ANNUAL REPORT

1995-96

RENEWABLE NATURAL RESOURCES RESEARCH CENTRE

BAJO, WANGDUEPHODRANG

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

C O N T E N T S

ABOUT THIS CENTRE

Established in 1982 as the Centre for Agricultural Research and Development (CARD) basically to undertake research on rice and rice-based crops, it has been renamed as the Renewable Natural Resources Research Centre (RNRRC) to incorporate research on livestock and forest that are inseparable components of the Bhutanese farming systems. The Centre is located at Bajo (1300 m) in Wangduephodrang, which is about 70 km west of the capital Thimphu.

RNRRC Bajo is designated as the coordinating centre for Field Crops (cereals, oilcrops, 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 Wangdue, Punakha, Gasa, Tsirang and Dagana in arable agriculture, livestock and forestry. The Centre has a 30 ha research farm and its immediate future expansion plans include construction of a research complex to house offices, laboratories, training hall, library and a genebank.

The Centre undertakes an intensive program of research; extension through its onfarm 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-forest system.

RNRRC Bajo receives technical support and improved germplasm from IRRI, AVRDC, CIMMYT, ICRISAT, ICARDA and a number of other regional agricultural research 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.

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ABOUT THIS REPORT

This is the eleventh technical report produced from this research centre since 1984. Unlike the earlier reports that were based on calender years, the present report follows the RGOB's financial year that runs from 1 July to 30 June. This report covers research conducted during July 1995 - June 1996. The report refers to crops sown in November 1995 and harvested in April-May with respect to winter crops like wheat, oilcrops 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.

Following the recent reorganization at the ministerial level and the subsequent change in the nomenclature and even the mandate of this centre, the reporting format has been slightly modified. In order to facilitate the broadening of its mandate, the centre has adopted a more disciplinary research approach built on programs, subprograms and projects that cuts across commodities. This has necessarily altered the reporting format and structure of this technical publication.

In the process of reorganization, four programs- Field Crops, Horticulture, Livestock, and Forestry Program, were recognised at the national level in addition to the Systems Resource Management Program at the regional level. The report is presented program by program.

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 noted. 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 in IRRI, Philippines.

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

This program report was edited by Mahesh Ghimiray supported by GB Chettri, Sangay Duba, and TR Gurung.

EXECUTIVE SUMMARY

Field Crops Research

Field crops include - rice, maize, wheat, barley, buckwheat, millet, oilseeds, grain and legumes. In cereals, the centre mainly works on rice and wheat. The pricipal objectives 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 diseases and insects, and medium growth duration.

Rice

In 1995-96, more than 400 varieties and breeding lines were tested in the research station as well as in the farmers' fields. Breeding lines were also tested in Paro to make selections for high altitude rice environments and at the station for mid-altitude rice areas.

From among the genotypes assessed for yield in the Initial Evaluation Trial (IET), a cross-bred line IR56346-1-1-R-1-9-1 recorded the highest yield of 6.80 t/ha which was slightly better than the yield of a check variety-IR64 (6.66 t/ha). In Advanced Evaluation Trial (AET), IR61331-2-148-B produced significantly higher yield of 7.22 t/ha than the local check Zakha and other entries except IR64. Interestingly, IR64 is seen as a very competent check variety for varietal selection program. In farmers' fields at Pre-production Evaluation Trial, averaged across locations, the standard check IR 64 produced the highest mean grain yield of 5.22 t/ha, which was 1.91 t/ha higher than that of the local cultivars. The test lines CARD21-3-2-1-1-3 and CARD21-15-2-1-3-2-1, yielded higher by 23% over the local checks. Testing genotypes in farmers' fields for potential variety as spring rice indicated that the standard check variety Barket as the highest yielder (3.81 t/ha).

As a longer-term strategy for improving local rice cultivars, a shuttle breeding program has been in operation since 1985 in collaboration with IRRI. The major objectives are to improve traditional rices of Bhutan by incorporating desirable genes from improved parents and to develop varieties that are more appropriate for Bhutan's medium and high altitude rice environments. The breeding lines were evaluated at two sites - Paro for high altitude materials and at Bajo for medium altitude entries. At Bajo a total of 464 pedigree lines (428 selected by breeders and 36 lines selected by farmers) and 79 bulked lines were selected for further evaluation. While at Paro, 451 lines were selected from 12 populations from two separate evaluations. Aside from introduction and breeding works, seeds of 76 local rice germplasms collected from various rice growing Dzongkhags were rejuvenated and characterized for conservation.

Wheat

Compared to previous years the wheat research was so much downsized as the other RNR research centres embarked on wheat research based on agroecology. At RNRRC Bajo, the research on wheat concentrated mainly on irrigated spring wheat or wheat in a rice-based system. The primary objective of wheat research is to identify genotypes, that are high yielding, disease resistant, and suitable in a rice-based system, and develop improved crop management

practices. During 1995, about 44 varieties/crosses were tested in different trials at the station. However, farmers' field trials with new materials were not carried out due to the lack of superior entries.

New materials from CIMMYT were evaluated for the required plant charateristics. Few new arrivals were observed to be promising in terms of height, maturity, and yield. In IET, there was no genotype which produced yield significantly higher than the standard checks-Bajoka 1&2, and Sonalika. However, the lines 150.83/2WALRUS1 SWTB89, 279-1Y-4PAP-OELV-OFM yielded higher (2.48 t/ha) than the best check Bajoka 2 (2.32 t/ha). The line, however, takes 20 days longer to mature than the check entries. Similarly in AET, the lines VL-728 and VL-725 were the best test lines. Incidence of diseases was very minimal and entries could not be fully evaluated for their resistance.

Horticultural Research

The main research objective of this program is to diversify the horticultural crops while simultaneously emphasizing the high value crops that would meet both nutritional and cash income needs of rural households.

Vegetable

The research on germplasm improvement of vegetables was carried out on cherry tomato and chilli. High yield, adaptibility to local conditions, earliness, and insect and disease resistance to prevailing insect pests and diseases were the major selection criteria. The germplasms were mostly from the South Asian Vegetables Research Network (SAVERNET).

Out of four cherry tomato entries tested, CHT 160 significantly out yielded all the test entries including a local cherry tomato check. Other test varieties produced yields comparable to the check. The number of fruits per kg was significantly higher in the check variety than the test varieties. High number of fruits/kg was associated to small fruit size. All entries had good number of seeds per fruit.

In chilli trial, Variety CARDIII, a selection from the local chilli, produced significantly higher yield (30.6 t/ha) than all other test entries except local Sha Ema. The varieties - Launghi, S. Mukhi, and K-II were prolific types yielding significantly higher number of fruits per kg and fruits per plant. These varieties had significantly shorter fruit length and diameter which make them more suitable for pickling.

Research on production and management in vegatables looked at bolting problems in two cabbage varieties and the effect of application of effective microorganism (EM) technology on the growth and productivity of six vegetable crops. The recommended cabbage varieties - Golden acre and Copenhegan, did not bolt when sown in November and transplanted in early January. It is speculated that bolting becomes a problem when the crop is planted later than the above planting time.

In a trial comparing the effect of EM on the productivity and pest reaction of six vegetable crops - Chilli, Cherry tomato, Brinjal, Cabbage, C.flower, and Broccoli; against the recommended practice of chemical fertilizer application, crop yields depended on the

effectivity of plant extract (EM X) against major insect pests of a particular crop. In chilli there was no major pest problems and yields were comparable under both the treatments.

For cabbage, cauliflower, and broccoli the major problem was the infestation of diamond backmoth (Pluettella xylustella). Spray of plant extract solution was able to repel the DBM which resulted in the reduction of DBM population in the field. The yield of the crops was, therefore similar to the yields obtained under recommended practice where insecticides were sprayed to protect the crops from the pests. EMX or the plant extract exhibited repellent effect rather than an insecticidal effect.

In the case of tomato and brinjal, the main problem was the attack by stemborer and fruit borer. The plant extract was not effective against these insect pests. Consequently, the yield of these crops under EM were much lower than the yields obtained under the recommended practice. Brinjal was more severely affected than tomato.

Sub-tropical Fruits

During 1995-96, the main emphasis was given to asexual propagation of citrus and introduction of new materials besides maintaining the trials established in previous years.

Varietal evaluation of subtropical fruits and nuts continued at the station. Few of the species like peach, pear, and mango have started to bear fruit. Early 1996, four citrus rootstocks and twelve commercial varieties of citrus were introduced from California through J.G.A.G project.

Six grape vines were also evaluated for their yield, disease resistance, and sweet taste. The variety Chasselas produced the highest cumulative yield (15 t/ha) followed by Pinot blanc (11 t/ha). Both the varieties moderately sweet. Perlette and Chardonny gave less yield but were the sweetest among the entries tested. Mild to moderate attack of powdery and downy mildews was observed in all varieties particularly Chardonny was susceptible.

. In another trial where citrus response to budding and grafting propagation methods were evaluated, citrus responded successfully to both the methods. Out of 233 grafts made from 13 commercial cultivars, 101 (43%) grafted plants survived while out of 62 buddings made from four citrus cultivars, 33 (53%) plants survived. 12-18 months old rough lemon seedlings were used as root stocks.

Livestock Research

The main objective of this programme 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.

Adequate feed and fodder for livestock is a major constraint to farmers practicing wetland dominated farming systems. To aleviate the above problem, both native and exotic fodder species were evaluated for their biomass yield and adaptability both at the station and in the farmers' fields.

In 1996, 15 forage species - 8 grass and 7 legume, were introduced from the CSIRO, Australia. Except *Setaria sphacelata* (grass*) and Arachis pintoi* (legume), all other species gave good germination. Anothher set of perennial grass and legume were evaluated also evaluated for biomass yield. Sudan grass produced the maximum fresh weight of 345 t/ha followed by stylo

(160 t/ha), seratro (125 t/ha), and Glycine (120 t/ha). Sudan grass was also the fastest growing species.
Italian rye grass was tested as potential winter fodder. It produced 37.3 t/ha biomass yield when sown in November and harvested in March.

Aside from pasture species, tree fodder species play an important role during winter months by providing green fodder to livestock. Four tree fodder species - *Ficus roxburghii, Gmelia arborea, leucaena leucocephala*; were planted, on the wastelands at the station, to observe their adaptability and fodder yield. All species have come up very well and its fodder yields will be recoded in the subsequent years.

In farmers fields at Kabji, Lobesa, and Gaselo; sudan grass produced 57.5, 52.5, and 30 t/ha biomass yield, respectively.

Systems Resource Management

As an interlink between the various programs at the national level, the Systems Resource Management Program is in place. It is coordinated centrally from the REID of MoA. It comprises of subprograms on Farming systems research, Soil and water management, Agroforestry, and IPM.
The objective of this program is to address issues or problems that cut across the four national programs.

Farming Systems

Under the subprogram, three diagnostic surveys were conducted during 1995-96. Each survey was published in detail as the centre's technical report. For detail reading, interested readers are referred to the centre's technical papers publications.

a) **Famers need assessment survey in Goenkhatoe and Goenkha'me gewogs of Gasa Dzongkhag**. The major objectives of the survey were to obtain first-hand knowledge and understanding of the existing farming systems; identification of production problems and opportunities; and to gain insights into resources use and their interactions. The survey adopted participatory rural appraisal approach as the method for the survey.

The survey covered three main villages - Khoilo, Damjee, and Gasa proper, of the above two gewogs. Major problems were identified and ranked by farmers in each village. Across villages the most common priority problems of farmers were : food deficit, farm labour shortage, and wild animal damage to crops. The survey report published as the technical paper documents recommendations to mitigate the identified problems.

b) **Survey on rice weed management in Punakha - Wangdue Valley**. The survey was conducted with the objectives of; a) to monitor the changes in weed species consequent to repeated use of the recommended weedicide Butachlor; b) to assess the intensity of weeding by farmers in the light of several years of butachlor application; and c) to record modifications by farmers on the recommended application rate and time of Butachlor. The survey used PRA/RRA approach as the method.

The survey revealed that although Butachlor has been in use for the past 7-8 years, only farmers with purchasing capacity have benefitte most from Butachlor technology. Predominant weeds in the valley are Shochum (*Potamogeton distinctus), Guchem (Cyperus spp.), Mani (Scirpus spp.), Damperu (Monochoria vaginalis), and Jaam (Echinochloa spp.).* Butachlor is reportedly effective against all these weeds except Sochum.

On an average, the rate of Butachlor application ranges from 10-13 kg/acre. Normally, 1-2 hand weeding are done - the first at 20-30 days after transplanting followed by the second at an interval of about 25 days. Significant changes in weed species were not recorded and attributed to the continuous use of Butachlor. But Sochum population seemed to have increased, possibly due to elimination of other competing species.

c) **Survey on rice post-harvest management systems in Paro and Punakha-Wangdue Valley**.

The survey was carried out with the objectives to a) document rice post-harvest management practices in the two most popular rice growing valleys; and b) quantify harvest-related handling losses. Informal survey methods were used during the survey.

Survey documented that farmers of both the valleys harvest rice much later than at the recommended physiological maturity - when atleast 85% of the upper portions of panicles turn straw coloured. Rice is harvested manually using non-serratd local sickles by both the gender groups. The local sickles are reported to be effective, however, they require frequent sharpening to maintain efficiency. Regardless of varieties, farmers leave their harvest to dry in the field for 2-3 days. Sun drying is reportedly essential to reduce the initial moisture in grain and straw.

There are clear differences among varieties in the degree of shattering. In Paro, maximum shattering variety was Drumbja (25.5%) while in Wangdue - Punakha it was Toeb Machum (31.2 %). The average harvest loss across varieties were 5% in Paro and 2.7% in Wangdue and Punakha.

Integrated Nutrient Management

Farmyard manures and composts are by far the most important sources of plant nutrients in the traditional rice-based farming systems in the country. However, with the intensification of cropping patterns combined with the use of modern varieties, the rate of nutrient depletion is faster than replenishment and crop yields are declining. Research on integrated nutrient management, therefore, is of immense significance in developing integrated management packages that will encompass amalgamated use of FYM/compost and inorganic supplements; legumes; crop sequences and mixtures; and green manures and biomass utilization.

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 scant resources. A long term trial on the integrated nutrient management for rice-wheat cropping systems was begun in 1989. This is the seventh year of the trial and fuller interpretation of results will be given after completion of ten years.

Agroforestry

Agroforestry here is defined as a land use system which intentionally combines annual agricultural crops with trees or shrubs and/or livestocks within the same land management unit to achieve diversified, and increased production. Thus following the recent redifination of our mandates and placement of a forestry personel we have initiated research on agroforestry at the station level. The actual activities started in August 1995. For the time being the centre attempts to propagate the locally availlable planting materials while trying to understand the agroforestry research area and focus in the existing farming systems.

In 1995-96, different multipurpose tree species for fodder, fuelwood, soilbinder, leguminous, and timber species were introduced and evaluated. Locally available fuelwood cum fodder species were propagated. Agroforestry nursery has been created for generating seedlings of multipurpose tree species.

ABBREVIATIONS & ACRONYMS

ADP	Area Development Project
AET	Advanced Evaluation Trial
AVRDC	Asian Vegetable Research and Development Centre
a.i.	active ingredient
BL	Blast
CAN	Calcium Ammonium Nitrate (see N)
CARD	Centre for Agricultural Research and Development
CIMMYT	International Maize and Wheat Improvement Centre
cm	centimeter
CRI	Crown Root Initiation
CV	Coefficient of Variation
DMRT	Duncan's Multiple Range Test
DOA	Department of Agriculture
DAT	Days after transplanting
DAS	Days after sowing
ESWYT	Early Spring Wheat Yield Trial
FAO	Food and Agriculture Organization
FLW	Flowering
FYM	Farmyard manure
gm	gram
GA	Genetic advance
GCV	Genetic Coefficient of Variation
ha	hectare
hr	hour
Ht.	height
IBWSN	International Bread Wheat Screening Nursery
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
ICARDA	International Centre for Agricultural Research in the Dry Areas
IDRC	International Development Research Centre
IET	Initial Evaluation Trial
IFAD	International Fund for Agricultural Development
IIRON	International Irrigated Rice Observation Nursery
INTHOPE	International Hot Pepper Trial Network
IPM	Integrated Pest Management
IPNS	Integrated Plant Nutrient Study
IRCTN	International Rice Cold Tolerance Nursery
IRDSN	International Rice Drought Screening Nursery
IRRI	International Rice Research Institute

INGER	International Network for Germplasm Evaluation of Rice
ISWYN	International Spring Wheat Yield Nursery
K	Potassium (K_20, Muriate of potash 60% K)
LSD	Least significant difference
m	meter
MAT	Maturity
MoA	Ministry of Agriculture
MP	Muriate of potash (see K)
N	Nitrogen (urea 46%, calcium ammonium nitrate 20% N)
NASEPP	National Seed and Plant Programme
NPPC	National Plant Protection Centre
no.	number
n.s.	not significant
NWAB	National Women Association of Bhutan
P	Phosphorus (P_20_5, single super phosphate 16% P)
PaCp	Phenotypic Acceptability
PCV	Phenotypic Coefficient of Variation
PON	Preliminary Observation Nursery
PE	Panicle Exsertion
PET	Production Evaluation Trial
PI	Panicle initiation
PRET	Pre-production Evaluation Trial
RCB	Randomised complete block
REID	Research, Extension and Irrigation Division
RGOB	Royal Government of Bhutan
RNRRC	Renewable Natural Resources Research Centre
SAVERNET	South Asian Vegetables Research Network
S.E	Standard error
S.E.S	Standard Evaluation System for rice
Sh.Bl	Sheath Blight
Sh. Rot	Sheath Rot
sqm	square meter
SSP	Single Super Phosphate (see P)
t or mt	metric tonnes (1000 kg)
w/w	Weight/Weight

P E R S O N N E L

Research Scientists

Ganesh B. Chhetri MSc (Plant Breeding)	Program Coordinator
Mahesh Ghimiray BSc (Agri)	Research Officer
Tayan Raj Gurung BSc (Agri)	Research Officer
Sangay Duba MSc (Agronomy)	Asst. Research Officer
Yuden Dorji BSc (Agri)	Asst. Research Officer

Field Technicians

Sangay Dorji Agri. Diploma	Senior Research Inspector
Dhurba D. Chhetri Agri. Certificate	Research Inspector
Sib Charan Kujur Agri. Diploma	Research Inspector
Chandra B. Tamang Agri. Diploma	Research Supervisor
Neelam Pradhan Agri. Diploma	Research Supervisor
Kezang Tashi Agri. Diploma	Research Supervisor

Administrative/support staff

Ram K. Chettri	Account Clerk
Sangay Gyaltshen	Store Incharge
Sita Chhetri	UDC Gr.1
Sonam Jamtsho	Tractor Driver
Hemlal Kattel	Tractor Driver
Desh B. Rai	Driver
Ugyen Tashi	Driver
Nidup	Driver

National Work Force/Field labourers

Male	14
Female	14
Total	28

Research Programs

Field Crops Research

FIELD CROPS RESEARCH

The principal research objective of this program is to increase and sustain the productivity and the production of rice, maize, wheat, mustard, vegetables and grain legumes. This program is segregated into 3 distinctive subprograms aimed at germplasm development, production management, and post-harvest management. These subprograms are further divided into a number of projects that contain a series of activities. As an interlink between the various programs at the national level, the Systems Resource Management Program is centralised within the REID of MoA. It comprises of projects on Farming systems research, Soil and water management, Agro-forestry, IPM and Irrigation management.

Integrated Germplasm Development

The main focus of this subprogram is to develop improved germplasm with high yield potential, superior grain quality, multiple resistance to major diseases and insects, and medium growth duration. This subprogram is essentially broken into 5 projects to embody rice, wheat, oilcrops, vegetables and fruits, and fodder species.

Rice

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

F To increase the productivity and the total production of rice at the national level

F 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

F To improve the traditional rice varieties through breeding and selection

F 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 subjected to moderate fertilizer 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. Fertilizer doses applied are 70-40-20 kg NPK/ha, with half the N topdresses at PI. Weeds are controlled using Butachlor and spot weeding as necessary. Harvest and post-harvest operations are done manually.

To achieve the above stated objectives, following strategies are presently pursued :

1. Germplasm Introduction

Rice germplasm are introduced from regional and international research institutes and thoroughly evaluated under Bhutanese field conditions. In 1995-96, more than 300 varieties and breeding lines were tested in the research station as well as in the farmers' fields. Of these, about one-third were selected for further assessment.

1.1 Introduction Nursery (IN)

In the Introduction Nursery that consisted of 29 early maturing entries from IIRON, all lines were selected for further observation (Table 1). Though most of the entries were shorter than IR 64 in plant height, however, they will be further evaluated as observation nurseries. Some of the major selection criteria used were flowering and maturity days, plant height, tillering ability, and overall phenotypic acceptability at maturity. Insect and disease pressure was not adequate for differential rating.

Table 1. Selections from Introduction Nursery.

Designation	50% FLW (days)	Plt. Ht. (cm)
1. BATANG SUMANI	104	96
2. BR1067-84-1-3-2-1	104	88
3. CT6551-19-51-31-51	104	84
4. CT8707-1-7-6-1	104	81
5. CT9145-4-21-1-1	100	85
6. CT9159-13-2-2-1	104	84
7. GIZA176	104	85
8. GZ4196-36	104	87
9. H13-4-1-1-2	100	87
10. IR50	100	89
11. H13-4-1-2-1	100	87
12. H257-2-1-1	104	97
13. H257-33-2-1	104	88
14. H270-19-1-1	104	103
15. H274-16-1-1	100	95
16. H13-4-1-2-2	100	81
17. IR47310-16-2-2-2	100	83
18. IR563883-35-3-2-1	104	81
19. IR58082-126-1-2	104	82
20. IR58100-62-3-2	107	84
21. IR59601-49-3-1	100	81
22. IR60133-184-3-2-2	104	85
23. IR60819-53-2-2	104	84
24. IR60829-50-1-1-3	104	87
25. IR62156-138-3-3-2-2-2	104	82
26. PNA1022-F4-110-1	111	103
27. RP2068-32-6-1	107	96

28. RP2333-253-30	104	90
29. SLG12	104	99

1.2 **Observation Nursery (ON**)

Ten entries were tested in a single plot of 10 sqm. These materials were selected from the previous years introduction nursery and were evaaluated for yield, plant height, and maturity period. Obervations are presented in Table 2. The entry BKNB5073-16 was the highest yielder with a yield of 7.12t/ha. Few entries from the nursery will further evaluated under replicated yield trials.

Table 2. Performance of entries evaluated in Observation Nursery

Designation	50% FLW (days)	Plt. Ht. (cm)	Yield (t/ha)
1. BKNB5073-16	116	91	7.12
2. CL SELECTION 56	112	87	6.71
3. CL SELECTION 87	112	84	6.25
4. CT8262-8-2-2-M-3P	112	89	6.71
5. CT8455-1-13-1-M-2P	116	90	4.66
6. CT8455-1-24-1P-M-4P	116	85	4.92
7. H202-7-1-1-1	116	91	4.57
8. H255-43-1-1-1	112	82	-
9. H274-97-1-1	112	97	4.77
10. ZHEN-GUI-AI-1	116	81	6.36

1.3 Evaluation of Elite Cross-bred lines for Spring Rice Crop

Varieties for the first crop, in rice double cropping, requires seedling cold tolerance and shorter maturity period besides good yield potential.

Seven cross-bred lines along with two check varieties were planted in single plots of 45.5 sqm at the station. All lines had red kernel. Lines were sown on 1 February, 1996 and transplanted on 15 March 1996. Yields were estimated through crop-cuts from 5 sqm area. The results are in Table 3. The test lines yielded hihger than the checks. However, the test lines took longer duration to mature than the check varieties. Due to longer maturity period, the test lines are not suitable for rice double cropping. The same lines will be tested for yield and suitability under normal crop.

Table 3. Yield and plant characters of Seven Elite lines as First Crop in Rice Double Cropping -

Lines	50% FLW (days)	Mat. (days)	Plt. ht. (cm)	Yield (t/ha)
1. CARD21-14-1-1-3-3-B	141	174	81	3.94
2. CARD21-14-1-1-3-2-B	141	174	80	3.57
3. CARD21-15-2-1-3-1-3-B	141	173	91	4.16
4. CARD21-15-3-2-3-3-2-B	137	172	81	4.09
5. CARD21-15-3-2-3-3-1-B	142	176	85	2.94
6. CARD21-14-1-1-3-2-1-B	138	174	81	3.69
7. CARD21-15-3-2-3-2-3-B	137	174	82	5.07
8. BARKET (CHECK)	121	150	84	2.70
9. NO.11	126	154	76	2.62

1.3 Initial Evaluation Trial (IET)

Following the standard evaluation procedure, 18 entries were tested along with local (Zakha) and standard check varieties - IR64 and IR20913. The objective of this trial was to identify varieties that have the desired maturity period, resistance to prevailing insect pests and diseases and high yield potential.

The entries were laid out in a randomized complete block with three replications. Inorganic fertilizers were applied at the rate of 70-40-20 kg NPK/ha, with half the N as topdress at PI. Seedlings were transplanted in 10 sqm plots at a spacing of 20 x 20 cm. Grain yield was estimated from 5.04 sqm and moisture content standardized at 14%.

Statistical analyses of grain yield and other characters are presented in Table 4. All most all the entries except IR64429-B-B-R-B-B yielded at par with the checks. A cross-bred line IR56346-1-1-R-1-9-1 recorded the highest yield (6.80t/ha) followed by the check IR64. Occurrence of insect pests and diseases was negligible. Few entries will be further evaluated for yield in AET.

Table 4. Grian yield and other plant characters of varieties/lines in IET

Varieties	Yield (t/ha)	50% Flw (days)	Plt.ht (cm)
IR61328-1-136-2-1-2-3	6.80 a	120 ab	95 fg
IR 64	6.66 a	113 e	86 ij
RP1848-213-5-1	6.57 a	113 de	106 cd
CU8068	6.48 ab	112 a	92 fghi
IR61331-2-38-21-1-1	6.30 ab	117 c	87 hij
KUNMING830	6.24 ab	108 f	95 fg
CARD20-21-3-2-1-1-1	6.11 ab	113 e	82 j
CARD20-21-3-2-1-3-2	6.09 ab	115 d	91 ghi
CARD20-21-3-2-3-1-1	5.93 ab	119 b	87 hij
IR61331-2-25-2-3-1-1	5.93 ab	120 ab	93 fgh
CARD20-21-3-2-1-3-1	5.88 ab	114 de	87 hij
ZAKHA	5.84 ab	119 b	124 a
IR61331-2-25-2-3-1-1	5.77 ab	121 ab	92 fghi
IR61328-192-2-3-1-1	5.76 ab	108 f	118 b
IR61328-192-2-3-2-2	5.75 ab	114 de	113 bc
CARD21-10-1-1-3-2-3	5.73 ab	114 de	102 de
IR60553-2B-7-1-2	5.57 ab	114 de	98 ef
IR58100-144-3-2	5.36 ab	121 ab	106 cd
CARD21-15-4-1-2-2-2	5.30 ab	110 f	110 c
IR20913	5.06 ab	106 g	108 cd
IR64429-B-B-R-B-B	4.54 b	106 g	112 bc
CV %	16.5	0.9	3.7

1.4 Advanced Evaluation Trial (AET)

Thirteen varieties and advanced breeding lines along with checks were evaluated in this experiment. The entries in this trial were among the best performers at the station level. The objective of the trial was to select the most promising varieties in terms of grain and straw yields, maturity period and resistance/tolerance to biotic stresses. The elite materials generated from this trial would then be tested in the farmers' field conditions.

The trial was laid out in a randomised complete block with three replications. Seedlings were transplanted in straight rows at a spacing of 20 x 20 cm in 10 sqm plots. Chemical fertilizer was applied at the rate of 70-40-20 kg NPK/ha, with half the N topdressed at PI. Weeds were controlled by using Butachlor 5G at the rate of 1.5 kg a.i./ha. Spot handweeding was done whenever necessary. Grain yield was obtained from a harvest area of 5.04 sqm. Results are presented in Table 5.

Statistical analysis on grain yield showed that IR61331-2-148-B produced significantly higher yield (7.22 t/ha) than the local check Zakha and other entries except IR64. Maturity-wise,

the line took slightly longer period to mature compared to Zakha but has optimum plant height.. However, no significant insect damage occurred, precluding a differential rating among the entries. The elite selections from this trial will be evaluated in farmers' field trials in the ensuing season.

Table 5. Performance of varieties and advanced breeding lines in AET, RNRRC 1994.

Variety	Yield (t/ha)	50% Flw (days)	Plt.ht (cm)
IR61331-2-148-B	7.22 a	121 ab	97 b-e
IR 64	6.89 ab	123 a	91 de
IR56346-1-1-R-1-9-1-1	6.22 bc	119 ab	87 e
CARD21-3-2-1-1-3	6.20 bc	119 ab	92 de
CARD20-21-3-2-3-2-B	6.06 cd	120 ab	86 e
CARD21-10-1-1-3-2-3	5.89 cd	113 c	95 b-e
ZAKHA	5.85 cd	114 c	121 a
CARD21-13-2-1-3-1-B	5.84 cd	121 ab	94 c-e
CARD21-17-4-1-2-B	5.68 cd	121 ab	93 cd
CARD21-10-1-1-3-2-2	5.54 cd	115 c	94 c-e
IR60553-2B-7-1-2	5.43 c-f	120 ab	91 de
CARD21-15-2-1-3-2-1	5.36 def	122 ab	99 bcd
CARD21-15-2-1-3-2-2	5.31 def	119 ab	94 cde
IR64429-B-B-R-B-B	4.84 ef	106 d	103 bc
IR60023-6-43-B	4.68 f	122 ab	105 b
CV %	7.4	1.6	5.7

1.5 Preproduction Evaluation Trial (PRET)

Four varieties including checks were tested in the Preproduction Evaluation Trial (PRET) in the Wangdi-Punakha valley. The objective of this trial was to compare the yield and genetic stability of two promising lines with IR 64 and popular local cultivars under farmers' field conditions.

The trials were laid out in randomised complete blocks with three replications at five locations from 1250m to 1400m altitude. Seedlings were raised in semi-dry nurseries in the third week of May and transplanted between 2 June and 26 June at 20 x 20 cm spacing in lines in 2 x 5 m plots. Land was manured and prepared by cooperator farmers following local practice. Weeds were controlled by Butachlor 5G at the rate of 1.5 a.i./ha applied 3-6 DAT and spot weeding by hand. All the trial sites were topdressed with 35 kg N/ha at 35-40 DAT. Plot yields were obtained from the central 5.04 sqm from each plot, corrected for off-types, and computed at 14% moisture content.

Performance of varieties was examined by analysis of variance of the five sets of data combined across locations (Table 6). There were significant (P=0.01) location and variety effects while variety x location interaction effect was not significant. This reflects the variation among locations in altitude, fertility, soil types and the management Averaged across locations, the standard check IR 64 was the highest yielding variety with a mean grain yield of 5.22 t/ha, which was 1.91 t/ha higher than that of the local cultivars. This indicates the superiority of this variety with regard to yield and suitability over a wider environmental conditions. The test lines CARD21-3-2-1-1-3 and CARD21-15-2-1-3-2-1, yielded higher than the local checks.

Table 6. Performance of six varieties in PRET in Wangdue-Punakha Valley

Lines	Locations					Mean
	Bajo	Serigang	Chuzomsa	Sopso	Richa	
CARD21-3-2-1-1-3	4.91 b	4.10 a	3.90 a	4.84 b	3.21 a	4.19
CARD21-15-2-1-3-2-1		5.41 bc	2.69 a	3.75 a	4.88 b	3.15 a
3.98						
IR 64 (Std. Check)	6.12 c	4.90 a	5.24 b	5.84 b	3.98 a	5.22
Local Check	3.04 a	3.52 a	3.39 a	3.36 a	3.25 a	3.31
L-mean		4.87	3.80	4.07	4.73	3.40
CV %	9.2	32.7	8.5	11.1	22.3	

Comparison	S.E.D	LSD(5%)	LSD(1%)
2-V means at each Location	0.602	1.230	1.656
2-L means at each Variety	0.629	0.550	0.740

F Location (L) : **
F Variety (V) : **
F LxV : ns
In a column, means followed by a common letter are not significantly different at the 5% DMRT.

1.51 Pre-production Evaluation Trial for Spring Rice Crop

Five promising CARD lines along with a check were evaluated in farmers field conditions. The trials were laid out in a randomized complete block design with three replications under two locations. The yield was estimated from a harvest area of 5.04 sqm. The results are in Table 7.

Averaged across locations, the standard check variety - Barket, produced the highest yield (3.81 t/ha) followed by CARD21-15-3-2-3-3-2-B and CARD21-14-1-1-3-2-1-B. The performance of varieties differed significantly within a location. The good lines will be further evaluated in PET.

Table 7. Yield (t/ha) of six promising entries, for Srping Crop, in PRET

Vars./Lines	LOCATION		V-Mean
	R/gang	Hesothangkha	

CARD21-14-1-1-3-2-1-B	2.48 a	3.29 b	2.89
CARD21-14-1-1-3-2-2-B	1.67 a	2.59 ab	2.13
CARD21-14-1-1-3-2-3-B	2.42 a	2.39 ab	2.41
CARD21-15-3-2-3-2-1-B-B	2.65 a	2.22 ab	2.44
CARD21-15-3-2-3-3-2-B	3.76 b	2.28 ab	3.02
BARKET	5.71 c	1.90 a	3.81
L-mean	3.15	2.44	
CV(%)	27.7	18.8	

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

1.6 Production Evaluation Trials (PET), in Wangdue-Punakha Valley

The most promising line - CARD21-10-1-1-B was distributed to the extension agents in the valley. The extension agents could not collect trial data as they were busy combating the outbreak of rice blast disease. Hence, the data could not be included in this report. However, the same genotype will be re-evaluated in the ensuing season.

2. Hybridization

As a longer-term strategy for improving local rice cultivars, a shuttle breeding program has been in operation since 1985 in collaboration with IRRI. The major objectives are to improve traditional rices of Bhutan by incorporating desirable genes from improved parents and to develop varieties that are more appropriate for Bhutan's medium and high altitude rice environments.

2.1 Pedigree selection from bulk populations at station

A total of 464 pedigree lines and 79 bulk selections were selected from 8 populations (Table 8). The major selection criteria were intermediate plant height (100-110 cm), plant vigor, uniformity in flowering and grain maturity, high fertility, insect-disease freeness, compact panicles and dense grains. During the selection period, farmers from the neighbouring farms were involved for selection with the breeders. Out of 464 pedigrees, 36 are farmer selected lines. Interestingly, farmers didn't have any lines selected from three populations whereas the breeders made selections even from those populations. The selected lines will be further evaluated in pedigree rows while bulk harvests of 79 progenies will be tested in obervation nursery.

Table 8. Plant and bulk selections from eight Bulk populations at RNRRC, Bajo

Cross designation	Plant Selections		Bulk Selections
	Breeder	Farmer	
IR62467-B-R-B	60	12	17
IR62470-B-R-B	61	7	10
IR62473-B-R-B	60	2	9
IR63332-B-R-B	46	7	16
IR62745-B-R-B	41	-	4
IR62476-B-B	40	-	4
IR62476-B-B	60	-	8
IR65239-B-B	60	8	11
Total	428	36	79

2.2 Pedigree selection from bulk populations at Paro sub-station

At the high-altitude sub-station at Paro, a total of 413 pedigree lines were harvested from 7 populations (Table 9). Crosses involved mostly cold-tolerant Suweon or YR lines and Chummro, Barket or Maap varieties of Paro and Thimphu. Apart from cold-tolerance, high yield and red grains, blast resistance is another important criterion for the improved types coming out of this breeding program. Pedigree row testing for 5th generation will be done for

the selected lines. The bulk populations will be planted in observation nursery in the ensuing season.

Table 9. Pedigree selections from seven bulk populations at Paro

Cross designation	Parents	Plants selected
IR66408-B-P	IR55259-B-3-3-2-2/Chummro	74
IR66412-B-P	IR60060-AC2-1/Chummro	152
IR66068-B-B-P	YR3825-11-3-2-1// YR3825-11-3-2-1/Barket	86
IR62746-B-P	Suweon359//IR41996-118-2-1-3/Thimphu Maap	19
IR65892-B-B-P	No.11/Chummro	23
IR62734-B-P	Suweon 353//No.11/Th.Dumja	16
IR65232-B-B-P	IR60060-AC2-1/ YR3825-11-3-2-1	43
Total		413

2.21 Bulk Population Evaluations at Paro

Nineteen F2 bulk populations were evaluated at the high altitude site in Paro. 38 plants were selected from five populations (Table 10). Rest of the populations were discarded.

Table 10. Plant selections from five F2 populations

Designation	Parents	Plants Selected
IR68136-B	BARKET/KOCHUM	7
IR68142-B	IR64/ZAWA BONDEY	7
IR68146-B	JP5/GYEMBJA	9
IR68147-B	JP5/KOCHUM	7
IR68149-B	JP5/ZUCHEM	8

TOTAL	38

3. Collection and conservation of local rice germplasm

Collection, rejuvenation, characterization and preservation of rice germplasm are considered as important activities in varietal development for increased and sustainable rice production. Lack of a gene bank so far has discouraged mass collection and conservation of traditional germplasm; however collections are made at the research stations for evaluation purposes as well as for future utilization. In 1995, 76 local cultivars from Wangdue, Punakha, Trongsa, Zhemgang, Mongar, Trashigang, S/Jongkhar, P/gatshel and Paro were rejuvenated at the station (Table 11). Basic characteristics such as plant height, flowering, maturity period, grain colour etc. of these varieties were also recorded.

Table 11. Local rice germplasm rejuvenated in 1995

Variety	Altitude grown(m)	Village	Dzongkhag	Pericarp color	50%FLW (days)	Plt.ht. (cm)
Gyemja	1800	Changray	Trongsa	White	116	134
Raymaap1	2100	Essa	"	Red	116	140
Gyemja	2120	T/dingkha	"	White	116	136
Raymaap2	2100	Essa	"	Red	119	158
Chonaam	1800	Refey	"	Red	123	159
Raykar	1650	K/rabten	"	White	119	150
Gyemja S1	1980	Samcholing	"	White	123	140
Gyemja S2	1900	Samcholing	"	White	123	136
Zakha	800	Jangaray	Wangdue	White	116	115
Mabnagchang	1350	Tagchha	"	Red	119	149
Kongteray	1350	Tagchha	"	White	119	82
Mabphokhum	1350	Tagchha	"	Red	116	137
Lhamzama	1330	Dorjipokto	"	Red	123	164
Tanditshering	1400	Khengna	"	White	123	158
Kathramathra	1120	Dagauma	"	White	119	150
Kaap	1200	Gangtey	“	White	123	119
Kap-Zakha	1500	Gogona	"	White	116	128
Hemjam	1500	Gogona	"	White	116	162
Bondame	-	Dangchu	"	Red	116	158
Kinlay Tshering	1800	Kazi	“	-	116	138
Hamzom	1600	Y.Nawang	“	-	119	159
Babukaap	1900	Gangkha	Punakha	White	123	137
Macha	1800	Dochu	"	Red	123	163
Kapchy	1950	Sari	"	Red	116	146
Janam	-	Taloo	"	Red	123	160
Naja	-	Taloo	"	White	123	118
Genja	-	Lapchakha	"	Red	123	137
Reysap	1350	Gumakha	“	White	116	110
Baybu	1230	Changyul	"	White	116	119
Ngap Bja	-	Samadingkha	“	-	119	131
Tandin Tshering		“	“	-	119	130
Gymokap	2400	Chento	Paro	White	116	126
Zamsakap	2300	Zamsa	"	White	116	157

Kuchum Map	2300	Phondo	"	Red	116	152
Reynaam	-	Sasamchoten	"	Red	116	142
Reykaap	-	Sasamchoten	"	White	116	148
Rey Naab	-	Namjo	“	-	116	156
Local white	-	Wachukha	Paro	-	119	114
Local Red	-	Khangkhu	Paro	-	119	138
Janam	2300	Dawakha	“	-	119	123
Dumja	2250	Sebjana	“	-	119	152
Kuchum	-	Phongdo	“	-	116	147
Zuchum	2350	Kharibje	“	-	116	152
Thimja	2100	Gangri	“	-	116	144
Nam	2100	Gangri	“	-	116	135
Dumja	2200	Dankha	“	-	116	136
Janak	2200	Jagathong	“	-	116	144
Dumja	2200	Kichu	“	-	116	143
Nam	2300	Sebjana	“	-	116	151
Zuchum	2300	Kharibje	“	-	116	143
S/J Local	-	-	S/Jongkhar	-	116	118
Khangtangbara	-	-	-	-	116	130
Numering	-	Khamdang	Trashigang	-	116	119
Lumchangbara	-	Khamdang	“	-	116	124
Dakpo	-	Khamdang	“	-	116	128
Sambara	-	Kangpara	Trashigang	-	116	113
Gasapangbara	-	Fuwang	-	-	116	139
Bremipangbara	-	-	-	-	116	116
Rashmibara	-	Zobel	P/gatshel	-	119	106
Kalomalo		Yangtse	-	-	119	154
Labshu		yangtse	-	-	116	141
Jyogopa		Drangmaling	Mongar	-	118	125
Khobtang	-	-	-	-	116	132
All-Dem	-	-	-	-	116	171
Karmatakpa	-	-	-	-	116	158
Aullngbara	-	-	-	-	119	154
Gunurumlengbu		-	-	-	116	161
Sonala	-	-	-	-	116	165
Limsangpa	-	-	-	-	116	139
Kamsing sinty	1200	Tong	Zhemgang	-	119	135

Kamsing Khartlla	1200	Tama	“	-	119	126		
chakarpa	-	Dakpai	“	-	119	148		
Bjena maap	1400	Titokha	“	-	119	135		
Thagom	1400	Themakha	“	-	116	152		
T.Tshering	1400	Talgang	“	-	119	128		

Crop Production Management

Improved crop management practices are necessary to help achieve potential yields. Local management practices needs to be improved to derive fuller benefits from improved crop varieties. Therefore, the major aim of this sub-program is to improve the ways in which a crop is managed thereby maximising the yield per unit area.

Nature farming using EM technology

The simplest definition of nature farming is a farming method without using agrochemicals.This method approaches the natural system thereby sustaining the long term productivity of renewable natural resources. The major objective of nature farming using EM technology is that while improving the productivity and efficiency of resources use, utmost respect is also provided to the environment/nature on which the production is based.

The nature farm was established at the station in 1995. The farm roughly measure 10703 sqm. It is a long term study in a rice-based system. Crops included rice followed by rice, or wheat or mustard. In an upland condition, maize followed by potato system is also included. Legumes are grown on rice-bunds and tree species planted at the fringes of the terraces.

For all crops inorganic fertilizers and pesticides are not applied. All crop residues are incorporated into the soil along with 7 t/ha FYM and 10 t/ha EM Bokashi at the time of land preparation. Further, EM solution prepared at the ratio of 1:1:100 (EM:Molasses:Water) is sprayed at the rate of 10 litres/ha to all crops in addition to FYM and EM Bokashi. Three additional sprays of EM solution is provided to all the crops during its growing period. Other management practices followed the normal practice for each individual crop. Besides crop yield, weed pressure, soil health, pest and disease incidences are being monitored and recorded. Weed pressure was monitored using a quadrat of 0.25 sqm while grain yield was estimated through crop cuts from 5 sqm. area for all crops except maize from 9 sqm..

This being the first year of nature farming, in rice during 1995-1996, there was severe weed pressure. Weed count recorded 81 numbers of weeds (sedges and broadleaf) per 0.25 sqm area which in terms of fresh weight was 4.12 t/ha. Despite heavy weed pressure, the yield of 8.7 t/ha was obtained which was on the higher side.

In other crops , only the yield were monitored. Wheat yield was 0.77 t/ha, mustard 0.26 t/ha and maize 6.37 t/ha. Overall, this being the first year, the nature farm system is in its transition state from a previously modern agriculture practised site to a more natural system of cultivation.

Germplasm Improvement of Wheat

2.1 Introduction

The wheat research programme continued with emphasis on varietal improvement and crop management. The volume of wheat research reduced markedly since the major wheat research will be done RNRRC, Jakar. Varietal screening was done based on the formalised procedure adopted in 1986. About 44 varieties/crosses were tested in different trials at the research station. Farmers' field trials with new materials were not carried out due to the lack of promising entries. However, various programs of demonstration and promotion were done using the released varieties in different dzongkhags.

2.2 Observation Nursery (ON)

Seventeen varieties from CIMMYT were screened in this nursery to evaluate their yield and yield attributing characters and disease reaction. Each entry was sown in a single 5 x 1 m plot size. Selected entries (Table 12) will be advanced to more intensive testing during the following cropping season.

Table 12. Selections from the Wheat Observation Nursery

Variety	Yield (t/ha)	Plt.ht. (cm)	Mat. (days)	Spikes/Sqm. (Nos.)
1. SONALIKA	1.94	84	147	296
2. KAU*2/YACO//KAUZ CRG 873-2Y-010M-OY	1.92	66	153	312
3. BAJOKA-1	1.90	77	153	260
4. CHECK (Local check)	1.75	82	153	672
5. Maya /Nac	1.58	70	153	320
6. SARA/THB//VEE CM 87582-013 TOPM-2Y-DH-DSY-1M-OY	1.58	85	153	212
7. Bajoka-2	1.41	74	147	296
8. KAUZ/GEN,CRG178-2-49B-OY-030M-6Y-2Y-OM	1.41	80	153	268
9. IRENA CM 91575-34Y-OM OY=2M=OY	1.40	85	153	240
10. PFAV/VEE#911VRES CM 94295-F-OM-OY-3Y-OB	1.40	88	153	340
11. ROLLER CM88930-12Y=				

OM-OY-4M-2Y-OB	1.36	87	153	188
12. F60314-76/MRL//CNO79 CM77694-A-IY-02M-OSY-IB-1Y-0B	1.29	87	153	176
13. OBATA/KILL;CM97029-10Y-OB-OY	1.28	85	153	232
14. BUGU CM98248-OM-4Y-OAL-6Y-3Y-OY	1.28	90	153	304
15. MIMUS CM100684-B-OB-OY	0.89	76	153	276
16. TAN/PEW//SARA CM88386-23M-OSY-OH-1Y-OM	0.87	79	153	316
17. BAU//BJY/COC CM100770 30Y-7B-10RES-030B-OY	0.75	81	153	154

2.3 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. 15 entries were seeded in November in an RCBD with a plot size of 3m x 3m. Seeds were sown at a row spacing of 0.20m. A fertilizer dose of 60-40-20 NPK kg/ha was applied with 50% N topdressed at CRI. The crop was irrigated thrice- once at CRI, tillering and flowering stages. Harvests were made from the centre of the plot measuring 7.5 m^2 and yield computed to tons per ha.

Results of the analysis are presented in Table 13. No line significantly outperformed the standard checks BK-1 (Bajoka-1), BK-2 and Sonalika. Few best entries will be promoted to AET.

Table 13. Performance of entries in Initial Evaluation Trial

Sl. No.	Variety	Yield (t/ha)	Plt.ht (cm)	Mat. (days)	Spikes/Sqm. (No.)
1.	150.83/2WALRUS1 SWTB89, 279-1Y-4PAP-OELV-OFM	2.48 a	88 def	171	149 a
2.	BAJOKA-2	2.32 a	80 bcd	149	217 ab
3.	JUN CN33483-C-7M-1YOM -20B-DY	2.26 a	84 cde	156	275 b

4. LAD 622 81//2TESMO1 MUSX603 SWTB89,252-22Y -2PAP-OELV-OFM	1.96 a	90 def	171	176 ab
5. 150.83/SONNIE SWTY91, 13-3FM-OFM	1.91 a	84 cde	158	148 a
6. LT1071.82/2SORI SWTB89. 225-5Y-3PAP-OELV-OFM	1.89 a	76 abc	171	161 ab
7. VEE/KOEL	1.71 a	70 abc	156	152 a
8. BAJOKA-1	1.59 a	73 a b	156	217 ab
9. 6TB 277/2BULL 1-1SWTB89-307-9Y-3PAP-OELV-OFM	1.54 a	91 ef	171	177 ab
10. VL-719	1.50 a	71 ab	156	184 ab
11. FFN/VEE#5	1.47 a	76 abc	156	168 ab
12. SONALIKA	1.45	68 a	149	180 ab
13. KAUZ*211 SAP/MON/3/KAUZ CRG, 969-2Y-010M-0Y	1.44 a	74 abc	158	151 a
14. 150.83/SONNIE SWTY91.13-6FM-OFM	1.37 a	96 f	158	208 ab
15. MO88 CM64624-2Y-1M4Y-OM-34Y-OM	1.26 a	77 abc	156	245 ab
CV(%)	34.7	7.2		33.8

2.4 Advanced Evaluation Trial (AET)

The principle objective of this trial was to select promising varieties for high grain yield, medium maturity period, and resistance to rusts at the station level.

The trial was laid out in randomised complete blocks with 3 replicates. Nine test entries with 3 standard checks were seeded in lines at a row spacing of 20 cm in 10 sqm plots. Inorganic fertilizer was basally incorporated at the rate of 60-40-20 kg NPK/ha, with half the N topdressed at CRI. Weeds were controlled by handweeding. Grain yield was obtained from a harvest area measuring 5.28 sqm.

Results of the statistical analysis on yield and other characters are presented in Table 14. None of the varieties could significantly outyield the checks BK-1, BK-2, and Sonalika although VL 728, VL-725, TL 2801, and a few others yielded comparable to the checks. The incidence of rust diseases was very minimal and significant differences among entries were not recorded. The best performers from this trial will be tested in the farmers' fields.

Table 14. Yield and other parameters of varieties tested in AET

Sl. No.	Variety	Yield (t/ha)	Plt.ht (cm)	Mat. (days)	Spike/sqm (no.)
1.	Bajoka-1	2.08 b	67 a	156	140 a
2.	VL-728	1.79 ab	79 a	156	147 a
3.	VL-725	1.63 ab	68 a	159	169 a
4.	Sonalika	1.50 ab	72 a	150	155 a
5.	TL-2801	1.46 ab	75 a	156	148 a
6.	WK-429	1.45 ab	79 a	156	181 a
7.	BOW/NAC/VEE/3/ BJY/COC	1.35 ab	69 a	156	132 a
8.	HPW-79	1.31 a	77 a	156	187 a
9.	VEE/KOEL	1.29 a	90 def	156	151 a
10.	HB-208	1.26 a	69 a	156	163 a
11.	Bajoka-2	1.27 a	81 a	150	173 a
12.	BOW/PRL/BUC	1.22 a	72 a	156	135 a
C.V %		26.9	11.5		29.3

Seed Increase for Research

To ensure ready availability of seeds for research purposes, the Centre routinely multiplies seeds of released varieties as well as those varieties and elite lines that have reached the advanced stages of testing in farmers' field. The details of seed increase are presented in Table 17. Nucleus seed of some released and promising varieties are also being maintained (Table 18).

Table 17. Amount of seed increased for crops for research purposes in 1995-96.

Varieties/lines	Seed Category		Total (kg)
	Pre-basic	Basic	
Rice			
IR 64	-	238	238
Barket	66	140	206
IR20913	133	275	408
NO. 11	-	100	100
CARD21-10-1-1-B	315	-	315
CARD21-3-2-1-1-B	-	175	175
IR64429-B-B-R-B-B	-	86	86
CARD21-15-2-1-3-2-1	-	104	104
Total	514	1118	1632
Wheat			
LYP 73	-	72	72
Bajoka-1	-	142	142
Bajoka-2	-	243	243
Sonalika	-	244	244
Total		701	701
Oilseeds			
Groundnut	-	175	175

Table 18. Nucleus seeds of six varieties

Variety	Selection Type	No. of Sample

1. CARD21-10-1-1-B	Panicle selection	101
2. CARD21-15-2-1-3-2-1	Panicle selection	101
3. BARKET	Hill selection	100
4. NO.11	Hill selection	100
5. IR20913	Hill selection	100
6. IR64429	Panicle selection	100

HORTICULTURAL RESEARCH

Introduction

The main research objective of this program is to diversify the horticultural crops and emphasize high value crops that would meet both nutritional and cash income requirements of farmers. The foregoing objective will be realized through introduction and evaluation of exotic species besides the evaluation and improvement of local germplasms.

VEGETABLES

Cabbage Variety Observation Trial

The objective of the trial was to study the earliness, pest reaction, and bolting characteristics in two improved cabbage varieties.

The varieties were grown as single plot observation of 5 sqm. plot. The varieties were sown on 31 November, 1995 and transplanted on 3 January 1996. Each variety was sown in four beds spaced at 50 x 45 cm. Fertilizer was applied at the rate of 60:100:20 NPK kg/ha in addition to well decomposed FYM applied at the rate of 30 t/ha. Malathion 50EC at the rate of 1% was sprayed every two weeks interval against aphid. Weeds were removed by handweeding twice at 30 days interval. Yields were estimated based on the harvests made from inner three beds which gave about 20 heads per variety. Results are presented in Table 1.

Both the varieties were light green in colour with same maturity period. The cabbage heads of Golden acre were, however, more compact than the heads from Copenhegan. On the other hand, both the varieties did not exhibit the problem of bolting when sown in November and planted in early January. The same observation trial will be continued to observe bolting problems when planted in late March.

Table 1. Characteristics of two cabbage varieties

Characters	Variety	
	Copenhegan	Golden Acre
1. No. of head harvested	20	20
Head Size		
2. Length (cm)	16.05	13.10
3. Width (cm)	14.15	11.80
4. Total Weight (kg)	30.00	20.55
5. Marketable Weight (kg)		
6. Wt. of largest head (kg)	2.60	2.25
7. Wt. of smallest head (kg)	1.50	0.90
8. Plant height (cm)	35.50	33.20

Cherry Tomato Advanced Evaluation Trial

This experiment was conducted with the objective of evaluating and comparing the performance of three selected AVRDC cherry tomato lines with the Local cherry variety for their yield, horticultural characters and their adaptability to the Punakha-Wangdue environment.

The trial was laid in an RCB design in a plot size of 9 sqm. with three replications. Seeds were sown on February 1995 and transplanted in the field on third week of March 1995 with a spacing of 75 x 60 cm. Fertilizer dose of 75:100:20 NPK kg/ha + 30 t/ha FYM was applied basally. Additional 50 kg/ha N as CAN was applied as top dressing. The field was flood- irrigated during planting and continued at an interval of 15 days. Plots were kept weed-free by hand weeding at 15 and 35 days after planting. Bamboo poles were used as staking support after first flowering and the plants were tied to the stakes every week. Pinching/pruning was done before flowering every week. Cypermethrin 30EC was sprayed once against fruit borer. There were 7 harvests. The first harvest was taken on 24 May 1996 and the last harvest on 15 September 1996. Yield and yield characters are represented in Table 2 and 2(a).

The total yield and marketable yields were significantly higher in CHT 160 compared to all the test entries including the check. Other test varieties produced yields comparable to the check. The number of fruits per kg was significantly higher in the check variety than the test varieties. High number of fruits/kg in the check was associated to its small fruit size compared to the test varieties. All test varieties were significantly taller than the check while all entries had good number of seeds per fruit.

CHT 104 and CHT 160 will be taken to farmers' fields for further evaluation in the ensuing seasons.

Table 2. Yield and yield characters of five Cherry tomato entries 1995

Variety	Total yield (t/ha)	Mkt.yield (t/ha)	Seeds/fruit (No.)	Fruit /Kg (No.)
CHT 172	30.43 a	26.70 b	68.00 ab	27.75 a
CHT 160	42.30 b	39.00 a	66.25 a	31.00 b
CARD CHT (check)	28.95 a	26.08 b	73.75 bc	60.50 d
CHT 104	31.85 a	28.48 b	76.25 c	46.25 c
CV %	16.4	15.2	6.2	4.9

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

Table 2(a) . Horticultural characters of five Cherry tomato entries

Variety	Plt.ht. (cm)	Fruit length (cm)	Fruit dia. (cm)
CHT 172	163 c	4.15 c	3.83 c
CHT 160	138 b	4.33 c	3.58 b
CARD CHT (check)	124 a	2.60 a	2.68 a
CHT 104	156 c	3.50 b	3.50 b
CV(%)	2.7	5.3	3.2

Chilli Varietal Trial - SAVERNET 1996

The following varieties received under SAVERNET were tested for yield and yield characters.

Variety	**Country of Origin**
1. Sha Ema	Bhutan
2. CARDIII	Bhutan
3. Cap Early	FAO Accession
4. Launghi	Pakistan
5. Surya Mukhi	Nepal
6. KA-II	Sri Lanka

The experiment was laid out in RCB design with three replications. The plot size was 5 sqm. Seeds were sown on the first week of January, 1996 under polytunnel house and transplanted on 21 February 1996. Plants were spaced at 60 x 50cm with 20 plants per plot. Fertilization at the rate of 60:100:10 NPK kg/ha and 30 t/ha FYM was applied. Half of nitrogen was given 30 days after transplanting. The crop was hoed and weeded four times during the growing period. Plants were irrigated immediately after transplanting and then sprinkler irrigated once in a week until harvest. Cypermethrin 30 EC was sprayed at 30 DAT against

aphid and thrips. A total of seven harvests were carried out starting from last week of April to 3rd week of July, 1996. The results are presented in Table 3.

Variety CARDIII, a selection from the local chilli at the station, produced significantly higher yield (30.6 t/ha) than all the test entries except local Sha Ema. The varieties - Launghi, S. Mukhi, and K-II; were prolific types indicated by significantly higher number of fruits per kg and per plant. However, these varieties had significantly shorter fruit length and diameter; compared to Sha Ema, CARD III, and Cap Early; which indicated small fruit sizes more suitable for pickling. The fruit size of Cap Early was comparable to local chilli. CARD III exhibited the smallest plant width indicating that its yield per unit area could further be increased through increasing plant density.

During a public exhibition in Thimphu, farmers and consumers expressed strong interest for all the tested entries for varied purposes. The entries will be further evaluated in farmers' field in the ensuing season.

Table 3. Yield and horticultural characters of six chilli varieties

Variety	Yield (t/ha)	Fruit/kg (No.)	Fruit/plt. (No.)	Fruit Leng. (cm)	Fruit Dia. (cm)	Plt.ht. (cm)	Plt.wid (cm)
Sha Ema	28.3 cd	67.0 a	47.5 a	10.0 f	2.0 b	73 d	42.7c
CARD III	30.6 d	51.9 a	39.6 a	8.1 e	3.0 c	65 c	5.0 b
Cap Early	15.5 a	75.4 a	29.2 a	6.6 d	2.7 c	27 a	21.7 a
Launghi	26.5 bc	201.4 b	133.8 b	2.0 a	1.5 a	65 c	35.7 b
S.Mukhi	17.4 a	281.7 c	123.3 b	4.0 b	1.6 ab	62 b	56.7 d
K-II	24.7 b	344.2 d	212.6 c	5.7 c	1.4 a	75 d	74.3 e
CV(%)	6.3	12.2	16.9	7.2	10.5	1.7	5.2

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

Effect of Effective Micro-organism (EM) on spring season vegetable crops

The objective of trial was to observe the effect of EM on productivity and pest reaction of seven vegetable crops and compare with recommended practice with chemicals fertilizers. The six vegetable crops tested were - Chilli, Cherry tomato, Brinjal, Cabbage, C.flower, and Broccoli.

Six different types of vegetables were tested under two different treatments - with normal practices i.e using standard fertilizer ratio of 60:100:20 NPK kg/ha plus FYM, and the other using EM technology.

The vegetable seeds for the EM treatment were socked in EM solution for 2 minutes before sowing. The nursery bed was irrigated with 1% EM solution twice in a week. Other times the seedlings were given plain water once a day till the seedling was ready for planting. For the treatment with normal practice, the nursery bed was prepared with plain compost at the rate of 30 t/ha. For both the treatments, seeds were sown on 1st week of January 96 and transplanted in the field on 3rd week of February 1996.

The experiment was carried out in a single plot observation of 5 x 1 meter for both the treatments. The EM treated plot was at least 30m away from the plot with normal practice. The EM treated plots were broadcast with EM 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 in every week till harvest. The plots with normal practice were fertilized with 60:100:20 NPK kg/ha plus 30 t/ha of well rotten FYM. 1/2 of the total N was applied as basal while 1/2 was given as sidedress. Other practices were maintained as recommended for each crop species.

The plots with normal practice treatment were sprayed twice with 1% Malathion 50 EC. Tomato and brinjal were given one spray of Cypermethrin (Symbus 20 EC) at the rate of 1% to control fruit borer and stemborer. To control insect pests in EM treated plots, plant extract (constituted of 3% EM1, 3% molasses, garlic 30 g/litre, Datura weed 40 g in 100 litre of water, lemongrass 30 litres in 100 litres of water, and Artimesia 30 g in 100 litre water) was sprayed five times.

Five to six harvests were carried out for tomato, brinjal and chilli from 21 May to the last week of July, 1996. Cabbage, cauliflower and broccoli were harvested on 14 June 1996. The results are in Tables 4-9.

The results could not be statistically analyzed as it was a single plot observation trial. However, interesting observations have been recorded. In chilli, under both the treatments, there was no major pest problems and yields are comparable (Table 4). Under EM treated plots, for

cabbage, cauliflower, and broccoli the major problem observed was the infestation of diamond backmoth (Pluettella xylustella). Plant extract was sprayed to counter the problem. Observing that the first spray of plant extract had reduced the DBM population, the plots under EM were drenched with the extract solution. Interestingly, it was noticed that the extract was repelling DBM and did not exhibit insecticide effect. The controlling effect of plant extract was observed in the yields of cabbage, cauliflower, and broccoli (Tables 5-7). The yields are slightly lower in EM treated plots but not so much compared to the yields under recommended practice.

For tomato and brinjal, the main problem was the attack by stemborer and fruit borer. The plant extract was not effective against these insect pests. Consequently, the yield of these crops under EM were much lower than the yields under the recommended practice (Tables 8&9). Brinjal was severely affected than tomato. The trials will be continued with proper design and data gathering in the ensuing season.

Table 4. Yield and horticultural characters of chilli treated with EM and under recommended practice

Character	Treatment			
	EM		Normal practice	
Total yield (t/ha)		32.0		25.2
Marketable yield (t/ha)	32.0		25.2	
Yield/plant (kg)		0.80		0.63
Fruits/kg (Nos.)		80.68		95.00
Seedling height (cm)		13		12
Plant color		Light green		Green
Plant height (cm)		73		71.3
Plant width (cm)		39.3		45
Fruit color		Green		Green
Fruit length (cm)		10		9.1
Fruit diameter (cm)		2.6		2.2

Table 5. Yield and horticultural characters of cabbage treated with EM and under recommended practice

Character	Treatment			
	EM		Normal practice	
Total yield (t/ha)		37.20		47.40
Marketable yield (t/ha)	37.20		47.40	
Yield/plant (kg)		0.93		1.18
Fruits/kg (Nos.)		1.86		1.18
Seedling height (cm)		11.30		11.00
Plant color		Light green		Darkgreen
Plant height (cm)		36.00		36.00
Plant width (cm)		42.00		41.50
Fruit color		Purple red		Green
Fruit length (cm)		15.00		20.00
Fruit diameter (cm)		13.00		14.00

Table 6. Yield and horticultural characters of cauliflower treated with EM and under recommended practice

Character	Treatment		
	EM		Normal practice
Total yield (t/ha)	17.20		16.40
Marketable yield (t/ha)	14.60	16.40	
Yield/plant (kg)	0.43		0.41
Fruits/kg (Nos.)	2.33		2.44
Seedling height (cm)	12.00		11.70
Plant color	Light green		Darkgreen
Plant height (cm)	60.00		55.00
Plant width (cm)	50.00		50.00
Fruit color	C. curd		C. curd
Fruit length (cm)	19.60		20.00
Fruit diameter (cm)	12.70		15.00

Table 7. Yield and horticultural characters of broccoli treated with EM and under recommended practice

Character	Treatment		
	EM		Normal practice
Total yield (t/ha)	6.40		8.20
Marketable yield (t/ha)	6.40	8.20	
Yield/plant (kg)	0.16		0.41
Fruits/kg (Nos.)	6.20		4.88
Seedling height (cm)	14.00		13.10
Plant color	Light green		Darkgreen
Plant height (cm)	62.10		60.70
Plant width (cm)	43.30		45.00
Fruit color	Darkgreen		Darkgreen
Fruit length (cm)	14.60		14.20
Fruit diameter (cm)	11.30		12.00

Table 8. Yield and horticultural characters of cherry tomato var. CHT 160 treated with EM and under recommended practice

Character	Treatment	
	EM	Normal practice
Total yield (t/ha)	27.10	29.6
Marketable yield (t/ha)	25.20	27.2
Yield/plant (kg)	0.67	0.74
Fruits/kg (Nos.)	37.56	37.70
Seedling height (cm)	14.00	12.00
Plant color	Light green	Green
Plant height (cm)	125.00	130.00
Plant width (cm)	-	-
Fruit color	Dark red	Dark red
Fruit length (cm)	3.60	3.70
Fruit diameter (cm)	3.50	3.50

Table 9. Yield and horticultural characters of brinjal treated with EM and under recommended practice

Character	Treatment	
	EM	Normal practice
Total yield (t/ha)	12.40	20.4
Marketable yield (t/ha)	5.40	17.8
Yield/plant (kg)	0.10	0.51
Fruits/kg (Nos.)	21.60	12.86
Seedling height (cm)	12.6	11.30
Plant color	Light green	Light green
Plant height (cm)	84.40	79.40
Plant width (cm)	64.20	66.00
Fruit color	Purple	Purple red
Fruit length (cm)	23.20	25.20
Fruit diameter (cm)	3.50	4.00

TREE CROPS

During 1995-96, the main emphasis was given on asexual propagation of citrus besides maintaining the trials established in previous years.

Continuation of subtropical fruit trials established in 1994

Varietal evaluation of subtropical fruits and nuts are being continued at the station. Many of the planted varieties are coming up very well and few of the species have started to bear fruit. Materials for propagation are also being used and maintained. The list of existing materials are in Table 10.

Table 10. Subtropical fruit species under evaluation

Sl.No.	Activity	No.of entry	Objective
1.	**Varietal Evaluation of Sub-tropical fruits and nuts**		
	a) Peach	03	Evaluate and identify highyield, early maturing pest/diseases resistant adap- table for mid altitude areas. (Each tree is a replication)
	b) Plum	03	
	c) Apricot	02	
	d) Almond	08	
	e) Pecan	04	
	f) Pear	04	
	g) Mango	06	
	h) Pomegranate	05	
	i) Guava	04	
	j) Avocado	03	
	k) Medicinal plants	04	
2.	**Materials under propagation**		
	a) Citrus (Satsuma type mandarin)	13	budded/grafted on rough lemon/local mandarin & R. trifoliate rootstocks
	b) Strawberry	11	Under runner propagation
	c) Avocado	01	will be used as stock for improved cultivars
	d) GF-677	01	Seed production and stock raising

Introduction of citrus materials

Early 1996, additional citrus materials were introduced from California through J.G.A.G (spell out) project. The following materials are under propagation.

Table 11. Citrus materials under propagation

Material Type		
Rootstock:	Rangpur mandarin	
	Cleopatra mandarin	
	Troyer citrange	
	Carrizo citrange	
Commercial cultivars:	Sweet Orange	Valencia
	Mandarin	Lane Late
	Grapefruit	Fremont
	Tangelo	Minneola
	Tangor	Murcott
	Lime	Bearss

Observation trial on citrus grafting and budding

The objective of the trial was to observe citrus response to budding and grafting propagation methods.

Commercial citrus cultivars were budded in September and grafted in March on to stocks of rough lemon (Citrus jambhiri). 12-18 months old rough lemon seedlings as stocks were used in grafting and budding. The stocks were raised in flat beds with mixtures of sand, soil, FYM, and bokashi at the ratio of 2:1:3:3. T-budding and side grafting methods were adopted. The number of propagated plants depended on the availability of scion/bud woods. Soon after scion and stocks were united, the union portion were sealed with plastic to avoid desiccation. Plastic cover was removed after 21 days of budding and after complete union for grafted plants. The budded stocks were removed gradually to allow proper growth. Results are presented in Table 12.

Both the methods gave quite satisfactory results. Initially the budded plants showed better success rate which declined upon removable of plastic covering the budded portion. Decline in survival rate is suspected to direct sunlight penetration to the budded portion. This will be further investigated under different conditions. Grafting though it is the first time to be used in citrus, the results were encouraging. The method though requires a lot of scion woods can produce faster planting materials than budding method.

Table 12. Number of plants successfully propagated from 13 citrus cultivars

Cultivar	Budded (No.)		Grafted (No.)	
	Total buds	Successful buds	Total graft	Successful grafts
Miyauchi Iyo	13	02	20	12
Okitsu wase	13	08	28	19
Oota Ponkan	18	14	18	07
Matsuda Unshu	18	09	04	00
Kishu			39	02
Miyagawa wase			25	00
Encore			19	04
Ichifumi Wase			22	06
Clementine			11	08
Murcott			12	12
Seminole			22	11
Iyo			14	08
Minneola			19	12
Total	62	33 (53%)	233	101 (43%)

Grape Evaluation Trial

Six varieties of grape vines - three table (Perlette, Muscat, & Chasselas) and three wine (P.Blanc, Chardonny, & Cab Franc) types, were planted in 1994. This is the second year of evaluation at the station. Trials details are provided in the centre's 1994-1995 annual report. Test for total soluble sugar (TSS) was done using refractometer. Cumulative fruit yields and TSS results are in Table 13.

Overall due to untimely rainfall which coincided with fruit ripening resulted to splitting and rotting of fruits in all varieties. Chasselas produced the highest cumulative yield (15 t/ha) followed by Pinot blanc (11 t/ha). Perlette and Chardonny showed the highest total soluble sugar content. Mild to moderate attack of powdery and downy mildews was observed in all varieties particularly Chardonny was susceptible.

Based on two years result, three table varieties will be promoted to few farmers in Wangdue and Punkha.

Table 13. Fruit yield and TSS of six grape genotypes

Cultivar	Yield (t/ha)	TSS
Perlette (table type)	5.73	17.5 - 19.5
Muscat (table type)	6.38	15.4 - 16.5
Chasselas (table type)	15.00	14.5 - 17.0
Pinot blanc (wine type)	11.00	16.0 - 16.5
Chardonny (wine type)	3.68	17.5 - 19.2
Cab Franc (wine type)	5.93	16.0 - 16.4

LIVESTOCK RESEARCH

FEED AND FODDER RESEARCH

The main objective of this programme 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. Efforts will be made to have better understanding of the system.

Adequate feed and fodder for livestock is a major constraint to farmers practising wetland dominated farming systems. The strategies adopted to realise the foregoing objective are through introduction and evaluation of both native and exotic fodder species.

Introduction trial on Grass and Legume species

A total of 15 forage species - 8 grass and 7 legume, were introduced from CSIRO, Australia.The trial was conducted on-station in single plots of 10 rows x 4m x 0.40 m. The objective of the trial was to select those species that are suitable under local soil and climatic conditions. Following species were planted on 20 March 1996.

Grass	**Legume**
1. *Panicum maximum (Gotton)*	*1. Macroptilium purpureum*
2. Panicum maximum (Petrie)	*2. Neonotina wightii*
3. Bothriochloa insulpta	*3. Stylosanthes scabra*
4. Chloris gayana	*4. Desmathus virgatus*
5. Setaria sphacelata	*5. Aeschynomeus villosa*
6. Digitaria milanyana	*6. Chamaecrista rotundifolia*
7. Digitaria smutssi	*7. Arachis pintoi*
8. Setaria incrassata	

The above species were sown on land that was pre-prepared and pre-irrigated. Seeds of legume species were inoculated before sowing. All species were given a basal dose of N and P at the rate 40:30:0 kg/ha. One irrigation was provided after sowing and before germination. The trial is ongoing and only the interim results are reported here.

Among grass species, only seven germinated while species No. 5 did not germinate. Germination of grass species Nos. 1, 2, 3, 4, 6 and 8 was recorded on 1 May, 1996 and flowering on 30 June 1996. The species No.7 germinated on 30 June 1996. Germination of legume species No.7 was recorded on 1 April 1996 and 50% flowering on 1 May 1996. While the species Nos. 2, 3, 5 and 6 germinated on 30 June 1996. However, the species No.6 did not germinate at all. Additional data on germinated species are being collected.

Observation trial on perennial grass and legume

This trial was established on 23 April 1995. The data collection is being continued. Crop cuts for fodder production was done when the species were at about 1% flowering stage. The results are in Table...

All species in general produced good biomass yield. Sudan grass with four cuttings recorded the highest fresh weight of 345 t/ha followed by stylo (160 t/ha), Seratro (125 t/ha), and Glycine (120 t/ha). Sudan was also the fastest growing species followed by Seratro and Glycine (Table 1). Among grass species, Sudan produced the highest fresh weight followed by Molasses and paspalum whereas among legume species Stylo was the highest yielder followed by Seratro and Glycine. Centro, however, has very few plants and the crop cut was not considered. The trail will be further evaluated in the ensuing season.

Table 1. Cumulative fresh weight and plant height of twelve fodder species

Species	Date of harvest	Plt.ht (m)	Fresh wt. (kg/sqm)	Cumu. Fresh wt. (t/ha)
Sudan	3.7.95	1.5	12	
	19.9.95	1.7	12.5	
	3.11.95	1.2	6	
	3.4.96	1.1	4	345
Guinea	14.9.95	0.5	2.5	
	3.11.95	0.6	2	
	13.6.96	1.1	5	95
Signal	14.9.95	0.3	2.5	
	3.11.95	0.4	2	45
Molasses	12.9.95	0.2	2.6	
	3.11.95	0.3	2.5	
	13.6.96	1.2	6	111
Paspalum	12.9.95	0.5	4	
	3.11.95	0.4	3	
	13.6.96	0.3	3.5	100
G.L.D	28.7.95	0.4	1.3	
	14.9.95	1.0	2.5	
	3.11.95	0.2	2	
	3.4.96	0.8	3.5	93
S.L.D	3.11.95	1.5	1.3	
	13.6.96	0.7	5	63

Glycine	28.7.95	0.5	3	
	14.9.95	0.5	2	
	3.11.95	0.2	2	
	13.6.96	0.7	5	120
Seratro	28.7.95	0.5	3.5	
	12.9.95	0.6	2	
	3.11.95	0.2	2	
	13.6.96	0.5	5	125
Stylo	14.9.95	0.6	9	
	3.11.96	0.5	7	160
Dolichos	3.11.95	1.8	6.5	65
Centro	Few plants only, didn't do crop cut.			

Observation Trial on Italian Rye Grass (*Lolium multilrorum*) as winter fodder

Though the Italian rye grass is a temperate species, it was tried on-station for potential winter fodder. The crop was planted in a single plot of 345 sqm. It was broadcast sown on 16 November, 1995. Nitrogen was applied in the form of urea at the rate 75 kg/ha. Crop-cuts from 1 sqm., taking average of 3 random samples, was used to estimate biomass yield. Crop-cut was taken on 8 March 1996.

The biomass yield was quite appreciable. It produced on the average of 37.3 t/ha of biomass yield. Seed production was not possible since plant started to dry from April due to heat.

Demonstration/Observation trial

This observation reported here is the continuation of trial established on 6 August, 1993. Data are collected every year. Results are in Table ....

Four harvests/cuttings was possible in one season from all the species. All the three species gave good biomass yield. Napier produced the highest cumulative fresh biomass yield (364 t/ha) and it was also the fastest growing species among the three (Table 2). The trial will be monitored further in the following seasons.

Table 2. Cumulative fresh weight and plant height of three fodder species

Species	Date of crop cut	Plt.ht. (m)	Fresh wt. (kg/sqm)	Cumu. Fresh Wt. (t/ha)

Napier	24.7.95	2.4	6.6	
	22.9.95	2.3	14	
	19.3.96	1.1	5	
	4.6.96	1.9	10.8	364
Seteria	24.7.95	1.0	2.8	
	22.9.95	1.2	6.3	
	19.3.96	0.6	3.5	
	4.6.96	1.3	9	216
Signal	24.7.95	0.5	2.8	
	22.9.95	1.0	4.5	
	19.3.96	0.6	3.0	
	4.6.96	1.3	5.8	161

Tree Fodder Plantation

Some seedlings of fodder tree species were planted in 1993 on the wastelands in and around the research station. The objective of the plantation was to observe its adaptability and biomass yield. The following species were planted and are doing very well.

Species	Planting date	No. of seedling planted	No. of seedling survived
Ficus roxburghii	6 August 1996	26	26
Glimena arborea	6 August 1996	14	14
Leucaena leucocephala	11 October 1995	15	15

Seed multiplication/propagation

The objective of this trial was to understand the seed production or propagation ability of a species. Sudan grass was sown on 2 April 1996 to an area of 450 sqm. 20 kg seed was collected from the above plot.

Napier grass was also transplanted on the slopes of about 300sqm area. Enough planting materials are available in the station.

Lathyrus cicera was sown in an area of 500 sqm. 20 kg of seed was collected from the above area.

On farm Trial on Sudan Grass

Sudan grass since its introduction in 1994 was found to be a very promising fodder species at the station. In order to test its potential and suitability under farmers condition, in 1995-96 it was sown in three farmers' fields. Seeds were broadcast sown in single plot in March 1996 in each site. Farmer prepared the land and FYM was applied as a basal dose.

Two times harvest from each site at Kabji and Lobesa produced 57.5 and 52.5 t/ha biomass yield respectively. From a site at Gaselo with one harvest, a biomass yield of 30 t/ha was recorded. The yields were less than what was observed at the station. Data collection from the trial will continue in the next season.

SYSTEMS RESOURCE MANAGEMENT

Introduction

As an interlink between the various programs at the national level, the Systems Resource Management Program is in place. It is co-ordinated centrally from the REID of MoA. It comprises of subprograms on Farming systems research, Soil and water management, Agroforestry, and IPM.

The objective of this program is to address issues or problems that are common to the four national programs. The areas common to the four programs are delineated as subprograms of the systems Resource Management Program.

Farming Systems

The subprogram is not a new program since all the past research activities were conducted with farming systems perspective. Having it as a subprogram further recognises the importance attached to understanding the system.

During 1995-96, the following three diagnostic surveys were conducted under the subprogram-farming system. Each survey was published in detail as the centre's technical report. Only the salient outcomes of the surveys will be presented in this report. For detail reading, interested readers are referred to the centre's technical papers.

a) **Famers need assessment survey in Goenkhatoe and Goenkha'me gewogs of Gasa Dzongkhag**. The major objective of the survey were to obtain first-hand knowledge and understanding of the existing farming systems; identification of production problems and opportunities; and to gain insights into resources use and their interactions. The survey adopted participatory rural appraisal as the method for the survey. It identified the following problems and generated the below recommendations. Entire survey report was published as the centre's Working paper No.1.

The following major problems were identified and ranked as the most important by farmers in each village. Team observations, after verifying with farmers, have also been included.

Khoilo Village

- Wild boar
- Weeds in rice
- Marketing of produce
- Shortage of farm labour
- Imbalanced sex ratio
- High percolation rate

Damjee Village

- Food deficit prior to rice transplanting and wheat harvest
- Wild animals
- Inadequate irrigation water
- Shortage of labour; and lack of oil expeller
- Damage to pasture
- Insufficient drinking water

Gasa Village

- Wild animals
- Damage of improved wheat by wild animals
- Fodder deficit during winter
- Food deficit prior to wheat/barley harvest; labour shortage
- Wild boar in improved pasture
- Marketing of produce
- Cattle mortality during winter

Across villages the most common priority problems of farmers were : food deficit, farm labour shortage, and wild animal damage to crops.

Survey recommendations

Ø Wild animals threaten crop production leading to reduced harvests and necessitating extra labour for guarding. Farmers recommend intermittent shooting by professional army hunters to bring down wild animal (boar) population to manageable limits. Concerted efforts to evolve viable solutions from the Ministry of Agriculture, Home Affairs and local authorities must be placed to contain this problem.

Ø To spur economic development and facilitate marketing and creation of markets for agricultural produce, it is strongly recommended that the feasibility of building a road to connect Gasa dzong be looked into as early as possible by the Ministry of Communications.

Ø To mitigate food deficit problem, it is recommended to intensify cropping patterns and systems, and to consolidate land holdings as opposed to fragmentation. Promotion and exploitation of tourism to benefit local communities, and cultivation of mushroom are other potential income-generating activities to secure food. Inputs from RNR Research, Tourism Authority of Bhutan, National Mushroom Development Centre and allied wings of MoA are crucial.

Ø Insofar as labour shortage is concerned, it is recommended that the local authorities time obligatory labour contributions, goongda woola for instance, to coincide with lean agricultural periods so that labour is freed for optimization of farm activities. Other

means are farm mechanization wherever feasible, use of weedicides to substitute manual labour etc. in collaboration with AMC and RNR Research Centres.

Ø In order to smoothen information flow systems, it is strongly recommended that the extension centre in Damji be revived and upgraded to a functional RNR centre. Further the commission agent should be based in Damji for easy access to required agricultural inputs. Placement of additional RNR staff to effectively cover the dzongkhag is another urgent priority.

b) **Rice weed management in Punakha- Wangdue Valley**. The survey was conducted with the objectives of a) to monitor if there are changes in weed species consequent to repeated use of the recommended weedicide Butachlor; b) to assess the intensity of weeding by farmers in the light of several years of butachlor application; and c) to record modifications by farmers on the recommended application rate and time. The survey used PRA/RRA approach as the its method. The following recommendations were generated from the survey. The entire survey was published as the Technical paper No.1

Ø Study and compare the merits and demerits of using Butachlor before and after rice transplanting to provide authoritative technical advice to the farmers

Ø Promote increased collaboration between CA, extension agents and gups in the demand and delivery of inputs, and necessary technical information

Ø Involve GYT in BDFC loan facilitation, particularly for the resource-poor farmers

Ø Encourage CAs to maintain sufficient Butachlor stock round the year in order to lure farmers to purchase as and when cash is available - this may require dialogue with NPPC

Ø Devise ways (greater interaction between CAs and extension staff ?) to make available technical information along with inputs to the farmers

Ø Promote and integrate the use of specific weedicides (Sanbird, NC311) for shochum with traditional management systems.

c) **Rice post-harvest management systems in Paro and Punakha-Wangdue Valley**. The survey was carried out with the objectives to a) document rice post-harvest management practices in the twomost popular rice growing valleys; and b) quantify harvest-related handling losses. Informal survey methods were used during the survey. Following recommendations were generated out of the survey. For detailed report, the readers are referred to the centre's Technical paper No. 2.

Survey recommendations

- Majority of the popular local varieties possess intermediate threshability. However, there are a few cultivars like Drumbja and Toeb Machum that shatter too easily. It is recommended that rice breeders improve this trait without losing other desirable varietal characteristics.

- Farmers use locally made sickles for harvesting that are non-serrated and have a long curvature. To improve efficiency, it is recommended that AMC modify these sickles by providing serration, appropriate curvature, size and weight. Once developed, the extension services must demonstrate the efficiency of these improved sickles.

- It is recommended that the effect of mixing different Maap varieties at heaping and threshing on the milling recovery and grain quality be studied. Further, AMC should also look into the appropriateness and operation of the existing rice mills given that the percent broken rice is very high.

- An easily shattering wild-type of rice is emerging as a potential weed problem and contaminating cultivated varieties in some farms in Paro, Wangdue and Punakha. It is recommended that a thorough study be done on this latent problem and suggest viable solutions to arrest further proliferation. Rice breeders should look into the possibility of exploiting desirable traits (plant vigour, pest resistance) in variety development efforts.

- There are several promising traditional rice varieties (Dawa Yangkum, for instance) with high yield potential and other desired traits. Rice breeders must utilize such varieties in the future breeding and improvement programs.

- It is recommended that the seed exchange systems of farmers be fully documented and understood for further improvements in the future.

- Farmers in the Wangdue-Punakha valley have slightly modified their pedal thresher to minimize grain loss during threshing. The extension service of Paro can help adopt such innovations to reduce post-production losses.

- Rice is necessarily harvested in Paro within a short period using hired labour. In such a situation rice reapers are ideal and should be promoted for quick and efficient harvest operation.

Integrated Nutrient Management

Farmyard manures and composts are by far the most important sources of plant nutrients in the traditional rice-based farming systems in the country. However, with the intensification of cropping patterns combined with the use of modern varieties, the rate of nutrient depletion is faster than replenishment and crop yields are declining. Research on integrated nutrient management, therefore, is of immense significance in developing integrated management packages that will encompass amalgamated use of FYM/compost and inorganic supplements; legumes; crop sequences and mixtures; and green manures and biomass utilization.

IPNS in a Rice-Wheat Rotation

Fertilizer 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, farmers 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 aims:

* when inorganic NPK is not limited in a rice-wheat rotation, should rice or wheat receive optimum FYM ?

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

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

* assess the value of Sesbania aculeata as green manure in a rice-wheat rotation

The trial was established as an RCBD with 3 replications and 10 treatments in 21 m^2 plots with bunds to prevent surface movement of nutrients from one plot to another. Standard management practices were followed for both rice and wheat. IR 64 or Milyang 54 and Sonalika or Bajoka 1 were used as varieties for rice and wheat respectively. Results for 1995 season are in Table 1.

This is the seventh year of this trial. Since it is a long term trial, full interpretation of results will be given after completion of ten years.

Considering 1995 result, it is observed that application of FYM either to rice or wheat did not significantly affect yield of either crops when NPK are not limiting in a rice-wheat rotation. At constant N and K, there was no significant yield reduction in rice when P was applied only to

wheat, indicating a possible carryover of P in a rice-wheat system. Likewise, wheat yields did not decline when P was applied only to rice. Application of P either to rice or wheat seems sufficient if these crops are grown in quick succession. Initial soil analysis data indicated a high level of P in all the plots. However, lack of post-trial soil analysis results precludes authoritative conclusions. At constant levels of N and K and with the addition of FYM, the yield of either rice or wheat was not reduced in the absence of P. This suggests that the P requirement of rice and wheat was fulfilled by FYM. Incorporation of Sesbania aculeata as pre-rice green manure significantly increased rice yields 17%. Supplementing green manure with NPK at the rate of 35:40:20 kg/ha furthered increased yield by 22%.

Table 1. Effect of integrated use of FYM, NPK and green manures on the yield of rice and wheat in a rice-wheat rotation, 1995.

RICE				WHEAT				1995	
N	P	K (t/ha)	FYM (t/ha)	N (t/ha)	P	K	FYM	Rice (kg per ha)	Wheat (t/ha)
0	0	0	0	0	0	0	0	4.18 c	1.06 a
70	40	20	0	60	40	20	0	5.42 a	1.64 a
70	0	20	0	60	40	20	0	5.26 ab	1.68 a
70	40	20	0	60	0	20	0	5.28 ab	1.62 a
70	40	20	7	60	40	20	0	5.14 ab	1.77 a
70	40	20	0	60	40	20	7	5.36 bc	1.99 a
70	0	20	7	60	0	20	0	4.66 ab	2.04 a
70	0	20	0	60	0	20	7	5.09 ab	1.73 a
0	0	0	gm	0	0	0	0	4.92 ab	0.78 a
35	40	20	gm	0	0	0	0	5.13 ab	1.08 a
CV %								7.35	13.3

Mean separation in a column by DMRT at 5% level.

Agroforestry

Introduction

Agroforestry here is defined as a land use system which intentionally combines annual agricultural crops with trees or shrubs and/or livestock within the same land management unit to achieve diversified, increased production. Thus following the recent redefinition of our mandates and placement of one forestry personnel we have initiated research on agroforestry at the station level. The actual activities started in August 1995 after the placement of one forestry personnel in July 1995. Agroforestry is a new research component and for the time being the centre attempts to propagate the locally available planting materials, while trying to understand its research area and focus in the existing farming systems. The different multipurpose tree species includes fodder, fuelwood, soilbinder, leguminous, and timber species.

Planting of windbreaks

The centre receives very strong wind. In order to protect the crops from strong winds some trees as windbreaks were planted as early as late 1980s. The centre has approximately 8.04 acres of land which are not suitable for cereals and horticultural crop production.

In 1995 some more species were planted as windbreaks along the boundaries of agricultural crops. Following multipurpose and fast growing tree species were planted in the centre.

1. *Melia azederach*
2. Cupresses spp.
3. Leucaena spp.
4. Thuja spp.
6. Ficus roxburghii
6. Gmelina arborea
7. Poplar

Maintenance of existing trees at the centre

Several tree species are planted for varied purposes in wastelands at the station. Some species like Cupresses were planted in the station in late 1980s to early 1990s. The plantation consists of the following species and number of plants per species that are being maintained at the station.

Species	**No. of plants**
Cupresses	472 Nos.
Poplar	193 Nos.
Melia	136 Nos.
Willow	155 Nos.
Ficus religoisa	8 Nos.

Creation of Agroforestry Nursery

A nursery shade with a dimension of 40'x 4' was constructed using bamboo thatch to raise tree seedlings. Seedlings of the following multipurpose tree species were raised in the nursery.

Seeds were sown, as and when the seeds became available, on a bed with 4'x4' prepared with fine soil and manure. The seed beds were watered as and when moisture was needed. Polytunnel is necessary if the nursery is raised in winter months. List of species are in Table 2.

Seeds of most of the species germinated and produced good number of seedlings (Table 2). Gold mohur seeds germinated but seedlings eventually did not survive. The local altitude probably is not appropriate for growing the species. The seeds of Bamboosa bamboo did not germinate at all. The seedlings produced will be distributed to farmers.

Table 2. Nine multipurpose tree species multiplied through seed

Species	Sowing date	Seedlings generated(No)	Purpose	Seed source
Melia azederach	9/1/96	90	Fodder & fuelwood	Local
Thuja orientalis	9/1/96	411	Ornamental	Local
Gold Mohur	9/1/96	0	Ornamental	Dehra dun, India
Leucaena	9/1/96	110	Fodder & G M	Local
Acacia	24/5/96	190	Legume soilbinder	Dehradun, India
Dendrocalamus	30/6/96	470	Poles, fodder	Dehradun, India
Bamboosa bamboo	30/6/96	0	Poles, fodder	Dehradun, India
Bauhinia purpuria	30/6/96	30	Fodder & fuelwood	Dehradun, India
Bombax ceiba	9/1/96	88	Timber	Local

Vegetative Propagation of tree fodder species

Vegetative propagation means producing a plant from a cutting, piece, or part of an existing plant. The plant thus produced will be genetically identical to the mother plant and is called a clone. The use of hardwood cuttings is of the cheapest and easiest ways of propagating plants vegetatively. The cuttings should be made from wood of 1 to 2 years old growth. Cuttings are best made in late winter before the tree start actively growing.

In 1995, five tree fodder species were propagated through cuttings. The objective of the study was to observe whether the popular fodder species could be propagated vegetatively through cuttings. Cuttings of 15-20cm length were prepared in the morning using a sharp knife. The base of the cut shoots were placed in water before planting. Then the cuttings were planted/inserted into a pre-prepared

hole. Planted cuttings were watered regularly to maintain moisture. The species and the number of planting stock raised through cuttings are in Table...

Cuttings of willow was prepared on 29 January 1996 and planted on 30 January 1996. Two months after planting the sprouted and 71% of cuttings survived (Table 3).

Planting materials of *Ficus religoisa* were collected from Tsirang im March 1996. The specific objective was to study the propagative potential through cuttings. Eight out of ten cuttings survived indicating fairly easy propagation through cuttings.

Melia azederach is one of the fast growing species. Through seeds it takes long time to achieve its useable size. Propagating vegetatively would save time. Out of 10 cuttings planted, only two survived. The surviving plants have attained 3.7 meter tall within 10-11 months of growing period. The study will be repeated in the ensuing season to ascertain its propagation potential through cuttings.

Two different poplar species- suckering and non-suckering types, were raised through cuttings. The planting materials were locally collected and planted on the nursery bed on 30 December 1996. The cuttings started to sprout from first week of March 1996. Out of 280 cuttings of suckering type poplar planted, 259 number of cuttings survived (Table 3). The plants are 2.7 meter tall by August 1996 exhibiting profuse and speedy growth. This observation demonstrates that poplar species can be easily multiplied through cuttings.

Table 3. Five tree fodder species and number of cutting propagation

Fodder species	No. of cuttings planted	No. of cuttings survived
Poplar spp. (suckering type)	280	259 (92.5%)
Poplar spp. (non-suckering type)	150	100 (66.7%)
W. willow (Salix babylonica)	280	200 (71.4%)

Gmelia arborea	5	3 (60%)	
Melia azederach	10	2 (20%)	
Ficus religoisa	10	8 (80%)	

TRAINING & EXTENSION PROGRAM

Seminars, meeting and training attended by RNRRC staff
1995-1996

30 Sept. to 6th Oct.95 Sangay Dorji EM, Technology Workshop at Saraburi, Thailand.

19-11-95 to 23-11-95 GB Chettri EM Technology Conference held at Bangkok, Thailand.

23-1-96 to 28-1-96 Yuden Dorji Workshop on Final Phase I and Joint Planning Meeting DD Chettri for follow up activities, Kathmandu, Nepal.

5-3-96 to 7-3-96 GB Chettri Conference on Scientific Research Partnership for sustainable Development to be held in Zurich

30-4-96 to 5-5-96 Sangay Dorji Study tour to premier irrigation Ltd. (Drip & Sprinkler) Calcutta, India

Visitors during 1995 To 1996

5-6-95 Dr. Walter Roder, IRRI Prof, M Menzi MoA & other Swiss delegation members to discuss about research, infrastructure etc. to develop master plan for RNRRC Bumthang.

25-8-95 Officer and staff from Yusipang visited RNRRC study tour programme.

31.5.95 Mr. Shintance Technical Officer APNAN conduct workshop on EM Technology for Extension Agent Farmers.

20-11-95 LUP Training organised by LUP attended by Planning officers DAO, DAHO Wangdi , Trongsa, Punakha, Bumthang and Gasa.

7-12-95 LUP Training organised by LUP attended by DAO, DAHO, Planning Officers Punakha, wangdi, GASA, Trongsa and Bumthang.

11-12-95 NRTI student Lobeysa Agriculture student (30 N0s.) leb by R.B Chhetri study, field visit.

16-12-95 DRS.S.Kanatsu and C.Muru Gaboopathi ADA, Project finding mission led by G.B.Chhetri, Program Coordinator RNRRC, Bajo for master plan study of integrated Agri. Development in Eastern Region of Bhutan.

31-1-95 Dr. Ian Wallace IRRE Phillipines to management of library and it's related works.

29-1-96 All extension agents with 5 DAo's of Punakha, Wangdi, Gasa and Thimphu blast management training for extension staff.

21-2-96 Regional RNR REs Planning workshop held at RNRRC Bajoattended by DAO's DAHO's Planning Officers, RNR sector heads of Punakha, Wangdi, Gasa. Thimphu, Chirang and Dagana 2nd Regional RNR Research Planning workshop.

21-1-96 Jojo Lapitan IRRI Manila for 2nd Regional RNR Res. Planning workshop.

15-3-96 Mr. Joep Carlier, Citrus specialist J.G.A.G John Goelet possibility for establishment of citurs nurseries.

18-5-96 Health staff Wangdi, Punakha, Dagana, Chirang, Thimphu attended by HA's AN and DHSO 18 Nos. for family planning workshop.

21-3-96 Elizabeth Badon Ghijben, Head South East Asian Countries Section. The Hague the Netherland field and station visit (Horticulture).

26-3-96 Health staff, Wangdi, Punakha, Dagana, Damphu & Thimphu (attended by Doctors of Wangdue DHSO, AN, ANM, HA) 18 Nos. family planning workshop.

26-3-96 Farmers from Trongsa led by EA's farmers study tour.

8-4-96 Farmers from Haa led by DAO for field visit study tour.

26-4-96 Farmers from Samdrupjongkhar led by DAO for field visit study tour.

19-4-96 to 27-5-96 Dr. K KC Singh Consultant IRRI for PRA training for one month.

6-5-96 Dr. Anne Frio IRRI, Philipines for PRA training one week.

13-5-96 Mr. Vander Struik, Agri. counsellor of the Royal Neltherland, Embassy, New Delhi Hort field visit.

16-5-96 Dasho Sherub Gyeltshen (Head), Thimphu and Peter, IRRI, Philippines for inauguration of Drip and Sprinkler irrigation system.

17-5-96 IFAD mission Mr. Musharraj Project controlled visit of PWVDP & RNRRC.

21-5-96 IFAD OPS Superuison mission for IFAD and RNRRC visit.

22-5-96 Dr. Willem S. Hulscher, Chief Technical Adviser, Regional wood energy development programme, Thailand for field visit.

28-5-96 Canadian Journalist discuss IDRC support.

30-5-96 Ole S. Pedersen (team leader) Regional Project TCP/RAS/4554 Agro-Retailers training programme for commission agent.

4-6-96 to 5-6-96 Dr. Black AVRDC, Itinerary for the short term consultant for chilly wilting.

Publications

Duba S. and M. Ghimeray. 1995. Rice weed management in Wangdi-Punakha Valley. RNRRC Bajo technical paper No.1

Duba S., M. Ghimeray and Y. Dorji. 1995. Rice post-harvest management in Paro and Wangdue- Punakha valleys. RNRRC Bajo technical paper No.2

Duba S., M. Ghimeray, and TR Gurung. 1995. Need assessment survey in Goenkhatoe and Goenkham'e gewogs under Gasa Dzongkhag. RNRRC Bajo Working paper No.1

Proceedings of the second regional research and extension planning workshop held at RNRRC Bajo from ....to....1995.

APPENDICES

Finances

Appendix III : Financial report for 1 July 1995 to 30th June 1996

Object Classification	Amount in Nu.
Personnel emoluments	717570.58
Other Personnel emoluments	305091.50
Travel	148029.00
Utilities - Telephone	10946.00
Utilities - Fax, tlx, postage	5256.00
Utilities - Electricity	14957.62
Rental of property - Bldg.	15750.00
Supply & Materials - Prtg.	554.00
S & M - fertilizer/manure	5772.18
S & M - uniformm extn kits	-
S & M - other sup. & cons.	-
Other supply and consumption	41084.25
Maintenance of property - Bldg.	8763.00
MOP - Vehicles	163228.03
MOP - Equipments	18535.90
Opt. Exp. Handling charges	663.00
Operating expenses - handling	700.00
Retirement benefits	25236.00
Total :	2220177.87

Appendix : Weather summary

JANUARY - DECEMBER 1995

	Air Temperature 'C					
Months	Abs.Max	Mean Max	Abs.Min		Mean Min	Rainfall (mm)
Jan	19.4	17.1	0.6	4.9	15.2	

Feb	21.9	17.4	4.1	8.3	16.0
Mar	28.0	23.1	7.0	12.1	13.8
Apr	30.2	26.8	5.4	13.0	5.2
May	32.2	28.9	13.6	17.3	21.7
Jun	32.2	28.8	16.0	20.9	102.9
Jul	29.6	27.4	18.4	19.8	155.7
Aug	30.7	28.1	18.6	20.2	112.0
Sep	30.2	26.3	15.1	19.7	123.0
Oct	28.2	25.7	7.1	13.6	6.4
Nov	29.3	22.0	6.6	9.5	86.0
Dec	20.7	18.2	3.6	8.2	6.2

Total Annual Rainfall 665.4

MEAN OF 11 YEARS (1985-1995)

	Air Temperature 'C				
Months	Abs.Max	Mean Max	Abs.Min	Mean Min	Rainfall(mm)
Jan	21.1	17.5	2.8	5.2	20.7
Feb	21.9	18.4	4.7	8.0	16.1
Mar	27.4	23.0	10.4	11.4	12.5
Apr	30.1	26.6	10.9	13.2	26.7
May	32.0	28.7	16.5	17.4	28.8
Jun	32.7	29.1	18.5	20.4	106.3
Jul	31.2	28.6	20.9	20.1	143.9
Aug	31.7	28.9	20.1	20.2	138.1
Sep	30.5	27.2	17.8	19.5	95.4
Oct	28.6	25.8	10.9	14.3	6.8
Nov	27.8	22.2	8.4	9.1	44.7
Dec	21.7	19.9	5.9	6.5	3.7

Total Annual Rainfall 643.7

Altitude ; 1180 m.a.s.l
Longitude ; 89'54"
Latitude : 27'29"