FIELD CROPS RESEARCH

Executive summary

Field crops research program was continued with the objective to increase the productivity of cereals (rice, maize, wheat and other cereals), oilseeds (rapeseed-mustard) and grain legumes (soybean and groundnut). The strategies used were cross breeding local varieties with improved parents, introduction and identification of suitable varieties and development of appropriate and affordable technologies that best suit the field conditions. The research activities were executed both in on station and on farm for evaluation and validation of technologies respectively.

In rice, nine lines in AET were tested in station for yield potential, optimum maturity, pests and diseases resistance and other agronomic traits. Selection of seven populations from cross bred lines were continued with employing both bulk and pedigree methods. They have now attained eighth filial generation. Study on new technology called System of Rice Intensification (SRI) has been started which needs further validation and confirmation.

Through BUCAP Program, a few improved rice varieties were tested in the remote villages of Taksha, Silly, Tsara and Adang under Wangdue Dzongkhag. Seed selection training to improve the local cultivars was also imparted. The sector has also carried out seed production and maintenance of rice, maize, soybean, groundnut, wheat and mustard for research and extension purposes.

1.1 Rice Research

1.1.1 Advanced Evaluation Trial

With the aim to select suitable varieties with high yield potential, medium height, optimum maturity and resistance to pest and diseases for mid-altitude regions, nine entries including local and standard checks were evaluated in 2008 season in the Advanced Evaluation Trial.

As per standard norms, the trial was laid out in a randomized complete block design with three replications. Forty five days old seedlings were transplanted in 10 m^2 plot with a spacing of 20 cm x 20 cm. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha with half the N as top dress at panicle initiation.

Butachlor 5G was applied at the rate of 1.5 kg a.i./ha after two days of transplanting to control the monocot weeds and hand weeding at later crop period for controlling s*hochum* (*Potamogeton distinctus*) and *Monochoria viganalsis*.

Timely monitoring for pests/diseases incidence and irrigation were ensured. Parameters like 50% flowering days, tiller numbers, plant height and grain yield were analysed using GENSTAT software. Grain yield was estimated from a harvest area of 5.04 m^2 and grain moisture content standardized at 14%. Statistically it showed that the tested lines had high significant difference from the standard and local checks in plant height and grain yield (1%) and 50% flowering days and tiller number (5%). The promising lines have been selected for further evaluation in the farmers' fields.

Table 1: Agronomic traits of entries in AET, 2008

Variety	50% flw (days)	Tiller No.	Plant height (cm)	Grain Yield (t/ha)
WAS65-11-1-7-5-3	137	15	82	5.57
IR77700-84-2-2-2	136	16	86	5.98
IR72860-98-3-2-1	134	18	99	5.76
94016-TR1585-2-1-1	140	14	90	5.86
CT8887-10-16-2-1	134	15	95	6.56
MTU1010	131	15	96	6.29
BW328-2	136	15	85	8.86
AT362	132	16	97	5.62
Nabja	132	17	143	4.56
F	<.001**	0.794*	<.001**	
SD	2.673	4.623	7.159	
CV%	1.1	17.3	4.3	

* significant at 5%, ** significant at 1%,

1.1.2. Observation Nursery (INVEDUST)

A total of 78 lines including a standard check were tested under the international nursery of example varieties for distinctiveness, uniformity and stability test (INVEDUST) trial in 2008 season. These lines were the introduction from International Rice Research Institute, Philippines with the aim to evaluate and

identify the promising lines for Bhutanese agro ecological conditions in mid altitude rice areas.

The trial was laid out in a single observation plot of 5m x 2m size. Forty five days old seedlings were transplanted with spacing of 20 cm x 20 cm. Butachlor was applied at the rate of 1.5 kg a.i/ha to control monocot weeds two days after transplanting while inorganic fertilizer at the rate of 70:40:20 NPK kg/ha was applied. Half of the nitrogen was top-dressed at panicle initiation stage.

It was observed that most of the entries were short statured (70-80 cm) and early maturing and were attacked by rodents and birds. Some of them were also susceptible to sheath rot disease. Field rejections were done for these lines and only promising entries were promoted for further evaluation. The basic agronomic traits of the selected lines are outlined below.

Table 2: Performance of entries in INVEDUST, 2008

Variety	50% flw (days)	Tiller No.	Plant height (cm)	Grain Yield (t/ha)
PSB RCSO	128	22	109	5.80
IR 28	127	16	96	4.91
PSB RC 92	123	14	107	4.92
PSB RC 44	128	13	116	5.39
PSB RC 9	133	14	109	5.22
BPI 76	133	14	116	3.97
MATATAG	128	18	89	5.72
PSBRCS	120	15	105	5.81
PSBRC 46	132	18	115	5.03
IR 22	130	23	84	5.04
PSB RC 1	131	15	117	5.36
IR 43	132	14	105	6.09
PSB RC 88	131	13	108	5.03
PSB RC 60	132	14	101	4.05
IR 46	131	21	92	3.98
IR 8	127	14	82	4.50
PSB RC 2	131	13	82	4.59

IR 64	132	19	83	5.90

1.1.2 Observation Nursery of Breeding lines

In continuation to the previous selection, the breeding lines of five populations were subjected for Pedigree selection. The pedigree lines were then observed in a single plot of 10 m^2 with the spacing of 20 x 20 cm. All the crop management practices and fertilization were done as usually followed in other trials. The main objective of the trial is to observe the uniformity and see whether the populations are still segregating. The lines that were disease susceptible, undesirable traits and still in segregating stage were discarded. The details are given below.

Table 3: Pedigree lines and their traits

Population	Yield (kg/ac)	Traits	Remarks
IR 80484 (IR 65598-112-2/Dago Yangkum)			
Panicle 1	1100	Uniform, Grains acceptable	**Selected**
2	1328	Uniform, Grains acceptable	**Selected**
3	1448	Uniform, Grains acceptable	**Selected**
4	1744	Uniform, Grains acceptable	**Selected**
5	676	Chaffy	Rejected
6	780	Lodging problem	Rejected
7	772	Short, blast susceptible	Rejected
8	1320	Tall, blast susceptible	Rejected
9	988	Blast susceptible, not uniform	Rejected
10	1044	Blast susceptible, strawy	Rejected
11	1588	Uniform, Grains acceptable	**Selected**
12	1312	Tall and lodging problem	Rejected
13	1688	Blast susceptible	Rejected
14	1208	Tall and lodging problem	Rejected
15	1564	Tall and blast susceptible	Rejected
IR 80485 (IR 65598-112-2/Local Yangkum (red))			
1	1264	Tall and blast susceptible	Rejected
2	1168	Chaffy grains	Rejected
3	1708	Lodging & blast problem	Rejected
4	1312	Blast and small panicles	Rejected
5	1308	Tall and lodging problem	Rejected
6	1260	Lodging & blast problem	Rejected

7	1468	Lodging & blast problem	Rejected
8	1548	Good panicles	**Selected**
9	1292	Good panicles	**Selected**
10	888	Lodging problem	Rejected
11	1708	Good panicles	**Selected**
IR 80490 (IR 71684-36-3-3-2/Dago Yangkum)			
1	1480	Big panicle, blast problem	Rejected
2	1064	Small panicles	Rejected
3	1292	Chaffy grains	Rejected
4	936	Chaffy grains	Rejected
5	1332	Awned and leafy	Rejected
6	1560	Compact panicle & good	**Selected**
7	1252	Awned and leafy	Rejected
8	1400	Tall and lodging problem	Rejected
9	1908	Tall and lodging problem	Rejected
IR 80491 (IR 71684-36-3-3-2/Local Yangkum (red))			
1	864	Late maturing	Rejected
2	1380	Small panicles	Rejected
3	1448	Good but awned	Rejected
4	1480	Good grain	**Selected**
5	816	Tall and lodging problem	Rejected
6	860	Good grain but low yield	Rejected
7	1020	Good grain	**Selected**
8	868	Tall and strawy	Rejected

1.1.3 Bulk and pedigree selections from breeding

The selections for uniformity in panicles, maturity, disease and pests resistance and other desirable traits were continued from the four cross bred populations.
Both pedigree and bulk methods of selections were employed. In the pedigree selection, a total of 44 panicles were selected whereas in bulk method sufficient amount of seeds of each population were collected for further selection. The selection and evaluation will continue till the lines attain uniformity.

Designation	Parents
1. IR 80484	IR 65598-112-2/Dago Yangkum
2. IR 80485	IR 65598-112-2/Local Yangkum (red)

3. IR 80490 IR 71684-36-3-3-2/Dago Yangkum
4. IR 80491 IR 71684-36-3-3-2/Local Yangkum (red)

1.1.4 Demonstration of released varieties

The centre annually receives number of farmers, extension and visitors on study tours. In order to demonstrate them the characteristics of released rice varieties physically, the following rice varieties were established at the research station.

Varieties:

1. Bajo Kaap 1
2. Bajo Kaap 2
3. Bajo Maap 1
4. Bajo Maap 2
5. IR 64
6. IR 20913
7. Khangma Maap
8. Khumal 2 (Wengkhar Rey Kaap 2)
9. Yusi Ray Maap
10. Yusi Ray Kaap
11. BR 153
12. M 54

1.1.5 Seed Maintenance and production of released/promising varieties

Besides carrying out adaptive research, the sector also maintains sufficient quantities of rice seed for demonstration or carrying out trial in new sites. Moreover the ad hoc requests from Dzongkhags or Agriculture Extension are met from such seed stock. Therefore the following quantities of seed of different released varieties were produced and maintained in 2008 season.

Table 5: Seed production of released varieties in 2008

Variety	Quantity (kg)
BR 153	200
Bajo Maap 1	500
Bajo Maap 2	500
Bajo Kaap 1	500
Bajo Kaap 2	500
Wengkhar Rey Kaap 6	100
Milyang 54	100

Mama	100
No 11	100
Khangma Maap	150
IR 64	1000
IR 20913	680
Yusirey Kaap	70
Yusirey Maap	90
Barket	70
Machapucheray	250
Paro China	40
Guojiang 4	500
B2983B	500
Total	**5950**

1.1.6 SRI Observation Trial

SRI was developed in Madagascar in early 1980s by Father Henrie de Laulanie, a Jesuit Priest. After its development many NGOs and government organisations worked for its promotion throughout the world. SRI is tested in Asia continent too with positive results. It is said that the average yield of SRI is 8-9 t/ha with some farmers even getting 10-15t/ha.

SRI works with any variety and no external inputs are needed to benefit from SRI. It emphasizes more on organic manure use rather than inorganic fertilizers as their experience show high yield with organic manure. Minimum of 2 weeding is recommended in SRI with rotary weeder for good soil aeration.

SRI at Bajo

The trial was continued in 2008 season with the objective to observe and ascertain its performance. An improved variety IR 64 was tested. All the basic principles involved the system was followed.

Transplanting of young seedlings

Seedlings of 15 days old were transplanted. The nursery was established in a semi dry bed method with a good irrigation source. The seedlings were transplanted as soon as it is removed from the nursery. As far as possible, the seedlings with intact seed sac were used which supplies food to the infant roots.

Seedlings are transplanted singly rather than in clumps
Seedlings were transplanted singly rather than in conventional methods of three or more. This facilitates individual plants to spread their roots and prevent competing with other rice plants for space, light and nutrients.

Wide spacing
A wide spacing of 30 cm x 30 cm was used. In traditional method, farmers do maintain 10-15 cm. A nylon rope with demarcation was used to maintain the required spacing. Wide spacing expose plants to more sunlight, air and nutrients resulting in more root growth and more tillering.

Moist but un-flooded soil conditions
As recommended, the soil was kept moist without flooding till vegetative stage. During heavy monsoon the excess water was drained out while irrigation was provided during field cracking. However optimum water level of 2-3 cm was maintained once the crop has reached reproductive stage.

Weeding
Two hand weeding were done during the entire crop period. The first weeding was done 20 days after transplanting to churn the soil and improve the soil aeration. The second weeding was done 30 days after the first weeding to remove the weeds that were grown after the first weeding. It is also intended to improve the soil aeration as aeration is considered to be important in SRI. Rotary weeder was used. It was found that there were not many weeds as Butachlor of 3 kgs was applied two days after transplanting.

Organic fertilization
SRI encourages more organic fertilization rather than inorganic. Some countries have modified the technology in terms of fertilization to suit their local conditions. In Bajo, the SRI was raised organically without any inorganic fertlization. Farm yard manure at the rate of (2t/2 tractor) was applied and incorporated during the last puddling. However it is fair to say that there must be some residual effects from the previous season's fertilization.

Results and Discussions

The crop came to maturity at 125 days. No major pests infestation or diseases incidence were observed during the cropping season. Three crop cuts were taken from the field and results are presented below.

Table 4: Agronomic traits of SRI in 2008

Sl	Plant Ht	Tillers no	MC %	Plot yield	Yield kg/acre	Yield t/ha
1	86 cm	31	18.4	5.5 kg	3440	8.60
	90 cm	43				
	89 cm	40				
2	93 cm	37	17.5	5 kg	3164	7.91
	85 cm	69				
	90 cm	55				
3	87 cm	52	17.8	5.8 kg	3672	9.18
	90 cm	45				
	85 cm	51				
Av	88.3	47	17.9	5.43	3425.3	8.56

No significant difference was observed in plant height and days to maturity with that of conventional method. However there has been difference in terms of tiller number by 70-80% (conventional method bears 20-25 tillers). The highest productive tiller number observed was 75 though not in the crop cut area. There has been yield increase by 15% from that of normal practice (Average 7-7.5 t/ha)

Nursery bed

A well levelled field

Transplanting

1.2 BUCAP activities in the West-Central region (2008)

The Biodiversity Use and Conservation in Asia Program (BUCAP) activities have been implemented in the project sites with the broad objective of conserving and developing agricultural biodiversity, facilitate farmers' access to improved genetic materials and enhance farmers' capacity in plant genetic resources management. Most of the activities were in continuation of previous season in the existing sites.

Samthang

1.2.1 Training on Improved Package of Practices for Rice Production

Rice being the most preferred and staple crop in theses villages and new improved ones being adopted, it was felt that training on complete package of practices is needed. Moreover farmers are new to the varieties and they need to be acquainted with the entire practices to maximize the production. Therefore a training on

improved package of practices for rice production was imparted to the communities of Samthang and Rukha with the following objectives:

- To train the farmers on improved practices of rice production for higher production
- To create awareness about the different aspects involved in rice production
- To increase the capacity of farmers in rice production practices.

The training covered all aspects from nursery raising till seed storage. The opening outlined the activities carried by RNRRC Bajo and number of improved rice varieties released so far by the centre as per the altitude. Brief introduction of other Research Centres were also given since they too conduct research on rice.

Nursery Raising Methods

Farmers were taught about the timing of nursery sowing as per the altitude and nursery raising methods. It was observed that most of the farmers in Rukha follow dry bed method due to lack of assured irrigation water while Samthang farmers follow wetbed method. Farmers were told about their merits and demerits and also introduced another method called semi dry bed method which RNRRC Bajo usually follows. Raising nursery in poly tunnel at high altitude was also discussed though it was not relevant to these villages.

Manures and Fertilizers

It was generally observed that farmers of both the villages do apply farm yard manure in their fields. Farmers were encouraged to continue with the same practice. On the other hand the application of inorganic fertilizers is not common and farmers were even reluctant to use. It was due to the feeling that soil gets hard when the inorganic fertilizers are applied. Therefore farmers were reminded that indiscriminate applications of inorganic fertilizers do bring negative effect to the soil and if applied as per the dosage there will be no harmful effects. Moreover farmers were told that the improved varieties are responsive to fertilizer application.

The following dosages were recommended to them - 61 kilograms of Urea per acre, 100 kilograms of SSP per acre and 13 kilograms of Muriate of Potash per acre. Farmers were asked that they may not apply SSP and MoP but urged them to at least apply some urea. Urea is split as basal application, top dressing and second top dressing. In the basal application, 30.5 kilograms of urea need to be

applied during the final puddling while 20 kilograms of urea is broadcast after 35-40 days of transplanting as first top dressing. The remaining quantity of urea of 12 kilograms is applied 5-10 days before flowering. The flow of irrigation water should not be allowed from one terrace to another for atleast 3 days after transplanting.

Weed Control

Farmers do apply Butachlor 3-4 days after transplanting for weed management. Their application and hand weedings were found to be good. Therefore farmers were reminded to continue with same practice.

Water Management

Farmers were asked to keep the water level at 2-3 cm for a week after transplanting. The minimum water level facilitate development of roots and its intact to the soil. The irrigation should be given at short interval without letting the field to crack. The flowering is the most critical stage and there should not be moisture stress. Water should be drained out 10-15 days before harvest to enhance ripening.

Seed Production

Though farmers are aware of quality seed for good growth and yield, they have not followed good seed production procedures. They revealed that seeds are usually kept from the general harvest and during needy times they often land up in consuming as food which was meant for seed purpose. That must be the reason for varietal mixtures and deteriorating. Therefore farmers were asked to follow the following practices:

- Select seed from the standing crop before or at harvest time
- From the standing field, identify plants that confirms the varietal characteristics
- From these plants, harvest individual healthy panicles (if there is more area, more panicles have to be harvested)
- Sun dry the harvested panicles and bundle them.
- Hang them in safer place like ceiling of the house.

Farmers were urged not to use seed for consumption under any circumstances as seed is the basic and most important factor for good yield.

Farmers Feedbacks

Farmers described the training as very educative and informative. They said that the training was timely as they have started adopting the improved varieties and knowing their complete package was essential for optimum yield. The fertilization rate and all other management practices were important and informative.

1.2.2 Rice Double Cropping Trial

In 2008 season, a double cropping trial was initiated at Samthang given its potential and congenial conditions. A rice variety that is recommended for double cropping, No.11 was used as first crop. Nursery was sown in mid February using the poly tunnel technology to prevent the crop from frost damage and enhance seedling growth. Semi-dry method was used for nursery establishment as it was convenient for erecting the poly sheets and weeding against their normal practice of wet bed method.

The crop was transplanted on 25th March with their existing traditional practice. It was transplanted randomly with two to three seedlings per hill. No inorganic fertilizers were applied as there was abundant farm yard manure through cattle tethering.

The crop did perform well in first month of transplanting as there was no problem of irrigation. However the crop succumbed to irrigation shortage as the irrigation channel has been blocked by the on going road construction. Farmer was helpless with the problem and thus the trial was discontinued. The crop in the vegetative phase has been indeed promising. Farmer wants to continue the trial in later years once the road has been stabilized.

1.2.3 Promotion and monitoring of new improved rice varieties

Farmers of Samthang and Rukha have adopted improved rice varieties after the PVS. While some farmers have already maintained the seed, there has been demand from other farmers for these improved varieties. Hence RNRRC Bajo has supplied 50 kgs of IR 20913 seed for 5 Rukha farmers, 30 kgs of B2983 B seed for 3 Samthang farmers and 20 kgs of IR 64 for a farmer in same village.

Apart from seed supply, there has been continuous monitoring and backstopping in cultivation of these varieties. There has been no incidence of major pests outbreak or disease incidence. At harvesting time, a yield assessment was done to

observe its performance and yield trend. The yields have been found to be consistent with IR2093 (5t/ha), B2983B (4.3t/ha), IR64 (4.5t/ha).

Taksha and Silli

1.2.4 Participatory Varietal Selection

Two promising improved varieties namely Khangma Maap and Machapucherey-3, were evaluated along with their local variety as check. Nursery was sown in April and crop was transplanted in mid June. All the management practices were that of existing farmer's practice without detecting the practices either by the researchers or extension. Butachlor application at the rate of 10 kg/acre after 2 days of transplanting to control the weed is a common practice but inorganic fertilizers are not applied either as basal or top dress. Research and Extension facilitated the activity with timely monitoring.

1.2.5 Material support

In order to reduce the drudgery of paddy threshing, BUCAP have supplied 2 paddy threshers each for Silli, Tsara and Taksha village. They were grouped as per the location and convenience to transport the thresher during threshing time. The supply of thresher is expected to reduce the labour and time requirement in threshing the paddy thereby getting more time to attain other agricultural activities. The supply is also expected to boost and motivate the farmers in implementing the BUCAP activities which will contribute to Plant Genetic Resources (PGR) conservation and development directly or indirectly. A simple demonstration on use of thresher was organized.

1.3 Wheat Research

1.3.1 Observation Trial of Nepal Advanced Lines (NAL)

In 2008-2009 season, out of 48 lines, 10 promising test lines were evaluated with the objective to assess the performance of these lines under Bhutanese agro-ecological conditions in terms of yield, disease resistance and other agronomic traits. The trial was laid out in an area of $15m^2$ with the spacing of 20 x 20 cm. Inorganic fertilizer was applied at the rate of 60:30:20 NPK kg/ha with timely hand weeding and irrigation.

Table 5 : Agronomic traits of Nepal Advanced Lines

Lines	Plant ht. (cm)	Yield (kg/ha)
BL2818	78	0.5
BL2930	79	0.04
BL3046	78.8	0.06
BL3264	74	0.04
GAUTAUM	74	0.06
WR1123	74	0.04
WK1182	78	0.03
WK1204	69	0.05
WK1444	93.2	0.04
WK1481	100	0.03

1.3.2 Seed production & maintenance of released and promising lines

The following quantity of seeds of different released and promising varieties were produced and maintained at research centre for future use.

Table 6 : Wheat seed produced in 2008

Variety	Quantity (Kg)
Bajoka-1	83
Bajoka-2	44
Sonalika	48
Pasang Lhamu	59
Anapurna 4	11
VL786	13
UP 262	10
Total	**258**

1.4. Oilseeds Research

1.4.1 Seed maintenance and production of released oilseed crops

The following quantities of oilseed crops were produced:

Table 7 : Mustard seed production

Variety/Type	Quantity (kg)
Bajo Peka-1 (BSA)	7
Bajo Peka-2 (PT-30)	3.2
M-27	0.2
T-9	1.6
Lumley Local	2
Total	**14**

1.5 Grain Legumes

1.5.1 Seed production and maintenance of Soybean and Groundnut

The following quantities of released and promising Soybean and groundnut varieties were produced and maintained for research purpose in the future.

Table 8 : Soybean seed production

Variety	Quantity (kg)
AGS 258	12
Bragg	12
Japanese Black Grade LL	10
Japanese Black Grade L	8
Chinese Black Variety 2	5
Nepal 1	10
Total	

Table 9 : Groundnut seed production

Variety	Quantity (kg)
Kadiri	5
ICGV 87920	5
ICGV 86699	7
Total	17

1.6 Maize

The foundation seed production was carried out in the station for ensuing season use or supply to extension.

Table 10 : Maize seed production

Variety	Quantity (kg)
Yangtsipa	185
Khangma Ashom I	200
Khangma Ashom II	40
Sweet corn	12
Pop corn	10
Total	447

1.7 TSIRANG SUB-CENTRE

1.7.1 Bulk selection of cross bred lines

The lines that were bred through shuttle breeding at IRRI, Philippines were evaluated at Tsirang for uniformity in panicles, maturity, disease and pests resistance. There were a total of seven populations.

The crop health was not that good mainly due to shortage of irrigation water thereby delaying the transplanting. However vigorous selection was done and around one kilogram of seed was bulked from each population. It was planned that the selection be continued in the following season with the harvested and backup seed from Bajo as there is hope that few populations may perform well if transplanted on time.

Table 11 : Parents and cross designation

Designation	Parents
1. IR 80486	IR 65598-112-2/Attey
2. IR 80487	IR 65598-112-2/Choti Masino
3. IR 80488	IR 65598-112-2/Sukhimey
4. IR 80492	IR 71684-36-3-3-2/Attey
5. IR 80493	IR 71684-36-3-3-2/Choti Masino
6. IR 80494	IR 71684-36-3-3-2/Sukhimey
7. IR 80497	IR 71684-36-3-3-2/Choti Masino

1.7.2 Seed production and Maintenance

The centre carried out foundation seed production mainly for two improved varieties that are suitable and promising under Tsirang environment. The maintained seed will be supplied to extension or farmers for further dissemination.

Table 12 : Seed production in 2007

Variety	Quantity (kg)
Wengkhar Rey Kaap 2	135
Wengkhar Rey Kaap 6	145
Total	280

1.7.3 Maize seed production

The following quantities of released Maize varieties were produced and maintained for ensuing season use.

Table 13 : Seed production in 2007

Variety	Quantity (kg)
Yangtsipa	78
Khangma Ashom II	38
Total	116