Sudan grass was ranked as the topmost species with green yield production of 12.5t/ha.

FORESTRY

The Center handles many multipurpose tree species by raising seedlings in the nursery. The seedlings then are planted in the centre's premises to further monitor their growth habits, propagative potential, biomass production and to study its impact on agricultural crop
The main species included *Poplar spp*, *Salix spp*, *Gmelia arborea*, and *Ficus religiosa*. In 1996, 4 tree fodder species were further propagated through cuttings. All the test species demonstrated their ability to propagate vegetatively. The original planting material was brought from Tsirang. The species has great potential in the agroforestry system. Propagation through stem cuttings has greater advantage over raising seedling through seeds, because the seeds are very minute and takes longer period in the nursery. Collection of seeds of some promising local tree species, mainly fodder tree species, was undertaken to further propagate them in the nursery.
The center also procured and introduced different tree species seeds from Dehra Dun in India. The main purpose was to introduce and evaluate multipurpose tree species for agroforestry / Community forestry program. The different tree species seeds are under evaluation in the nursery.

SYSTEMS RESOURCE MANAGEMENT

The program addresses issues and problems that cut across the four national research programs.

Farming systems studies

During 1996-97, two surveys were conducted to understand the current citrus and tree fodder use and adoption by the farmers of this region. The findings and

details of the survey have been published separately as the technical working paper of the Center (interested readers could contact the Center for a copy).

a) Mandarin cultivation in Tsirang and Dagana Dzongkhags.

The major objectives of the survey were to understand and document the existing mandarin management practices in general and specifically to identify areas of research and extension intervention. The survey adopted the Rapid Rural Appraisal method. It was carried out in the two major mandarin growing Dzongkhags in the region, Tsirang and Dagana. Under Dagana Dzongkhag, it covered the geogs of Suntaley, Goshi, Tashiding and Drujegang, while in Tsirang, the survey included Goseling, Tshokona, Kikhothang, Dunglagoun and Semjong. The main findings were that in almost all the orchards, the mandarin trees were propagated sexually from seeds, very few farmers follow any routine fertilisation schedule and the management was very poor. The survey report published as the technical paper documents recommendations to mitigate the identified problems.

b) Tree Fodder Use and Adoption Survey

It was part of a Nation wide survey co-ordinated by RNRRC Jakar. For this region, the Center, and the Dzongkhag extension staff jointly carried out survey. The major objective of this survey was to document the importance of tree fodder, species used and the place of trees in the cropping system and to assess the need for additional supply of tree saplings and species preferred.

The survey revealed that tree fodder was very important for the farmers of the region, which increases with decrease in altitude. The most important species were found to be *Ficus cunia* and *Ficus roxburghii.* RNRRC Jakar published information at the national level. Interested readers may contact the center for detailed report.

Integrated Nutrient Management Study

Rice-wheat rotation is the most common rotation in the wetland dominated farming systems. Fertilizer recommendations are generally made for individual crops. Given the possible carryover effects, integrated nutrient management for rice-wheat system will allow judicious apportionment of scarce resources. A long-term trial on the integrated nutrient management for rice-wheat cropping systems begun in 1989 was terminated after 9 years. The trial was designed to answer the some questions regarding the use of N, P, K and FYM in a rice-wheat rotation system.

In terms of practical recommendations it is clear that green manuring of rice with *Sesbania aculeata* has the potential to replace the current recommended fertilizer application for rice although the full effect of this may not be apparent until green manure has been applied for three years. Although a comparison between farmers' current manuring practice for rice and the experimental fertilizer application was not made in this trial, results from the earlier fertilizer trials in this area suggest that this fertilizer application would have resulted in a significant increase in yield and therefore, it is assumed, that *Sesbania aculeata* green manuring would led to significant increases in yield over current farming practice. Wheat yields were unaffected by green manuring and fertilizer application is required to increase its yield.

To meet the manuring requirements of an increased cropping intensity, from traditionally one rice crop per year to two or three crops at present, in the Wangdue-Punakha Valley, farmers need to spread their limited FYM resources more thinly and increasingly supplementing their traditional organic manuring system with the use of inorganic fertilisers, predominantly in the form of urea. In the light of unbalanced nutrient management situation, it is recommended that future long-term trials should focus on studying sustainability of yields and soil conditions under such nutrient management systems.

Integrated Pest Management

The Regional Plant Protection Center at Bajo carried out two major activities in 1996-97, besides regular plant protection advisory services to the Dzongkhags. A wild boar study to assess yield loss, socio-economic surveys and population control and trapping trials had been initiated in a pilot site (Nagkhor) at Shemgang District. Another study was made to try out various cultural practices to reduce the incidence of *Phytopthora* blight in the chilli crop. Although the wild boar study is still continuing, results and observations will be published separately after the entire study is completed and analysed. Interested readers may kindly refer to the publication for detailed report.

Water Management Research

The Water Management Research (WMR) Program was started by the first half of 1997 due to the need felt by the Ministry of Agriculture for an integrated research efforts on water and soil management for sustainable crop production. The research program was also designed to fit well with the Ministry's policy on diversification of irrigated crops in view of the potential for horticultural crops. The Water Management Research Program has a national mandate to co-ordinate research on water management issues related to crop production.

1 FIELD CROPS

The principal goal of this research program is to increase and sustain the productivity and the production of cereals (rice, maize, wheat, and other minor crops), oilseeds (mustard, etc.) and legumes. This program includes integrated germplasm development, production management, and post-harvest management of the field crops. The short-term objectives of the program are to identify, adapt or develop appropriate technologies or management strategies in field crops for optimising the integrated production processes within the RNR system while maintaining ecological integrity.

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, and 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. Fertiliser doses applied are 70-40-20 kg NPK/ha, with half the N topdressed at PI. Weeds are controlled using Butachlor and spot weeding as necessary. Harvest and post-harvest operations are done manually.

1.1.1.1 Advanced Evaluation Trial (AET)

Following the standard evaluation procedure, 21 entries, including local and standard check varieties, were tested in AET. The objective of the trial was to identify suitable varieties with high yield potential, medium height, optimum maturity and resistance to prevailing pest and diseases.

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.

Statistical analyses of grain yield showed that few of the entries yielded comparable to the standard check variety IR 64. The check IR 64 was the best yielder (7.34 t/ha). However, a number of test varieties yielded better than the local check Zakha (5.70 t/ha). Occurrence of insect pests and diseases was negligible during the test season. Few of the better performing entries will be further evaluated for yields in Advanced Evaluation Trial (AET).

Table 1 Yield and agronomic traits of entries in AET.

Varieties	Yield (t/ha)	50%Flw (days)	Mat. (days)	P.ht (cm)
H202				
IR 61331-2-25-2-3-1-1	6.91	116	149	95
IR 64	6.65	116	149	94
CARD20-21-3-2-3-1-1	6.34	128	160	90
CARD21-14-1-1-3-2-1-B	6.27	116	150	99
BKNB 5073-16	6.24	116	149	96
CARD20-21-3-2-3-2-B	6.00	116	150	94
CARD 21-15-4-1-2-2-2	5.91	116	149	102
CARD21-15-3-2-3-2-B-B	5.79	116	148	88
CARD 21-15-2-1-3-1-3-B	5.69	116	149	114
IR 61328-192-2-3-1-1	5.43	127	160	80
CARD 21-15-3-2-3-3-2-B	5.41	116	149	91
CARD 21-14-1-1-3-3-B	5.3	126	159	110
IR 61328-192-2-3-2-2	5.29	116	149	92
CARD 21-15-3-2-3-3-1-B	5.27	112	145	113
IR 60553-2B-7-1-2	5.24	124	157	86
IR 61331-2-38-21-1-1	5.14	124	158	78
CARD 21-10-1-1-3-2-B	4.93	124	157	84
IR 20913	4.92	124	158	78
IR 58100-144-3-2	3.73	111	145	104
ZAKHA	3.47	128	161	120
CV%	9.8	0.5	0.4	3.8
SED	0.45	1	1	3

1.1.1.2 Initial Evaluation Trial (IET)

Twelve varieties advanced from breeding lines along with two checks were evaluated in this experiment. The objectives of the trial was to select the most

promising varieties in terms of grain and straw yields, maturity, height and resistance/tolerance to biotic stresses.

The trial was laid out in a randomised complete block design with three replications. Seedlings were transplanted in straight rows at spacing of 20 x 20cm 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. Results are presented in the Table 2.

Statistical analysis on grain yield showed that the test varieties IR61331-2-25-2-3-2-2 and IR61328-1-136-2-1-1-3 produced significantly higher yields (8.32 and 8.03 t/ha) than the local check variety Zakha and other test entries. The above two entries also yielded 11.7% higher than the standard check IR-64 (7.45 t/ha) though the increase was statistically not significant. Maturity-wise the entries were similar and the lines also had optimum height. However, no significant insect and diseases damage occurred precluding a differential rating among the entries. The elite selection from this trial will be evaluated in the farmers' field in the ensuing season.

Table 2 Grain yield and characters of entries in IET-1.

Variety	Yield (t/ha)	50%Flw (days)	Mat. (days)	P.ht (cm)
IR-60133-184-3-2-2	7.95	118	152	99
IR-64	7.56	118	152	89
CT9145-4-21-1-1	7.42	118	152	95
IR-60829-50-1-1-3	7.18	118	152	96
IR-62156-138-3-3-2-2-2	7.08	113	147	83
BR-1067-84-1-3-2-1	7.02	118	152	95
IR47310-16-2-2-2	6.90	108	142	94
IR-56383-35-3-2-1	6.46	107	142	92
BATANG SUMANI	6.37	132	165	115
IR-50	6.33	106	142	83
GIZA 176	6.26	118	152	90
CT8707-1-7-6-1	6.17	118	152	82
H 13-4-1-1-2	5.95	107	143	96
H 257-33-2-1	5.46	118	152	92
ZAKHA	5.24	123	156	129
JP-5	5.02	102	137	105
PNA1022-F4-110-1	4.99	127	162	114
CV%	7.6	0.9	0.4	3.5
SED	0.45	1	1	3

Table 3 Grain yield and other traits of entries in IET-2

Varieties	Yield (t/ha)	50%Flw (days)	Mat. (days)	P.ht (cm)
IR-64	6.66	126	158	87
IR-62467-B-R-B-10-B	6.44	126	159	132
IR-62467-B-R-B-60-B	6.29	118	151	134
IR-62467-B-R-B-41-B	6.11	116	148	133
IR-62467-B-R-B-44-B	6.11	114	149	135
IR-62467-B-R-B-8-B	6.06	118	152	130
IR-	5.93	118	152	137
IR-62467-B-R-B-66-B	5.91	121	152	137
IR-62467-B-R-B-52-B	5.89	123	157	138
IR62467-B-R-B-29-B	5.83	111	147	130
IR-62467-B-R-B-28-B	5.79	127	159	135
IR-62467-B-R-B-39-B	5.76	112	147	133
ZAKHA	5.70	121	155	129
IR-62467-B-R-B-76-B	5.57	118	151	126
R-62467-B-R-B-19-B	5.56	112	147	130
IR-62467-B-R-B-7-B	5.31	112	147	134
IR-62467-B-R-B-33-B	5.19	118	152	122
IR62467-B-R-B-38-B	4.97	126	158	143
IR-62467-B-R-B-27-B	4.59	129	160	144
IR20913	4.52	105	139	112
CV%	7.9	1.1	0.4	2.7
SED	0.37	1	1	3

Table 4 Grain yield and other traits of entries in IET-3.

Variety	**Yield (t/ha)**	**50%Flw (days)**	**Mat. (days)**	**P.ht (cm)**
IR 64	7.91	126	159	88
IR 62745-B-R-B-38-B	7.21	111	147	101
IR 62473-B-R-B-15-B	7.07	111	147	121
IR 62745-B-R-B-18-B	7.03	118	152	91
IR 63332-B-B-B-26-B	6.81	110	147	103
IR 63332-B-B-B-3-B	6.78	106	140	99
IR 62745-B-R-B-5-B	6.72	118	152	119
IR 63332-B-B-B-25-B	6.67	107	141	113
IR 62473-B-R-B-12-B	6.61	119	154	125
IR 62473-B-R-B-3-B	6.40	118	151	124
IR 63332-B-B-B-35-B	6.25	126	159	104
IR 63332-B-B-B-33-B	6.20	107	141	101
IR 63332-B-B-B-9-B	6.19	107	141	101
IR 62745-B-R-B-8-B	6.14	111	147	112
IR 63332-B-B-B-36-B	6.11	107	141	103

IR 63332-B-B-B-2-B	6.05	107	141	108
ZAKHA	5.81	121	156	124
IR 63332-B-B-B-14-B	5.38	107	141	109
IR 20913	5.16	106	141	112
IR 63332-B-B-B-F51-B	4.99	109	147	105
CV%	8.7	0.9	0.4	3.3
SED	0.45	1	0.5	3

Table 5 Grain yield and other traits of entries in IET-4.

Variety	Yield (t/ha)	50%Flw (days)	Mat. (days)	P.ht (cm)
IR 64	7.15	126	159	81
IR62467-B-R-B-50-3-B	6.91	118	152	126
IR62467-B-R-B-1-1-B	6.66	112	147	122
IR62472-B-B-50-B	6.64	126	159	116
IR62472-B-B-1-B	6.59	126	159	96
IR62467-B-R-B-64-1-B	6.15	126	159	126
IR62467-B-R-B-34-2-B	6.1	132	164	118
IR62467-B-R-B-63-1-B	6.01	125	159	127
IR62472-B-B-14-B	6	118	152	97
IR62467-B-R-B-4-2-B	5.74	126	159	130
IR62467-B-R-B-72-1-B	5.63	126	159	125
IR62472-B-B-18-B	5.39	126	159	89
IR62472-B-B-5-B	5.32	114	147	91
IR62472-B-B-61-B	5.3	132	164	95
IR62467-B-R-B-4-1-B	5.27	126	159	128
IR62472-B-B-39-B	5.27	118	152	106
ZAKHA	4.9	122	157	119
IR62467-B-R-B-75-1-B	4.77	118	152	118
IR62467-B-R-B-33-2-B	4.69	119	152	120
IR62472-B-B-8-B	4.52	132	164	91
IR20913	2.72	104	140	105
CV%	5.8	0.8	0.2	3.7
SED	0.27	1	0	3

Table 6 Grain yield and other traits of entries in IET-5

Variety	Yield (t/ha)	50%Flw (days)	Mat. (days)	P.ht (cm)
IR 64	7.99	112	146	85
IR65239-B-B-50-B	6.91	113	147	133
IR65239-B-B-47-B	6.79	112	146	124
ZAKHA	6.12	112	146	128
IR20913	5.7	92	129	118

IR645239-B-B-17-B	5.66	112	147	106
IR62470-B-R-B-28-B	4.17	112	146	122
IR65239-B-B-37-B	5.02	120	153	117
IR62470-B-R-B-12-B	8.82	112	146	137
IR62476-B-B-30-B	4.67	112	146	126
IR65329-B-B-38-B	4.28	120	153	110
IR62470-B-R-B-6-B	4.18	112	146	114
IR62476-B-B-39-B	4.17	112	146	88
IR62470-B-R-B-36-B	3.76	100	136	121
IR62470-B-R-B-60-B	3.71	112	146	118
CV%	9.2	0.7	0.4	6.5
SED	0.40	1	0	6

1.1.1.3 Observation Nurseries

Seventy-seven entries from 8 different populations were tested in a single plot of 10 sqm. The entries were evaluated for yield, maturity period and height. The seedlings were transplanted at a spacing of 20 x 20 cm. Inorganic fertilisers were applied at the rate of 70: 40: 20 NPK kg/ha. Butachlor was applied at the rate of 1.5 kg ai /ha to control weed pressure. The performances of test entries are presented in Table 3.
The observed yield ranges from 2.86 t/h to 8.13 t/h. The yields of most of the entries are higher than the local check variety Zakha. The selected entries will be further evaluated in replicated yield trials.

Observation-I

In this experiment thirty-one entries were tested with one local check variety (Zakha) and two standard checks IR-64 and IR 20913. These entries were evaluated for grain yield, plant height and maturity.
The trial was laid out in a single plot of 10 sqm with a spacing of 20 x 20 cm. The results are presented in Table 4. The yield ranged from 2.14 - 9.10 t/ha. The highest yield was obtained from variety IR 60133-184-3-2-2 (9.10 t/ha) which was 55% higher than the local check Zakha (5.86 t/ha). Some of these entries will be further evaluated in replicated plots for yield.

Table 7 Yield and agronomic traits of entries in Observation Nursery I.

Entries	Yield	50%Flw	Mat.	P.ht
	(t/ha)	(days)	(days)	(cm)
IR62467-B-R-B-73-1-B	6.76	121	155	138
IR62467-B-R-B-6-1-B	6.68	112	148	127
IR62467-B-R-B-24-1-B	6.47	119	155	139
IR62467-B-R-B-34-3-B	6.46	124	160	125
IR62467-B-R-B-F/60-1-B	6.38	119	155	115

IR62467-B-R-B-F/49-1-B	6.3	124	160	131
IR62467-B-R-B-4-3-B	6.27	121	155	134
IR62467-B-R-B-13-1-B	6.26	121	155	136
IR62467-B-R-B-35-3-B	6.14	119	155	130
IR62467-B-R-B-69-2-B	6.11	112	148	128
IR62467-B-R-B-49-3-B	6.08	119	155	136
IR62467-B-R-B-F/8-1-B	6.02	114	150	125
IR62467-B-R-B-35-2-B	6	121	155	135
IR62467-B-R-B-68-1-B	5.95	119	155	132
IR62467-B-R-B-F/5-1-B	5.95	112	148	130
IR62467-B-R-B-16-1-B	5.88	121	155	135
IR62467-B-R-B-56-1-B	5.7	114	150	132
ZAKHA	5.53	125	160	117
IR62467-B-R-B-67-2-B	4.72	112	148	131
IR20913	3.87	109	145	110

Table 8 Yield and agronomic traits of entries in Observation Nursery II.

Entries	**Yield**	**50%Flw**	**Mat.**	**P.ht**
	(t/ha)	**(days)**	**(days)**	**(cm)**
IR62470-B-R-B—14-1-B	5.90	126	160	129
IR62470-B-R-B—14-2-B	5.85	126	160	124
IR62470-B-R-B—82-2-B	5.54	119	150	125
ZAKHA	5.53	126	1960	128
IR62470-B-R-B—86-1-B	5.23	114	148	117
IR62470-B-R-B—86-2-B	4.69	120	150	122
IR62470-B-R-B-33-5-B	4.62	119	150	113
IR62470-B-R-B-85-4-B	4.58	114	148	126
IR62470-B-R-B-76-1-B	4.56	114	149	114
IR62470-B-R-B-F/9-1-B	4.36	120	150	110
IR62470-B-R-B-76-3-B	4.33	114	149	116
IR62470-B-R-B-78-1-B	4.33	114	149	117
IR62470-B-R-B-33-1-B	4.32	119	150	123
IR62470-B-R-B-55-1-B	4.25	119	150	112
IR62470-B-R-B-77-2-B	4.23	119	150	112
IR62470-B-R-B-80-2-B	4.18	114	149	119
IR62470-B-R-B-3-1-B	4.17	119	150	110
IR62470-B-R-B-61-1-B	4.14	119	150	111
IR62470-B-R-B-61-1-B	4.12	109	145	110
IR62470-B-R-B-33-3-B	3.85	119	150	114
IR62470-B-R-B-3-2-B	3.57	119	150	118

Table 9 Yield and agronomic traits of entries in Observation Nursery III.

Entries	Yield t/ha	50%Flw days	Mat. days	P.ht cm

IR62473-B-R-B-30-1-B	6.58	116	150	119
IR62473-B-R-B-20-1-B	6.49	126	159	105
IR62473-B-R-B-30-3-B	6.46	119	155	112
IR62473-B-R-B-F/17-1-B	6.21	114	150	113
IR62473-B-R-B-30-2-B	6.08	115	150	112
IR62473-B-R-B-24-2-B	6.06	119	150	117
IR62473-B-R-B-16-3-B	5.86	126	159	119
IR62473-B-R-B-36-1-B	5.81	126	159	117
IR62473-B-R-B-20-4-B	5.68	119	150	124
IR63332-B-B-B-18-1-B	5.66	114	150	120
IR63332-B-B-B-29-1-B	5.42	114	150	114
ZAKHA	5.41	126	159	128
IR63332-B-B-B-27-1-B	5.34	114	150	82
IR63332-B-B-B-15-1-B	5.22	114	150	103
IR62473-B-R-B-13-3-B	5	126	159	115
IR63332-B-B-B-29-2-B	4.88	114	150	114
IR62473-B-R-B-13-2-B	4.75	126	159	114
IR20913	3.97	109	146	115
IR63332-B-B-B-35-1-B	3.53	119	150	139

Table 10 Yield and agronomic traits of entries in Observation Nursery IV.

Entries	Yield	50%Flw	Mat.	P.ht
	(t/ha)	(days)	(days)	(cm)
IR65239-B-B-13-1-B	7.29	121	155	130
IR62745-B-R-B-16-1-B	7.25	114	150	91
IR62745-B-R-B-20-1-B	7.14	114	149	121
IR65239-B-B-7-1-B	7.14	126	159	121
IR62745-B-R-B-5-1-B	6.7	120	150	128
IR65239-B-B-68-1-B	6.5	126	160	121
IR62472-B-B-61-1-B	6.44	126	159	99
IR62472-B-B-58-1-B	6.34	114	150	127
IR62472-B-B-60-1-B	6.09	114	150	112
IR20913	6.05	109	146	114
IR62745-B-R-B-32-1-B	6.	114	149	126
IR62472-B-B-31-1-B	6	126	159	122
IR62472-B-B-39-1-B	6	115	150	83
IR62472-B-B-1-1-B	5.98	126	159	96
IR62472-B-B-12-1-B	5.94	115	150	102
IR62472-B-B-50-1-B	5.94	116	150	115
IR62476-B-B-36-2-B	5.93	114	150	120
IR62745-B-R-B-33-1-B	5.92	114	149	125
IR62745-B-R-B-27-2-B	5.87	114	149	116
IR65239-B-B-51-2-B	5.75	113	145	110
IR62745-B-R-B-39-1-B	5.74	114	150	121
IR62745-B-R-B-18-3-B	5.74	114	150	95
IR65239-B-B-24-2-B	5.71	127	160	106
IR62745-B-R-B-36-1-B	5.42	115	150	113
IR62476-B-B-36-1-B	5.41	121	155	87
IR62472-B-B-57-1-B	5.18	124	159	90
IR65239-B-B-16-1-B	5.16	114	150	100
IR65239-B-B-37-2-B	5.15	127	160	133
IR62745-B-R-B-16-1-B	4.78	114	150	119
ZAKHA	4.77	126	160	129
IR65239-B-B-20-1-B	4.71	126	159	112
IR62472-B-B-48-1-B	4.66	115	150	123
IR65239-B-B-17-2-B	3.17	127	160	112

Table 11 Yield and agronomic traits of entries in Observation Nursery V

Entries	Yield	50%Flw	Mat.	P.ht
	(t/ha)	(days)	(days)	(cm)
KUNGEN 217	9.61	99	133	114
YUNLEN 16	7.93	91	127	95
YUNLEN 18	6.78	98	134	104
YUNLEN 10	6.67	112	145	165
KUNMING 830	6.60	93	128	126
YUNLEN 9	6.59	100	135	122
YUNLEN 20	6.58	106	141	131
YUNLEN 5	6.54	100	135	95
YUNLEN 13	6.10	100	134	114
YUNLEN 11	5.86	112	145	140
YUNLEN 8	5.85	105	141	128
YUNLEN 1	5.39	91	128	92
YUNLEN 7	5.05	100	136	121
KUNGEN 4	4.92	91	129	105
YUNLEN 6	4.89	112	145	143
YUNLEN 17	4.72	92	128	105
YUNLEN 12	3.67	105	141	145

Table 12 Yield and agronomic traits of entries in Observation Nursery VI.

Entries	Yield	50%Flw	Mat.	P.ht
	(t/ha)	(days)	(days)	(cm)
BHUTAN LOCAL	10.44	92	128	121
HEYN-NO	9.63	91	128	98
PEINGZONG	9.02	121	156	88
GUICHO-2	8.8	124	159	98
CHINA 6	7.98	124	159	98
HEXI 24	7.73	105	141	100
CHINA 7	7.5	100	135	111
TAO-YIN	7.24	119	152	91
GUCHIO-2	7.23	126	156	89
CHINA 1	7.15	129	164	86
TAO-IN	6.95	124	159	94
CHINA 8	5.37	96	132	95
CHINA 2	5.24	99	135	112
CHINA 3	5.17	119	121	97
CHINA 5	5.13	119	122	105
XINGYUN COUNTRY	5.06	91	128	121
CHINA 4	3.99	99	135	97

Seed Production and Maintenance

Table 13 Nucleus Seed Selection

Variety	No. of samples
CARD 21-10-1-1-B	157
IR 20913	148
IR 64	158
Barket	213
Chumro	181
IR 61331-2-148-B	201
IR 62470	108
CARD 21-10-1-1-3-2-1	150
IR 61328-136-2-1-2-3	150

Table 14 Seed production of released and pre-release varieties.

Rice

VARIETY	TOTAL (KG)
IR 20913	156
Chumro	160
IR 62470	34
CARD 21-10-1-1-3-2-1	483
Barket	274
CARD 21-14-1-1-3-2-1-B	192
IR 61328-136-2-1-2-3	264
IR 64	428
CARD 21-10-1-1-B	165
Purple check	54
IR 62467-B-R-B-4-1	74
IR 56346-1-1-R-1-9-1-1	99
IR 61331-2-25-2-3-2-2	137
IR 61331-2-148-B	297
35 Breeding lines for high altitude	10-20 each

Oil Crops

Groundnut	40 kg
PT 30	7 kg
B. S. A	15 kg
M-27	2 kg

1.1.1.4 Pre-production Evaluation Trial

The objective of the trial was to identify a better performing variety across locations and biophysical conditions.
The trial was established in 8 locations in RCB design with 3 replications per location. Individual analysis of variance at each location, based on grain yield, is presented in Table 5. Combined analysis of variance (for yield) could not be done in the absence of statistical software.
From the results, the performance of varieties differed significantly in each location. The average yield across location showed IR61331-2-148, IR61328-1-1-136, and IR64 (standard check) to be better performers. The collaborating farmers for the trial, based on phenotype, identified and saved seeds of IR61331-2 and IR61328-1- for the next planting season. These two varieties will be further evaluated for wider farmer acceptance.

Table 15 Mean yield of promising rice varieties tested in PPET, 1996-97

Variety	Location				Means for all
	Tewang	Kabji	Chubu	Bjena	locations
IR61331-2-148	3.50 ab	3.16 a	3.08 a	6.12 a	5.84
IR62470-B-R-	0.89 c	1.71 c	1.94 a	2.17 b	3.01
IR61328-1-136-	4.63 a	3.08 ab	3.64 a	7.45 a	6.05
IR64	4.20 a	2.45 b	3.11 a	6.18 a	5.79
LOCAL	2.37 b	1.40 c	2.28 a	5.76 a	3.79
L-Means	3.12	2.36	2.81	5.54	4.90
CV(%)	21.6	14.6	22.8	16.1	

Variety	Location				Means for all
	Sopsokha	Thetsho	Chongsekha	Richa	locations
IR61331-2-148	9.28 a	9.18 ab	6.43 a	5.99 a	5.84
IR62470-B-R-	4.13 c	6.52 b	3.78 b	2.92 b	3.01
IR61328-1-136-	7.61 b	9.93 a	6.14 a	5.88 a	6.05
IR64	8.96 a	9.21 ab	5.70 a	6.50 a	5.79
LOCAL	4.61 c	2.28 c	5.90 a	5.68a	3.79
L-Means	6.92	7.42	5.59	5.40	4.90
CV(%)	7.2	21.8	8.8	10.1	

Means followed by a common letter are not significantly different at the 5% level by DMRT

1.1.1.5 Production Evaluation Trial

The objective of the trial was to ascertain the yield and performance of two promising varieties in farmers, under farmer's management levels, across varied growing environments in the Wangdue-Punakha Valley.
The trial was conducted in 6 locations. The trial could not be analysed since both the varieties were not evaluated by the same farmer at one location and there

were no crop-cut yields of the local varieties. However, the performance of the 2 varieties is as in Table 6

Table 16 Mean grain yield of 2 promising varieties in PET, 1996-97

Location	CARD21-10-1-1-B	IR62470-B-R-B-B
	Yield (t/ha)	
Khawazara (Tewang)	5.83	-
Srigang (Kabji)	7.36	7.15
Langmana (Phangyul, 1300m)	4.84	5.80
Changchay (Gaselo, 1300m)	5.76	-
Nalabji (Thetsho)	5.73	-
Ave. yield (t/ha)	5.91	6.48

1.1.1.6 Hybridisation

Towards a sustainable strategy for improving local rice cultivars, a shuttle-breeding program was initiated since 1985 in collaboration with the International Rice Research Institute (IRRI) in the Philippines. The major objectives are to:

a) improve traditional rice of Bhutan by incorporating desirable genes from improved parents, and
b) develop varieties that are medium tall, resistant to major insects pest and diseases and high yielding under moderate inputs levels and adaptable to medium (1000-1500 masl) and high altitude (1500-2500 masl) rice growing environments.

a) Pedigree Lines

Out of 463 pedigree lines from 8 different populations, 99 uniform progenies were bulk selected (Table 7). The major selection criteria were medium plant height (100-110 cm), plant vigour, uniformity in flowering and grain maturity, high fertility, insect pests and diseases freeness, compact panicles and dense grain. Based on the phenotypic observation the lines were selected for further yield evaluation in advanced yield nurseries. The details of the selected lines are provided in the Appendix 1.

Table 17 Bulk selected lines and their parental details

Designation	Parent	Field ID	Selected for IET	Selected for OBS
IR62467-B-R-B	S358/Attey	POP1	8	18
IR62470-B-R-B	S358/Punmaap	POP2	2	20
IR62473-B-R-B	S358/Zakha	POP3	-	11
IR6332-B-R-B	Akihikary/Zakha	POP4	-	8
IR62745-B-R-B	S359//IR41996/ ThimphuDimja	POP5	-	10
IR62476-B-R-B	S359/SimMap2	POP6	-	2
IR62472-B-R-B	S358/Sukkimay	POP7	-	11
IR65239-B-R-B	YR3825/Attey	POP8	-	9
TOTAL			10	89

Note: IET = Initial Evaluation Trial; OBS = Observation nursery

1.1.1.7 Seed increase for Research

To make seeds readily available for research works, the center routinely multiplies seeds of released varieties as well as the emerging new varieties for further testing in farmer's field. Nucleus seeds of released and promising varieties are also being maintained.
The quantity of seeds multiplied and the list of varieties whose nucleus seeds are being maintained are presented in Table 8.

Table 18 Variety and quantity of seeds multiplied

Variety	Quantity (kg)
NO 11	257
Kashmir Basmati	200
Basmati 370	81
Basmati T-23	59
IR 62470-B-R-B-B	350
M-54	165
IR61331-2-148-B	355
Chumro	525
CARD21-10-1-1-B	180
IR-64	569
IR61328-1-136-2-1-2-3	124

Table 19 Nucleus seeds of 11 rice varieties

Variety	Selection Type	No.of Sample
Chumro	Panicle selection	201
T-23	do	203
K.Basmati	do	100
CARD21-10-1-1-3	do	200
Milyang –54	do	200
B-370	do	198
No. 11	do	204
IR-64	do	171
IR61328-1-136-2-1-2-3	do	110
IR62470-B-R -B-B	do	101
IR61331-1-2-148-B	do	100

1.1.1.8 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 potential and sustainable rice production. Considering its importance and use for the future 117 local rice germplasm were rejuvenated characterised and preserved at the station (Table 10).

1.1.2 Wheat

1.1.2.1 Introduction

The wheat research program continued with emphasis on varietal improvement and crop management. The volume of wheat research reduced markedly since the major wheat research will be done at RNRRC Jakar. Varietal screening was done on the formalised procedure adopted in 1986.

1.1.2.2 Initial Evaluation Trial (IET)

The main objective of this experiment was to select lines having higher yield, suitable growth duration and resistance to rust diseases under normal conditions.

Nineteen entries were seeded on 9 November 1996 in an RCBD design with a plot size of 10 rows x 5m x 0.20 m. A fertilizer dose of 60-40-20 NPK kg/ha was applied with 50% N top dressed at CRI. The crop was irrigated thrice, once at CRI, tillering and at flowering. The plot yield was estimated from a harvest area of 7.2 sqm. Other than slight insect damage at the earlier stages in some of the entries no major diseases were encountered. Rat damage and lodging were observed to be severe in Bajoka - 2. The results are presented in Table 11.

Statistical analysis indicated that none of the test lines yielded significantly better than the check var. Sonalika. However, the line TAN/PEW//SARA CM88386-23M-OSY-OH-1Y-4M-OM was the best yielder with 4.04 t/ha. Some of these lines will be further tested in advanced yield nurseries.

Table 20 Grain yield, plant height, and maturity of 19 wheat varieties in IET

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1.1.2.3 Advance Evaluation Trial (AET)

The objective of this trial was to select promising varieties for high grain yield, medium maturity, and resistance to rusts under normal conditions under rice - wheat rotation. The trial was laid in randomised complete blocks with 3 replicates. 17 entries were seeded in lines at a row to row spacing of 20 cm in 10 m^2 plots on 18 November 1996. Inorganic fertilizer was applied at the rate of 60-40-20 kg NPK/ha, with half the N top dressed at crown root initiation (CRI). Weeds were controlled by hand weeding. Irrigation was applied three times, once at CRI, tillering and flowering. Grain yield was obtained from a harvest area of 7.2 m^2. Results are presented in Table12.
There was no incidence of rust and other diseases. Slight insects and rat damage was recorded in the early growth stage, but no preventive measures were undertaken. Plant lodging was severe in Bajoka-2.
The analysed results indicated that four test lines/varieties (Sl.no. 1-4) significantly out yielded all the checks. On an average the out yielding test lines (3.99 t/ha) performed 76.5% higher than the average yield of checks (2.26 t/ha). The test lines were taller but by maturity the varieties were comparable. Some of these lines will be evaluated under farmers' field conditions.

Table 21 Grain yield and morphological characters of 14 wheat varieties

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1.1.2.4 Seed Increase for Research

The seeds of released varieties are annually maintained and multiplied for use in on-farm research. During this year, 150**,** 400 and 450 kgs seeds of Bajoka-1, Bajoka-2 and Sonalika, were respectively multiplied.

1.1.3 Grain legumes

1.1.3.1 Evaluation of yield potentials of mustard varieties

Increasingly farmers' have started to use more input such as fertilizers to obtain better yields. The improved crop varieties were evaluated based on moderate to sub-optimal levels of management. It was unknown how the same recommended varieties would respond in terms of yield to higher input levels under local biophysical conditions.
This study was conducted to ascertain the value of some of those released mustard varieties under higher management conditions. The trial was laid in RCB design with 4 replications. The plot size measured 7m X 3m with a spacing of 30 cm row to row. Fertilizer was applied at the rate of 90: 60: 30 NPK kg/ha and 7 t/ha of FYM. The seeds were sown at the rate of 9 kg/ha in the first week of November and harvested in the third week of March. Insect pest was controlled with the use of Cypermethrin at the rate 1 ml/100ltr of water. The result is shown in the Table 16.

Table 22 Seed yield of 6 mustard varieties

Variety	Straw wt. (t/ha)	Seed yield(t/ha)
T9	1.28 a	1.24 a
M27	1.12 a	1.25 a
PT30	0.85 a	0.83 a
BSA	1.22 a	0.90 a
89 LSVE	0.96 a	0.83 a
T30	1.00 a	0.92 a
CV%	34.91	26.17

Means followed by a common letter are not significantly different at the 5% level by DMRT

Though the dose is not very high (90:60:30NPK) yet the yield is satisfactory. The yields are not significant in respect to varieties. Though not significant, T9 and M27 have reacted better than the rest of the varieties to the given fertilizer.

1.2 Crop Production Management

1.2.1 Long Term IPNS Trial (Rice- Wheat). To be replaced with CFN's

It is a long-term trial, initiated in 1988 and terminated in 1997. Fertiliser recommendations are generally made for individual crops. For instance, certain NPK rates for rice and also for wheat are recommended. Given the possible carryover effects, integrated nutrient management for rice wheat system will allow judicious apportionment of scant resources. In the high and medium altitude valleys, farmer's predominately apply FYM, which is known to adequately supply organic P, to their rice crop. Against this background, a long-term trial on the integrated nutrient management for rice-wheat cropping systems was begun in 1989 with the following objectives:

- When inorganic N, P & K are not limited in a rice-wheat rotation where is the optimum placement of FYM?
- When inorganic N & K are not limited either to rice or to wheat , is there carry-over of inorganic P between the two crops.

- When inorganic N & K are not limited to rice or wheat and no inorganic P is applied in the form of FYM adequate?
- \What is the value of *Sesbania aculeata* as a green manure in a rice-wheat rotation?

The trial was laid in 3 replications with plot size of 3m X 7m. The variety used were mainly IR-64 and Milyang -54 for rice and Sonalika for wheat. There were 10 treatments used.

Treatments are as follows:

	R I C E					W H E A T			
T.No.	**N**	**P**	**K**	**FYM**	**GM**	**N**	**P**	**K**	**FYM**
1	0	0	0	0	0	0	0	0	0
2	70	40	20	0	0	60	40	20	0
3	70	0	20	0	0	60	40	20	0
4	70	40	20	0	0	60	0	20	0
5	70	40	20	7t/ha	0	60	40	20	0
6	70	40	20	0	0	60	40	20	7t/ha
7	70	0	20	7t/ha	0	60	0	20	0
8	70	0	20	0	0	60	0	20	7t/ha
9	0	0	0	0	GM	0	0	0	0
10	35	40	20	0	GM	0	0	0	0

Result:

1. N: P2O5: K2O /ha is applied to wheat there is no benefit to applying 7tFYM/ha to either rice or wheat and there is no evidence of an optimum placement of FYM between the rice and wheat crops.
2. There is no benefit to increasing application of phosphorus from 40 kgsP2O5/ha to 80kaP2O5/ha and there is no difference in applying 40kg P2O5 /ha to either the rice or the wheat crop.
3. A consistent positive response, although significant in only two years, to the application of 40kg P2O5/ha to both rice and wheat crops when 7t/ha of FYM was applied indicates that P application through FYM is not adequate.
4. Green manuring increased rice yield in relation to the control plot in all years with an increasing the size of the effect over the first three years. From the third year green manuring was able to replace an application of 70:40:20 Kg NPK /ha to rice in terms of its effect on rice yield. Green manuring, however had no effect on wheat yield. In six of the eight year's application of 60:40:20 kg NPK/ha to wheat lead to a significant increase in yield.

Recommendation:

In terms of practical recommendations it is clear that green manuring for rice with Sesbania aculeata has the potential to replace the current recommended fertiliser application for rice although the full effect of this may not be apparent until the third year. As wheat yields were unaffected by green manuring, fertiliser application is required to increase its yield.

1.2.2 Yield Potential of Released Rice Varieties

The objective of this trail was to see the maximum potential output that rice varieties can give with higher dose of fertiliser, (150: 60: 40 NPK Kg/ha) and FYM at 14 t/ha with normal management practices. Half of N was topdressed after 30 days after transplanting. The trial was laid as an RCBD with 7 released varieties as treatments.

The trial had 4 replications and a plot size of 3.5m X 4m. The nursery was raised on 3rd week of May with seed rate of 50kg/ha. The seedlings were transplanted on 4th week of June with spacing of 20cm X 20cm. Normal cultural practices were carried out. Butachlor was applied at the rate of 16 kg/acre after 4 days of transplanting to control weeds. A few of the early varieties (IR 20913, Milyang 54 & No.11) were harvested in 2nd week of October and later varieties were harvested in 4th week of October. Grain and straw yield data are presented in Table 23.

Table 23 Grain and straw yield of improved rice varieties.

Variety	Rank	Straw Yield t/ha	Grain Yield t/ha
IR- 64	1	6.60	7.876a
Milyang-54	3	12.18	6.584b
IR-20913	2	10.12	6.635b
BR-153	6	10.44	4.854cd

No.11	4	6.20	5.884bc
Barket	5	5.64	5.343cd
BW-293	7	9.41	4.283d
MEAN		8.66	5.923d
CV %			11.23

The late varieties recommended for low altitudes (BW-293 & BR-153) did not perform well. The early and intermediate varieties obtained good yield. The highest yield was given by IR-64 followed by IR-20913 Milyang-54**.**

1.2.3 Yield Potential of Breeding Lines

The yield potential trial was carried out also with 8 breeding lines to see their production potential. The trial was laid as an RCBD with 4 replications and plot size of 3m X3m. The nursery was raised on 3rd week of May with seed rate of 50kg/ha. The seedlings were transplanted on 4th week of June with spacing of 20cm X 20cm. Normal cultural practices were carried out. All the varieties except IR 56346 and CARD 21-14 were harvested in the last week of October and the remaining lines were harvested in the 1st week of November. The result is presented in Table 24.

Table 24 Grain yield of some breeding lines

Variety	yield (t/ha)
IR-62470-B-R-B-B	4.190c
CARD 21-10-1-1-B	5.610abc
CARD 21-10-1-1-3-2-1-(R)	5.890ab
IR 61331-2-148-B	6.721a
IR 61328-1-136-2-1-2-3	6.189ab
IR 61331-2-25-2-3-2-2	6.876a
IR 56346-1-1-R-1-9-1-1	5.038bc
CARD 21-14-1-1-3-2-1-6 (R)	6.381ab
MEAN	5.862

CV% = 13.4%

Means followed by a common letter are not significantly different at the 5% level by DMRT.

Possible reasons for low yield could be:

- Variety No. 1 to 3 were seen affected by panicle blast but proper investigation and scoring was not done.
- Seedlings were weak due to less FYM.
- The terrace used for this trial was not able to retain water after irrigation even for one day. Hence it led to everyday irrigating the field.

The trial will be repeated with the chosen high yielding varieties from both sets of trials in the next season.

1.2.4 Sochum Management Trial

The aim of the trial was to see if coinciding water draining and stress period during critical period of rice-sochum competition has any beneficial effect on weed competition and grain yield. The trial was laid with 3 replications in RCBD with a plot size of 5m x 5m. Fertiliser was applied at 70:40:20 NPK kg/ha. Treatments were as follows:

1 Draining water 20DAT with stress period of 7 days
2 Draining water 20 DAT with stress period of 14 days
3 Draining water 30 DAT with stress period of 7 days
4 Draining water 30 DAT with stress period of 14 days
5 Standing water, hand weeded 20, 35 DAT
6 Standing water, unweeded
7 Standing water, weed free (NC 311)

From the field observation and data collected it was seen that draining out of water did not control sochum but suppressed to some extent. When sochum was suppressed, other weeds were encouraged to grow and ultimately the yield did not increase. Farmers' practice (2 hand weedings) and weedicide NC311 kept the field sochum-free all the time and the yield are high. Among the draining out treatments, stress period of 14 days 30 DAT was the most effective to suppress sochum. One of the factors why draining out of water was not successful was that during monsoon the field was wet from the rainfall favouring sochum to recover from stress and grow again.

Treatment	Yield t/ha
Draining water 20DAT with stress period of 7 days	4.904b
Draining water 20 DAT with stress period of 14 days	5.339ab
Draining water 30 DAT with stress period of 7 days	5.684ab
Draining water 30 DAT with stress period of 14 days	5.046b
Standing water, hand weeded 20, 35 DAT	4.554b
Standing water, unweeded	4.381b
Standing water, weed free (NC 311)	6.796a
MEAN	5.243

Means followed by a common letter are not significantly different at the 5% level by DMRT.

LEGUME:

Though legume is not very popular in Bhutanese diet, research is being carried out by seeing its potential in source of generating income of a household, because of its high price within the country and across the boarder. It is also

widely eaten in eastern and southern part of the country. This region targets mainly the legume growing pocket area i.e. Dagana and Tsirang but Wangdue and Punakha are also taken up since some legumes are being grown.

1.2.5 International Mungbean Nursery Evaluation Trial:

The International Mungbean Nursery (IMN) program is basically a yield trial co-ordinated by AVRDC to provide an effective link among the mungbean improvement program around the world.

The main objectives of the IMN are:
1. Distribute the elite lines to mungbean researchers around the world either for direct or indirect use in their breeding programs.
2. Provide information on genotype X environment interaction and identify genotypes with wider adaptability.
3. Provide mungbean researchers with an opportunity to assess the performance of their own lines under different environment.

Among the 30 varieties which we received from AVRDC (Thailand) 10 varieties were chosen for this year. Local as check was used to compare performances with those of exotic.

Our objective:
Select the suitable and best yielding variety for West-central Region.

Result:

The result is presented in the table:

Sl no.	*Variety*	*Days to Maturity*	*Yield t/ha*
1	VC – 6173 B -13	80 – 90	0.6357ab
2	VC – 6173 B- 33	80 – 100	0.6217ab
3	VC _ 6173 B- 11	80 – 100	0.3530a
4	VC – 6173-B-14	80 – 90	0.4330a
5	VC – 6153 B - 20 P	80 – 90	0.9583ab
6	VC – 6173 B-6	80 – 90	0.9453ab
7	VC 6173 B -10	80 – 90	0.9187ab
8	VC 6371 - 93	80 – 90	0.7037ab
9	VC – 6173-C	80 – 90	0.7040ab
10	Local (payalo dal from Chirang	90 – 100	1.1353b
	MEAN		0.7453

Comment:
The yields, compared to last year cropcut are low due to damping off problem. Yield for local has come significant because it was not affected by this problem. But it took more days to mature than the rest of the varieties. The varieties will be further evaluated in the centre to choose the suitable varieties for the Punakha Wangdue Valley.

Parallel to the selection of varieties, it is essential also to study and find out to which cropping system this legume will fit in the Bhutanese Farming System.

1.2.6 EM activities

INTRODUCTION:

The EM activities are being carried out with cereals, vegetables and fruits in the centre. This is a short report, which contains past and present activities carried out in the centre on EM.

1.3 FIELD CROPS

1.3.1 Nature Farming Demonstration Plot:

For all the crops, during land preparation 10t/ha FYM for rice and 5t/ha for wheat/mustard and 10t/ha EM Bokashi is applied. Further, EM solution prepared at the ratio of 1:1:100 (EM: Molasses: Water) is sprayed at the rate of 10 litres/ha in addition to FYM and EM Bokashi. EM and EM Bokashi at the rate of 5t/ha were spread in 30 DAT.

Wheat:

The crop was sown in the last week of December and harvested in the second to third week of May. This year as compared to the previous subsiding years, the sowing was bit delayed due to the weather condition. The yield this year is therefore lesser than the previous year, but the difference is negligible.
There was no problem faced during the implementation of this trial.
The result is presented in the table below.

Mustard:

The crop was sown in the first week of November with the same method and same amount of inputs as that of previous years. It was randomly broadcasted. The variety used this year is M-27. It was irrigated for once only after 5 weeks of sowing. Harvesting was done in the 2nd week of December. There was no problem encountered with this trial.
The result is presented in the table below.

On- going activities:
Rice

Rice, like every year, this year has also been transplanted with 10t/ha Bokashi and 10 t/ha FYM. This year transplanting is bit delayed due to late repair of irrigation channel from where maximum irrigation has to depend on. Almost 1½ month old seedlings were transplanted in line in the first week of July. Now, the crop at present is standing in the field and is being weeded. Further the crop will be given again EM Bokashi at the rate of 5t/ha and spray EM at the same ratio as

above at the time of panicle initiation. The crop will be probably harvested in October last to November first after taking the cropcut sample.

Maize

It is sown in the first week of May with the spacing of 60cm X 50cm. Bokashi was applied at the rate of 10t/ha and FYM 5t/ha during land preparation. 5t/ha of Bokashi were spread after 35 days of sowing. The variety used is Yangtsipa. Simple weeding and hoeing was given once after 30 days of sowing. Other cultural practices were carried out as mentioned above. Now the crop is standing in the field. It will probably be ready for harvest by September last.

Table: 1. Nature Farm Demonstration Plot (Yield t/ha of over the years).

Crop	95-96	96-97	97-98	98-99
Rice	8.7 (IR-64)	4.4(IR-64)	5.05(IR-64)	standing crop
Wheat	0. 766(sonalika)	1.25 (sonalika)	1.058 (Bk-2)	-
Mustard	0.26 (PT-30)	0.27(PT-30)	0.406 (M-27)	-
Maize	6.37(Yangtsipa)	5.82 (Yangtsipa)	6.84(Yangtsipa)	standing crop

Conclusion:

The use of EM in the cereals, rice, wheat, mustard and maize shows that the yields can be obtained moderately. The yields are quite significant though chemical fertilizers are not used. But in case of rice, weed infestation has **become the major problem, which in future proper EM technology for suppressing weeds has to be looked into. EM technology is a long-term investment and results of these preliminary trials may not be suitable for any concrete conclusion yet. Various other effects like the effect on soil quality, texture and quality of the grains need to be further evaluated. Economics of this labor-intensive technology and possibilities of trying other alternatives to control weeds need to be studied.**

VEGETABLES

EM in Winter Vegetables

The long-term trial established in 1995 to evaluate the use of EM in vegetable crops still continues. The treatment remains the same i.e.

T1 – EM only
T2 - EM with chemical fertilizers
T3 - Chemical fertilizers + compost
T4 - Compost only

All the four treatments are replicated three times and the trials are laid out in a Randomized Complete Block Design. Vegetable crops are established as per the local growing season.

The objective of the trial was to observe the effect of EM on productivity and pest reaction of various vegetable crops and compare with recommended practices with chemical fertilizers and pesticides.
The vegetable seeds for the EM treatment were soaked in EM solution for 2 minutes before sowing. The nursery bed was irrigated with 1% EM solution twice a week. Other times, the seedlings were given plain water once a day till the seedlings were ready for transplanting. The EM treated plots were broadcasted with bokashi 5 days before planting. After planting, EM plots were supplemented three times at the interval of 30 days with EM bokashi. In addition to this, Em plots were also sprayed with EM solution once a week till harvest. Other practices remained as recommended for each crop species. To control insect pests in the EM plots, EM5 was sprayed weekly. Fermented plant extract spray was not available so no spraying could be done. The chemical pesticides were sprayed by using a plastic shield around the plots to prevent arial leaching of the chemicals into adjacent plots.

In 1997, a start was made with the chili crop. The trial was established, however, due to a high incidence of the chili blight disease (*Phytopthora capsici*) during the flowering stage, necessary data and results could not be recorded.
However, the trial still continued with some winter vegetables like broccoli, cauliflower and saag (mustard green). The results are still under preliminary analysis.

Cauliflower

The seeds of the local variety Snowball 16 were sown in the 1st week of December 1997 following the required treatment structure. The curds were ready for harvest by the 1st week of January.

Table 1. Yield and other observations of cauliflower treated with EM and under recommended practices.

Treatments	Yield/plot (kg)	Curds/plot (nos)	Curd colour	Pest and disease incidence/Remarks
T1	No recordable yield was measured, all plants heavily damaged by insect pest (Aphids), most plants bolted.			
T2	2.16	7.33	creamish	No major damage. Healthy good curds
T3	4.56	11.33	creamish	Good quality curds
T4	5.16	11.3	creamish	Curds of high quality
CV %	14.5	14.1		
LSD (0.05)	1.3	3.19		

A general observation was that the EM treated plots were ready for harvest 10 days earlier than the chemical treated plots. The plots with treatment 1 i.e. EM only were badly damaged by insect pests like aphids. Even repeated spraying with Em5 did not save the crop. The other treatments however, showed no damage by insects. The highest yield was observed in treatment 4 i.e. Compost only, followed by treatment 3, chemical fertilizers + compost. Statistically, there were highly significant differences in plot yield between the treatments ($P<0.01$). T3 produced the highest plot yield followed by T3 and T2. There was no yield

from T1. However, the numbers of plants per plot were not significantly (P>0.05) different between the various treatments.

Broccoli

The local variety Dessico was used for the trial. The seeds were planted in the 1st week of November. All necessary practices were followed as per the treatments. Harvesting was carried out from the 1st week of January till the second week of January

Table 2. Yield and other observations of broccoli treated with EM and under recommended practices.

Treatments	Yield/plot (kg)	Curds/plot (nos)	Curd colour	Pest and disease incidence/Remarks
T1	No recordable yield was measured, all plants heavily damaged by insect pest (Aphids), most plants bolted.			
T2	2.43	10.67	light green	no major damage. Good curds.
T3	3.0	11.33	dark green	no major damage. Good curds.
T4	4.6	13.0	dark green	no major damage. Good curds.
cv%	12.1	11.1		
LSD (0.05)	0.63	2.9		

It was also observed that all the plants under treatment 1 did not produce any marketable or recordable yield due to heavy infestation of aphids and other insect pests. There were highly significant (P<0.01) differences between the treatments in plot yield. The highest plot yield was observed in T4 followed by T3 and T2. There was no yield from T1. The numbers of heads produced per plot were not significantly different between the treatments.

Saag (mustard green)

The common variety Phulmaya was used for this trial. All necessary practices were followed as per the treatments. With saag, all the plants survived in all the treatments, however, there were few visual differences in the colour and quality of the leaves produced.

Table 3. Yield and other observations of saag treated with EM and under recommended practices.

Treatment	Yield/plot (kg)	Nos/plot	Leaf colour	Pest and disease incidence/Remarks
T1	2.6	5.0	light green	no major pest, plants spindly and tall
T2	2.2	8.66	dark green	no major pest, plants normal
T3	4.36	7.0	dark green	no major pest, plants normal
T4	2.1	6.0	dark green	no major pest, plants normal
cv%	66.1	37		
LSD (0.05)	3.45	3.47		

There were no significant differences between the treatments in both plot yield and numbers of plants per plot. (P>0.05). The highest yield was observed in T3, the other treatment had no significant differences in plot yield.

Conclusion

All the experiments show that the yields were higher for those treatments where chemical fertilizers and pesticides were used. The EM only treated plants basically produced no marketable yields. This was mainly due to the heavy infestation if insect pests during the growth and development of the crop. Vegetables being more susceptible to a large number of insect pests, it was easier to control by the use of pesticides.
However, the effects of EM on the performance of vegetable crops have yet to be established. EM technology is a long-term investment and results of these preliminary trials may not be suitable for any concrete conclusion yet. Various other effects like the effect on soil quality, texture and quality of the vegetables need to be further evaluated. Economics of this labor-intensive technology also need to be studied. Possibilities of trying other alternatives to control pests need to be tried and established, atleast on major vegetable crops.

The trial will be continued in the coming season with a summer vegetable; okra (lady's finger). Evaluation by growing various other vegetable crops will continue.

Early Spring Saag in screenhouse

A small observation trial was conducted to evaluate the performance of a green leafy vegetable under a screen house, comparing the effect of applying EM and following recommended conventional practices. Each treatment was replicated three times. The plot size was 2.5 x 1 sqm. The local popular variety Phulmaya was used. Sowing was done on 16th December 1997 and transplanted on 12th January 1998. There were a total of 12 plants in each bed.
In the EM treated plots, regular practices of applying Bokashi, EM solution and EM5 were followed. In the control plots, recommended fertilizer doses were applied.
The plants on the whole were very pale green and some were affected by Downy mildew. Harvesting was done in February. The yield and other observations are as follows.

Character	Treatment	
	EM	Control
Total yield/plot (kg)	2.9	3.2
Mkt yield/plot (kg)	1.0	2.5
Plant height (cm)	57.7	49.3
Plant width (cm)	45.0	62.3
Leaf color	Pale green	Dark green
Downy mildew*	3	1

The results are average of three plots.
Downy mildew score: 0 = nil, 1 = slightly affected, 2-3 = heavy or severely affected.

Observation

Generally observing, plants treated by EM tend to grow taller with more slender leaves as compared to the control plants, which were broader and short. There were not many differences in the total yield but the marketable yields of the control plants were double that of the EM treated plants. This was due to leaf damage by insects and downy mildew, which reduced the marketability. The EM treated plants were severely affected by Downy mildew while the control plants showed some tolerance. As observed in many experiments, the color of the leaves were pale in the EM treated plants.

Conclusion

This short experiment also showed that the EM technology in vegetable production is constrained by the heavy infestation of insect pests and diseases. Better ways to minimize or repel the pests need to be sought and tested. Spraying of EM5 is not very successful under our conditions. Further trials need to be planned and other pest controlling techniques need to be established.
Better composting techniques, utilizing sawdust, an abundantly available raw material here in this area, need to be tested. More trials are to be planned for the coming year in consultation with the APNAN field officer who will visit the Centre in September.

FRUITS
During 1997-98, the centre did not carryout any EM activities on fruits. However the centre is planning from this year.

RECOMMENDATION:

Crop production using EM in the country has been greatly emphasised. The use of EM and compost is going to replace the inorganic fertilizer that is expensive, hazardous and deprive the soil quality if not used regular. By seeing a good potential, if it succeeds in the Bhutanese Farming System, perhaps the use of inorganic fertilizers will be reduced. In the past lot of staff have been trained on EM technology from the centre, yet there is need of some more studies to be made on the aspects like, storage of EM, preparation of EM5 and plant extract, quality of good and deteriote EM and perhaps the exposure to the other EM technology used countries.

The present EM plot on cereal is only a demonstration plot, which may not give the satisfactory answer to “is EM effective in the cereal production?” as adequate amount of FYM is also being used. Therefore if a longer-term trial on rice is planned from next year with the appropriate treatments, to answer the above question perhaps the objective may be fulfilled.
The use of EM in rice production is adequate, but there is a need to discuss and develop methods with EM technology to suppress these weeds.

In the vegetable production as mentioned above that further trials need to be planned and other pest controlling techniques need to be established.

2 HORTICULTURE RESEARCH

2.1 Sub-tropical fruits

2.2 Vegetables

2.2.1 Potato Sequential sowing trial 1997-98

The sequential sowing date trial was conducted with the objective to determine the correct time of sowing potato after rice.
Three sowing dates at an interval of 10 days were evaluated with the two popular released varieties Yusikap and Desiree.
The 1st sowing was done on 10.1.98, 2nd on 20.1.98 and 3rd on 30.1.98. The tubers were sown in plot sized 4m x 3m, 6 rows with 14 tuber per row with 25cm plant to plant and 60cm row to row. Fertilisers at the rate of 100:80:30 kg/ha NPK was applied as basal dose at the time of sowing. The experiment was laid out in a randomised block design with 3 replications. Harvesting was done on 15.6.98.

Table 25 Effect of sowing date on tuber number and yield of two potato varieties.

Variety	Sowing date	Yield(t/ha)	Nos./plot
Yusikap	10.1.98	7.62	182
Yusikap	20.1.98	9.87	214
Yusikap	30.1.98	13.88	280
Desiree	10.1.98	7.88	190
Desiree	20.1.98	7.87	191
Desiree	30.1.98	14.25	253
Significance		ns	ns
Variety		**	*
S.date		ns	ns
Interaction(v X s.date)			
LSD (P=0.05)		5.7	84.5

ns = not significant, * = significant at 0.05, ** = significant at 0.01.

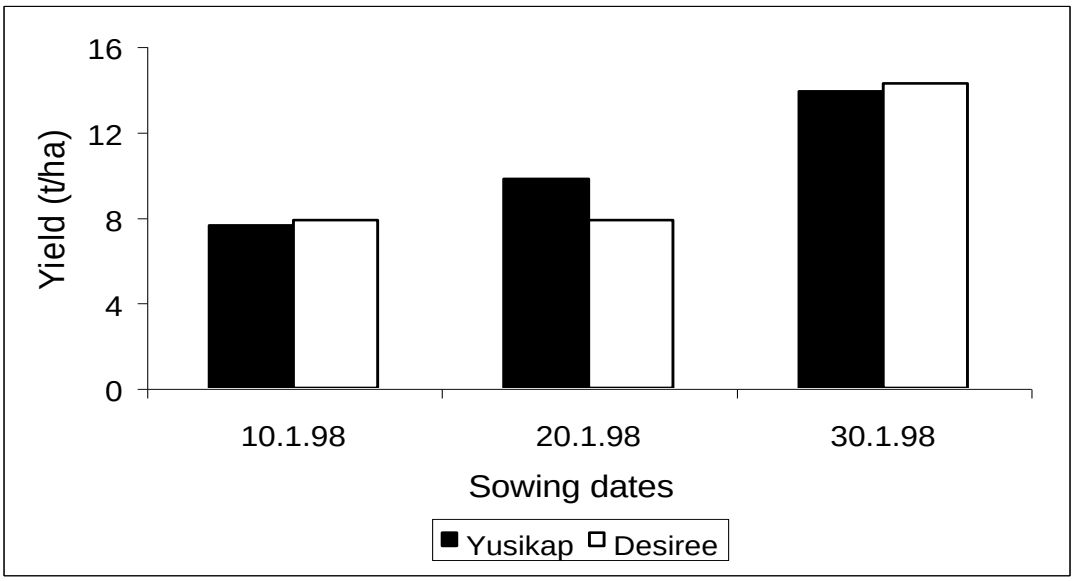


Figure 1. Effect of sowing date on the yield of two potato varieties.

The statistical analysis shows that there are no significant differences in the performance of the two varieties in different sowing dates. However, sowing date had a highly significant effect ($P<0.01$) on the total yield and number of tubers per plot ($P<0.05$). The third sowing date produced the highest yields in both the varieties.

Conclusion
The results indicate that a later sowing date towards the end of January gives higher yield. It is therefore not necessary to sow potatoes earlier than February in this altitude. This quite explains the fact that the early sown potatoes remained dormant in the soil due to the cold frosty conditions in December and early January.

2.2.2 Potato varietal evaluation trial

The objective of the trial was to identify varieties that were early maturing and suitable for production in this valley before the rice crop. Three new entries (720060, 720053 and 800085) were tested in the station along with a local check Desiree. The experiment was laid out in a RCB design with three replications on 15th January 1998. The plot size is 3m x 4m. Each plot contains 7 rows, 14 tubers per row in a spacing of 60cm row to row and 25cm plant to plant. Fertiliser NPK at the rate of 100:80:30 kg/ha was applied as basal dose during field preparation.

The main criteria for evaluation are early maturing short duration varieties for production after the rice crop. Other characteristics are yield, tuber quality and major pest and disease incidence.

Table 26. Yield and tuber count of 4 potato varieties.

Variety	Plot yield (kg)	Yield (t/ha)	No of tubers/ plot	Plant height (cm)	Remarks/ Observation
720060	2.99	2.5	171.3	54.9	White to coarse brown skin. Maximum tuber size 4cm.
720053	2.27	2.28	223.3	78.8	White with purple at eyes. Non-marketable quality.
800085	6.67	5.56	446.7	49.1	Light red skin. Small size, 2-6cm.
Desiree	10.88	9.06	279.0	42.2	Red skin, firm. No visible disease. 3-8 cm tuber size.
LSD (0.05)		5.18	332.5		

Statistical analysis shows that there is a significant differences in the performance of the four varieties ($P=0.05$). The local check Desiree outyielded all the test varieties. The highest yield was obtained from Desiree, the local check (9.06 t/ha), followed by 800085 (5.56t/ha). The other two varieties produced no tubers of marketable quality. The tubers

were very small and hardly edible. The variety 800085 produced the largest number of tubers, which were very small and non-marketable. The variety 720053 had the tallest plant height of 78.8 cm, followed by 720053 54.9cm. Desiree and 800085 were of similar height of 42 – 49cm.

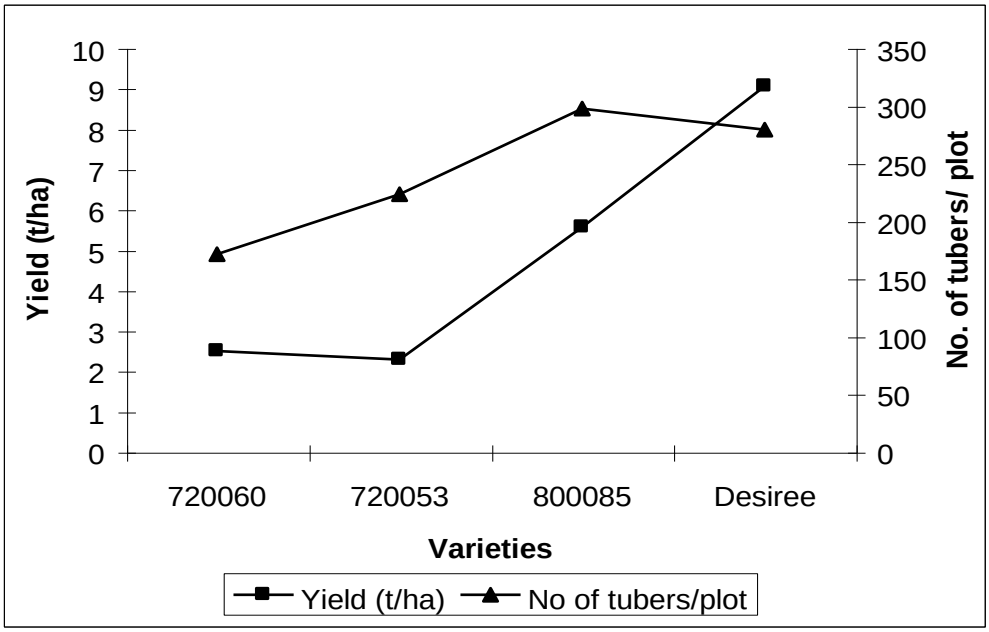


Figure 2. Performance of potato varieties.

Conclusion

It can be concluded that the varieties tested for production in this trial were all not very suitable and had very poor marketing quality. The local check Desiree performed the best and produced fairly good yield. The new materials might have been bred with resistance to certain pest and diseases but the quality and size of tubers did not appeal many observers. More materials need to be tested in the future.

2.2.3 EM in winter vegetables 1997-98

The long-term trial established in 1995 to evaluate the use of EM in vegetable crops still continues. The treatment remains the same i.e.

T1 – EM only
T2 - EM with chemical fertilisers
T3 - Chemical fertilisers + compost
T4 - Compost only

All the four treatments are replicated three times and the trials are laid out in a Randomised Complete Block Design. Vegetable crops are established as per the local growing season.

The objective of the trial was to observe the effect of EM on productivity and pest reaction of various vegetable crops and compare with recommended practices with chemical fertilisers and pesticides.

The vegetable seeds for the EM treatment were soaked in EM solution for 2 minutes before sowing. The nursery bed was irrigated with 1% EM solution twice

a week. Other times, the seedlings were given plain water once a day till the seedlings were ready for transplanting. The EM treated plots were broadcasted with bokashi 5 days before planting. After planting, EM plots were supplemented three times at the interval of 30 days with EM bokashi. In addition to this, Em plots were also sprayed with EM solution once a week till harvest. Other practices remained as recommended for each crop species. To control insect pests in the EM plots, EM5 was sprayed weekly. Fermented plant extract spray was not available so no spraying could be done. The chemical pesticides were sprayed by using a plastic shield around the plots to prevent arial leaching of the chemicals into adjacent plots.

In 1997, a start was made with the chilli crop. The trial was established, however, due to a high incidence of the chilli blight disease (*Phytopthora capsici*) during the flowering stage, necessary data and results could not be recorded.

However, the trial still continued with some winter vegetables like broccoli, cauliflower and Saag (mustard green). The results are still under preliminary analysis.

2.2.4 Cauliflower

The seeds of the local variety Snowball 16 were sown in the 1st week of December 1997 following the required treatment structure. The curds were ready for harvest by the 1st week of January.

Table 27. Yield and other observations of cauliflower treated with EM and under recommended practices.

Treatments	Yield/plot (kg)	Curds/plot (nos.)	Curd colour	Pest and disease incidence/ Remarks
T1	No recordable yield was measured, all plants heavily damaged by insect pest (Aphids), most plants bolted.			
T2	2.16	7.33	Creamish	No major damage. Healthy good curds
T3	4.56	11.33	Creamish	Good quality curds
T4	5.16	11.3	Creamish	Curds of high quality
CV %	14.5	14.1		
LSD (0.05)	1.3	3.19		

A general observation was that the EM treated plots were ready for harvest 10 days earlier than the chemical treated plots. The plots with treatment 1 i.e. EM only were badly damaged by insect pests like aphids. Even repeated spraying with Em5 did not save the crop. The other treatments however, showed no damage by insects. The highest yield was observed in treatment 4 i.e. Compost only, followed by treatment 3, chemical fertilisers + compost. Statistically, there were highly significant differences in plot yield between the treatments ($P<0.01$). T3 produced the highest plot yield followed by T3 and T2. There was no yield from T1. However, the numbers of plants per plot were not significantly ($P>0.05$) different between the various treatments.

2.2.5 Broccoli

The local variety Dessico was used for the trial. The seeds were planted in the 1st week of November. All necessary practices were followed as per the treatments. Harvesting was carried out from the 1st week of January till the second week of January

Table 28. Yield and other observations of broccoli treated with EM and under recommended practices.

Treatments	Yield/plot (kg)	Curds/plot (nos.)	Curd colour	Pest and disease incidence/Remarks
T1	No recordable yield was measured, all plants heavily damaged by insect pest (Aphids), most plants bolted.			
T2	2.43	10.67	light green	No major damage. Good curds.
T3	3.0	11.33	dark green	No major damage. Good curds.
T4	4.6	13.0	dark green	No major damage. Good curds.
Cv%	12.1	11.1		
LSD (0.05)	0.63	2.9		

It was also observed that all the plants under treatment 1 did not produce any marketable or recordable yield due to heavy infestation of aphids and other insect pests. There were highly significant ($P<0.01$) differences between the treatments in plot yield. The highest plot yield was observed in T4 followed by T3 and T2. There was no yield from T1. The numbers of heads produced per plot were not significantly different between the treatments.

2.2.6 Saag (mustard green)

The common variety Phulmaya was used for this trial. All necessary practices were followed as per the treatments. With Saag, all the plants survived in all the treatments, however, there were few visual differences in the colour and quality of the leaves produced.

Table 29. Yield and other observations of Saag treated with EM and under recommended practices.

Treatments	Yield/plot (kg)	Nos./plot	Leaf colour	Pest and disease incidence / Remarks
T1	2.6	5.0	light green	no major pest, plants spindly and tall
T2	2.2	8.66	dark green	no major pest, plants normal
T3	4.36	7.0	dark green	no major pest, plants normal
T4	2.1	6.0	dark green	no major pest, plants normal
Cv%	66.1	37		
LSD (0.05)	3.45	3.47		

There were no significant differences between the treatments in both plot yield and numbers of plants per plot. (P>0.05). The highest yield was observed in T3, the other treatment had no significant differences in plot yield.

Conclusion

All the experiments show that the yields were higher for those treatments where chemical fertilisers and pesticides were used. The EM only treated plants basically produced no marketable yields. This was mainly due to the heavy infestation if insect pests during the growth and development of the crop. Vegetables being more susceptible to a large number of insect pests, it was easier to control by the use of pesticides.
However, the effects of EM on the performance of vegetable crops have yet to be established. EM technology is a long-term investment and results of these preliminary trials may not be suitable for any concrete conclusion yet. Various other effects like the effect on soil quality, texture and quality of the vegetables need to be further evaluated. Economics of this labour-intensive technology also need to be studied. Possibilities of trying other alternatives to control pests need to be tried and established, atleast on major vegetable crops.

2.2.7 Early Spring Saag in screen house

A small observation trial was conducted to evaluate the performance of a green leafy vegetable under a screen house, comparing the effect of applying EM and following recommended conventional practices. Each treatment was replicated three times. The plot size was 2.5 x 1 m^2. The local popular variety Phulmaya was used. Sowing was done on 16th December 1997 and transplanted on 12th January 1998. There were a total of 12 plants in each bed.
In the EM treated plots, regular practices of applying Bokashi, EM solution and EM5 were followed. In the control plots, recommended fertiliser doses were applied.
The plants on the whole were very pale green and some were affected by Downy mildew. Harvesting was done in February. The yield and other observations are as follows.

Table 30. Plant and yield characteristics between EM treated and control plants.

Character	Treatment	
	EM	Control
Total yield/plot (kg)	2.9	3.2
Mkt. yield/plot (kg)	1.0	2.5
Plant height (cm)	57.7	49.3
Plant width (cm)	45.0	62.3
Leaf colour	Pale green	Dark green
Downy mildew*	3	1

The results are average of three plots.
Downy mildew score: 0 = nil, 1 = slightly affected, 2-3 = heavy or severely affected.

Observation
Generally observing, plants treated by EM tend to grow taller with more slender leaves as compared to the control plants, which were broader and short. There were not many differences in the total yield but the marketable yields of the control plants were double that of the EM treated plants. This was due to leaf damage by insects and downy mildew, which reduced the marketability. The EM treated plants were severely affected by Downy mildew while the control plants showed some tolerance. As observed in many experiments, the colour of the leaves was pale in the EM treated plants.

Conclusion
This short experiment also showed that the EM technology in vegetable production is constrained by the heavy infestation of insect pests and diseases. Better ways to minimise or repel the pests need to be sought and tested. Spraying of EM5 is not very successful under our conditions. Further trials need to be planned and other pest controlling techniques need to be established.
Better composting techniques utilising sawdust, an abundantly available raw material here in this area, need to be tested. More trials are to be planned for the coming year in consultation with the APNAN field officer who will visit the Centre in September.

2.2.8 Tomato On-farm trial 1997-98

The tomato varieties available for general cultivation have either become susceptible to pest and diseases or their yields have declined. It is important to identify new varieties, to replace the older ones with high yielding and that has better resistance to pest and diseases. The Centre had identified two promising varieties through the SAVERNET program. They have performed extremely well under station conditions and were thus tested in the farmer's fields under farmers' management conditions.

Two farmers, one in Chuzomsa and one in Lobesa were selected for this trial. The plot size was of 20 sqm. with three replications per variety. The spacing maintained by the farmers were 50cm plant to plant and 60cm row to row. Fertilisers were applied at the rate of 60:75:20 kg/ha NPK with 30 t of FYM. A total of four hand weeding was done. Daily irrigation was done right after transplanting till proper establishment of the plants. After 15 days, flood irrigation was done at an interval of 15 days. Two sprays of Chloropyriphos 20EC was given, 1st three weeks after planting, 2nd 50 days after planting when 50% of the plants had flowered.
A total of 6 harvests were carried out beginning from the 2nd week of May till the 2nd week of June. The harvest plot size was 10 sqm.

The major diseases observed were Anthracnose, powdery mildew and late blight. The main pests were fruit borers. Physiological disorders like cracking of fruit was also observed.

Both the varieties performed similarly. There was no significant effect of sites or variety. This was probably due to the less number of sites covered.

Table 31. Yield of the two tomato varieties under farmer's conditions.

Location	Variety	
	Pusa Sheetal	Ratan
Location 1	10.57	10.87
Location 2	12.43	12.87

These promising varieties are to be further tested on more sites including a local check.

2.2.9 Tomato off-season production under polytunnels

Four new varieties from the SAVERNET countries, along with a local check, were tested for off-season production under polytunnels. The seeds were sown on 10.10.97 and transplanted on 8.11.97. A randomised block design with three replications was followed. The plant to plant spacing was 50cm and row to row spacing was 60cm. There were two plants per variety in every replication.
The first flowering was observed in the variety BARI 4. The varieties were ready for harvest by the first week of March and the harvest period continued till the end of April. There were no major pest problems encountered. There was a slight incidence of powdery mildew after flowering. CARD CHT was found to be most susceptible to powdery mildew, Ratan and BARI 4 were least affected.
Statistically, there was a highly significant difference in the yielding ability of the five varieties (P<. 001). Ratan produced the highest yield, followed by BARI 5 and Manik. CARD CHT produced the lowest yield.

Table 32. Performance of five tomato varieties for off-season production under polyethylene tunnels.

Variety	Average plant yield (kg)	P. mildew score	Fruit quality
BARI 4	0.74	1	Poor, Small fruits
BARI 5	0.90	2	Good
CARD CHT	0.31	3	Poor, very small
Manik	0.81	2	Good
Ratan	1.69	1	Very good
LSD (0.05)	0.41		
CV%	24.5		

Conclusion
The trial was simply to test the performance of the new varieties for production under polytunnels. Though significant differences in the performance of the different varieties were observed, this trial shows that tomatoes can be produced in the early months of March under polyethylene tunnels. The cost benefit analysis of the production was not done since the trial was not large enough.

However, detailed cost-benefit analyses of producing off-season tomatoes need to be done with the best performing variety.

2.2.10 Asparagus varietal evaluation trial

The main objective of this study was to identify suitable high yielding varieties of asparagus in order to be able to provide a wider choice for the farmers since there is only one released variety available right now. It also exploits the possibilities of growing high yielding disease and pest resistant hybrid varieties.
A total of nine F1 hybrid varieties were transplanted in March 1995. The experiment was conducted using Randomised Completely Block Design (RCBD) with four replications in plot sized 7sqm. The row to row spacing was kept at 1.5 m and 25 cm plant to plant. First harvesting of the spears began in March 1997, which carried on till late May. A total of 16 cuts were done. The evaluation of the performance of the hybrid varieties continues and this is the second year of harvest. The spears were ready for harvest from the beginning of March and harvest continued till the end of May, after which the spears were left to encourage fern growth. A total of 26 cuts were done.
The yield and number of spears produced are presented in the table below.

Table 33. Performance table of the nine Asparagus varieties.

Variety	Yield (t/ha)	Nos/plot
F1UC 157	10.75	487
Larak	9.45	419
Carlim	7.76	522
Gijlim	10.71	698
Thielim	10.74	466
D.Argentinal	5.78	355
Baklim	6.57	271
Hyb-90-0-70	6.43	375
Hyb-90-0-136	5.84	463
CV%	19.4	27.4

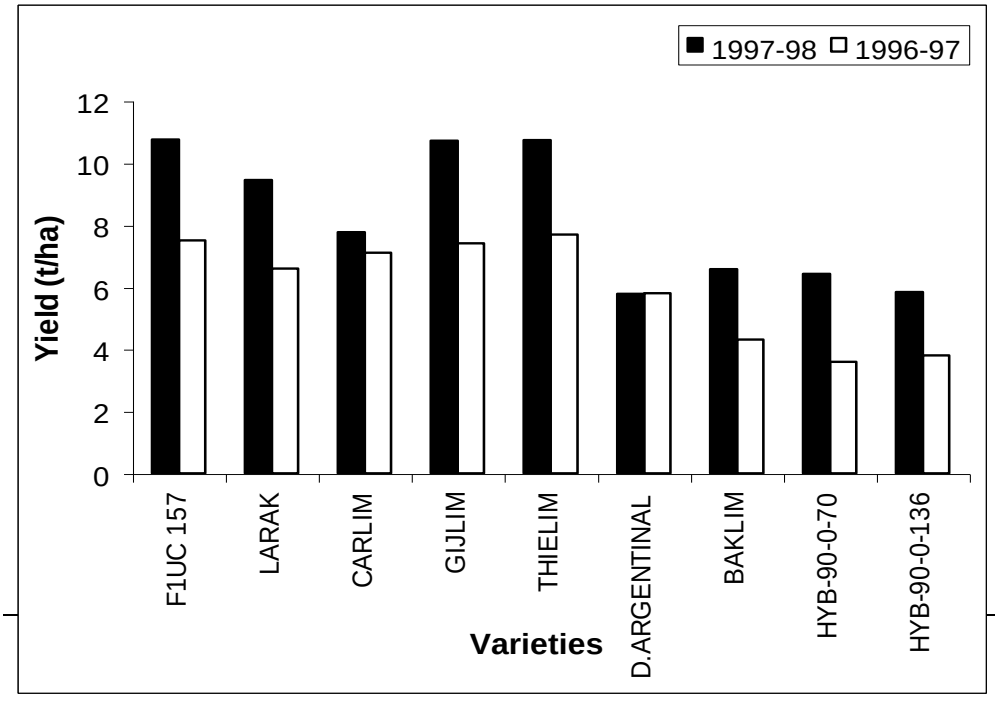


Figure 3. First and second year yields of the 9 hybrid asparagus varieties.

There was a general increase in yield in the second year in all the varieties under test. The variety Theilim, F_1UC.157, Gijlim yielded significantly higher than rest of the entries, followed by Larak and Carlim. Among the entries variety D. Argentinal and HYB. F_1 90-0-136 yielded the lowest. The quality of the spears produced was more or less similar to the first year. F_1UC.157, Thelim and Larak produced thick, big green spears. D.Argentinal, F_1 90-0-136, Baklim and Carlim produced medium sized spears. F_1 90-0-136 and F_1 90-0-70 produced whitish coloured spears.

2.2.11 Cauliflower early production trial

Three cauliflower varieties from SAVERNET (Pusa Deepali, Pusa Early Synthetic, Kauli Nepal) were tested along with a local check Snowball 16, for early production in this valley. Seeds were sown in September and transplanted in October. The trail was laid out in a randomised block design with three replications. The plant spacing was maintained at 60 x 60 cm. The bed size was 6m x 1m, with two beds per replication. Each replication had two beds per variety. Two varieties, Pusa Deepali and Pusa Early Synthetic bolted very early forming green curds. The remaining two varieties were evaluated.

Table 34. Yield and other characteristics of two cauliflower varieties.

Variety	Yield (t/ha)	Nos. /plot	P.width (cm)	P.height (cm)	Curd width (cm)	Curd length (cm)	Days to maturity
Kauli Nepal	11.6	30.7	49.1	42.9	14.3	10.6	127
Snowball 16	9.1	11.7	50.0	46.9	17.43	12.7	157
LSD (0.05)	13.75	30.1	16.3	8.64	4.04	3.12	

Statistically, there were no significant differences in yield and curd characteristics of the two varieties. However, there was a highly significant effect on the days to maturity. Kauli Nepal matured 30 days earlier than our local check variety Snowball 16.

Conclusion
The other two varieties that bolted needs to be evaluated for summer production. Kauli Nepal seems to be a potential early maturing variety. It will be further evaluated.

2.2.12 Melons as summer intercrop at Baychu orchard.

The main objective of the trial was to evaluate varieties suitable for cultivation in the region and to explore the possibilities of having melons as intercrop in a standing orchard. The trial could not be replicated due to lack of materials and poor germination of some of the varieties.
Seeds were sown in plastic pots on the 23rd of March and transplanted in the field on 15 May. Only three plants per variety were available for transplanting. Spacing at 1-1.5m RR and 1m PP were followed.

Observation

Table 35. Performance of various melons.

Variety	Days to harvest	No. of fruit/plant	Weight of single fruit (kg)	Yield / plant (kg)	Fruit shape and other remarks
Honey Dew	89	1	3.2	3.2	
Autumn Flavour	All plants died after transplanting				
China Dragon	89	2	4.5	9.5	Oval, dark green stripes, red, sweet flesh.
F1 Giant	89	1	4.4	4.4	Oval shaped
Odyssey	89	1	3.7	3.7	
CT Dollar	89	1	3.2	3.2	Round fruits
Sugar Baby	89	1	3.2	3.2	Round, dark green cover, red flesh. Sweet
Sky Rocket	All plants died after transplanting				
Lucknow Tender	89	1	2.1	2.1	

China dragon, an F1 hybrid from Taiwan was found to be the sweetest and preferred by all. All plants that survived fruited but not satisfactorily. Proper recording of data was not possible. The varieties need to be tested further for proper data recording, and replicated for statistical analysis.

2.2.13 Chilli Varietal screening against resistance to blight

The objective of the trial was to screen different chilli varieties (both local and from neighbouring countries) for resistance against blight disease. Another important parameter observed was the tolerance to cold for early production.

The seeds were sown in the nursery towards the end of November 1997 and transplanted at the end of February. The nursery was raised under polytunnels. The seedlings were pricked out into small pots 20 days before they were transplanted in the field. The plot size was 1m x 3.5 m, with 14 plants per plot. The design was randomised complete block design with four replication per each of the eight varieties tested. All recommended cultural practices were followed.

Harvesting of the fruits was possible as early as the second week of May. The number of plants wilted was not only due to blight but also due to frost damage soon after transplanting. The plants damaged due to the disease were identified according to the visual symptoms. The disease was observed mostly after the first harvest.

The yield and disease scoring are given in the table below.

Table 36: Yield and tolerance to frost and *Phytophthora* blight disease of 8 chilli varieties tested.

Variety	Yield (t/ha)	Nos.	% frost damage	% wilted	Blight score (0-3)*
KHOMA	16.25	1395	10.7	0	0
SHA EMA	12.89	1230	7	0	0
KORIEN	11.72	1406	10.6	0	0

KII	4.72	1395	30.4	46	3
CARD III	14.87	1387	10.6	8	1
LAUNGHI	5.47	2514	5.3	11	2
W MKT	14.17	1365	10.7	0	0
HOT WAX	18.42	1017	1.8	0	0
LSD (0.05)	0.71	2.42	10.85		

Blight score: 0=nil, 1= 0-10% wilted, 2=10-20% wilted, 3=>20% wilted.

The results show that Hot Wax produced the highest fresh yield, followed by Khoma and the Wangdue local market variety. The lowest yields were obtained from KII and Launghi. This was probably die to the characteristics of the fruit since these were small sized. The popular variety Sha Ema produced an average yield of 12.89 t/ha. The variety KII seemed to be the most susceptible variety to damage by frost. Khoma, Korien, CARD III and W.Mkt were equally susceptible. Launghi and Sha Ema were found to be fairly tolerant. Hot Wax was found to be the most frost tolerant variety. This would be the one that can be tested for early production during the off season. Most of the varieties tested were not affected the *Phytopthora* blight disease. The most susceptible variety was KII, where almost 50% of the plants were damaged by the disease. Launghi and CARD III were slightly susceptible. In the other varieties, none of the plants showed the symptoms of the disease.

3 LIVESTOCK RESEARCH

3.1 Feed and fodder research

3.1.1 Introduction Nursery on Sub-tropical Fodder Species

Observation on a total of 25 grass and 34 legume species established on 10/7/96 was continued. Details of establishment and preliminary are presented in 96 — 97 Annual Report. Biomass recording was done twice the first on 14/10/96 by visual observation and the second on 17/10/97 by taking crop cut in $1m^2$ area. *Paspalum atratum BRA 9610* recorded highest biomass yield of 42.0 t/ha among grass species and *Teramnus uncinatum CIAT 9012* with biomass of 69.5 t/ha among legumes. The trial site was not in a suitable location so this has been terminated and the same species has been established in June 98 in a new location. The good performers are being selected and will be taken to on-farm trials

Table 37. List of tested Grass species with their performance.

Sl. No.	Species/Cultivar	Accession	Fresh wt. (t/ha) 1st.	Fresh wt. (t/ha) 2nd	Total yield (t/ha)
1	*Andropogon gayanus*	CIAT 621	0	0	0
2	*Cenchrus ciliaris*	Bioloela	0	20	20.6
3	*Chloris gayana*	Callide	1.6	30	31.6
4	*Brachiaria decumbens*	Basilisk	1.0	30	31.0
5	*Brichiaria brizantha*	CIAT 6780	1.2	30	31.2
6	*Brachiaria insculpta*	Bisset	0	20	20.0
7	*Brachiaria pertusa*	Keppel	0	12	12.0
8	*Digitaria milanjianam*	Jarra	0	0	0
9	*Digitaria smutsii*	Premier	0	20	20
10	*Panicum coloratum*	CPI 16796	0	35	35
11	*Panicum maximum*	Bambasti	0	20	20
12	*Panicum maximum*	CIAT 6299	0	20	20
13	*Panicum maximum*	Gatton	7.4	10	17.4
14	*Panicum maximum*	CIAT 16051	0	0	0
15	*Panicum maximum*	Makueni	0	20	20.0
16	*Paspalum atratum*	BRA 9610	2.0	40	42.0
17	*Paspalum dilatatum*	86-088	2.5	20	22.5
18	*Paspalum guenoarum*	BRA 3824	0	0	0
19	*U. oligotricha*	CPI 47122	3.0	10	13.0
20	Big bluestem	Kaw	0	0	0
21	Switchgrass	Trailblazer	0	0	0
22	Indian grass	Holt	0	0	0
23	*Seteria sphacelata*	Nandi	5.0	30	35.0
24	*Seteria sphacelata*	Narok	4.5	30	34.5
25	*Panicum maximum*	RWS 602	0	0	0

Table 38. List of tested Legume species with their performance

Sl. No.	Species/Cultivars	Accession	Fresh wt. (t/ha) 1st	Fresh wt. (t/ha) 2nd	Total wt. (t/ha)
1	*Arachis pintoi*	Amarilo	22.2	0	22.2
2	*Aeschynomene histerix*	CIAT 9690	0	0	0
3	*Aeschynomene americana*	Lee	0	30	30
4	*Aeschynomene villosa*	CPI 93621	11.1	30	41.1
5	*Centrosema acutlfolium*	CIAT 5277	0	0	0
6	*Centrosema pubescens*	CIAT 15160	0	0	0
7	*Centrosema pubescens*	CIAT 442	0	0	0
8	*Centrosema pubescens*	Centro	1.85	0	1.85
9	*Chamaecrista rotundifolia*	Wynn	0	0	0
10	*Clitoria ternatea*	CIAT 772	25.9	0	25.9
11	*Desmanthus virgatus*	Marc	0.07	0	0.07
12	*Desmanthus virgatus*	Uman	0	0	0
13	*Desmanthus virgatus*	Bayamo	0	0	0
14	*Desmodium intortum*	Greenleaf	18.5	40	58.5
15	*Desmodium uncinatum*	Silverleaf	11.1	20	31.1
16	*Desmodium rensonii*	CPI 46562	22.2	20	42.2
17	*Lablab purpureum*	Highworth	23.0	0	23.0
18	*Macroptilium artopurpureum*	Siratro	22.2	0	22.2
19	*Macroptilium gracile*	DFC 546	18.5	0	18.5
20	*Macrotyloma daltonii*	CPI 60303	0.5	0	0.5
21	*Neonotonia wightii*	Clarence	1.85	0	1.85
22	*Neonotonia wightii*	Cooper	22.2	20	42.2
23	*Neonotonia wightii*	Tinaro	20.5	40	60.5
24	*Teramnus uncinatum*	CIAT 9012	24.5	45	69.5
25	*Teramnus uncinatum*	CIAT 7315	24.3	30	54.3
26	*Trifolium rueppellianum*	33177	0.11	0	0.11
27	*Trifolium rueppellianum*	33180	0.11	0	0.11
28	*Stylosanthes guianensis*	CIAT 184	22.2	40	62.2
29	*Stylosanthes guianensis*	CIAT FM05-3	33.3	23	56.3
30	*Stylosanthes guianensis*	CIAT FM05-1	29.6	0	29.6
31	*Stylosanthes guianensis*	Oxley	27.75	0	27.75
32	*Stylosanthes capitata*	10280	0	0	0
33	*Vigna parkeri*	Shaw	1.85	29	30.85
34	*Vigna parkeri*	49184	22.2	0	22.2

3.1.2 Introduction Trial Grass and Legume Species

Data collection on Introduction trial on grass and legume species established on 20th March 1996 was continued till June 1998. *Seteria sphacelata* recorded highest biomass yield of 200 t/ha (sum of the whole trial period) among grass species and *Chamaecrista rotundifolia* 64.3 t/ha among legumes. Following table is the summarised results of the tested species:-

Table 39. (What is the title of this table?)

Sl. No	Species	No of cuts	Total biomass (t/ha)
1	*Panicum maximum (Gatton)*	6	181.1

2	*Panicum maximum (Petrie)*	6	158.9
3	*Bothriochloa insculpta*	5	35.0
4	*Chloris gayana*	5	86.4
5	*Seteria sphacelata*	4	200.0
6	*Digitaria milanyana*	6	126.0
7	*Digitaria smutssi*	Damaged by frost	0.0
8	*Seteria incrassata*	3	13.5
9	*Macroptilium artopurpureum*	2	14.3
10	*Neonotina wightii*	1	1.3
11	*Stylosanthes scabra*	1	1.6
12	*Desmanthus virgatus*	Didn't come	0.0
13	*Aeschynomene villosa*	3	61.9
14	*Chamaecrista rotundifolia*	3	64.3
15	*Arachis pintoii*	Green throughout	Didn't cut

3.1.3 Observation Trial on Perennial Grass and Legume Species:-

Data recording on 7 legume and 5 grass species established on 23rd April 1995 was continued. The trial has been terminated after the last crop cut on 23/3/98. The result of 97-98 was good compared to previous two years because during this period irrigation was provided when extremely dry. *Sudan grass* was the best among grass species with 509 t/ha biomass followed by *Molasses* 260 and among legumes *Glycine* with 325 t/ha followed by *Siratro* 324.9. The trial has been terminated since there was water continuously entering the plot from the rice field above it

Table below is the summary of their performance: -

Table 40. (What is the title of this table?)

Sl. No	Species	Year	No. of cuts	Total biomass (t/ha)	Average plant. Ht. (m)	Total biomass (t/ha)
1	Sudan Grass	95-96 96-97 97-98	4 1 3	427 40 42	0.97 0.5 1.03	509
2	Guinea grass	95-96 96-97 97-98	3 1 4	95 20 74	0.73 0.6 0.8	189
3	Signal grass	95-96 96-97 97-98	0 1 4	0 20 82	0 0.6 0.7	102
4	Molasses	95-96 96-97 97-98	3 2 4	111 64 105	0.55 0.65 0.41	260
5	Paspalum	95-96 96-97 97-98	2 0 4	45 0 110	0.35 0 0.76	155
6	Greenleaf desmodium	95-96 96-97 97-98	4 1 4	92.8 30 94	0.6 0.5 0.77	216.8
7	Silverleaf desmodium	95-96 96-97	2 2	63 75	1.1 0.55	207

		97-98	4	59	0.77	
8	Glycine	95-96 96-97 97-98	4 2 4	120 95 110	0.46 0.9 0.5	325
9	Seratro	95-96 96-97 97-98	4 2 4	125.9 63 136	0.45 0.7 0.52	324.9
10	Stylo	95-96 96-97 97-98	3 1 3	140 15 80	0.37 0.35 0.31	235
11	Dolichos	95-96 96-97 (produced seeds) 97-98 (No re-growth)	1	65	1.8	65
12	Centro	95-96	Few plants	No cut		

3.1.4 Demonstration/Observation Trial on Grass Species.

Data collection on the demonstration plot established on 6th Aug. 1993 was continued. All the three species were found to be good biomass producer, *Napier* produced highest 663.6 t/ha in 3 years. Could not take crop cut of *Signal grass* on 24/6/98 since the plot was completely filled with *Setaria* plants. Table below is the summary of their performance.

Table 41. (What is the title of this table?)

Sl. No	Species	Date of crop cut	Fresh wt. (t/ha)	Plt. Ht. (m)	Cumu. Wt. (t/ha)	Average Plt. Ht. (m)
1	Napier	1st year (95-96) 24/7/95 22/9/95 19/3/96 4/6/96 2nd year (96-97) 26/8/96 6/1/97 2/6/97 3rd (97-98) 27/8/97 14/11/97 16/2/98 24/6/98 **Total wt./ Av. Ht.**	 66 140 50 108 816 15 59 77 40 38 29	 2.4 2.3 1.05 1.93 2.56 3.2 2.16 2.3 1.5 1.3 1.2	 364 115.6 184 **663.6**	 1.92 2.64 1.57 **2.04**
2	Setaria	1st year (95-96) 24/7/95 22/9/95	 28 63 35	 1.0 1.2 0.55		

		19/3/96 4/6/96 2nd year (96-97) 26/8/96 6/1/97 2/6/97 3rd (97-98) 27/8/97 14/11/97 16/2/98 24/6/98 **Total wt./ Av. Ht.**	90 57.5 37 50.8 25 20 16 36	1.33 1.2 1.0 1.95 3.7 1.1 0.95 1.0	216 145.3 97 **458.3**	1.02 1.38 1.69 **1.36**
3	Signal	1st year (95-96) 24/7/95 22/9/95 19/3/96 4/6/96 2nd year (96-97) 26/8/96 6/1/97 2/6/97 3rd (97-98) 27/8/97 14/11/97 16/2/98 24/6/98 **Total wt./ Av. Ht**.	28 45 30 58 45 40 07 40 20 25 No cut	0.5 1.0 0.6 1.25 1.25 0.9 0.85 1.2 1.3 1.0	161 92 85 **338**	0.84 1.0 1.16 **0.99**

3.1.5 Tree Fodder Demonstration

Some seedlings of fodder tree were planted at the station with an objective to observe its adaptability and biomass yield. The following have been planted.

Table 42. Xyz

Sl. No	Species	Planting date	No of seedling planted	No of seedling survived
1	*Ficus roxburghii*	6/8/93 17/7/96	26 47	20 25
2	*Gmelia arborea*	6/8/93	14	12
3	*Leucaena leucocephala*	6/8/93 20/7/96	12 75	12 69
4	*Chamaceyttisus Probilerus*	11/11/95	15	3

The seedling has been planted all scattered. *Ficus roxburghii* planted on 6/8/93 and *Gmelia arborea* plants lopping was done on 22/6/98 since their growth was not satisfactory. *Chameceyttisus probilerus* produced seeds. Most of the *Lecucaena leucocephala* planted on 6/8/93 have been felled down due to heavy production of seeds, which fall down on the ground and germinated as weed vigorously.

3.1.6 Observation on Velvet bean (*Mucuna pruiens*)

80 numbers of Velvet bean seeds have been received from RNRRC, Jakar to observe its potential for fodder production and soil cover/green manure under sub-tropical climatic conditions. Line sowing was done on 27/6/97 with 0.5m row to row and seed to seed distance in single plot. Basal dose of p_20_5 at the rate of 50kg/ha was applied. 49 seeds germinated and produced 5 kilograms of seed. The materials appear to be promising considering the prolificity in seed production

3.1.7 Seed Multiplication/Propagation

Objective of this activity is to multiply enough seeds for on-farm and on station trial. The centre has produced 70 kg *Sudan grass*, 3 kg *Astragalus sinicus*, 2 kg *Italian rye* 20 kg *Vicia villosa* 250 kg *Oat* and 0.2 kg *Berseem*. *Berseem* was sown in a very small plot to observe its possibility of seed production and found to be successful. *Sweet clover*, *Crimson clover* and *Lathyrus* seed production was not successful this year. *Lathyrus* was sown in a large plot but all the plants died during flowering stage by rotting, *Sweet clover* and *Crimson clover* plants germinated but didn't grow till flowering stage. Slips of *Napier grass* in an area of 300 m^2 are readily available for further transplantation.

3.1.8 Winter Fodder Species Evaluation Trial

With an objective to evaluate selective species for their potential to provide winter fodder the trial was established. A set of materials was provided by RNRRC, Jakar, though the trial was proposed for on-farm research we were interested to have one set at station also and the trial was established. Following is the list of tested species with its seed rate.

	Species	Seed rate (Kg/ ha)
1.	Farmer's traditional species (took As wheat, var. Sonalika)	120
2.	Berseem & Italian rye (Westerwold)	25/20
3.	Winter vetch & rye	80/100
4.	Oat	150
5.	Astragalus	15

The land was pre-irrigated before ploughing, NPK was applied at 40:20:10 kg/ha, and half-N top-dressed after first irrigation. Seeds were line sown on 18/11/98 in plot size of 2m x 6m with row distance of 25cm, 8 rows per plot with 3 replicates. Three times irrigation was provided on 1/1/98, 3/2/98 and 26/2/98.

Table 43. Data recordings.

Species	Survival % 10 days after planting	Biomass 40 days after planting (t/ha)	Biomass at the time of harvest (t/ha)	Biomass on 3/4/98	Plant ht. On 3/4/98
Sonalika	70	2	50	29	1.06
Berseem Italian rye	80 80	0.8	35	34	0.3 0.67
Wint. Vetch Rye	50 30	2.5	30	37.6	1.29 1.14
Oat	95	4	70	40.6	1.31
Astragalus	05	0.05	5.0	10	0.37

Sonalika reached time of harvest on 20/2/98, *Berseem, Italian rye, winter vetch, Rye* and *Oat* on 12/3/98 and *Astragalus* on 2/3/98. Data recording at the time of harvest is by visual estimate and by crop cut from an area of $1m^2$ on 3/4/98. Biomass for the mixtures were taken together but height was measure separately. *Berseem* plants were very weak, thinly populated and highly dominated by *Italian rye grass* and the plant population ratio was likely to be 10: 90. *Winter vetch* and *Rye* combination was good with plant ratio of 40: 60.

All the species were found adaptable in the area, researchers feel it is also important to evaluate number of cuts per species, their nutritive value and possibility of harvesting seeds before start of paddy transplantation.

3.2 ON FARM TRIALS

3.2.1 Introduction

Cattle especially those lactating require feed supplements such as grass. But this requires labor for collection of fodder. Although availability of green fodder is abundantly available in summer, most of these fodder are poor in their nutritive quality. In addition farmers are not aware of the improved fodder. And in winter the farmers face shortage of fodder. Thus to reduce these acute shortages and to provides better quality feeds, some pasture species were evaluated during 97-98.

3.2.1.1 Testing of sub-tropical fodder species.

The objective was to identify suitable fodder species for the particular location. Small kits of 10-15 gm of seeds were provided to cooperators of five locations in the watershed depending on the availability of land. The list of species tested and other details are sown in table 1. The status of performance of each species in each location is also presented in table 2.

Table 44 Fodder species Adaptation trial in the watershed

Dzongkhag	4 VILLAGE	5	**Farmer**	**Species planted**
Punakha	**6 LIMBUKHA**	1	Ap Kuta	*Paspalum artatum*, Sudan, Ruzi *Paspalum dilatatum*, Lucerne and white clover
	7 DOMPOLA	**8**	Dhaw	Ruzi, Sudan, Molasses, *Brachiaria brizantha*, Lucerne, stylo cook, Piotoi and peanut
	Nabji	1	Namgay Tshering	Sudan
	Omtekha	1	Am Nalam	Sudan, Seteria, *Paspalum dilataum*, *Paspalum artatum, Panicum maximum, Desmodium intortum,* lucerne, *desmodium uncinatum*
Thimphu	Matalumchu	1	Saga	Sudan, Ruzi, *Panicum maximum, Desmodium uncinatum*
		2	Ugay	*Paspalum atratum, paspalum dilatatum, Desmodium uncinatum*
		3	Ap saga	Molasses, Seteria, Pintoi peanut, Sudan, *Desmodium intortum, Brachiaria brizantha*

The result presented in table 2 is based on visual observation of the individual species performance in each location.

Table 45 Best performing summer fodder species in each location/village

Altitude (m)	**Village**	**Remarks**
2170	Limbukha	Of the 6 species only white clover and *Paspalum dilatatum* were found to be the best with competition and suppressed local weeds. The ability of the species to overcome pressure from local weeds is very important under situations where open grazing is a rule and improved fodder species are not given good management attention by farmers.
2100	Dompola	Of the 7 species sudan grass was

		found to be the best followed by molasses, and pintoi peanut.
1600	Omtekha	Of the 8 species sudan grass followed by setaria, *Panicum maximum*, *Paspalum atratum*, silver and green leaf desmodium performed very well.
1500	Matalumchu	12 species were tested, out of which sudan, followed by *Panicum maximum*, *Paspalum atratum*, Ruzi, stylo cook, green and silver leaf desmodium were good performers.

Conclusion

After observing for one and half years the following species can be recommended. Sudan, *Paspalum atratum, Panicum maximum*, setaria, molasses, green and silver leaf *desmodium*, pintoi peanut, and stylo cook for locations within an altitude range of 1500 – 2100 masl. Whereas white clover and *Paspalum dilatatum* are good species for locations above 2000 masl.

Summer fodder shortage is not considered by farmers as a critical problem. Lush growth of local grasses provides ample source of fodder in summer for an open grazing system. Besides during summer most of the land are under rice production and farmers do not have land for growing pasture crops. Hence, most of the above trials were laid out in farmers' kitchen garden which is needed for growing vegetables and fruits.

Therefore, the observation of the above trials will be terminated by end of 1998 to free the land to farmers. Additional trials on summer fodder will be taken up on a case to case basis

Winter fodder

Trial title Monitoring biomass of 4 grasses and 3 legumes species during January to April.

Objective To identify winter hardy species as green fodder during the critical feed shortage and compare the biomass yield with local wheat.

Method 12 farmers were selected in the watershed area within the altitude range 1300 – 2170 masl. Farmers were given at least two different species in the single large plot to compare the biomass production. The seeds were sown at the time of wheat sowing. The result are based both on the researchers inputs and farmers feed back.

Conclusion.

Out of 4 grasses and 3 legumes, berseem did not germinate. Improved species was found to be better local species like wheat. Oat was the best followed by italian rye, winter vetch, lytharus and rye. The trial not only convinced the test farmers but others also agreed to continue in the future**.**

3. Feeding trial on chopped green fodder mixed with rice straw.

Objective To assess the effect of chopped green fodder on the intake of straw

Method 2 locations were selected in the watershed area. Farmers are provided with some oat seeds to produce green fodder. The harvested green fodder and rice straw were chopped with 50 :50 at volume basis and fed to animal for 10 days.

Results

- Palatability of straw improved by 90% due to green fodder
- More time spent chopping
- Technology is most appropriate for farmers with fewer cattle heads which are stall fed
- Proper mixing avoids selection of fodder by the cattle
- Wastage of straw is reduced

Table 46 Results of the winter fodder trial

Treatment	Farmer Village	Improved Yield t /ha	Local Yield t/ha	Remarks/ farmers feed back
Oat Vs Wheat	Sigay Limbukha	30	22	Oat is fast growing, has high biomass, high palatability and more cuts. Time required to collect fodder is saved
Oat Vs Wheat	Wangdi Limbukha	33	21	Same as above feed back,. Farmer would like to continue for next season with her own seeds
Italian Rye Vs Rye	K. Wangdi Limbukha	17 12	-	Italian rye showed poor germination initially. Good growth from march, obtained 2 cuts and one grazing till may.

				Italian rye grows better in Limbukha due to their moist soil condition. Farmers complain about the difficulty in ploughing after Italian rye as compared to others Rye had only one cut, may he have not cut till it was flowered.
Oat VS wheat	Baaghu Dompola	25	10	Oat found to be better than wheat in palatibility, yield and number of crop cuts
Italian Rye VS Wheat	Kencho Bidha Dompola	15	10	Poor germination initially. 2 cuts were posssible later. The farmer was convinced with the high biomass.
Oat VS wheat	Febda Dompola	25	20	Would like to continue growing oats
Oat Vs Wheat	Zala Umtekha	20	10	Oat found to be better as in Dompola
IR VS wheat	Am Nalam Omtekha	8	10	Not happy with Italian rye, will stick with oats next season
Lytharus Vs W. vetch	Tshetu Omtekha	20 21		Took 4 months to grow. Only one cut at the right time and would like to try again with seed mixtures
IR Vs Wheat	Saga Matalungchu	5	15	Italian rye sown in the dry land rather than wet so only one cut was obtained
W.vetch Vs Lytharus	Gasab Matalungchu	Nil		Plants died after irrigation despite good germination initially Will try oats in the coming season
Oat Vs wheat	Rinzing Matalumchu	30	21	2 cuts obtained despite stray animal grazing. Farmer will continue with oats

4. Seed mixture trial.

This trial was proposed by RNRRC, Jakar as a nation wide trial in 1996. The trial was established on 10.6.96 in Phobjikha. One harvest was taken on 3.6.97 to measure biomass and botanical composition. However, due to lack of appropriate weighing balance the figure could not be analyzed and presented.
In the subsequent months the data could not be collected as the stray animals grazed on the trial site and it was also found that the site was used for keeping timber. The observation was discussed with Dr. Walter Roder when he visited the Bajo to review on the past and present fodder activities. Another visit in March 1999 to see the survival of individual species was proposed by Dr. Roder.

5. Orange orchard trial

Trial title Testing of legume as cover/fodder crop in the orchard.

Objective To develop orchard management system that optimize soil fertility, soil conservation and minimize labor requirement for maintenance and weeding

Method

As a Nation wide trial for 1997, one site under Wangdue Dzongkhag was established on may 1997. Green leaf desmodium and Pintoi peanut were used to compare with control plot (only weeds).

Results

Pintoi peanut grew well while desmodium plants did not germinate.
The orchard was badly managed by the frequent changes in the caretaker. The plot was left unattended and the caretakers cattle grazed on the plot. However, the trial is still monitored for pintoi peanuts.

9 FORESTRY

INTRODUCTION

Though forestry research started at the centre from 1995 not much had been accomplished until 1997 mainly constrained by a lack of forestry researchers. With the initiation of the community-based research at the Lingmutey Chu watershed, the forestry research program of the centre concentrated on agroforestry research as highlighted by this report.

10 COLLECTION, INTRODUCTION AND EVALUATION OF MULTIPURPOSE TREE SPECIES.

The objective was to evaluate and identify suitable species for social forestry activities besides expanding the diversity of species in use. Seeds of 20 native species, 10 exotic, and 2 ornamental species were broadcast sown between June 1997 and June 1998. The list of species are given in Table 1and 2.

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

Table 47. List of Native species

Native Species		LOCAL/COMM-ON NAME	Sowing date	Seed source	Collection time
1	*Eriolobus indica*	Mehel	2.3.98	Nahi	Dec 97
2	*Albizzia spp.*	Guyay siris	2.3.98	Kalikhola	Feb. 98
3	*Melia azedarech*	Bakaina	2.3.98	W/due	Dec.97
4	*Spondis axillaris*	Lopshe	2.3.98	Tsirang	Dec. 97
5	*Alnus nepalensis*	Uttis	2.3.98	Tsirang	Jan. 98
6	*Quercus lanata*	Gum	26.3.98	Rimchu	Jan 98
7	*Ficus roxburghii*	Nevaro	2.3.98	Tsirang	Sept.97
8	*Ficus cunia*	Khanyu	2.3.98	Wangdi	Sept.97
9	*Cupressus*	Cypress	2.3.98	T/gang	-
10	*Trema orientalis*	Kuyal	2.3.98	Punakha	-
11	*Albizzia lebbeck*	Siris	2.3.98	India	-
12	*Ficus bengalensis*	Bar	2.3.98	India	-
13	*Ficus religiosa*	Pepal	2.3.98	India	-
14	*Chickrassis tubularis*	Chickrassis	2.3.98	India	-
15	*Morus alba*	Kimbu	2.3.98	India	-
16	*Acrocarpus raxinifolius*	Mandanay	2.3.98	India	-
17	*Michelia champaca*	Champ	2.3.98	India	-
18	*Albizzia procera*	Siris	2.3.98	India	-
19	*Tectona grandis*	Teak	2.3.98	India	-

Table 48. List of Exotic species

Exotic species		Local/common Name	Sowing date	Seed Source
1.	*Acacia villosa*	-	2.3.98	Phillipines
2.	*Flemingia*	-	2.3.98	Philippines
3.	*Calliandra*	-	2.3.98	Philippines
4.	*Tithonia diversifolia*	W/sunflower	2.3.98	Philippine
5.	*Desmodium ransoni*	-	2.3.98	Philippines
6.	*Robina psedoacacia*	-	2.3.98	India
7.	*Acacia arabica*	-	2.3.98	India
8.	*Tamarindus indica*	Titiri	2.3.98	India
9.	*Cederla toona*	Tooni	2.3.98	India
10	*Cassia spectabilis*	-	2.3.98	India

11 PLANTING OF MULTIPURPOSE TREE SPECIES

The centre raises many tree species in the nursery for the purpose of evaluating and introducing multipurpose tree species for Agro-forestry and Community forestry programmes in the valley. The different tree saplings raised during the course of evaluation are planted in the centre's wasteland where agriculture production is not possible, for further screening. Table 3 shows the number and quantity of species planted.

Table 49 Number and quantity of tree species planted

Tree species		Quantity planted	Observation
1	*Melia azedarach*	200	Annual ht. increment of 5m with 35mm diameter at breast height (dbh)
2	*Bombax ceiba*	19	
3	*Cupressus*	250	
4	*Poplar spp.*	50	Annual ht. increment of 5m with 35mm dbh
5	*Salix babylonica*	40	
6	*Ficus religiosa*	08	
Ornamental			
1	*Bottle brush*	150	
2	*Dodonea viscosa*	45	
3	*Thuja*	33	

12 DEVELOPMENT OF VEGETATIVE PROPAGATION TECHNIQUES BY STEMS CUTTINGS

1. *Poplar spp.* (Kashing*)* 2*. Brassaiopsis mitis* (Phutta*)* 3*. Ficus religiosa* (Pepal)
4. *Ficus infectoria* (Kabra*)* 5. *Salix babylonica* (Willow).

Many fodder and timber species can be produced vegetatively if proper measures are taken for successful establishment. The objective of this study was to generate improved vegetative propagation techniques for various multipurpose tree species.

12.1 Origin of the cuttings

Cuttings were made from the following:

- One-year-old shoots of the crowns of vigorous young trees.
- Fully mature shoots sprouted from the trunk of a pruned tree.
- Shoots from the stems of plants cut back in the nursery, either transplanted or rooted directly on the site.

It is important to use young materials taken from healthy and vigorous trees or plants to ensure successful propagation.

12.2 Methodology

Thump sized (10-12 mm diameter) and 15-30 cm long cuttings were made for each of the species with sharp secateurs during February-March and inserted into pre-prepared holes in the nursery and allowed to root.

13 UNDERSTAND AND IDENTIFY SUITABLE PROPAGATION METHODS FOR LOCAL AND EXOTIC BAMBOO SPECIES

13.1 Introduction

Bamboo has multiple uses in the Bhutanese community (e.g. roof mats, fencing pole and post, canning of shoots of edible species, building construction, basket, etc.). Bamboo species are distributed throughout the country, though they are most common in the higher rainfall areas. They can be found from Tropical Southern borders to the tree line where they form extensive areas of pasture for higher altitude cattle like yak and sheep.

Bamboo also plays a important role in soil conservation by virtue of their dense surface root, which helps protect from sheet and gully erosion. It can be planted in slope and landslide areas for stabilisation. It can also be planted along the agricultural field boundary and home garden as a windbreak to protect the crop.

Bamboo remains one of the most important multipurpose plant in the Bhutanese society. Traditional ways of bamboo propagation are not well documented and less frequently understood. Hence it was felt important to study and document propagation methods for both local and exotic species. To this end the following sub-activities were carried out.

13.2 Farmer interviews to understand and document propagation methods of local bamboo species

Informal interviews were done in Tsirang and Wangdue in May 98 during the course of collecting different bamboo species rhizome for planting in the research centre. It was realised that the farmers propagated bamboo only through rhizome and were not aware of other techniques as seed and stem (node) propagation.

13.3 Evaluation of different bamboo species using various methods

Six different species of bamboo germplasm were collected locally from Tsirang and Wangdue for long term research purpose in the centre. Collection of more species will be

done in the future. A simple trail to study the success and comparative advantage of multiplying bamboo-planting materials vegetatively by different methods was established.

13.3.1 Propagation through Rhizomes

This technique involves burying whole culms with their rhizomes still attached. This produces rooting plants along the culm and each plant develops from the shoot growing from branch buds. The results of the trail are given in table 4.

Table 50 Propagated through Rhizomes

Species		Local Name	Qty	Collection time	Source
1	*Dendrocalamus hookerii*	Bhalu Bas	02	8.5.98	W/due
2	*Bambusa nutans*	Mal Bas	10	8.5.98	W/due
3	*Dendrocalamus hamiltonii*	Choya bas	15	28.5.98	Tsirang
4	*Bambusa calvata*	Chile bas	02	28.5.98	Tsirang
5	*Himalayacalamus hookerianus*	Padang	02		Tsirang
6	*Yushania maling*	Malingo	20	10.5.98	N/ding

13.3.2 Propagation through single node (eye)

This technique involves planting single-node culm sections horizontally with both ends buried enabling the exposure of a large area of the vascular culm tissue to the wet soil. This maximises water entry into the culm section and then into each branch and its buds. The details of bamboo propagated with this technique are given in table 5.

Table 51 Bamboo propagated through single node

Species		No. Propagated	Time of Propagation	Source
1	*Dendrocalamus hookerii*	17	May 98	Wangdue
2	*Dendrocalamus hamiltonii*	20	May 98	Tsirang

13.3.3 Bamboo multiplication raised through seeds.

Multiplication through seeds is a simple method for mass propagation of *Dendrocalamus strictus* and *Dendrocalamus calastachyous* for raising large-scale planting materials vegetatively. This methods ensures that each propagules posses shoot, root and rhizomes even at the time of tiller separation, enabling rapid establishment and very high survival of propagated materials. The dependence on bamboo seed production in nature is totally eliminated from second year onwards for mass production of field plantable bamboo propagules. The method developed is simple, easy and involves use of locally available materials.

Seeds are sown between March and July with the pricking done when seedlings have attained a height of about 5-10 cm (i.e. about Aril-August). By the last week of May the next year, about five to six tillers on an average are produced in each plastic tube.

Cutting rhizomes for production of more propagules separates these tillers. After separation, each propagule is planted in the plastic tube for further growth and development. By July the following year, a number of propagules for each species are retained in the nursery for production of more propagules next year. The process can be repeated depending on the amount of seedling required.

14 ACTIVITIES IN THE LINGMUTEY CHU WATERSHED

RNRRC Bajo has embarked on the Natural Resources Management (NRM) research in the Lingmutey Chu watershed. The objective is to adopt a farmer participatory research and identify appropriate methodology which integrates the RNR sectors for the management of natural resources. Social forestry is one of the major components of the NRM research in the watershed.

Agro-forestry research is a priority area under the NRM research. Under this research category, in collaboration with Bhutan-German Sustainable RNR Development Project (BG-SRDP), the RNR Research centre has identified and drawn up work plan for 1997-98 FY. The community, RNR-Research Centre Bajo and BG-SRDP jointly took up the following planned activities.

14.1 Creation of community forestry nursery (CFN) in the watershed

The research objective of this activity is to identify and generate diverse multipurpose tree species suitable for fodder, fuel, timber, community plantation, gully plugging, hedgerow planting, and reforestation in heavily degraded areas. The nursery was established in the watershed (i.e. at Omtekha village) with an aim to make implementation participatory and accessible to beneficiary communities. Further, the objective of establishing nursery in the watershed is to expose communities to nursery establishment techniques, variety of species available in the nursery and enable smooth transfer of nursery management to the community. The test species includes both native and exotic that are chosen by the community and based on the experiences of the participating institutions.

The seedlings generated from the nursery will be evaluated on-farm/site for various purposes and the appropriately identified species will be promoted. The list of species is in Table 6.

Table 52 List of tree species in the CFN

	Tree species	Local name
1	*Quercus griffithii*	Sisi (oak)
2	*Quercus lanata*	Gum (Oak)
4	*Robina psedoacacia*	-
5	*Alnus nepalensis*	Gama (alder)
6	*Leucaena leucocephala*	-
7	*Dodonea viscosa*	-
8	*Ficus roxburghii*	Bakushing (Nevaro)
9	*Macaranga denticulata*	
10	*Dendrocalamus spp*	Pagshee (Bamboo)
11	*Salix babylonica*	Changmashing
12	*Albizzia procera*	Siris
13	*Cupressus cashmeriana*	Tshendenshing
14	*Albizzia spp.*	Guyay siris
15	*Schima wallichii*	Puyamshing

14.2 Community forestry plantation

Forest resources degradation in and around villages has compelled the communities to meet their requirement for the same from distant resource-rich areas. Further these degraded areas are more often than not the public forestlands, which does not receive any management attention. These areas are characterised by heavily eroded soils with very little vegetation cover resulting in formation of deep gullies. With the objective to help reforest such lands, the degraded areas has been planned to be brought under community plantations involving the participation of user group communities. The total area earmarked for 97-98 FY was 8 ha. including both Matalumchu and Omtekha community. The details of the plantation at Matalumchu are given in table 7i and 7ii and those of the Omtekha are given in table 8.

Table 53 Details of Matalumchu plantation (Plot I)

Compartment no.	Land pattern	Soil type	Plant species
I	Slightly gentle	Clay	• *Albizzia procera* • *Alnus nepalensis* • *Dodina viscosa* • *Leucaena leucocephala* • *Melia azadarach* • *Quercus lanata* • *Quercus grifithii* • *Robina pseudoacacia*
II	Flat/gentle	Clay	• *Cupressus corneyana* • *Leucaena leucocephala* • *Melia azaderach*
III	Flat/gentle	Clay	• *Quercus griffithii* • *Quercus lanata*
IV	Sligtly gentle and marshy	Clay	• *Albizzia procera* • *Alnus nepalensis* • *Cupressus corneyana* • *Dodonea viscosa* • *Dendrocalamus spp* • *Salix babylonica*

Table 54 Details of Matalumchu plantation (Plot II)

Compartment no.	Land pattern	Soil type	Plant species
I	Slightly gentle	Clay	• *Albizzia procera* • *Dodonea viscosa* • *Leucaena leucocephala* • *Melia azadarach* • *Quercus lanata* • *Quercus griffithii* • *Robina pseudoacacia*
II	Slightly gentle	Clay	• *Alnus nepalensis* • *Cupressus spp.* • *Quercus lanata* • *Quercus griffithii*
III	Steep	Sandy clay and sedimentary rocks	• *Alnus nepalensis* • *Cupressus spp.* • *Dodonea viscosa* • *Leucaena leucocephala* • *Melia azadarach* • *Quercus griffithii* • *Robina pseudoacacia*
IV	Slightly gentle	Clay	• *Alnus nepalensis* • *Cupressus spp.* • *Dodonea viscosa* • *Melia azadarach* • *Quercus lanata* • *Robina pseudoacacia*
V	Gentle	Clay and Marshy	• *Alnus nepalensis* • *Cupressus spp.* • *Dendrocalamus spp.* • *Erythinia arborescens* • *Salix babylonica*

Table 55 Details of plantation at Omtekha

Compartment no.	Land pattern	Soil type	Plant species
I	Gently sloping	Sandy/clay	• *Cupressus spp.* • *Melia azadarach* • *Poplar spp.* • *Robina pseudoacacia* • *Quercus griffithii* • *Quercus lanata* • *Alnus nepalensis* • *Leucaena leucocephala*
II	Steep	Sandy/Clay	• *Robina pseudoacacia* • *Dodonea viscosa* • *Melia azadarach* • *Erilobus indica* • *Dendrocalmus strictus* • *Leucaena diversifolia*

			• *Spondias axilloris* • *Cupressus spp.* • *Quercus lanata*
III	Gently sloping	Clay	• *Cupressus spp.* • *Melia azadarach* • *Robina pseudoacacia* • *Quercus griffithii* • *Quercus lanata* • *Erilobus indica* • *Spondias axilloris* • *Castanopsis spp.* • *Albizzia procera* • *Leucaena leucocephala* • *Macaranga denticulata*

15 SYSTEMS RESOURCE MANAGEMENT

The program addresses issues and problems that cut across the four national research programs. The issues are addressed through the four major subprograms as under.

15.1 Farming systems studies

Surveys

During the 1996-97, two surveys were conducted to understand the current citrus and tree fodder use and adoption by the farmers of this region. The findings and the details of the surveys have been published separately as the technical working paper of the Centre (interested readers could contact the Centre for a copy). The recommendations that emerged from the surveys are presented below.

15.1.1 Citrus survey

Recommendations of Citrus survey

1. Farmers need to be trained and demonstrated on the method of application and management of inorganic fertilizers in mandarin.
2. Trunk/twig borer is one of the major insect pests of mandarin. It is recommended to identify and evaluate borer resistant stocks and attempt to use vegetatively propagated planting materials to overcome the problem.
3. Fruit drop is another major problem faced by Mandarin growers in the region. Some farmers have adopted chemical control methods but without much success. It is recommended that extension must train farmers on different types of fruit drops and their causes/causal organisms. Extension must also advise farmers to adopt community approach in spraying their crop against fruit flies.
4. Mandarin orchards are located in a contiguous fashion rather than in isolated patches. There are also several unattended orchards, which serves as sources of fruitflies to the neighboring orchards. Given the above scenario, the available fruitfly control through baiting system may not prove to be as effective as elsewhere in the country. Therefore, it is recommended that research must try to carefully adapt the control method to local situations.
5. Farmers prune taproots of mandarin seedlings before transplanting them to a permanent site. It is claimed that such seedlings result to a better tree longevity, larger tree canopy, and shorter tree height. Taproot functions to anchor the plant in its upright position and this is especially important when trees are planted on slopes. It is therefore recommended to study the effect of pruning taproot on the above plant characteristics.
6. Farmers claim that mandarin trees developed from murcotting has poor longevity compared to seedling trees. Murcotting or vegetative propagation method is desired for maintaining true- to- type characteristics of a plant. Research should, therefore initiate studies to validate the claims.
7. Manuring with cattle dung and/or tethering cattle at the tree basin is a common practice of fertilizing mandarin trees among growers. This has become

impractical with the growing numbers and sizes of mandarin orchards, and due to sloppy terrain.

8. The existing mandarin growers are attempting to maximize production through either increasing the number of orchard and/ or by expanding the size of the orchard. Such practices have not only resulted to sub-optimal management levels but this has severely constrained the distribution of scarce resources. This situation has affected the production capacity of the orchards. It is therefore recommended that extension agents must advise/campaign that better management of orchards is the key to increased production.
9. Farmers have acquired excellent skills in producing their own planting materials through seed/sexual methods. Though they aim to develop materials from the best-selected trees and fruits, their attempts are often defeated due to true-to-type being not maintained by sexual method of propagation. It is recommended that farmers must be trained to propagate planting materials vegetatively - other than murcotting.

15.1.2 Tree Fodder Use and Adoption Survey

In many parts of Bhutan, fodder tree is an important resource for feeding ruminant livestock animals. It has been estimated that fodder tree contributes about 20% of fodder requirements of existing livestock.
First tree fodder extension activities were launched in 1982, when farmers were advised to plant some species. From 1982, fodder trees were an important component of the fodder development program of the extension services under the Ministry of Agriculture.
A survey was carried out in 1996 with the objectives to:

- Document the importance of tree fodder, species used, and the place of trees in the cropping system.
- Document farmers assessment on the quality and yield of individual tree species
- Evaluate the impact of past extensions activities on the extend of tree fodder used by the farmers
- Assess the need for additional supply of tree saplings and species preferred.

This was part of the Nation wide survey coordinated by RNRRC Jakar. For the West Central Region, RNRRC Bajo and the Dzongkhag extension staff of Punakha and Wangdue jointly carried out the survey. Information was collected at the household level using a formal questionnaire. Information recorded included livestock numbers; landuse, tree fodder species, and issues related to planting and use of tree fodder species. In each Dzongkhag the survey was carried out in 8-10 villages that are located in 1-3 Geogs. All households in the selected villages were included in the survey.
The report of the survey painting a national picture is published by the RNRRC Jakar. Interested readers may contact the Centre for a copy of the report. The extract below presents the survey findings in the two West-central Dzongkhags.
The survey generated the following information.

- The tree fodder is very important source of winter fodder for the farmers.
- The importance of tree fodder increases with decreasing elevation.
- The average number of species per household was less than two.

- The most important species for the two Dzongkhags was *Ficus cunia* (Khanue) followed by *Ficus roxburghii* (Bakushing). Interesteringly, *F. cunia* is predominant in Punakha while Wangdue farmers popularly grow *F. roxburghii*.
- Ficus species are the most preferred species because of quality, yield, and availability of feed in dry season. It was reported that Ficus species could provide green fodder in the first and second Bhutanese months.
- The existing fodder trees are mainly found near the house, along fences or along the border of cropland. The new plantations are more likely to be along cropland border and in separate fields.
- Two sources of planting materials – Forest and Animal Husbandry Department, were recognized in addition to few locally existed ones.
- The extension impact was highest in the two Dzongkhags, which corresponds with a high extension concentration.
- Most of the tree species were ranked as equal or better in nutritional values comparing to rice straw. *Ficus roxburghii* was almost unanimously ranked as being superior to straw.
- When comparing the tree species to *Ficus roxburghii*, species like Lumashing, Kulem, *Ficus nemoralis,* and Lucaena were ranked as superior to *F. roxburghii*. Yield was reported to be highest for *F. roxburghii*.(with 5 loads/tree) followed by F.cunia (with 3 loads/tree). Other species were said to yield about 3 loads per tree.

15.2 Integrated Nutrient Management

A long term trial on the integrated nutrient management for rice-wheat cropping systems begun in 1989 was terminated after 9 years. The trial was designed to answer the following questions:

1. When inorganic nitrogen, phosphorus and potassium are not limited in a rice-wheat rotation where is the optimum placement of FYM?
2. When inorganic N & K are not limited either to rice or to wheat, is there carry-over of inorganic P between the two crops?
3. When inorganic N and K are not limited to rice or wheat, and no inorganic P is applied, then is the P applied in the form of FYM adequate?
4. What is the value of *Sesbania aculeata* as a green manure in a rice-wheat rotation?

The results were analyzed by analysis of variance using a series of single degree of freedom of contrasts amongst the treatments for each year. This method was used in preference to conducting combined analysis over the years, as the heterogeneity among variances of year-wise individual analysis was highly significant (P <0.001) Experimental treatments are presented in Table 42.

Table 56 Experimental treatments

Treatment	Rice					Wheat			
	N	P205	K20	FYM	GM	N	P205	K20	FYM
1	0	0	0	0		0	0	0	0
2	70	40	20	0		60	40	20	0
3	70	0	20	0		60	40	20	0
4	70	40	20	0		60	0	20	0
5	70	40	20	7		60	40	20	0
6	70	40	20	0		60	40	20	0
7	70	0	20	7		60	0	20	0
8	70	0	20	0		60	0	20	0
9	0	0	0	0	Yes	0	0	0	0
10	35	40	20	0	yes	0	0	0	0

GM=Sesbania aculeata sown in the first week of may and incorporated in the first week of July during land preparation.
N:P_20_5:K_20 kgha^{-1}; FYM=tha^{-1}

The following nine single df contrasts were used against the experimental objectives.

1. When inorganic N,P and K are not limited in a rice-wheat rotation where is the optimum placement of FYM ?

Contrast 1 (T5 vs T2): Is it worth applying 7t FYM ha^{-1} to rice when N, P and K are not limited ?

Contrast 2 (T6 vs T2): Is it worth applying 7t FYM ha-1 to wheat when N,P and K are not limited ?

2. When inorganic N and K are not limited to rice or wheat, is there a carryover of inorganic P between the two crops ?

Contrast 3 (T4 vs T2) : If 40 kg $P_20_5ha^{-1}$ is applied to rice, is there any benefit to applying further P to the wheat?
Contrast 4 (T4 vs T3): If only 40 kg P_20_5 ha^{-1} is applied, does it matter if it is applied either to rice or to wheat ?

3. When inorganic Nand K are not limited to rice or wheat, is the P applied through FYM adequate?

Contrast 5 (T5+T6 vs T7+T8): When 7 t FYM ha^{-1} is applied is there any benefit to applying 80 kg P_20_5 ha^{-1} (40 kg to rice and 40 kg to wheat).
Contrast 6 (T5+T7 vs T6+T8): Is there any difference between applying FYM to rice or wheat ?

4. What is the value of *Sesbania aculeata* as a green manure in a rice-wheat rotation.

Contrast 7 (T9 vs T1) : What is the effect of green manuring with *Sesbania aculeata* over no manure or fertilizer application?
The following additional contrasts were used to compare treatment effects also considered of interest.

Contrast 8 (T9 vs T2) : Can green manuring with *Sesbania aculeata* replace the application of 70:40:20 kg $N:P_20_5:K_20$ ha^{-1} to rice and 60:40:20 kg N: $P_20_5:K_20$ ha^{-1} to wheat?

Contrast 9 (T2 vs T1) : What is the effect of the application of 70:40:20 kg $N:P_20_5:K_20$ ha-1 to rice and 60:40:20 kg $N:P_20_5:K_20$ ha^{-1} to wheat in the absence of FYM application ?

Some conclusions based on experimental objectives, and recommendations of the trial are reported here. The detail report of the trial will be published as the center's technical paper. For additional reading interested individuals may ask for a copy of the technical paper.

Brief conclusions against each of the questions posed at the start of the trial are as presented below:

1. When inorganic N,P and K are not limited in a rice-wheat rotation where is the optimum placement of FYM?

When 70:40:20 kg $N:P_2O_5:K_2O$ ha^{-1} is applied to rice and 60:40:20 kg $N:P_20_5:K_2O$ $^{ha-1}$ is applied to wheat there is no benefit to applying 7t FYM ha^{-1} to either rice or wheat and there is no evidence of an optimum placement (i.e. timing) of FYM between the rice and wheat crops.

2. When inorganic N and K are not limited to rice or wheat, is there a carryover of inorganic P between the two crops?

The experimental treatments did not permit this question to be answered directly. However, the results from contrasts 3 and 4 show that there is no benefit to increasing application of phosphorus from 40 kg P_20_5 ha^{-1} to 80 kg P_20_5 ha^{-1} and that there is no difference between applying 40 kg P_20_5 ha^{-1} to either the rice or wheat crop.

3. When inorganic N and K are not limited to rice or wheat, is the P applied through FYM adequate?

A consistent positive response, although significant in only two years, to the application of 40 kg P_20_5 ha^{-1} to both rice and wheat crops when 7t FYM ha^{-1} was applied indicates that P application through FYM is not adequate.

4. What is the value of *Sesbania aculeata* as a green manure in a rice-wheat rotation ?

Green manure increased rice yield in relation to the control plot in all years with an increase in the size of the effect over the first three years. From the third year green manuring was able to replace an application of 70:40:20 kg $N:P_20_5:K_20$ ha^{-1} to rice in terms of its effect on rice yield although green manuring had no effect on wheat yield. In six of the eight years, application of 60:40:20 kg $N:P_20_5:K_20$ $^{-1}$ to wheat lead to a significant increase in yield even when green manure had been applied to the preceding rice crop.

Examination of the effects of experimental treatments on soil properties was limited by the lack of comparable before and after samples, and by lack of regular soil analysis throughout the experimental period. The effect of the fertilizer application was to increase pH (6.0-6.4) slightly, available P substantially (11-17 mg/kg) and it also resulted in an increase in organic C% (1.27-1.43%). *Sesbania aculeata* green manuring lead to an increase in N% (from 0.07-0.10%) and availability of K (from 29 to 56 mg/kg) and a reduction in C:N ratio (from 21.5 to 13).

Some recommendations

The practical application of the results for farming practice were restricted because farmers' practice (i.e. including FYM/compost application) was not used as a control treatment in the experiment and the trial is therefore a poor basis for comparing the other treatment effects as options for farmers. In terms of practical recommendations it is clear that green manuring of rice with *Sesbania aculeata* has the potential to replace the current recommended fertilizer application for rice although the full effect of this may not be apparent until green manure has been applied for three years. Although a comparison between farmers' current manuring practice for rice and the experimental fertilizer application was not made in this trial, results from the earlier fertilizer trials in this area suggest that this fertilizer application would have resulted in a significant increase in yield and therefore, it is assumed, that *Sesbania aculeata* green manuring would led to significant increases in yield over current farming practice. Wheat yields were unaffected by green manuring and fertilizer application is required to increase its yield.

To meet the manuring requirements of an increased cropping intensity, from traditionally one rice crop per year to two or three crops at present, in the Wangdue-Punakha Valley, farmers need to spread their limited FYM resources more thinly and are increasingly supplementing their traditional organic manuring system with the use of inorganic fertilizers, predominantly in the form of urea. In the light of unbalanced nutrient management situation, it is recommended that future long-term trials should focus on studying sustainability of yields and soil conditions under such nutrient management systems.

15.3 Integrated Pest Management

15.3.1 Wild Boar Studies carried out in Nangkhor Geog in Shemgang

15.3.1.1 Introduction

Crop raids by wildlife, wild boar in particular, has become one of the major problems to the farmers of Bhutan in the recent past. The toll it takes in terms of yield losses, labour and inputs needed for guarding of standing crops, social disruptions and even lethal casualties, already clarifies its difference in magnitude as compared to any other known pest problem. Moreover, no efficacious measures are available - leave alone affordable - to the farmers in order to either properly protect their crops from being raided, reduce the boar population pressure in their direct surroundings, or otherwise find some relief from the strenuous job of protecting ones crops. This regular seasonal vertebrate pest problem (especially wild boars) compel the farmers for crop protection efforts in the form of labour intensive crop guarding. Despite which the farmers still lose considerable amounts bringing big frustrations amongst the farming communities. With the decisions taken at the MoA last year to develop and evaluate both suitable crop protection measures feasible within the current legal settings, and as well as come up with an appropriate yield loss monitoring instrument. The RPPC-Wangduephodrang executed the Wild Boar studies in its pilot Geog of Nangkhor, under Shemgang Dzongkhag.

The following activities under the Programme will be discussed
- Yield losses and assessment protocols
- Socio-economic impact and surveys

The study aimed at reducing both agricultural losses caused by wild boars and other vertebrate pests, as well as look into the time and opportunities lost in crop guarding.

15.3.1.2 Yield losses and assessment protocols

A proper yield loss assessment protocol has been developed, unlike the regular crop cut method - it takes into account the nature of the crop damage, viz.; spot-wise, localised and of irregular patterns.
It also doesn't give the losses *on affected fields only,* but provides the total average loss for a village, based on the total cropping area.

Over a period of two years, yield losses as caused by wildlife have been determined for the main field crops under the Nangkhor farming systems. On an average this was, 4% for maize, 0.3% for paddy and 1.4% for millet (see Table 40. and Figure 7). Going by the current farm gate price (local rates) of Nu. 11 per drey (pathi) for maize, millet and unmilled paddy (Nu. 25 / drey for milled rice), the seasonal economic losses per household were as given in Figure 8 .

Table 57 Final yield loss per crop at harvest time as averaged over the total net cropped area.

	Kikher		Goling		Dakpai		Average		Average year
	1996	**1997**	**1996**	**1997**	**1996**	**1997**	**1996**	**1997**	
Maize	3.1%	3.8%	5.7%	4.1%	2.8%	2.1%	4.3%	3.6%	4.0%
Paddy	0.3%	0.5%	0.1%	0.1%	0.5%	0.4%	0.3%	0.3%	0.3%
Millet	1.6%	1.5%	0.9%	0.5%	--- %	--- %	1.5%	1.3%	1.4%

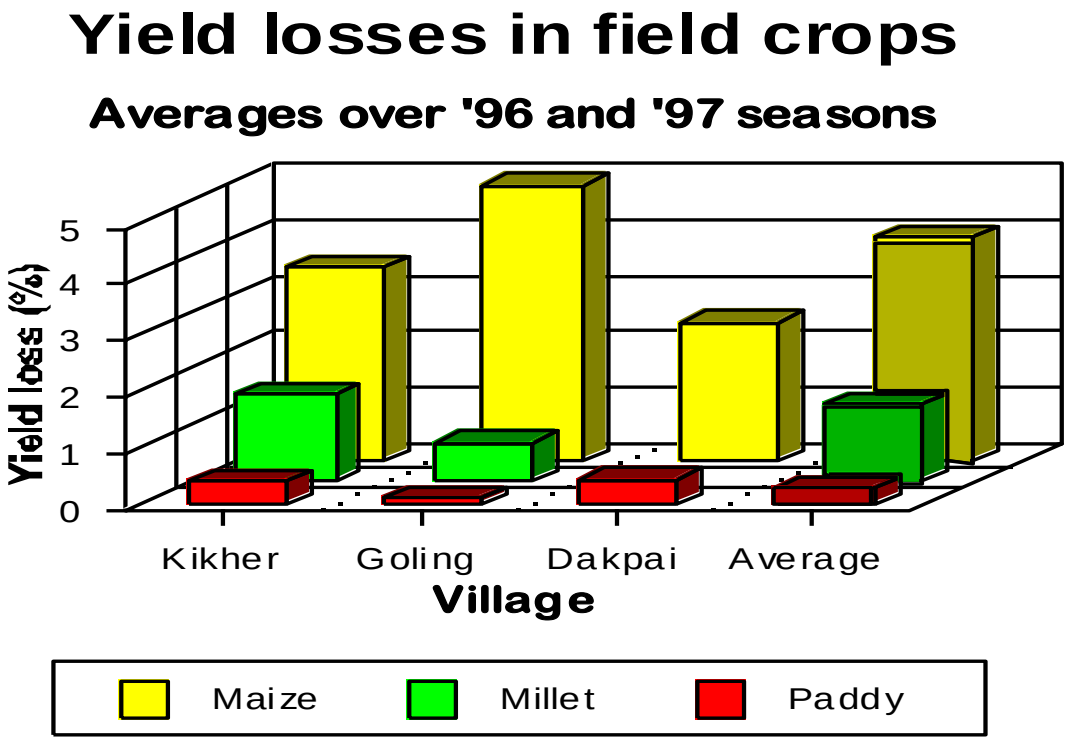


Figure 4 Yield losses by vertebrates (%) in different field crops

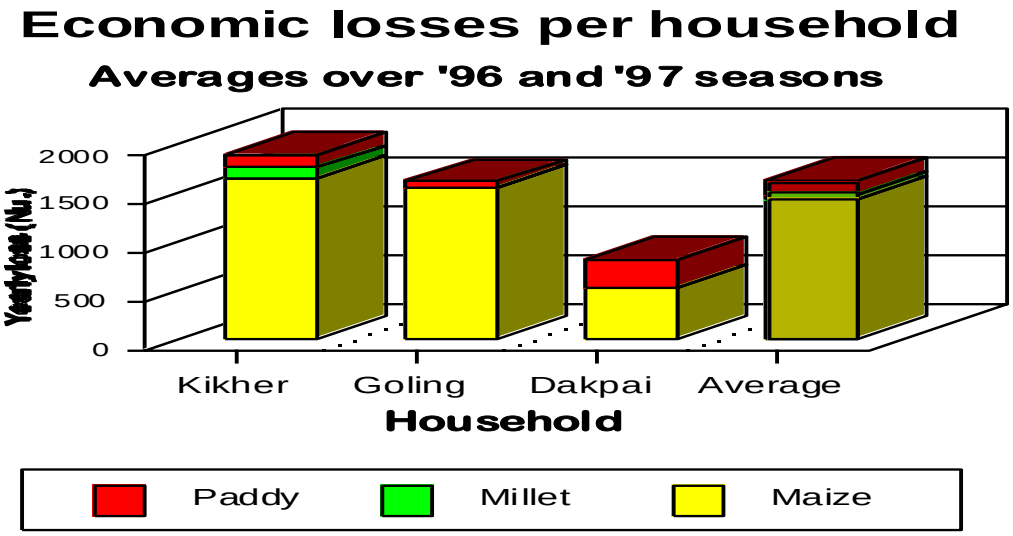
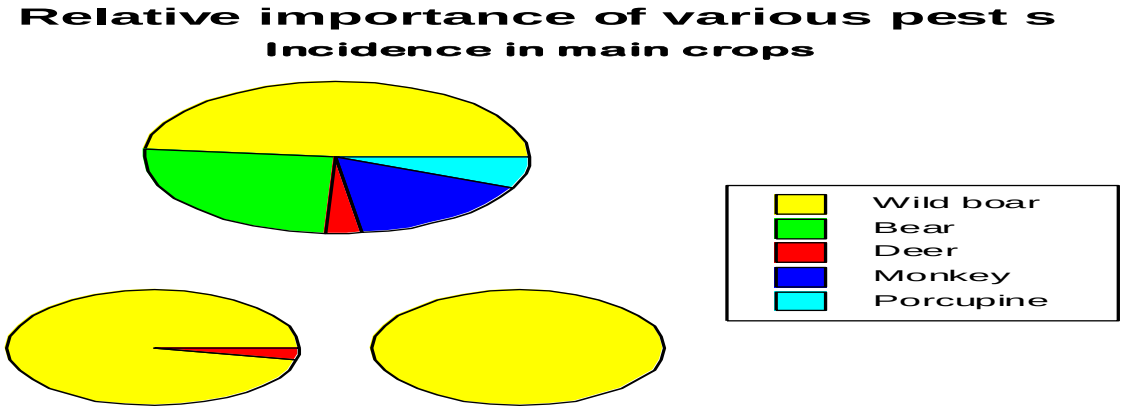


Figure 5 Household yield losses (in Nu.) by vertebrates in different field crops

As monitored over the past three years in the Pilot Area of Nangkhor geog the yield losses due to wild boars are on a continuous decline, which according to others and our observations seem to be a nation-wide trend. Besides wild boar, several other vertebrates cause severe yield losses as shown in Figure- 9, which



very much differ, from crop to crop.

Figure 6 Relative importance of various vertebrate pest species in different field crops.

Especially in maize an indirect but important additional loss is caused from the practice of early premature harvesting. In order to minimise the risk of crop damage by wildlife towards harvest time, during which the shortage of family labour for guarding is an important factor, 32% of the farmers are forced to harvest their maize one to three weeks early. Harvesting before the maize kernels are fully hard and ripe, inevitably results in extra post-harvest losses *e.g.*; attack by weevils. A further study in order to quantify these indirect post-harvest losses seems necessary.

15.3.1.3 Socio-economic impact and surveys

During the months of January and February 97 a socio-economic survey was conducted, in which 56 out of 85 households (63%) in the three pilot villages were interviewed without any gender differentiation. The main objective of the survey was to reveal other effects in the Nangkhor farming system besides yield losses, plus its socio-economic impact on household level

The socio-economic survey clearly revealed that the impact of crop guarding at night is in fact just as big as the actual yield loss, though its very hard to economically quantify. Further studies or control methods should therefore strongly concentrate on the reduction of time and opportunities lost due to crop guarding. For example, in maize 54% of the affected fields were guarded during daytime, which increased to 82% during the night-time. In paddy this is 4% and 71% respectively. The intensity of guarding is higher in maize than in paddy. On an average affected maize field were guarded by 2.3 people per day (24 hours), whereas in case of paddy it was 1.7 person. The average time span involved in guarding maize is 1.9 man-months per crop. For paddy this was 1.6 man-months per season, and for millet 0.9 man-months per crop.

Based on the above figures, at a daily wage rate of Nu. 40/ day, per household yearly an equivalent of *Nu. 4,950 is lost in time for crop guarding*. This corresponds with the figure of Nu. 5,034 as mentioned in the Report on Wild Boar Damage Assessment Project Phase 2 by NRTI.

Besides the yield losses and the guarding aspect, in paddy yearly some 5 kilometre of paddy bund is being destroyed in these three villages together. Repairs require 65 man-days. If capitalised at a daily wage rate of Nu. 40, this gives a total annual loss of Nu. 2,600, an equivalent of Nu. 35 per household.

Moreover, a significant impact can be observed in social inter- and intra-household issues (quarrels after and over boar raids), inputs for guarding (materials) and shortage of available family labour. Many people also mention a strong negative effect of the lack of sleep on their productivity, their health and their social behaviour.

Some other interesting highlights from the socio-economic survey are:

- 70% of the interviewees have never heard of the existence of the “1995 Forest and Nature Conservation Act”.
- 79% however (correctly), know that they are allowed to catch and kill pest species within their own private registered land; whereas 19% does not know.
- Damage by wild boar and other wildlife is mentioned as the main reason for the land being left fallow in 6% of the cases in wetland, and in 21% of the cases of dryland.
- Crop guarding is and has always been inherent to Bhutanese farming; 90% says that crop guarding is practised for over ten years already. People also expect it to stay- on in the future, which - to a certain limit!!! - is also accepted as part of the farming system.
- 98% of the interviewees qualifies their relation with the Forest Guards as an “average”.
- Nobody however has ever been fined for illegally catching boars or other

wildlife species.

- 35% of the interviewees think it is not possible to improve the system of crop protection against wildlife; 16% suggests a system of community guarding, and 31% opts for a better way of fencing (stone walls, mesh wire).
- Households spent Nu. 110 per year on equipment's and materials necessary for crop guarding, of which Nu. 47 is on torches, Nu. 52 on batteries and Nu. 9 on old tins to be used as drums.
- 11% of the farmers says to have changed its cropping pattern in the recent past years due to the wild boar pressure.
- In these pilot area, the use of snares is by far (i.e.; 77%) the most frequently used way of tackling the wild boar problem.

The following conclusions can be drawn from the Wild Boar Studies carried out so far:

- If an appropriate yield loss assessment protocol is applied, yield losses by vertebrate pest appear to be considerably less than what is often assumed.
- On the other hand, the socio-economic impact of the (nightly) guarding of the fields appears to be very big, and is in itself already a solid justification for the implementation of control measures.
- An appropriate, yet cheap and easy to implement population management device has been found in the form of strong modified local snare traps.
- Controlled implementation of these traps in hot spot areas should be considered, but only if and unless the Forestry Services Division can and will be very closely involved in its implementation and monitoring aspects.
- To measure the impact of such a programme on the boar population, the necessary monitoring instrument should be based on the methodology currently being studied in the NCS/ RNRRC-Plant Protection Sector Wild Boar Population Census Project.

15.3.2 Chili Wilt

Chili is one of the important vegetables in Bhutan. It is also an important cash crop for the farmers. But for the last 2 - 3 years wilting has become a serious problem in chili growing areas in Bhutan. The causal organism has been identified to be *Phytophthora capsici*.

The severe decline in chili yields due to the wilt, RPPC Wangdue took up a few preliminary studies in the Punakha-Wangdue Valley. The first activity was a potted trial in a hot plastic house in the 1995-1996 winter season. In this experiment seeds and soil from affected fields of three locations were submitted to the following 2 x 2 randomized block design:

Carbendazim seed treatment - soil steaming treatment
Carbendazim seed treatment - no soil steaming treatment
No Carbendazim seed treatment - soil steaming treatment
No Carbendazim seed treatment - no soil steaming treatment

In all the four treatments no signs of wilting was observed, so no conclusions could be drawn from the above trial, except that these indoor potted trials might not be suitable for *Phytophthora* screening purpose.

In the 1996 chili season, a series of trials were conducted in the Punakha, Wangdue and Thimphu Valley (Toeb and Baab geogs). Focus was given on the effect of different cultural practices, such as mulching, drainage and use of raised beds. The results indicated that by using raised production beds in combination with proper drainage in order to avoid any standing water in the field, yield losses due to wilt can be reduced by 50 to 90 percent. Additional mulching in the drains seemed to result in a slight additional improvement.

The collar rot phase of the disease is most severe in over-irrigated or poorly drained fields. Above ground blight infections are associated with extended periods of rainfall or overhead irrigation.

15.4 Water Management

15.4.1 Introduction

APPENDICES

Appendix 2. Seminars, meetings and training attended by RNRRC Staff

Appendix 3. Visitors during July 1996 to June 1997

Appendix 4. Financial report for 1 July 1996 to 30th June 1997

Object Classification	Amount in Nu
Personal emoluments	4105866.72
Other Personal Emoluments	683431.45
Travel	885679.50
Utilities – Telephone	166612.50
Utilities – Cable, tlx, fax,WT	48728.00
Utilities – Electricity	30608.83
S&M (Office Supplies)	146804.24
S&M (Fertilizers)	48567.00
S&M (Seeds & Seedlings)	1577.00
S&M (Uniform, Ext.Kits)	165651.00
S&M (Other supplies & consumables)	22147.50
MOP (Building)	47519.84
MOP (Vehicle)	494210.84
MOP (Equipments)	136788.30
Opt. Exp. (Taxes, Duties)	43676.05
Opt. Exp. (Transportation)	12670.00
Contribution – PF	90906.00
Expenditure on structure – building	20055.00
TOTAL	**2,688,928.58**

Appendix 5. Annual Weather summary

JANUARY – DECEMBER 1996

	Air Temperature (oC)		Humidity %		Rainfall (mm)
Months	**Mean Max**	**Mean Min**	**Mean Max**	**Mean Min**	**Avg**
Jan	19.2	3.6	96.0	31.0	75.3
Feb	21.2	1.6	95.0	16.0	68.0
Mar	28.2	4.6	96.0	9.0	66.1
Apr	30.2	6.6	93.0	28.8	60.7
May	31.2	13.6	0.0	0.0	0.0
Jun	32.2	14.6	0.0	0.0	0.0
Jul	31.2	17.6	0.0	0.0	0.0
Aug	31.2	14.6	0.0	0.0	0.0
Sep	30.2	15.6	0.0	0.0	0.0
Oct	29.2	8.6	0.0	0.0	0.0
Nov	27.7	4.6	0.0	0.0	0.0
Dec	22.2	0.6	0.0	0.0	0.0
Annual Avg.	23.6	13.1	28.5	12.2	22.2