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FOREWORD

It is a pleasure to serve as the Program Director and to be a part of one of the oldest and premier agricultural research organizations in the country. I am personally delighted to publish this 30th Annual Technical Report of RNRRDC Bajo corresponding to financial year 2014-15.

Also, I feel proud that RNRRDC Bajo has continuously impacted positively by identifying field constraints and opportunities and generating new technology to achieve national goal of food self-sufficiency and poverty alleviation. It is a contentment to reflect on the activities conducted and the achievement made thus far and we would remain committed to help our clients throughout their journey of increasing crop production and productivity.

The annual report synthesizes the research and development activities carried out within a fiscal year (from July to June). It covers the research and extension activities on field crops, horticulture, forestry, farming systems and engineering sector. The report also highlights on some of the activities implemented at Chimipang Royal Project/Frontline Agriculture Demonstration and Training Centre along with the center's information on the human resources, financial progress and visitors.

As a research organization, we accord high priority in testing and applying the generated technologies in the field in partnership with dzongkhag extension colleagues. In some cases, we directly bring our best technologies and promote among farming communities as part of research outreach program. It is believed that showcasing and promoting of technologies is also our prime responsibility and this fits very well with the new and expanded mandate of research and development as a cyclical process. We continue to build and strengthen our linkages and partnerships with regional and international agricultural research organizations, other national centres, extension partners, farmers and more.

I hope this report would serve as a useful technical reference to all stakeholders involved in agricultural research and rural development to attain Gross National Happiness in Bhutan and beyond.

Trashi delek

Ngawang
PROGRAM DIRECTOR

FROM THE EDITORS

The Ministry of Agriculture and Forests plays a crucial role in poverty alleviation and enhancement of rural livelihood of the Bhutanese people. This can be achieved only by enhancing the agricultural productivity by stimulating growth through technological innovations. The Research and Development centres are in the forefront in generation and dissemination of appropriate technologies.

This publication highlights the annual research and development work carried out from 1st July till 30th June of the financial year (2014-15). After Research Centres became Research and Development Centres, equal importance is given to promoting and disseminating proven technologies. Starting last year, we are pleased to report research activities and development activities in separate sections to emphasize their equal importance.

Research component includes mainly varietal evaluation trials of field and horticulture crops. In addition, research activities on crop production management are important. This report includes work on the system of rice intensification (SRI), a low cost technology that can boost rice production. Among grain legumes, research on adaptation of lentil, a new crop for our farmers, has been initiated. Lentil is an easy crop which can be grown under poor and marginal conditions. For the first time, research on bio-fortified wheat was started. Wheat varieties containing higher levels of Zinc micro-nutrient were evaluated. In horticulture, different grafting techniques for mango propagation were attempted. Also, new varieties of tomato containing high beta-carotene and resistance for late blight disease were experimented.

We hope this publication will serve as a useful information base and reference to our readers including academicians, development workers, students and field extension workers.

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RESEARCH AND SUPPORT STAFF

SN	Name	Qualification	Position Title
1	Ngawang	MSc. Tropical Agriculture	Program Director
Field Crops Sector			
2	Mahesh Ghimiray	M Phil. Plant Breeding	Rice Specialist II
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5	Tshering Wangchen	BSc. Agriculture	Research Officer
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8	Doley	Diploma in Agriculture	Sr. Research Assist-II
9	Lhab Gyem	Diploma in Agriculture	Sr. Research assist-III
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11	Jigme	MSc. Horticulture	Dy. Chief Research Officer
12	Kinley Dorji	MSc. Horticulture	Dy. Chief Research Officer
13	Sonam Chophel	BSc. Agriculture	Research Officer
14	Gyeltshen Tshering	BSc. Agriculture	Research Officer
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16	Dawa Drukpa	Certificate in Agriculture	Sr.Research Assistt-III
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19	Pasang Dorji	Diploma in Agriculture	Research Assistt -I
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21	Kinley Dorji	MSc. Horticulture	Sr. Research Officer
22	Sonam Chophel	BSc. Agriculture	Research Officer
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24	Tanka Maya Pulami	BSc. Agriculture	Research Officer
25	Karma Dema	Diploma in Agriculture	Sr.Research Assistt-II
26	Yeshi Zangpo	Diploma in Agriculture	Research Assistant -I
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27	Thinley Gyamtsho	MSc Natural Resource Mgt.	Principle Res Officer
28	Thinley Gyeltshen	Diploma in Civil Engg.	Dy.Executive Engineer
29	Puran Chhetri	Diploma in Civil Engg.	Assistant Engineer I
30	Indra Bdr.Raika	Electrical Engineering	Technician-I
RRCO			
31	Singye Phub	MSc. Agriculture	Principle Res Officer
32	Pema Lhamo	Certificate(XII)	Library Asst-III
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33	Purna Bdr. Gurung	BSc. Forestey	Research Officer
34	Kinzang Dorji	Diploma In Forestry	Sr.Research Assistt -III
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35	Karma Yozer	Certificate in Basic Laboratory	Sr. Lab.Assistant-IV

36	Loday Jamtsho	Certificate	Lab Assitant-II
37	Tshering Yangdon	Certificate in Seed testing	Sr. Lab Assistant-III
		ADTC / Royal Project	
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39	Tshering Dorji	Diploma in Agriculture	Research Assistant -II
40	Dorji Khandu	Diploma in Agriculture	Research Assistant -II
		Administration Sector	
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42	Tenzin	Diploma in Finance Mgt.	Accounts Assistant-II
43	Sangay Gyeltshen	Certificate in Store Mgt.	Sr.Store Keepeer
44	Thinley Norbu	Diploma in Information Mgt.	Sr.ICT-III
45	Lhamo	Certificate(XII)	Adm Assistant-III
46	Gyem Lham	Certificate(XII)	Sr.Despatcher
47	Ugyen Tashi	Certificate in Driving	Driver- I
48	Nidup	Certificate in Driving	Driver- I
49	Tenzin Loday	Certificate in Driving	Driver- I
50	Mon Bdr. Rai	Certificate in Driving	Driver- I
51	Deo Raj Pradhan	Certificate in Driving	Driver- II
52	Dorji Choden	Certificate (X)	PABX Operator
53	Bago	Certificate (VI)	Messanger
54	Bikash Rai	Certificate in Driving	Tractor Driver
55	Nedup	Certificate in Driving	Tractor Driver
56	Farm Attendants (Bajo)		34 numbers
57	Farm Attendants (ADTC)		30 numbers
	Night Guard		1 number

Executive summary

This report presents the outcome of the research and development activities of RDC Bajo for the financial year 2014-2015. The progress is reported sector wise.

Field Crops

The main objective of implementing the Field Crops research is to increase the productivity of different cereals, oilseeds and pulses. Research and Development works were equally emphasized both on station and on farm. The centre continued to evaluate elite lines and commercial varieties received through international research institutes. About 70 varieties of rice underwent various stages of evaluation. IR 28 was tested on farm to evaluate its potentiality for release. In addition we are validating SRI technology and will continue even in the coming years. The centre over the years played a crucial role in coordination and implementation of rice commercialization program.

Evaluation of high yielding varieties of wheat started gaining momentum with good number of materials received from ICARDA, CIMMYT regional office based in Nepal and CIMMYT Mexico. Seed production of promising varieties of wheat was taken, as a parallel activity to the evaluation trial of various materials, which will further be up-scaled in the ensuing season.

Seed production of released varieties of maize has been carried out on-station to maintain quality seeds. Community based seed production was implemented in Tsirang and Dagana mainly monitored by RDSC Tsirang. 11 improved varieties of lentil received through ICARDA project were evaluated on-station. Small scale seed production of Bajo Peka 1, Bajo Peka 2 and M 27 continued at the centre.

Horticulture

The core objective of horticulture crops research is to improve rural livelihood and to achieve vegetable and fruit self-sufficiency in the region and at the national level. The research activities of the horticulture sector include crop management technology, post-harvest practices, improved seeds, plant propagation techniques and maintenance of mother plants and breeder seeds of released crops besides varietal evaluation. The sector also focused on broadening the genetic base of the prioritized horticultural crops through either introduction or selection from local diversity. The on-station research comprised of research on fruits and

nuts, vegetables, and medicinal and aromatic plants at both Bajo and sub-station Tsirang.

The horticulture sector also gave equal importance to outreach programs wherein demonstration of superior varieties over the existing ones and alternative cash crops options were implemented based on location specific farming systems in collaboration with extension officials. Furthermore, the sector provided technical support to the farmers and also carried out capacity development of farmers and extension agents.

Farming Systems

Farming systems activities on station mainly consisted of production of Dhaincha seeds and vermin-composts. The sector focussed on the Gasa Organic Outreach Program through which activities such as upland rice demonstration, mustard production, garlic cultivation, pear production and commercial production of vegetables. The farm produce were further assisted in marketing.

Forestry

The activities of the Forest Research Program included management of on-station multipurpose tree species (MPTS) nursery and solving the on-farm regional needs of the client farmers. Owing to limited staff in the sector, the activities undertaken were very few, namely the management of the MPTS. The sector continued evaluation of species in the nursery and seedlings produced were distributed to schools and institutions. The sector also carried out plantations at Chimipang with avenue species for developing a recreational area below the *Lhakhang*.

Research and Communication Office

A number of visitors consisting of enthusiastic farmers, extension workers, and officials from various ministries including diplomats visited the centre and the sector mainly coordinated and documented the visit.

Engineering

Engineering sector mostly dealt with the implementation of developmental activities such as site supervision services of construction work, infrastructure development, and road maintenance and irrigation infrastructure.

Field Crops Sector

1.0 FIELD CROPS

1.1 Rice

1.1.1 Advance Evaluation Trial

As per the work plan, 6 entries including Bajo Kaap I (standard check) were assessed for grain yield, medium growth duration (140 – 150 days), medium stature (90-100 cm) and disease resistance. The entries were the selection from previous seasons initial evaluation trial but 4 entries from previous years AET were also included for further assessment. The trial was laid out in a RCB design with three replications. 25 days aged seedlings were transplanted in an area of 10 m^2 with a spacing of 20 cm x 20 cm. Chemical fertilizer of 80:40:40 NPK kg ha^{-1} was applied with half of N and the whole P and K applied as basal dose. The remaining N was top dressed at panicle initiation stage. NPK sources were from urea, single super phosphate and muriate of potash.

In order to control grassy weeds, Butachlor 5G was applied at 1.5 kg a.i $ha^{-1.}$ The application was done three days after transplanting. Broadleaved weeds such as pond weed (*Potamogeton distinctus*) and (*Monochoria vaginalis*) were managed through hand weeding. Irrigation was given when needed. No occurrence of pest and diseases were seen, hence no plant protection measures were taken. The crop was harvested from an area of 5.04 m^2 at 14 percent grain standardized moisture.

Table 1: Agronomic traits of different rice entries in Advance Evaluation Trial

Treatments	DTF	No.of tiller/hill	Plant height (cm)
3147738	118.33bc	10.67bc	92.67c
3147739	125.67ab	12.00ab	92.00c
3147740	125000ab	12.00ab	94.00bc
3147742	133.33a	13.33ab	91.33c
CT 16658	127.00ab	9.33bc	100.00a
IR 75288	128.67a	16.33a	92.33c
BK-1	130.67a	12.67ab	96.67ab
Pr> F values	0.001	0.010	0.000

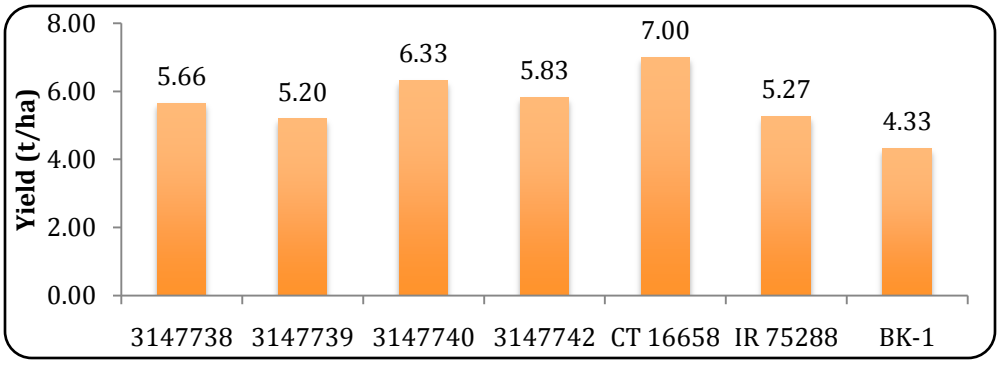

Figure 1: Graph of the yield of the entries in t^{-ha}

Result and Discussion

The entries that were evaluated showed significant differences in the parameters considered for evaluation. All the entries surpassed the yield of the standard check of 4.33 t^{-ha}. Hence the entries will be further tested in the coming season for confirmation.

1.1.2 Initial Evaluation Trial

A total of 4 treatments including Bajo Kaap I used as a standard check were tested under this trial. The entries were selected from the better performing lines of the previous seasons observation nursery. It was carried out with the objective to select varieties that are high yielding, resistant to insect pest and diseases and having preferred agronomic traits.

The trial was laid out in a RCB design with three replications. Fertilizer doses, weed management, irrigation scheduling and other agronomic practices were carried out similarly to that of the advanced evaluation trial. The crop was harvested from an area of 5.04 m^2 at maturity maintaining the 14 percent moisture content.

Table 2: Agronomic traits of different rice entries in Initial Evaluation trial

Treatments	DTF	No.of tiller/hill	Plant height (cm)
Wanxian 7777	135.33a	9.33b	100.33a
Tme 80518	125.33c	10.67b	96.00ab
Zhonghua 1	130.67b	10.67b	83.33c
Hha-17-Dt6sa13-Dt	126.33c	14.33a	91.00bc
Bk-2 (local check)	127.33c	12.67ab	95.67ab
Pr>F value	0.000'	0.007	0.007

Means with common letter (s) within the columns are not significant at 0.05% significance level

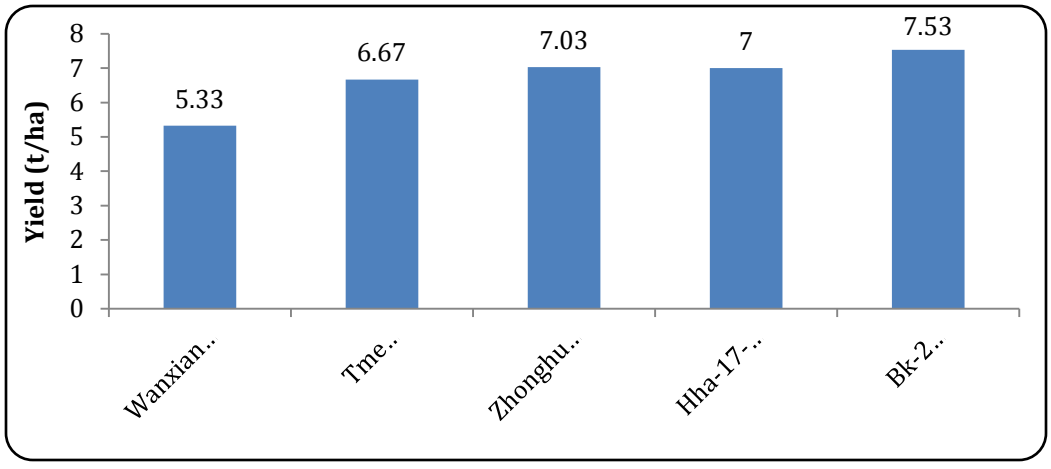

Figure 2: Graph of the yield of the entries in t^{-ha}

Result and Discussion

Yield among all the test varieties showed significant difference (p-value =.007). Wanxian 7777 had the lowest yield as compared to other varieties. However the yield differences in other varieties are not significant with production ranging from 6.67 to 7.53 t^{-ha}.

1.1.3 Introduction Nursery (IIRON Module I from IRRI)

The purpose of this nursery is to exchange elite breeding lines and varieties from the world's rice improvement programs and conduct preliminary evaluation of their performance under a wide range of irrigated rice environments. Due to more number of entries (60), smaller plot size of 7 m^2 was used to grow the breeding lines maintaining a spacing of 20 cm x 20 cm. Better performing varieties will be selected for another nursery trials in bigger plots or replicated trials (Initial Evaluation Trial) in the coming year depending on the work plan. Nutrient management, irrigation application and other agronomic practices were followed similar to the other trials.

Table 3: IIRON nursery yield data

Entry No	Plot No	Designation	HDG (days)	HT (cm)	Yield t/ha
008	101	CT 19558-2-17-4P-3-1-1M	132	97	1.428
029	108	IR 10N118	120	94	4.857
049	109	IR 06M144	128	109	7.142
039	110	KARJAT3	129	94	6.000
056	112	IR50	135	79	3.571
048	113	IR06M150	128	102	5.714
028	117	IR 10F364	129	102	6.000
023	120	IR 10A199	126	96	4.285

017	121	IR 09L120	121	97	6.000
031	122	IR 11A208	128	101	6.000
057	124	IR 64	126	97	5.714
052	129	IR 10F336	111	105	4.428
012	130	IR08N210	113	100	4.857
014	131	IR 06N155	123	109	5.857
012	132	OM 6379	115	104	4.428
041	135	IR 09A228	121	90	5.714
022	137	IR 09A220	123	105	5.714
016	139	BR 6902-14-4-2-5	116	92	4.285
015	140	IR 10N269	126	104	5.714
002	141	IR 05A235	126	105	6.142
051	142	PK 3445-3-2	130	98	6.000
037	144	IR 10N272	129	97	7.142
044	147	CB 08514	115	102	5.714
030	149	CT 18148-3-1-1P-1-2-2-M	128	94	5.714
003	153	IR 06N170	115	105	5.714
009	155	IR 11A287	128	107	4.857
013	157	IR 10A134	129	102	5.714
032	158	IR 10A323	130	107	5.714
021	160	LOCAL CHECK	130	102	5.714
027	202	IR 09N522	129	99	5.714
060	203	IR08N210	115	106	5.571
018	207	IR 09A228	122	90	5.714
014	209	IR 10A323	128	110	5.571
016	211	IR 10N118	122	96	5.714
037	212	IR 50	137	80	3.000
029	213	BR6902-14-4-2-5	125	88	5.571
056	214	IR 11A208	127	105	5.714
002	215	IR 10A136	123	95	5.714
031	216	KARJAT 3	126	92	5.714
022	220	OM6379	115	103	4.571
039	221	IR O6M150	128	101	5.857
041	223	IR 10N269	125	97	5.714
048	224	IR 64	125	92	5.714
021	226	IR 10A134	129	95	6.285
004	233	CT 16658-5-2-3SR-2-1MMP	135	92	6.000
019	235	IR 09N536	126	86	6.000
017	240	IR 09L120	123	83	7.142
007	242	CT 19298-(100)-1-2-3-1-4mp	130	98	6.000
047	246	IR 08N136	128	109	7.571
033	247	IR 11A298	126	108	6.000
003	251	CB 08514	126	108	6.000
023	255	IR 10A199	128	110	7.000
046	256	ZHONGZAO4	130	71	1.571
043	257	PD211	128	106	5.714
026	258	IR 10A314	126	107	5.857

Result and Discussion

Most of the breeding lines indicated higher yields and the better performing lines will be selected for further evaluation. IR 08N136 was the best breeding line yielding 7.5 ton per ha.

1.1.4 Demonstration of SRI technology

System of rice intensification is a methodology of increasing rice productivity by changing the management of plants, water and nutrients. There are studies showing better yield of SRI compared to the conventional method. SRI technology was tried both on farm and on station over the years. In the previous season SRI technology was assessed in terms of seedling age. As SRI is one of the sustainable approaches to rice production, the yield potential of SRI was demonstrated to the visitors and the experiment are continued annually to confirm the potential of the technology.

Table 4: Yield potential of SRI technology

NO	SRI	Plot Yield Kg per $6m^2$	Yield per ha (t^{-ha})
1	Sample 1	4	6.6
2	Sample 2	4.1	6.3
3	Sample 3	4.3	7.3
		4.1	6.7

1.1.5 Demonstration of released varieties

A number of visitors ranging from farmers, students, extension agents and dignitaries visit the centre for knowledge exchange and educational purposes. The visitors were demonstrated different varieties of rice suited to different ecological conditions of the country and explained the physical characteristics of the released rice varieties. The varieties were grown in a single large plot and management practices were similar to the other trials. The demonstrations of the varieties are presented in the table below.

Table 5: List of released rice varieties for demonstration

Variety	Recommended Agro ecology Altitude (m)	Crop
IR 64	600-1500	Main single
Bajo Kaap I	600-1500	Main single
Bajo Kaap II	600-1500	Main single
Bajo Maap I	600-1500	Main single

Bajo Maap II	600-1500	Main single
IR 20913	600-1500	Main single
Wengkhar Rey Kaap 2	600-1500	Main single
Khangma Maap	Above 1500	Main single
Kamja	Up to 600	Main single
karjat	Up to 600	Main single
Guojing4	600-1500	Main single

1.1.6 Seed Production and Maintenance of released varieties

The centre produced the basic seeds of the released varieties and potential varieties that are considered for release. The seeds that are produced will be used for on station and on farm trials particularly for evaluation of production and demonstration in new areas. The stocks that are maintained also helps to address ad hoc seed demand that the centre receives from extension. The seeds that are produced at the centre are shown in detail in the table below.

Table 6: Details of seed produced

Sr No	Variety	Quantity (kg)
1	IR 64	8185
2	Bajo Kaap I	1000
3	Bajo Kaap II	1000
4	Bajo Maap I	1000
5	Bajo Maap II	800
6	IR 20913	1100
7	Khangma Maap	300
8	IR 28	1092
9	No 11	400
10	Bhutan I	200
11	Bhutan II	150
12	Bhutan III	130
13	**Total**	**15357**

Through the implementation of seed production, RDC Bajo supported 3495 kgs of seed to rice commercialization. A mixture of 11028 kgs of paddy was sold to the staff and ESPs generating revenue of **55140 Nu** in the year 2014-2015.

Table 7: Seed support from RDC Bajo for developmental activities.

	Quantity (kg)			
Varieties	**Punakha**	**Tsirang**	**Dagana**	**Others**
IR 64	0		0	500
Bajo Maap I	100	400	150	0
Bajo Maap II	100	250	170	0
Bajo Kaap I	100	320	150	0

Bajo Kaap II	100	300	140	0
No.11	0	0	130	0
Khangma Maap	0	35	290	60
IR20913	0	0	0	200
	400	**1305**	**1030**	**760**

1.1.7 Pre-Production Evaluation Trial

IR 28 was advanced from on station trial after rigorous testing for yield, adaptability, pests and diseases incidence. This variety was found to be promising in all the aspects and the average yield over the last three years was (6.2 t/ha). Therefore it was felt that the variety should be tested in the farmers' fields under their management practices to know their yielding ability and suitability.

The evaluation trial was carried out in two Dzongkhags (Wangdue Phodrang and Punakha). The selected farmers raised half langdo each of IR 28 and compared with their popular local varieties. The crop was raised as per the existing farmers' practices with researchers and extension providing technical help. At the end of the cropping season, crop cuts were conducted in order to compare the productivity. The details of the Crop cut in the two Dzongkhags are represented in the table below.

Table 8: Performance of IR 28 on farm under Punakha and Wangdue Phodrang

Sr No	Name of the farmer	Location	Plant Ht	Tiller No	Plot Yield (Kg/6m^2)	Yield per ha (t per ha)
1	Kinley Penjor	Dzomi / Tsekha	98	17	4.2	6.5
2	Zam	Dzomi / Tsekha	105	13	3.7	5.7
3	Kinley Gyelmo	Dzomi/ Tsekha	104	12	4.3	6.4
4	Damchen	Kabji / Lakhu	101	11	4.2	6.9
5	Norbu Tshering	Kabji / Lakhu	90	10	2.6	3.4
6	Chezang	Kabji / Lakhu	87	8	3.3	4.6
7	Sangay Bidha	Kabji / Lakhu	95	11	3.0	4.5
8	Sangay Om	Shengana/ Manikha	90	12	3.2	4.6
9	Dorji Wangmo	Shengana / Domna	113	8	1.8	2.6
10	Choden	Thedtsho/ Thangu	97	13	4.1	6.2
11	Khandu Om	Thedtsho / Thangu	93	11	3.5	5.3
12	Ugyen	Thedtsho/ Thangu	93	8	4	5.7
13	Kinlay Om	Thedtsho /	95	12	4.0	6.2

14	Chundu	Thangu Habesa / Gaselo	74	9	3	4.3
15	Ugyen	Gaselo / Tsachu	70	10	1.8	2.5
16	Batom	Gaselo / Tsachu	69	8	5.5	2.9
17	Namgay Dem	Bjena / Themakha	93	17	2.8	3.8
18	Yangzom	Bjena / Themakha	96	19	2.9	4.2
19	Khandu Om	Bjena / Themakha	97	15	3.1	4.9
20	Tshering	Bjena / Wopokha	89	17	3.0	4.4
21	Local		111	14	3.0	4.2
22	Local / Bonday		94	11	2.5	3.7
23	On- Station	IR 28	105	14	4.2	6.7

Result: It can be seen that the yield of IR 28 is better than the local varieties in most of the trial sites yielding as high as 6.9 t^{-ha} in one of the trial sites located in Punakha. The yields from the previous year will be taken into consideration and will be put for release in the coming years.

1.2 Maize (On Station)

1.2.1 Seed Production and maintenance of improved varieties

Seeds production of released varieties were carried out and maintained in sufficient quantities for future use. The quantities of maize produced during the fiscal year 2014-2015 are shown in the table below.

Table 9: Quantity of maize seed produced

Sr No	Variety	Quantity (kg)
1	Yangtsipa	560
2	Khangma Ashom	220
3	Pop corn	4
4	Sweet corn	34
	Total	818

1.3 Grain Legumes

An adaptive trail on lentil (*Lens culinaris*) has been started at RDC Bajo through ICARDA South Asian Region Delhi, India. The project includes member states of Bhutan, Nepal, Bangladesh, India, China, Pakistan and Afghanistan.

The overall goal of this adaptive trial is to improve and sustain the rural livelihood and nutritional security through enhanced pulse production using conventional breeding techniques.

Materials and Methods

11 improved varieties of lentil from Bangladesh (LT-01 to LT-11) and 1 variety from Nepal (Shital) used as the Local check, maintained through pulse shuttle breeding program were tested in a single plot (3mX4m) of $12m^2$ area. The seed rate used was 50 kg per ha. Fertilizers rate of 18:46:20 kg NPK per ha was applied. Weeds were controlled through 2 hand weeding. The trial was implemented at RDC Bajo**.** The seeds were sown on the 27th of November 2014. Data on flowering, maturity, plant height and seed yield per plot were recorded. The crop cut was taken from a plot size of **$6m^2$**. The trials were harvested in the last week of April 2015 and the details of the data collected are shown in the table below.

Table 10: Flowering, maturity, seed yield for 11 lentil varieties from Bangladesh and 1 local check from Nepal

Variety	50% Flowering (days)	75% maturity (days)	Plant height (cm)	Seed Yield (kg/ha)	Remarks (Ranking)
LT-1	0	0	0	0	
LT-2	74	109	41	0.65	1
LT-3	74	110	40	0.55	5
LT-4	77	112	33	0.59	3
LT-5	77	112	32	0.36	10
LT-6	77	112	34	0.47	7
LT-7	77	112	44	0.53	6
LT-8	77	112	37	0.63	2
LT-9	74	110	45	0.46	8
LT-10	0	0	0	0	
LT-11	74	110	40	0.38	9
Shital (local Check)	73	109	47	0.56	4

Results and Discussions

The growth of lentil was poor due to coincidence of low temperature and sowing. Possibility of sowing early during the beginning week of November or sowing in standing rice crop could be explored in the coming season for better yield.

There were no significant differences in flowering, maturity and plant height between the ten varieties from Bangladesh. LT-1 and LT-10 week

after germination failed to maintain a healthy crop stand and eventually resulted in the failure of the two varieties. The maximum yield was harvested from LT-2 followed by LT-8 and LT-4.

1.4 Oilseeds

Although R&D in oilseeds has declined over the years, RDC Bajo still maintains small quantities of released varieties of mustard for future use. The yields of the varieties maintain are reflected in the table below.

Table 11: Quantity of oilseed production

Varieties	Crop cut sample	Yield per plot (kg) area=(6m^2)	Yield kg per ha
Bajo peka -1	Sample- 1	0.370	616.6
	Sample-2	0.428	713.3
	Sample-3	0.470	783.3
	Avg	**0.422**	**703.3**
Bajo peka-2	Sample- 1	0.250	416.6
	Sample-2	0.330	550
	Sample-3	0.460	766.6
	Avg	**0.346**	**576.6**
M-27	Sample- 1	0.280	466.6
	Sample-2	0.320	533.3
	Sample-3	0.350	583.3
	Avg	**0.316**	**526.6**
BARI Sharesa- 11 New variety from Bangladesh**(BARI Share-11)** adaptation trial	Sample- 1	0.452	753.3
	Sample-2	0.466	776.6
	Sample-3	0.562	936.6
	Avg	**0.493**	**821.6**

Horticulture Section

2.0 HORTICULTURE

2.1 Fruits and nuts

2.1.1 Pecan nut variety evaluation trial

The data collection and management of the pecan nut trial which was established in the year 2002 was continued in line to its objective to assess and select suitable cultivars for mid altitude region. There are currently four varieties namely Desirable, Wichita, Kiowa and Western Schley in the trial plots. Two plants per variety were planted with spacing of 3m x 3m between plant and rows. The trees are trained into modified centre leader system. Weeding, basin preparation and mulching are carried out in February-March every year and manure and fertilizer application are also carried out during this period. The fields are irrigated regularly, on an average of once per month, during the dry months which stretch from December till May in Bajo.

Table 12: Morphological characteristics and phenological period of pecan nut cultivars

Cultivars	Tree appearance	Bloom time	Leafing	Harvest time
Wichita	Vigorous	April	April	October
Western Schley	Vigorous	April	April	October
Kiowa	Vigorous	April	April	October
Desirable	Vigorous	April	April	October

No major pest and disease were observed except for minor incidence of trunk borer. Schedule spray of Cypermethrin and copper oxychloride were carried out to prevent fungal and pest problems. Weeding and basin maintenance of the plantations were carried out three times last season. Scouting and monitoring of the trees were carried out regularly.

Last year, the nuts were harvested in September by mechanically shaking the trees and the nuts picked up from each tree by hand. The nut's length, diameter, weight and kernel percentage of different varieties were already determined in previous years. This season, the data on only the total yield was collected. Like in the previous season, Wichita produced the highest yield with 9.03kg per tree followed by Western Schley and Kiowa with 5.6 and 4.4 kg respectively. The lowest yield was from Desirable this season with a yield of 2.25kg per tree as indicated in the table below.

Table 13: Nut characteristics, yield and quality of pecan nut cultivars

Cultivars	Shape	Wt. (gm)	Dia. (Cm)	Length (cm)	Percent kernal	Yield (kg tree^{-1})				
						2010	2011	2012	2013	2014
Wichita	Oblong	6.2	1.8	3.3	57	0.9	1.4	9	3.75	9.03
Western Schley	Oblong	7.6	2.2	3.7	58	1.2	1.2	1	3.8	5.6
Kiowa	Oblong	8.9	2.6	4.9	55	0			1.4	4.4
Desirable	Oblong	6.4	2.1	3.1	54	0.6	1.2		0.95	2.25

All the cultivars are doing well in Bajo condition and the yield is increasing year by year. The two cultivars namely Wichita and Western Schley will be proposed for release.

2.1.2 Citrus rootstock scion compatibility trail

The on-station citrus rootstock compatibility trial was established in 2009 with the objective to identify appropriate rootstock for local mandarin and also to evaluate the effect of local citrus on different rootstocks. In July 2008, Tsirang local were grafted on to six commercial rootstocks viz. Troyer, Cleopatra, Carrizo, Local, Rangpur lime, Volkameriana. The block consists of 30 plants; five plants each for six varieties; planted in single plot design with spacing of 3m x 3m plant to plant and 3m x 3m row to row.

The scheduled activities like fertilizer application, basin making and irrigation were carried out. The plants were monitored frequently for health, pest and disease.

The trial started bearing fruit from 2013. The graft compatibility (observation of graft union) and other parameters like yield, fruit quality characteristics, tree health and spread were studied.

Table 14: Fruit quality parameters of Tsirang local on different rootstocks

Treatment	Total fruit/ tree	Fruit Wt. (gm)	No. of seeds	Fruit Ht. (cm)	Fruit Dia (cm)	Rind thickness (cm)	TSS (%)	No. of locule
Local x Local	34.5	118.8	18.6	5.54	6.8	0.33	10.95	10
Volka x Local	71	146.46	16.4	5.97	7.17	0.35	9.16	11
Rangpur X local	14	149.72	15.6	5.79	7.27	0.32	9.55	10
Cleopatra X Local	25	117.2	17.1	5.4	6.52	0.29	11.2	10
Carrizo X Local	24	126.2	13.4	5.5	6.52	0.26	11	9
Troyer X Local	47	165.9	15.5	6.1	7.8	0.31	10.98	10

From the above table and figures, we can conclude that Tsirang local grafted on Troyer gives larger fruit than the one grafted on other rootstocks. Yield of tree grafted on Volkamariana were two times greater than other rootstocks, but weight per fruit for this cultivar was a little smaller than Rangpur and Troyer. However, TSS was the lowest while the rind thickness was highest among the different rootstock studied. The quality of fruit from this scion rootstock combination was not very good as indicated by these parameters.

In case of Cleopatra mandarin though TSS content was higher than the rest, the fruits were smaller with an average weight of 117g. The lowest TSS was from local rootstock and the smallest fruit was from Cleopatra rootstock. The Troyer rootstock gave the biggest fruit with a TSS value of 10.98%. Plants on Volkamariana, Cleopatra and Rangpur lime were severely affected by three types of scales (green scales, Mussel scales and Helmet scales).

These scales excrete honey dues, leading to development of sooty molds. Sooty mold covered the branches and leaves. Based on the above results Carrizo and Troyer rootstocks may be found most suitable for Tsirang Local. However, the trial will be continued for another few years for proper study.

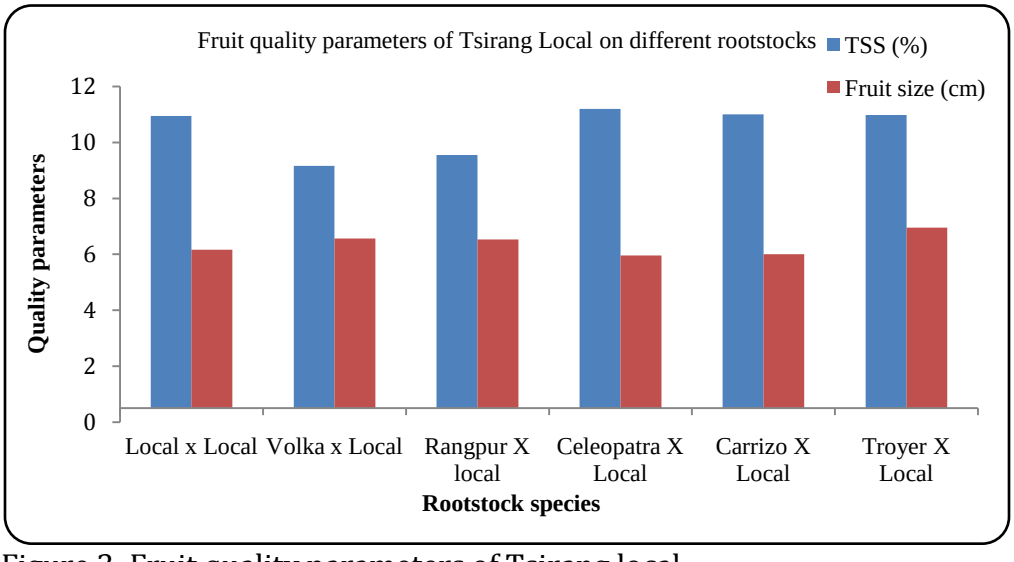

Figure 3: Fruit quality parameters of Tsirang local

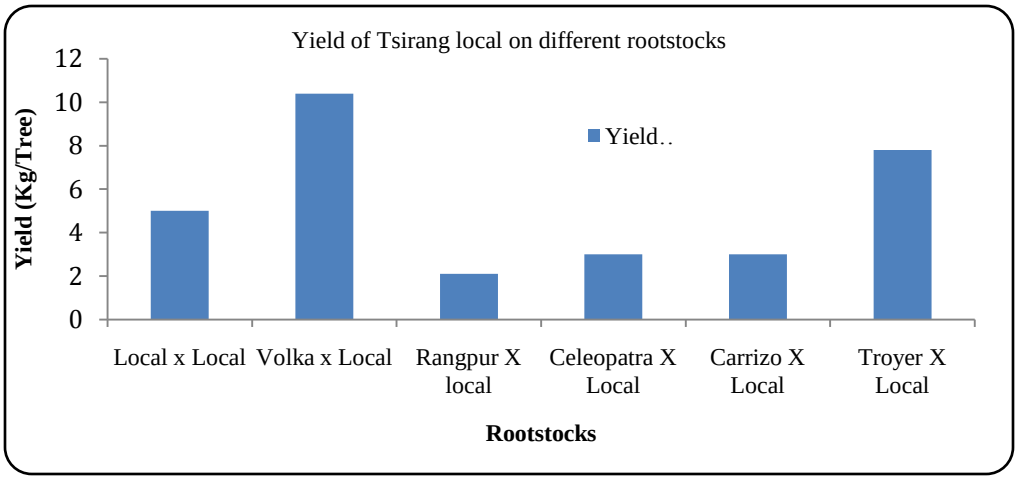

Figure 4: Yield of Tsirang Local on different rootstocks

2.1.3 Effect of Different Grafting Techniques in Mango

A study on the performance of different grafting methods in mango was carried out in the greenhouse of the horticulture field of RNRRDC-Bajo. Though mango can be raised from seed or propagated vegetatively, a grafted mango can bear fruits in 3-5 years while those from seed takes about 6-10 years. In addition, the grafted plants maintain the true characters of the mother plant and therefore desirable varieties can be grown. Therefore, it is advantageous to plant grafted seedlings over the seedlings raised from seed.

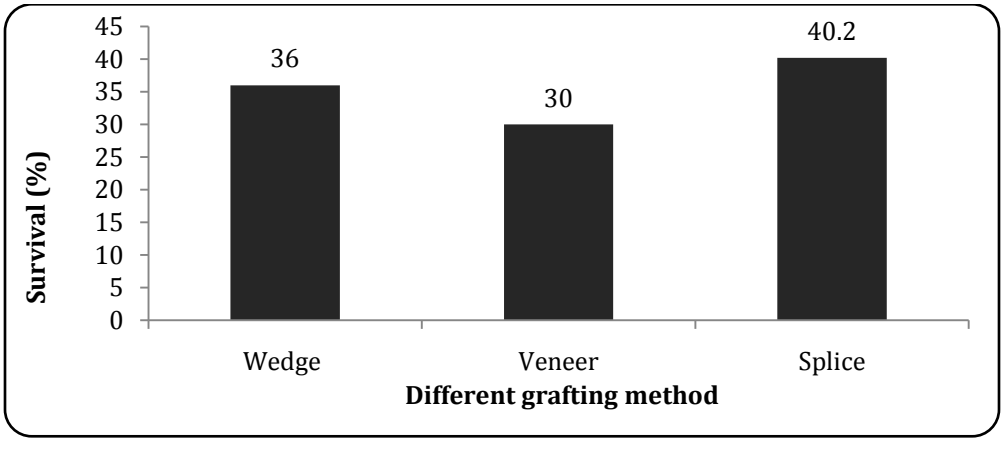

Figure 5: Performance of different grafting method (survival %) (n=5)

The performance of three different grafting methods i.e. wedge, veneer and splice grafting were compared. The grafting was carried out on 1st

May, 2014. Dasheri cultivar was used for both the scion and rootstock. The one year old rootstocks raised in poly bag, with thickness ranging from 0.8-1.4cm were used. The scion wood of uniform thickness were collected from the germplasm block and used after wrapping with Para film. The data on graft take shoot length and leaf length was recorded on weekly basis.

Among these methods, splice method had the highest survival rate with 40.2% followed by wedge grafting (36%) and veneer (30%) after 60 days of grafting (Figure 5). However, One Way ANOVA results indicates that this difference is not statistically significant (p=0.335). Similarly for shoot and leaf length, there is no significant difference between the different grafting methods (Figure 6).

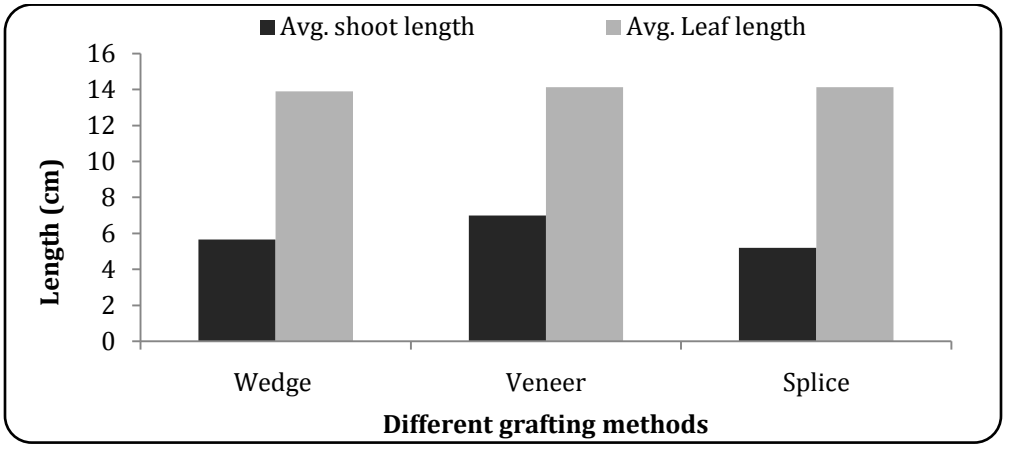

Figure 6: Effect of different grafting method on the length of shoot and leaf (n=5)

The study concluded that there was no significant difference in the success rate of mango among the treatments (p=0.335). However, without considering the statistical significance, the splice grafting is recommended as the appropriate technique for mango grafting under Bajo condition.

2.1.4 Nursery production and management of fruits

Lack of sufficient quality planting materials is one of the constraints which limit the promotion of horticulture. The RNRRDC-Bajo has been producing fruits seedlings of improved varieties for requirement in both outreach programs mainly for establishment of demo orchards. The nursery also serves as the training field for private nursery operators and

extension agents where, hands on training on different grafting techniques and technical guidance are provided.

The seed and seedlings of released varieties as well as potential varieties of fruits and nuts are produced. The nurseries are managed following the improved nursery production practices. For rootstock production seeds of local fruits are extracted in the absence of improved commercial rootstocks. Scion woods are collected from the mother block maintained at the station or brought from other centres like RNRRDC-Wengkhar.

Table 15: Planting materials produced and maintained in RDC Bajo horticulture nursery

Cultivars	Grafted	Non-grafted	Rootstock	Total
Citrus	393	300	1773	2466
Pomelo		922		922
Avocado		989		989
Pomegranate		2241		2241
Kiwi			180	180
Grapes		80		80
Gauva		71		71
Papaya		480		480
Loquat		180		180
Persimmon		84	163	247
Peach			50	50
Pear	600	400		1000
Walnut	370			370
	1363	**5747**	**2166**	**9276**

Fruit and nut nursery production technologies suitable within the region are available at RDC-Bajo. The centre should continue to support the local nursery operators, through hands on training and technical backstopping. To cater the seed and seedling needs of the region, private nursery growers' needs to be both supported and promoted.

2.1.5 Maintenance of Fruit Crop Mother Block

The RNRRDC-Bajo has maintained the mother block for both the released fruit crop and some other promising varieties. The mother blocks have been established with the prime objective to conserve the available fruit crop germplasm and to develop healthy and true-to-type good quality planting materials of these varieties. It also serves to familiarize the visiting farmers, from around the country, on different types of improved and introduced fruit crops. The mother blocks consist of various fruits including both temperate and sub-tropical fruit crops. The facilities from the centre are availed by the interested farmers for scion woods and

seeds. The recommended management practices are carried out so that the mother blocks are healthy and free of disease and insects.

Table 16: List of the fruit crop germplasm maintained

Fruit crop	No.of variety	Remarks
Walnut	19	Variety ranging from Bajo 1-19,
Pear	5	Tsirang local, Flemish Beauty, China, Gala and Chojuro.
Peach	3	Shin-i- Punjab, Florida Sun and July Elberta
Loquat	1	Tanaka
Apricot	2	New Castle and Kaisha
Almond	1	Kagzi
Chest nut	4	Neils, Morena, Early Brown and Wangdillagong
Pecan nut	8	Wichita, Western Shelby, Kiowa, Desirable, Cheyenne, Mahan, Barket, Neils
Citrus	14	Hayaka, Freemont, Tesiu Ponkan, Otha Ponkan, Washington Naval, Kinnow, Tsunokowari, Clementine, Lime Eira, Valancia, Minola, Fortune
Mango	9	Tommy Atkins, Chin Hwang, Himsagar, Duncan, Langra, Amrapali, Dasheri, Alphonso, Irwin
Apricot	2	Newcastle, Kaisha
Grapes	9	Perlette, Portland, Pinot Blanc, Chasselas, Muscat, Sultana, Waltham, Calmeria, Ruby Seedless
Banana	9	Japari, Hari Chand, Cali, Hatidat, Lung Lasey, Chini Champa, Tinkehsray, Ghiwkola
Avocado	4	Pinkerton, Hass, Zutano, Bacon
Pomegranate	6	Bedana, Chawla, Amar Surin, Khandari, P75-K5, P75-K3.
Guava	4	Local, Pink Flesh, Thai Giant, Allahabad Safeda
Apple	1	Anna

2.2 Vegetables

2.2.3 Evaluation of Late Blight Resistant Tomato lines from AVRDC

Tomato is the second most important vegetable in the world with outstanding vitamin contents. It is one of the daily ingredients in Bhutanese dish. However, foliage and fruit infections by late blight (*Phytopthora infestants*) contribute to significant yield lost during the rainy season. As of now, there is no variety resistant to late blight, although "Ratan" had shown some degree of tolerance compared to Roma. Therefore, seven late blight resistant lines from AVRDC were evaluated for the level of resistance, and yield performance. The trial was conducted from July to October from 2010 to 2014 at vegetable research plot of RDC-Bajo. A popular local variety Ratan was used as check. The area of plot size was $5m^2$ and RCB design with three replications was

used. Recommended management practices of tomatoes were followed. The resistant lines from AVRDC are: LBR-6, LBR-7, LBR-9, LBR-10, LBR-11, LBR-16 and LBR-17. The data was collected on marketable yield and fruit size. The data were analysis by one-way ANOVA using Duncan Multiple Range Test.

Table 17: Yield data of late blight resistant lines and Ratan (check) from 2013-2014 trial

Sl. No.	Line	Total yield (Mt ha^{-1})
1	Ratan (check)	8.6 ab
2	LBR-11	8.0 a
3	LBR-10	7.3 a
4	LBR-16	11.7 b
5	LBR-6	5.7 a
6	LBR-9	5.3 a
	P value	<0.001

The resistant lines were superior to existing cultivar Ratan in term of marketable yield and fruit quality. Based on yield, yield consistent for different year and fruit quality, LBR-6, LBR-11, and LBR-10 are promising lines. However, multi-location and social acceptability studies needs to be carried out.

2.2.4 Evaluation of High Beta-carotene Tomato Lines from AVRDC

Tomato is one of the vegetables with huge demand year-round. It supplies many essential vitamins and add variety of colours and flavours to food. Beta-carotene is one of the terpenoid compounds in plants known for its pro-vitamin A activity. The characteristics strong red-orange coloration of tomato is because of beta-carotene content. AVRDC has developed new lines of tomato with high beta-carotene content. They provide rich source of vitamin A (3-4 times) higher than normal tomato

on average. Therefore, six high beta-carotene lines were introduced and evaluated for yield performance at mid altitude region (Bajo condition)

Table 18: Yield of high beta-carotene tomato lines and Roma (check) from 2013-2014 trial

Sl. No.	Line	Total yield (Mt ha^{-1})
1	CLN2070A	14.3 b
2	CLN2366A	9.4a
3	CLN2071C	6.5a
4	CLN2366A	7.0a
5	Roma (check)	9.4a
	p-value	<0.001

The trial was conducted from June to August from 2010 to 2014 at vegetable research plot of RDC-Bajo. A popular local variety Roma was used as check. The area of plot size was 5m^2 and RCB design with three replications was used and recommended management practices of tomatoes were followed. The high beta-carotene tomato lines from AVRDC are: CLN2070A, CLN2071C, CLN2366A, CLN2366C and CLN1314G. The data was collected on marketable yield and fruit size. The data were analysed by one-way ANOVA using Duncan Multiple Range Test. Based on yield, yield consistent for different year and fruit quality, CLN2366C, CLN2366A and CLN2070A shows promising. However, multi-location and social acceptability studies needs to be carried out.

2.2.5 Evaluation of radish varieties of Reva seed enterprise

Radish (*Raphanus sativas*) is an annual vegetable belonging to the family Cruciferae (Brassicaeae), and is traditionally important vegetable in many countries. Most of radish cultivars are adapted to the cooler season. The normal root developed at a temperature range of 15.6 degree Celsius to 21.1 degree Celsius. However, many different types of cultivars have been selected for production for different seasons. Thus, a year-round production system has been established.

Table 19: Yield data and root characteristic of radish varieties

Varieties	Mkt yield (Mt ha^{-1})	NMkt yield (Mt ha^{-1})	Total yield (Mt ha^{-1})	Av. Root wt (g)	Root length (cm)	Root width (cm)	Root color
(F1 hybrid) YR White long	80	0	80	300	24.9	4.6	White
Chetki long	29	16	45	250	25.5	3.5	White
Mino Early	92	2.2	94.2	275	27.5	3.7	White
Spring Tokinashi (check)	67	9.4	76.4	215	26.8	3.5	white

Trial kits were received from horticulture division (Thimphu) with the direction to evaluate three imported radish varieties. The three radish varieties were imported by Reva seed enterprise from Ananya Seed Pvt. Ltd, Bangalore (Karnatka), India. The radish varieties were: (F1 Hybrid) YR White long, Mino Early and Chetki long. The trial was conducted from October 2014 to January 2015 at vegetable research plot of RDC-Bajo. A popular local variety Spring Tokinashi was used as the check. The area of plot size was 5m^2 and RCB design with three replications was used. The data were collect on yield, average root weight and size. The yield and root characteristic of radish varieties are given (Table 19). Result indicated that all the radish varieties are comparable to Spring Tokinashi (check) in term of yield and root characteristic, except the Chetki long. This was due to bolting of most of the plant of this variety. The trial will be repeated in coming season for confirmation of result obtained this year.

2.2.6 Evaluation of carrot varieties of Reva seed enterprise

Two imported carrot varieties (Ananya Desi Red and Noorie) by Reva Seed Enterprise from Ananya Seed Pvt. Ltd, Bangalore (Karnatka), India were evaluate from end of October 2014 to February 2015 with released variety Early Nantes. The trial design was RCBD with three replications. Recommended cultural practices of carrot were followed for the management of trials. The plot size was 5m^2 per treatment. Data only on root character were recorded and as most of plant of all the carrot varieties including Early Nantes did not form root due to late sowing time (received trial kits late). Root characteristics are given in Table 20. The trial will be repeated in 2015 season for yield and to pest and disease reaction.

Table 20: Root characteristics of carrot varieties.

Varieties	Root length (cm)	Root width (cm)	Root color
Ananya Desi Red	8.9	1.5	Pinks orange
Noorie	11.3	1.3	Pink orange
Early Nantes	4.9	1.3	orange

2.2.7 Vegetable production management

Home gardens, also known as kitchen, backyard, or nutrition garden, providing year round access to vegetables, are important to meet family nutritional requirements especially in areas where people have limited income-earning opportunities and poor access to markets. With the aim to scale up the home gardening practices throughout South Asia, RCSA and AVRDC have initiated a home gardening program in three states of India-Punjab, Jharkhand and Andhra Pradesh. A training on "Home Gardening" for participants from Bhutan and India was also organized. They have also developed 6x6m home garden models, where they include 25-27 crop for year round production with 12-13 crop per season (based on the crop preference and reasonability). Healthy diet gardening kits have been also developed are being distributed amongst the farmers for promotion of the concept of home gardening.

With the objective to promote the concept of home gardening to the visitors of the centre, same home garden models of AVRDC and RCSA was used with three replications. The crops included in summer/spring season were brinjal, tomato, chilli, bean, radish, ladies finger and gourd family. Cabbage, c/flower, broccoli, radish, carrot, bean and sag were included in winter season. Data on yield, sowing and harvesting date were recorded. The yield, sowing and harvesting date are given in Table 21.

Table 21: Yield data, sowing and harvesting date of vegetable (spring/ summer veg.)

Plot no	crop	Sowing date	T/planting date	Harvesting date		Yield (kg)
				From	To	
1	Brinjal		11/4/014	18/7/014	27/9/014	13.2
2	Chilli		"	18/8/014	29/8/014	3.3
3	Tomato		"	27/6/014	6/8/014	12.5
4	Bean	11/4/014		4/6/014	29/6/014	1.9
5	Radish	"		27/6/014	11/7/014	6.3
6	Ladies finger	11/5/014		15/8/014	30/9/014	5.8
7	Bitter gourd	"		"	"	1.8

8	"	"		"	"	1.7
9	"	"		"	"	2.5
10	Olachoto	"				No har.
11	"	"				Due to flo
12	"	"				drop
					Total	49

Table 22: Yield data, sowing and harvesting date of vegetable (winter veg.)

Plot no	crop	Sowing date	T/planting date	Harvesting date		Yield (kg)
				From	To	
1	Cabbage		19/9/014	23/12/014	30/12/014	13.6
2	Cauliflower		"	16/12/014	24/12/014	10.6
3	m.green		"	15/11/014	27/12/014	11.3
4	Brocali		"	21/11/014	6/12/014	3.6
5	Bean	19/9/014		8/11/014	6/12/014	2.8
6	Radish	"		21/11/014	30/12/014	3.0
7	Carrot	"		18/12/014	30/12/014	2.2
8	"	"		"	"	1.8
9	"	"		"	"	1.8
10	Lettuce			23/12/014	22/1/015	2.0
11	"			"	"	2.4
12	"			"	"	2.2
Total						58.3

Layout of Home garden

1. Area of kitchen garden = 6mx6m
2. Size: 3mx1m and 2mx1m
3. 5 blocks
4. 12 sub-plots
5. 3 replications

Table 21 and 22 show annual yield obtained from this home garden is 107.3 kg of fresh vegetable with 8 crops per season. However, this home garden will continue to record more data on fresh yield, sowing and harvesting date to give recommendation to farmers to showcase the concept of home garden to the visitors of the centre.

2.3 Medicinal and Aromatic plants program

2.3.3 Asparagus land races evaluation trial

The wild asparagus land race trial was established in the year 2009. It was established with the objective to domesticate wild asparagus and to generate appropriate technology for its cultivation and germplasm maintenance. However, the objective it not to harvest the spears but the

tuber, which has high medicinal value and can be marketed. There are seven land races collected from different altitudes in Tsirang, Punakha and Wangdiphodrang districts as indicated in the table below.

Table 23: Collection sites of *A. racemosus* landraces

Local name	Accession	Location	Altitude
Nyekhagchu	A. racemosus	Gaselowom, Wangdue	1200 masl
Nyekhagchu	A. racemosus	Nahi, Wangdue	1780 masl
Nyekhagchu	A. racemosus	Nahi, Wangdue	1700 masl
Nyekhagchu	A. racemosus	Nahi, Wangdue	1450 masl
Nyekhagchu	A. racemosus	Tshokhana, Tsirang	700 masl
Nyekhagchu	A. racemosus	Toeb, Punakha	1300 masl
Nyekhagchu	A. racemosus	Kabji, Punakha	1340 masl

Experimental trial is established in a lattice design with single plot at centre's station. 45 plants of all landrace are maintained in each plot. Asparagus crown were planted directly in trench applied with 2-3 kg of well-decomposed compost. The planting distance of 90 x 60 cm is maintained. The replanting was carried out in April 2014 as accidental flooding in June, 2013 resulted in deaths of almost all the plants. The basic management practices like weeding, application of compost and inorganic fertilizer and timely weeding and irrigation are carried out. The data on tuber yield per plant will be collected in coming season. No spear are harvested but cut off when it attains about 75cm to encourage maximum tuber growth.

2.3.4 Prickly ash (*xanthoxylum)* land race*s* evaluation trial

Zanthoxylum land race*s* evaluation trial was also established in the same year with the asparagus trial. It was established to study the wild and the cultivated species of *xanthoxylum* which are found in the country. It was undertaken to also to document wild and cultivated *xanthoxylum* species and races, identify potential races suitable for commercial production. The trial has not been doing well because of the location. The present location is prone to water stagnation whenever the nearby fields are irrigated. This has lead to poor growth of the trees. The species *xanthoxylum armatum* is for higher altitudes and is found not growing well under Bajo condition.

Therefore, the present location of the trial has to be shifted for the species *zanthoxylum beecheyanum*. The trees of species *xanthoxylum armatum* will be cut down and on-farm trial at a suitable location in higher altitude will be planned.

2.4 Mushroom production

Background

Figure 7: Oyster spawn

Mushroom plays an important role in income generation and creating employment opportunity. Unlike other crops, mushroom can be easily sold fetching a very good price as there is ready market. However, unavailability of spawns has always been a bottleneck and therefore, to meet the demand of the farmers, RDCs were entrusted with the mandate to multiply the mother spawn and also to provide other technical support for mushroom cultivation in the West Central Region in collaboration with National Mushroom Centre, Yusipang, Thimphu. With the appointment of one staff as mushroom focal person, spawn multiplication of oyster mushroom was initiated with the mother spawn support from NMC. Technical backstopping in shiitake mushroom was also provided to the farmers. A total of 950 bottles of oyster spawn were distributed till date to the districts under west central region. 718 were Wo-I of varieties and the rest are PBN.

Figure 8: Oyster mushroom in Sephu gewog

2.4.3 Shiitake Mushroom Program

Shiitake mushroom requires high level of technical expertise in spot identification of problems which needs to be addressed on the spot. With limited knowledge, it has become difficult to identify the related problem

and provide further solution without consultation of expertise. Therefore, RDC Bajo focused more on oyster mushroom production since it is easier in nature comparing to shiitake mushroom. With the development of technical capacity and other required facilities in the centre, the centre will scale up the shiitake mushroom in the region.

Table 24: Total number of billets inoculated

Sl.no	Dzongkhag	Households	No. of billets
1	Dagana	1	300
2	Gasa	3	1750
3	Tsirang	1	1500
4	Wangdiphodrang	5	2900

In the last financial year, the highest number of Shiitake mushroom was promoted in Wangdue with the total of 2900 billets followed by Gasa dzongkhags 1750 numbers of billet and Tsirang dzongkhag with 1500 numbers of billets. The least was in Dagana dzongkhag with 300 billets as shown in the table above.

Table 25: Oyster spawn distributed

Sl.no	Dzongkhag	House hold	varieties	qty. of spawn supplied.
1	Punakha	7	Wo-I	200
			PBN	30
2	Wangdiphodrang	10	Wo-I	385
			PBN	150
3	Gasa		Wo-I	90
			PBN	44
4	Tsirang		Wo-i	18
			PBN	3
5	Dagana	2	Wo-i	25
			PBN	5
Total spawn supplied				**950**

Monitoring

Since most of the farmers are taking this program for the first time, it has become crucial to visit the site especially during the incubation period. During this stage, the spawns are susceptible to spoilage due to insufficient/ unhygienic care. The frequent visit keeps the growers alert and enable us to provide necessary advice and recommendation in time. The involvement of extension personal at the time of monitoring has

become very important to share responsibility for obtaining highest degree of success rate.

2.5 Research Outreach Program (ROP)/On-farm Research (OFR)

The activities in the outreach programs are targeted to take the knowledge and skills that are generated in the research station or new ideas from outside the country into practice in the farmer's field. This involves the introduction of completely new crop, soil and crop management practices, better performing varieties and new crops to the farmer's field. The outreach programs are also taken up with the objective to promote commercial cultivation of crops especially fruits crops and vegetables. In the financial year 2014-2015, outreach programs were on development of demo orchards, commercial vegetable cultivation and ginger cultivation in Wangdue, Gasa and Punakha districts.

2.5.3 Promotion of Citrus through establishment of demonstration orchard

This activity aimed to show citrus growers on citrus orchard management based on an integrated crop health approach. It includes layout and design, proper soil and water management, good training and pruning, as well as integrated pest and disease management with emphasis on control against insect vector of citrus greening.

One acre orchard with 120 plants planted at spacing of 5m x 5m plant to plant and 5m x 5m row to row was established at located in Gamakha, Baap geog under Punakha dzongkhag. The Dorokha local is the variety grown in this demo orchard. The trees were planted on slope land and have good drainage. The orchard is well fenced and maintained properly.

2.5.4 Promotion of avocado through establishment of demo avocado orchards

The avocado demo orchard was established to demonstrate the proper management technology to farmer's in view of avoiding pest and diseases and timely fertilizer application, to disseminate the available technology to the farmer's field directly through on-farm demonstration and to serve as mother block for future propagation for farmers in the area.

The technical support with respect to site selection, lay out and planting were provided by RDC-Bajo in collaboration with the geog extension officers. The proper planting method and after care of the plantations were demonstrated to the participating farmers during the planting time.

One avocado demo orchard was established in Gamaluma village, Barp geog under Punakha dzongkhag. The total area of the demo orchard is an acre and 60 plants have been planted with spacing of 6m x 6m plant to plant and 6m x 6m row to row. In addition, about 83 non grafted and 27 grafted avocado seedlings were distributed to eight interested farmers of Gamaluma, after they attended the avocado orchard management training provided during demo orchard establishment.

At the same time, another avocado demo orchard with 28 seedlings was established in Rinzin Demas' orchard at Paulakha, Rubesa geog, under Wangdue dzongkhag. All avocado trees were planted on slope land and have good drainage. This orchard is also well fenced and maintained properly.

Table 26: Avocado seedlings distributed to farmers during June 2015

Dzongkhag	Geog	Village	Variety	Total Plants	
				Non-graft	Graft
Punakha	Barp	Gamaluma	Bacon	56	12
Punakha	Barp	Gamaluma	Hass	59	8
Punakha	Barp	Gamaluma	Lingmethang	0	7
Wangdue	Rubesa	Palokha	Hass	14	0
Wangdue	Rubesa	Palokha	Bacon	14	0
				143	**27**

2.5.5 Promotion of Soft-shell walnut through establishment demonstration orchard

This activity aimed to promote high value low volume crops to high landers, for income generation. The demo orchard will demonstrate the proper walnut management practices. Three walnut demonstration orchards planted with spacing of 6m x 6m plant to plant and 6m x 6m row to row, was established in Gasa dzongkhag. The orchards are located in two sites (two in Khatoe and one in Khamoe). In total 115 grafted soft shell walnut plants of local selections were planted.

2.5.6 Promotion of pecan nut through establishment of demonstration orchards

The pecan being a new crop, the demo-orchard was established to demonstrate the proper cultivation technology to farmers in the Punakha and Wangdue Dzongkhag. The technical support with regard to site selection, layout and planting were provided by RDC-Bajo in collaboration with the geog extension officers. The proper planting method and after care of the tree were demonstrated to the host farmers

during the planting time. The planting distance was maintained at 7m x 7m. One pecan nut demo orchard each in Wangdue and Punakha districts were established with 30 seedlings in Punakha and 20 in Wangdue. The demo orchard was established in March, 2015 in Kingley Wangmo's land at Lungsegang, Baap geog under Punakha dzongkhag and at Sumcho Pemo under Phangyul village in Wangdue.

2.5.7 Promotion of pomegranate through establishment of demonstration orchards

The technical support with respect to site selection, layout and planting were provided by RDC-Bajo in collaboration with the geog extension officers. The pomegranate demo orchards were established at Lungsegang, Barp geog under Punakha dzongkhag established during May, 2015 with 30 seedlings. In Phangyul, the pomegranate demo orchard was established with 20 seedlings in Sumcho Pemo's land in Phangyul village.

2.5.8 Promotion of Asian pear through establishment of demonstration orchards

RDC-Bajo in collaboration with the Gasa dzongkhag agriculture office had initiated and established three pear model orchards at Gasa. It was aimed to promote high altitude pear varieties to Gasa dzongkhag through establishment of pear model orchards in different locations with technical support from RC-Bajo. At the initial phase, rootstock seedlings were planted with spacing of 5m X 5m plant to plant and 5m x 5m row to row. Once the rootstock has properly established, RC Bajo will identify high altitude pear varieties, and carryout top working in collaboration with the Gasa dzongkhag agriculture office.

2.5.9 Improvement of local fruit cultivars by top working

- To improve local cultivars with improved and superior cultivars
- To diversify fruit cultivation by farmers

Material and Methods

Top working of local cultivars with improved and superior cultivars to diversify fruits in the locality, two nearby village were covered during April, 2015. The activity was carried out as few varieties of promising scion woods collected from RDC Wengkhar were available for grafting purpose. The numbers of top-worked fruit trees are as in detail in the table below.

Table 27: Details of top-worked fruit trees

Name of farmer	Village	Pear (Hosui)	Walnut (B17)	Peach (Nonome wase)	Plum (Oishi wase)	Citrus (Tayu)	Mango (Langra)
Tshering	Gamaluma	1			1		
Kinley Om	Laphuna	1		3	3	7	3
Namgey Lham	Laphuna	2	3	1			
Wangchuk	Laphuna	2		1	1		
Total		**6**	**3**	**5**	**5**	**7**	**3**

Recommendations

The purpose of outreach demonstration orchards are to demonstrate the performance of varieties, rootstocks or improved techniques of orchard management. RC Bajo had initiated few numbers of demonstration orchards within the region. There is no doubt that these orchards are playing an important role in dissemination of varieties and techniques. However, the follow up in terms of collection of meaningful data seems problematic. Therefore, clear guidelines need to be framed.

2.5.10 Assorted fruits and nuts model orchard at Walokha Nuns Buddhist College

Sangchen Dorji Lhendup Nun Buddhist College is located at Walokha village under Punakha dzongkhag at an elevation of 1550 masl. It was identified as outreach site in 2014 as per the command of the honorable Secretary of Ministry of Agriculture and Forest. The monastery has a total area of about 10 acres out of which about 2 acres of land are occupied by the monastery and other structures.

The orchard development plan for the 8 acres was prepared and land development works like levelling and terracing were done for about 2 acres of land. Blocks of different fruit crops were planned and mapped. The identified fruit crops for planting are avocado, pears, citrus, soft shell walnut, persimmon, loquat and pomegranate.

The fruit tree seedling planting was started from June, 2014 and about 5.5 acres has been planted with different fruit crops. The remaining area will be planted in March, 2016 as per the plan.

Table 28: List of fruit plants planted in Walokha Nuns Buddhist College
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Sl. No.	Fruit crop	Quantity
1	Mango	75
2	Avocado	75
3	Citrus	261
4	Loquat	30
5	Pear	45
6	Walnut	105
7	Persimmon	29
8	Pomegranate	40
	Total	**660**

2.5.11 Training school students on straw mushroom cultivation

In order to engage their student in meaningful learning and to inculcate the dignity of labor, the club coordinators of the Logodama primary school, Wangdue primary school and Technical Institute at Kuruthang requested for the technical support and materials for the oyster cultivation. Around 15 to 20 students including teachers and club coordinators attended the training which focused on straw mushroom cultivation and its management. The Centre supported with plastic, rubber band and necessary materials to the schools besides carrying out hands out training.

Figure 9: Logodama students participating in oyster mushroom training

2.5.12 Training on fruit tree nursery establishment and management

A total of 30 nursery growers and interested farmers of Punakha, Dagana and Tsirang districts were trained on nursery establishment and management. The trainings were conducted after the Hon'ble Agriculture Minister instructed that 50 acres of land be brought under fruits and nuts cultivation every year in a district. The Research and Development Centres were instructed to co-ordinate the program. The seedlings that

are produced from DSC would not be sufficient to meet the requirement to achieve this target, it was decided that farmers who are currently into fruit nursery business and the interested farmers would be trained to produce quality seedlings. In line to this, a list of interested farmers was collected through district agriculture office and accordingly they were trained.

The main objective of the training was to train the participants on how to establish, operate, maintain and manage the nurseries. The participants were also taught how to prepare scion wood, graft and budding seedlings, extract seeds, take cuttings, prepare nursery beds, prepare potting media and familiarized with nursery tools and equipments. They were also taught the functions and advantages of suing screen and poly houses.

The participants were familiarized / introduced to improved varieties of avocado, pecan, pomegranate, walnut, chestnut, mango, peaches etc. in the centre. The participants were also provided with seeds, scion woods and seedlings of improved varieties for raising rootstock in their nursery.

The training was very successful and the feedbacks received from the participants were very positive. Such training will help in producing enough quality seedlings and achieve our target to plant 50 acres of land with fruit crops ever year in a district. This will also help farmers to earn some income by selling their seedlings.

FARMING SYSTEMS

3.0 FARMING SYSTEM

3.1 Gasa Organic Outreach Program

Gasa dzongkhag was adopted as research out-reach site of RDC Bajo for organic farming, focusing on alternatives and best practices of organic farming particularly on pest, diseases and crop nutrient management since 2012. Relevant stakeholders and partners were identified as NOP, Horticulture Division, DoA, and Dzongkhag Agriculture extension to work for the organic program with the mission to enhance income and livelihood of farmers. The following activities were initiated and carried out during the fiscal year 2014-2015.

3.1.1 Upland Rice Demonstration

Upland rice (Kambja) demonstration trial was started since 2012 right after the inception of Orgainc Out-Reach program. Research and Development Centre (RDC) Bajo in collaboration with the Dzongkhag Agriculture sector of Gasa introduced upland rice in Khatoe geog as demonstration and on-farm trials in small areas in 2012. The objective was to evaluate the performance and adaptability of upland rice in this area. The result of the first year trial was promising and the performance was well accepted by the farmers. Thus it encourages more farmers to try at larger areas. So in 2013, the upland rice program was up-scaled to seven farmers cultivating upland rice on small areas with an average of half langdo land. By 2014 we had 10 farmers of Zamina and Baychu under Khatoegeog (2285 to 2465masl) growing upland rice covering almost 3 acres area in total.

The land preparation began in February and March with the clearing of area, followed by application of FYM which was spread evenly in the field. The land was then ploughed and prepared by removing the vegetative matters. After the land preparation, the Kamja seeds were broadcasted at rate of 30 kg per acre at the beginning of March. The first weeding was done when the seedling attained three to four leaves stage during the month of May. Due to prolonged monsoon and weed pressure, subsequently additional three hand weeding was done. Upon maturity, the crop was harvested in the month of November and the yield assessment was done through crop-cut. The result of the yield assessment is presented in Table 29.

Table 29: Yield assessment

Sl no	Farmer name	Village	Altitude (msl)	Yield per sample (kg/6m²)				Yield per acre	*SD*
				I	II	III	Average		
1	Lham	Baychu	2425	2.30	1.15	1.30	1.58	1066.64	0.63
2	Shena Zam	Baychu	2451	2.70	2.20	1.80	2.23	1504.52	0.45
3	Dem	Tsirina	2463	1.60	1.80	1.90	1.77	1190.14	0.15
4	Choden	Baychu	2352	1.80	1.50	1.80	1.70	1145.23	0.17
5	Gakhi	Baychu	2392	2.20	0.60	1.60	1.47	988.04	0.81
6	Zam	Zamina	2285	1.40	0.90	0.90	1.07	718.58	0.29
7	Karma Yuden	Datapangchu	2385	2.30	2.10	1.50	1.97	1324.88	0.42
Average								**1134.01**	**0.31**

Crop cuts were carried out with 7 farmers taking three samples of 6m² randomly selected areas. In total there were 21 samples crop cut. The average yield computed based on the crop-cut result is in 2014 is 1.13 tons/acre (±0.31) and the average number of tillers counted is 8.66 per hill. Although the yield is lower than in Eastern Bhutan (1.80 tons/acre), yet the technology is quite promising and farmers showed interest to go for larger promotion of upland rice. Although in smaller quantity, farmers are convinced that they have their own red rice produced from their field. Apart from its yield, farmers are more interested on the straw production which is very necessary for their livestock that includes cattle and horse especially for winter feeding. The result showed an average 3.33 tons/acre of straw was produced to supplement the livestock feed during winter. It reduced the cost of purchasing paddy straw and transporting it all the way from Punakha, which was their usual practice earlier. Table 30 provides the straw yield computed from each sample. The total straw production from upland rice cultivation at Gasa is computed at 10 tons approximately.

Table 30: Straw yield

Sl no	Farmer name	Straw Yield per sample (kg/6m²)				Yield per acre
		Sample I	Sample II	Sample III	Average	
1	Aum Lham	4.70	3.70	1.60	3.33	2245.56
2	Shena Zam	5.00	6.00	3.80	4.93	3323.42
3	Aum Dem	4.00	10.00	5.00	6.33	4266.56
4	Aum Choden	3.00	2.50	4.00	3.17	2133.28
5	Aum Gakhi	9.00	3.60	6.50	6.37	4289.01
6	Zam	5.60	5.00	6.30	5.63	3794.99
7	Karma Yuden	4.80	4.30	5.50	4.87	3278.51
Average					**4.95**	**3333.05**

Some of the constraints in upland rice production according to the farmers were during the early tillering stage there was an outbreak of army worm infection in the entire rice fields. As an intermediate measure, Neem oil was issued through NOP and farmers were advised to spray it to control army worm, which solved the problem besides the onset of

monsoon controlling the outbreak. Also since farmers had sown the Kamja seed densely, the effect of army worm was very negligible.

The other constraints were during the time of crop maturity when farmers faced problem of wild animal invasion and crop damage. Even there was report of bear and rodents attacking the crop during the maturity stage.

The demonstration concludes that the farmers were very satisfied with the crop performance and its yield. The feedback from farmers indicated that more farmers from the locality are interested in upland rice and would like to continue in the coming season covering more areas. This upland rice production program will ultimately contribute towards increased rice production in the area besides making availability of the paddy straw for their livestock.

3.1.2 Mustard Production Program

Mustard is a major oilseed crop grown in the country. However, there is an indication that the area and production of mustard in the country has declined over the years, which resulted in increasing import of cooking oil in the country from India. Technically and ecologically, Bhutan has the potential of achieving self-sufficiency in oil crops without displacing other crops. Khamae geog under Gasa dzongkhag has favourable agro-ecological conditions favouring mustard production considering the traditional mustard production practiced in the area by the farmers. Further, mustard plant releases biotoxic compounds or metabolic byproducts that exhibit broad activity against bacteria, fungi, insects, nematodes and weeds. It is also least preferred by pests and can be grown organically. Therefore, mustard production program was initiated at Khamae geog to evaluate mustard production through improved management practice to up-scale production and with the long term objective of marketing organic mustard oil in the local market.

During the first cropping season, 65 households were involved in mustard production covering 30 acres of wetland. The mustard seed was locally sourced out in the year 2012 and supplied to farmers for mass

production for the first time. Subsequently, farmers were advised to keep their own seed further for the following year. Constant monitoring for pest and disease attack was carried out. The crop matured after three months and yield assessment through cropcuts were taken from three villages with an area measuring 6 m^2. Table 31 presents the comparative result of cropcuts.

Table 31: Mustard Crop cut result for the Year 2015

Village	Altitude (msl)	No. of sample			Average yield per farmer	Average yield Kg/acre
		I	II	III		
Khalio		1.5	1.3	1.1	1.3	876.85
Yemina		1.3	1.4	0.9	1.2	809.4
Paniko		1.2	0.8	1	1	674.5
Damji		0.9	1.2	0.8	1	674.5
Average					**1.26**	758.81

The average yield computed for an acre is 758.81kg per acre which is higher than the previous years. This is attributed due the local seed adaptability in the area since we provided seed purchased locally from Khailo village.

There were no major pest and disease incidences observed during monitoring, only negligible incidences of aphid were observed. Farmers reported that they would further continue with the mustard production program and RDC, Bajo will continue to provide technical support. In addition, The NOP has supported the community by providing oil expeller for collective use. RDC Bajo will facilitate in developing the group by-laws for efficient and sustainable use of the oil expeller. It is estimated that in the coming season, the area of mustard production will be increase as per the consultative meeting held with the farmers and their plan. Further, in the coming year, RDC Bajo in collaboration with NOP and Dzongkag

administration will facilitate in packaging and marketing of organic mustard oil.

3.1.3 Pear Production Program

Pear Production and Marketing has been taken as one of the major activities of Organic Outreach Program, Gasa after the inception of outreach program. Technical support in orchard layout was carried out. Pear saplings were sourced and funded by NOP, Thimphu. Pear saplings were collected from NSC, Paro during February end and distributed to the farmers who have done pit digging and pit filling. During the fiscal year 2014-2015, 900 pear sapling were supplied to Khame farmers through the support from NOP. These farmers were demonstrated individually how to plant the sapling. They were demonstrated to keep the grafted portion above the soil and plant the sapling little raised from the surface. After the demonstration they were advised to water the plants for at least for two weeks if there is no rainfall. Around 48 households of Khame geog have benefited from pear plantation from 2013 till 2015. Daily monitoring of the orchards and technical assistance is carried out.

3.1.4 Garlic Production and Marketing

Garlic *(Allium sativum*) is a low volume high value crop, which is now in production by the farmers in Gasa dzongkhag. It is cultivated in commercial scale and considered as cash crop next to the potato. Khatoe and Khamae geogs in Gasa can produce diverse seasonal vegetables owing to favourable climate and rich soil. However, because of the unstable road conditions during monsoon besides having less population in the locality, the products are not absorbed within the dzongkhag. Subsequently, farmers were more careful in identifying and choosing the crops that have longer selflife, and garlic was one such crop of their choice. Garlic is a crop that has long duribility or shelf life for off-season marketing. As such, garlic production and marketing program was initated in the year 2012 with the objective to diversify organic crop production and enhance rural income. At the beginning of this program, garlic cloves was purchased locally by RDC Bajo from

Khailo and Damji villages and distributed to farmers of Khamae and Khatoe geog in 2012. In addition, farmers having their own seeds were encouraged to cultivate for assured market. The activity was continued with more farmers on larger scale of production. The farmers arranged their own seed by saving either from their last harvest or sourcing from neighbours. The major garlic growning ares are Khailo, Yemina, Damji at Khame geog and Bauchu, Tshirna and Remi at Khatoe geog. The total area of garlic cultivation in 2014 was estiamted about 5 acres.

RDC Bajo along with Dzongkhag Extension facilitated in monitoring, yield assessment and marketing of the produce. Based on the total land area of 5 acres, the total garlic production in 2014 was estimated at 5 MT. The garlic cloves were checked and sorted for appropriate quality and size to meet the market preferances. From the total production, RDC Bajo in collabaration with NOP facilitated in marketing of garlic in Thimphu Centennary market, Paro and Wangdue dzongkhags as seeds. The remaining were sold by farmers in small quantity at the local market in Punakha and Damji. The remaining stock was kept for home consumption and also as seed for next season.

Based on the income generated from the sale of the garlic, farmers are now motivated and encouraged to go for larger scale of production thereby increasing the area of cultivation. It is expected that in the coming year the production of garlic in Gasa will be double. To migitate the marketing problem, Dzongkhag Agriculture sector, Gasa and RDC Bajo will build capacity of farmers on garlic product diversification and production of garlic pickle, garlic flake, powder and find potential niche market.

3.1.5 Commercial vegetable production and marketing program

With the inception of organic program in Gasa since 2004, farmers had experienced and reported that there are diverse vegetable crops produced and it has solved problem of winter vegetable scarcity and increased self-sufficiency at household level. Owing to fertile soil and higher elevation, Gasa has advantage of producing summer vegetable and potential to capture good market when there is no import of Indian vegetable in the country. Therefore, the vegetable production program was initiated by RDC Bajo in collaboration with NOP and Dzongkhag Agriculture sector with the objective to enhance income through semi-commercial vegetable production.

The program was initiated in both Khatoe and Khamae geogs in May, 2012. It was started with a joint consultative meeting among

stakeholders and developed a joint activity plan for semi-commercial vegetable production. In total, 53 households were identified to start vegetable production in 20 acres of land. The potential market identified for marketing the vegetable were the local market, weekend market in Punakha and Wangdue, Centenary Farmers market in Thimphu and the Punatsangchu Hydro-power Projects.

To begin with the program, capacity building of farmers was done by providing basic training on vegetable production by the dzongkhag extension. Following the training, vegetable seeds were supplied by RDC Bajo for large scale production along with demonstration on nursery raising, transplanting, spacing and other management practices. The main vegetables crops promoted were cole crops (cabbage, cauliflower, and broccoli), root crops like radish and carrot, beans and pea seeds were also supplied for dual purpose to generate income and improve soil fertility. Besides, leafy green vegetables and garlic were also prioritized for commercial production since these crops are grown abundantly in the geogs.

Routine monitoring and field visits were done jointly by researchers and extension. Farmers reported the problem of crop damage by pest infestation especially the cutworm. To control the pest problem organically, hand picking of pest was practiced, in addition to use of cow urine solution at the ratio of 1:10 was recommended. Other pests like hopper and caterpillar also damaged nurseries, and bio-pesticides like neem oil, last straw and Jeevatu were provided by NOP as intermediate control measures. Liquid manure and Jeevatu solution were also made available at farms for pest/disease control.

The production from this semi-commercial vegetable program is sold at weekend market in Punakha and some farmers even take the products to Farmers Centenary Market in Thimphu. With the increased vegetable production in the locality, farmers also have an option to sell their fresh vegetables at the weekend vegetable market established at Damji to dzongkhag staff, boarding school, and other visitors in the locality. The weekend vegetable market was started in August 2014 by Dzongkhag in collaboration with RDC Bajo.

In future, there is the need to facilitate and establish marketing link between the producers and different consumers like Punatshangchu hydro-power projects and other potential buyers to sustain the program.

On-station activities

3.1.6 Production and maintenance of Dhaincha seeds

Production and maintenance of dhaincha ((*Sesbania acuteata*) a green manure crop seed is an on-going activity. The main objective of this activity is to maintain seeds of dhaincha and provide seeds for on-farm use. In 1014-2015, the sector produced 500 kg of dhaincha seeds and supplied to Agriculture Training Centre (ATC), Chimipang and to Punakha dzongkhag. The activity will be carried out to meet the seed requirement of the client dzongkhag and for trial purpose.

3.1.7 Vermicomposting

The sector is responsible to carry out organic on-station activities. In 2014-2015 the sector produced about 5000 kg of vermin-compost. The main objective of this activity is to produce vermin-compost locally using the local materials. The sector used the earthworms available locally. The activity will be carried out on research basis and in future the vermi compost will be analysed and accordingly the technology will be taken to on-farm especially on organic farming.

Forestry Sector

4.0 FORETRY

4.1 On station research

4.1.1 Evaluation of multipurpose tree species

The evaluation of multipurpose tree species (MPTs) is one of the on-going activities conducted by the sector on-station nursery. Different forest trees and other woody species including bamboo are evaluated in the nursery using different propagation technique. Species selected for evaluation is based on environmental condition and general public preferences; well some are based on their multiple uses. More priority is given to develop seedling propagation technique following different timing and also using different type of soil media, the species evaluated are basically meant for promoting Agro-forestry, private and community forestry.

The sector used two type of evaluation methods, one from seeds and other through vegetative cuttings (roots/shoot/branches/stem and rhizome. For example, peepal tree (*Ficus religiosa)* is used in traditional medicine for about 50 types of disorders including asthma, diabetes, diarrhoea, epilepsy, gastric problems, and inflammatory disorders, infectious and sexual disorders. Peepal tree is of great medicinal value. Its leaves serve as a wonderful laxative as well as tonic for the body. It is especially useful for patients suffering from Jaundice. It helps to control the excessive amount of urine released during jaundice. The leaves of Peepal are highly effective in treating heart disorders. It helps to control the palpitation of heart and thereby combat the cardiac weakness. Ayurveda makes an extensive use of the leaf of peepal due to the numerous benefits it provides.

4.1.2 Vegetative cuttings

Various economic trees and plants have been tried between February to May in 2014, the numbers by species, their mortality with success rate is presented in the table 32. The following tips were followed while preparing cuttings. Some figures of cuttings planted as an example are presented

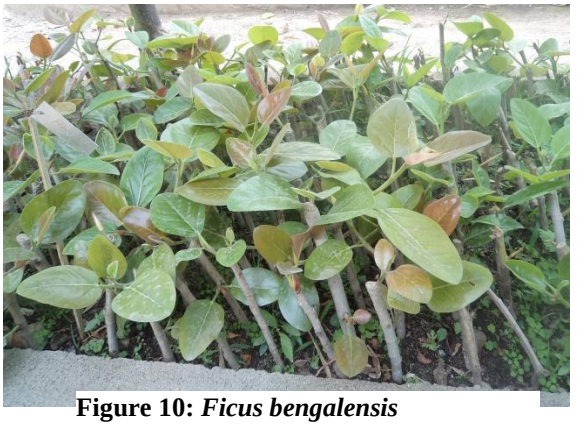

Figure 10: ***Ficus bengalensis***

Stems cutting, treatment and after care
General rule to follow

- Stem cutting should be taken during early morning hours – stock plants are to be hydrated
- Insert least one node below the media surface, two to three is better
- Place cutting in a bucket of water to prevent desiccation immediately after collecting

Figure 11: ***Euphorbia spp.***

- Always use sharp pruners/secature
- For most species, terminal cutting work best (depends on species)
- Always select cutting materials with good diameter (about thumb size but depends on species) – terminal cuttings are usually small.
- Select cuttings of 1-2 years old from a health mother plant

General steps to be followed are;

- Cut the woody stem at an angle
- Make the angled cut on the side of the closest bud
- Scratch/scrape the stem on the other side (wounding help better root initiation)

- Remove bottom leaves and/or cut bottom leaves in half to reduce transpiration
- Always use healthy, pest-free plants
- Maintain clean environment

Table 32: Results of vegetative propagation of MPTs

Sl No.	Species	Local Name	Qty.	Uses	Planting timing	%
1	*Ficus nemoralis*	Ficus	140	Fodder/ornamental	Feb-April	90
2	*Ficus benjamina*	Ficus	160	-do-	Feb-April	80
3	*Cacti*	Cactus plant	15	Ornamental	Feb-April	100
4	*Ficuselistica*	Rubber plant	400	-do-	Feb-April	95
5	*Ficus*	Jangchushing	200	Fodder/ornamental	Feb-April	95
6	*Bougainvillea(white)*		190	Ornamental	Feb-March	95
7	*Bougainvillea(Red)*		180	-do-	Feb-March	95
8	*Zanthozylum*	Thringa	300	Medicinal	Feb-April	80
9	*Duranta*	Hedges	500	Ornamental	Feb-July	98
10	*Fic us Tree*	Tshashing	300	Ornamental/Fodder	Feb-April	95
11	*Dendrocalamus spp.*	Bamboo	150	Ornamental	May	90

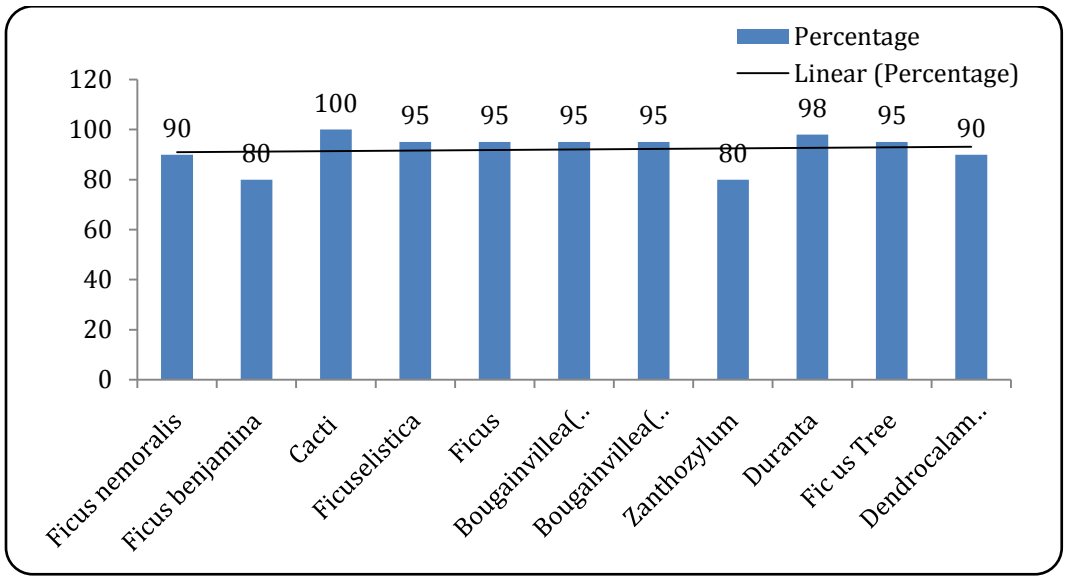

Figure 12: Results of vegetative cuttings by species

Table33: Seedlings supplied to organization, Institution and private individuals

SN	Species	Local/common name	Qty	Propose
1.	*Cupressus corneyana*	Tsenden	630	School
2.	*Meliag azaderach*	Jashing (Dz.)	145	School
3	*Phyllanthus emblica*	Amla	10	School
4	*Jacaranda mimosifolia*	Jakashing	460	School
5	*Quercus semicarpifolia*	Oak	30	Dartshang
6	*Callistemon Citrinus*	Bottle Brush	50	Dartshang
7	*Leucaena leucocephala*	IpilIpil	115	Dartshang
8	*Thujao occidentalis*	Thuja	10	Private individuals
9	*Albizia procera*	Sekpalashing	20	Private individuals
10	*Benthamedia capitata*	Dogwood	50	Private individuals
11	*Thevisa*	Lucky nut	90	Private individuals
12	*Duranta*	Hedge	630	Private individuals
13	*Silver oak*	Australian Silver oak	400	Institution (CNR)
14	*Syzygium cumini*	Ngatsi (Dz.)	250	Institution (CNR)
15	*Dendrocalamus species*	Bamboo	52	Institution (CNR
16	*Choerospondias axillaris*	Labsi (Lh.)	30	Institution (CNR
17	*Tamarind*	Titiri	10	Institution (CNR
18	*Thujag orientalis*	Thuja	10	Institution (CNR
19	*Delonix regia*	Gulmohar	400	Institution (CNR
20	*Saraca Indica*	Ashoka	120	Institution (CNR
21	*Araucaria columnaries*	Christmas	50	Institution (CNR Institution (CNR
22	*Olneyatesota*	Iron Wood	450	Institution (CNR
23	*Schefflera actinophylla*	Umbrella	450	Institution (CNR
24	*Quercus glauca*	Oak	50	Institution (CNR
	Total seedlings supplied		**4342**	

Table 34: Seed germination trial 2014-2015

Species	Local name	Collection/sowing period	Collection site	Germination %
Cupressus corneyana	Tsenden	Jan-Feb	Bajo	20
Melia azaderach	Jashing	Jan-Feb	Bajo	90
Phyllanthus emblica	Amla	Jan-Feb	Phayual	40
Jacaranda mimosifolia	Jakashing	Jan-Feb	Punakha and Bajo	95
Quercus griffithii	Oak	Dec-Jan	Dagana	50
Callistemon citrinus	Bottle Brush	August-Dec	Bajo	95
Leucaena leucocephala	IpilIpil	Jan-Feb	Bajo complex	95
Thuja occidentalis	Thuja	Jan-Feb	Bajo NSC	20
Albizia procera	Sekpalashing	March	Dagana D/gang	30
Juglans regia	Walnut	March	Dagana	90
Cassia spp.		April	Bajo	95

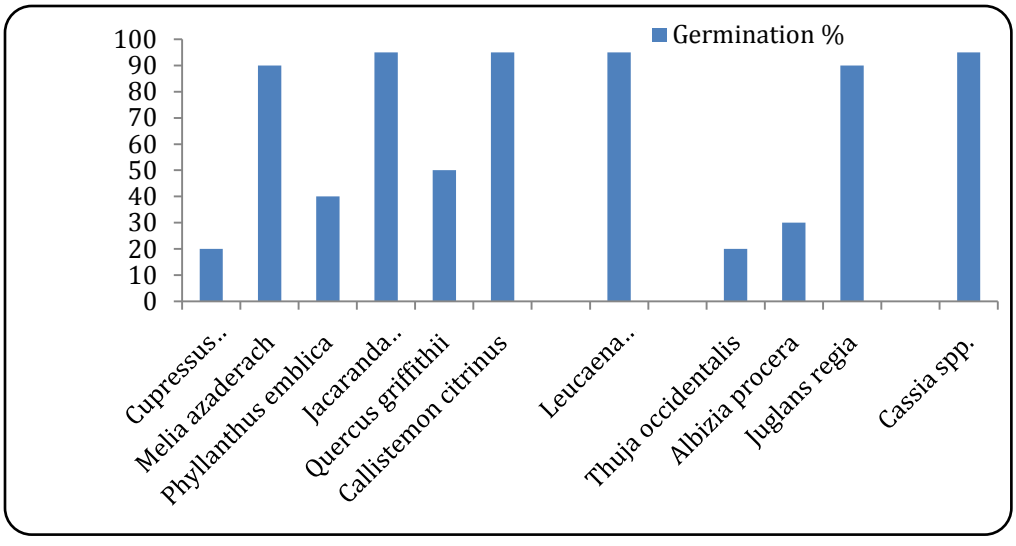

Figure 13. Seed germination trial

4.1.3 Maintenance of centre plantation and mini arboretum

Starting from year 1996 RNR-RDC Bajo led by forestry sector initiated forest tree saplings plantation around the campus. When viewed from other side of Punatshang Chu, the area used look very barren except with few Eucalyptus. In 1995 Punakha Wangdue Valley Projected (PWVP) provided monetary support of Nu 50,000.00 to establish screen house and nursery shed using bamboo mats. The project support was a great help, due to this center could establish shed house and nursery shed. After this, Multipurpose tree species (MPTs) seedling raising started. Different species of tree seedling were raised particularly focusing on broadleaf species which have multiple values. The actual broadleaf and ornamental plants plantation started from 2nd June 1996 and this program was kept as an annual event to this day. Currently the sector is maintaining 36 different trees, ornamental and 12 bamboo species. Centre still maintains the nursery to develop different propagation methods of MPTS.

4.1.4 Activities at ADTC Chimipang

As part of annual events to commemorate His Majesty The 4th King's 60th birth anniversary, a total of 2700 tree saplings were planted. The main objective was to rehabilitate the barren areas which are not suitable for cereal and other crops. The other aim was to plant mainly evergreen tree species as a windbreak since the area is too windy and dusty. The Lam of Chimilhakang was the chief Guest during the plantation program, the picture below depicts the inaugural plantation by the Lam.

The whole plantation group was divided into two groups; one group was led by Program Director and Forestry Sector Head and other group was led by ADTC Farm Manager and Sr. Forest Ranger. The Lam of Chimilhakang provided with refreshment and working lunch for all the participants. In total 40 participants took part during the plantation. The overall program was very successful and days program ended with vote of thanks to Lam, all staff and to ESPs of ADTC.

4.1.5 A low cost polyhouse

Two units of low cost screen house were constructed using locally available materials, the main materials used was bamboo and woods, the

poly house of standard size 10 x 5 meters. The cost benefit analysis of low cost poly house and conventional type was done.

4.1.6 Supply of Avenue trees to Bajo Muncipal (Bajo town)

The Program Director of RDC Bajo and Municipal personnel including Throm Dey Tshogpa and Forestry Research Officials and Horticulture of RDC Bajo had detailed discussion regarding supply of the MPTs and Ornamental and horticulture seedlings for plantation within and on the periphery of Bajo Town. The Forestry officials of RDC Bajo carried out a detailed site survey on 31/04/2015 & 01/05/2015 along with Municipal and Throm Dey personnel.

After the visit of Dasho Dzongda, Wangdue the centre supplied the following species of saplings (Table 35). The forestry sector also made timely visit giving advice on aftercare and management.

Table 35: Total plantation

Species	Local name	Quantity
Thevisa spp.	Lucky nut	200
Callistemon Citrinus	Bottle brush	71
Duranta spp.	Hedge	140
	Umbrella tree	5
	Iron wood	5
Dendrocalamus spp.	Bamboo	10
	Australian Silver Oak	3
Choerospondias axillaris	Lopsi	5
Euphorbia royleana	Wangchuk meto	16
Scheferia		20
	Total	**475**

4.1.7 Community Based Capture Fisheries Management in Hara Chhu, Adhang geog

RNR-RDC Bajo in collaboration with Department of Livestock (DoL), Wangdue Dzongkhag RNR Sector and JSWNP have formed the Hara Chhu Capture Fisheries Management Group in 2010 and accordingly handed over the management plan to Adhang geog communities. Adhang *Geog* comprises of seven *Chiwogs,* and among these, Rukha, Samthang, Lawa, Lamgang and Metena being traditionally dependent on fishing from Hara Chhu are considered to form the Harachhu Capture Fisheries Management Group (HCFMG) mainly for their livelihood and household nutrition. There are 72 household who are the beneficiaries from Hara Chhu and between 2010 – 2011 the communities have harvested **1157 kgs** fish as per the prescribed management plan.

In the past, the community mainly depended on fishing from Hara Chhu for livelihood. Besides fishing, the community depends on subsistence agriculture. The community is best known as source for *Nya-Doesem* (smoked fish). In the past the well-being of the community mainly depended on the success of seasonal fish harvest from Hara Chhu. The main product of Harachhu community is *Nya-Doesem*, prepared from snow trout using traditional smoking procedure. Fishes are caught/trapped using traditional methods/equipments such as *Drow* and *Dang.* The systems of fishing and dependence on each other during fishing within the community have evolved into a unique culture through generations. Therefore, it is of high importance that fishing in Harachhu should continue in view of preserving the identity of the community, specifically the traditional way of living as a fishing community. This will

also hold importance in view of preserving the original taste of *Nya-Doesem,* traditionally prepared from snow trout. Elderly member of the community still recall the payment of taxes in the form of *Nya-Doesem.*

Management Objectives

The formation of Harachhu Capture Fisheries Management Group (HCFMG) is meant to ensure sustainable harvest and management of fishery resources while improving household nutrition and cash income. Specific emphasis will be to manage the fish resources by putting sustainable community based conservation and management practices in place. Therefore, the specific objectives have been defined as follows:

Short term

1 Improve household level nutrition
2 Improve household income
3 Improve post-harvest processing and marketing of fish products
4 Empowering communities with rights, responsibilities and ownership to manage natural resources
5 Capacitate the communities in joint (cooperative) marketing

Long term

1 Poverty reduction
2 Promotion of eco-tourism
3 To promote flexible, resilient and sustainable management of capture fish resources

Activities

The history of bringing development intervention to those communities of Harachhu catchments started back in 2005 with a diagnostic survey to see the potential opportunities to uplift the livelihood of the communities (RNRRC, Bajo, 2005). This was followed by a feasibility study by Department of Livestock in 2007 (NCWFC 2007). A community consultation meeting was held in November 2009 with an idea to reaffirm the community's interests to manage the Capture Fishery in Harachhu (Dorji, 2009). This was followed by another meeting with the communities to elect the Committee members and also to discuss on the equitable distribution of fishing sites to all the subgroups (Gyamtsho & Dorji, 2010). After this, the resource management plan and the group by-laws were developed. The draft plan was later presented to all the village representatives in January 2010 to get final feedback and suggestion,

accordingly the plan was finalized in March 2010 and submitted to Department of Livestock for seeking further approval from Department of Forest and Ministry.

Until now there was no blue print document regarding the management regime of fresh water fish resources, thus, the current plan titled **"Harachhu Capture Fisheries Management Plan"** is to ensure legal fishing rights and sustainability of fish resources in Harachhu. The plan document spells comprehensive fish resources management strategies and group functioning mechanism. The plan is prepared for a period of five years and will be revised accordingly. The activities were conducted with financial support from EU-SLS Project based at Department of Livestock Thimphu.

4.1.8 Establishment of Bamboo arboretum at RNR RDC Sub-Centre Tsirang

Bamboo is a group of plants in the grass family (Family *Poaceae*). Some of its members are giants, and form the largest members of the family. Its stems, or 'culms', can range in height from a few centimetres to 30 meters (100 feet) or more, and from a diameter of a few millimetres (0.1 inch) to over 15 centimetres (6 inches). It is found in diverse climates, from cold mountains to hot tropical regions. It spreads mainly through its roots or *rhizomes*, which can spread widely underground and send off new culms to break through the surface.

There are 34 identified bamboo species from 15 genera found in the different vegetation types in Bhutan. Bamboos having multiple use to our rural communities some of these bamboos may get extinct if we do not implement *ex situ* conservation wherein we assemble and grow the collection of at least the bamboos that have high local and commercial demand. Therefore, seeing the potential the centre have initiated establishment of Bambusetum at Tsirang initially with seven different species of bamboo which are of high commercial value.

This would firstly preserve the bamboo species from extinction and also will act as a showcase for different bamboo species. The Bambusetum would serve as living bank for the bamboo species and will also provide information on bamboo, this can also serve as a useful facility for training and extension, research site for scientists, instructors and students of our country. Some of the exotic species that were introduced already will also be planted in the bambusetum to maintain diversity of species in the long run.

Objective:

a) To serve as *ex situ* conservation for both local and exotic bamboo species,

b) To maintain a living bank for the indigenous bamboo species, and

c) To demonstrate propagation techniques (vegetative/non-vegetative) for mass scale bamboo multiplication

Materials and Methods

Rhizomes, culm cuttings and seeds of all types of sub-tropical bamboo species will be collected from different parts of the country and plant following 6x6 meters distance (R-R and P-P).

4.1.9 Evaluation of multipurpose tree species

The evaluation of Multi-purpose tree species (MPTS) is one of the on-going activities carried out on station. The evaluation parameters are considered on the propagation techniques and its husbandry. Species are selected for evaluation taking in consideration the farmer's preference and its important uses. The main focus is on the native tree species which has multiple use and can be promoted in agro-forestry, private and community forestry programs.. The main research focus in the nursery is to critically look at propagation techniques either through seeds or other vegetative means. Basically two different types of propagation methods are used i.e. through seed and by vegetative cuttings (root/shoot/branch/stem/nodes) or rhizomes. The former is use for seed bearing important agro-forest species, while the later is used for important species with long seeding cycle especially bamboos and also for woody perennial species. Sometimes both the methods are also tried for species which has economic importance.

Species	Local name	Uses	Remarks
12 species of bamboo			
Albizia procera	Siris (Lh.)		
Phylanthus embilica	*Amla*		
Atrocarpus fraxinifolious			
Boungainvellia Red			
Boungainvellia White			
Araucari cookii			
Cassia semia			
Cassis fistula			
Choerospondias axillaris	Lapsi (Lh.), Hog Plum Eng.		
Cupressus			
Duranta spp.			
Euclyptus			
Ficus elastica			
Ficus bengalensis	Bar (Lh.), Indian banyan tree	Has Medicinal uses Properties	
Ficus religiosa	Peepal		

Ficus roxburghii	Fodder		
Terminalia bellerica	Bahera,(Lh.)	Medicinal	
Jacaranda mimosifolia		Ornamental, fuel-wood	
Khanyu			
Morus alba	Kimbu (Lh.)	Fodder, fruits	
Euphorbia pulchemeria	poinsettia, Christmas star, Christmas flower	Ornamental	
Leuceanea diversifolia			
Leucaena leucocephala	Ipil Ipil, White Leadtree	Fodder	Leguminous
Melia adzerach	Jashing (Dz.)		
Poplus			
Paulownia tomentosa	empress, princess, or foxglove tree		It is fastest-growing tree
Purnus			
Robinia pseudoacacia	black locust		
Schefflera actinophylla	Queensland umbrella tree, octopus tree and amate	Fodder, land management, ornamental even as drugs for animals	
Salix babylonica			
Thevisa			
Thysanolaena (broom grass)			
unknown spp. around veg field			
Wild cane			

Regional Research Communication

5.0 Regional Research Communication (RRC)

The Research Communication sector is mainly responsible for disseminating successful research results of all research disciplines of the centre to the extension system of various departments for their adoption and adaptation. It is largely done through extension leaflet distribution, organizing study visits in the centre, field days, review workshop and online information sharing. This sector also coordinates the maintenance of technology parks in the extension centre for demonstrating the successful technologies. Besides, it is also a focal sector for imparting training and backstopping the farmers groups formation and supporting school agriculture program in the region.

5.1.1 Technology dissemination

Publication of extension materials

The publication of the centres newsletters have been discontinued but this centre produces extension material from time to time depending on the emergence of new technology from the centre.

5.1.2 Coordinate centre visit by farmers, students and official guests

During this fiscal year 2014-2015, this centre have been visited by various groups of visitors comprising of farmers, students from various schools & College of Natural Resources, Dzongkhag RNR Extension staff, Research Assistants and other training institutes. Learning objectives of visitors varies from one group to another but in general they are interested on the relevant technologies available in this research centre.

It has been found that farmers are more interested in seeing new crop varieties, which are high yielding. Extension personnel are also keen on new technologies and information related to those technologies. Students are happy to see whatever is available in the field during the visiting season. Altogether there were 30 various groups who visited the centre this year alone.

5.1.3 Technical support to the existing farmers group

This centre provides technical support to farmers group in its formation stage and later on as well. During this year no groups from this region approached this centre through the Dzongkhag for any technical assistance.

5.1.4 Extension methodology research

Although no serious research work had been done by this sector, other sectors have already embarked on the outreach program based on the focus of the program and Communication sector has been actively involved in the group dynamics and record keeping in form of audio visuals. Since three years back, RDC, Bajo had embarked on an Outreach Program in the far-flung communities. A community is selected and supported in terms of input and technical backup for a fixed period of time. This program aims at improving the food self sufficiency in a sustainable manner and raise the living standard by increasing cash income through cash crop production at semi commercial level. Group formation is a part of the process adopted to efficiently utilize the inputs from outside, to improve their bargaining power and gain easy access to inputs.

5.1.5 Co-ordinate development of one model Technology Park in each Dzongkhag

Model Technology parks exist in all the Dzongkhags of this region. These Parks had been developed with the assistance of this centre for showcasing new technology in the gewogs. Any new varieties of fruits and vegetable which are promising are displayed in this centre.

5.1.6 Information Management

Under this program, detailed lists of RNR publications produced by RDC Bajo as well as publications shared by other sister RDCs have been collected. Library cataloguing is being continued.

5.1.7 School Agriculture Program (SAP)

Presently the School Agriculture Program of the HQ has not requested the centre for any specific support. However two groups of students have visited our centre this season to see the research activities and to interact with the researchers.

5.1.8 Information Management

This sector not only manages a library in the centre but also is responsible for the annual agriculture survey. As a focal parson this sector co-ordinates the implementation of the survey and crosschecking of the data abnormalities before being submitted to the Department.

RDSC TSIRANG

6.0 RDSC Tsirang

6.1 Rice

6.1.1 Seed Maintenance and Production of released varieties

One of the major activities of the center is to maintain basic seed and adequate production of released varieties recommended for higher elevations. As mandated, the following quantities of seed were produced (Table 36) which will be exclusively used for promotional program in the potential rice growing areas.

Table 36: Quantity of paddy seed produced in 2014 season

Variety	Productivity (t ha^{-1})*	Quantity (Kgs)
Khangma Maap	3.6	1000
Wengkhar Rey Kaap 2	4.1	500
Total		1500

*Data averaged of three observations

6.1.2 Participatory Varietal Selection of traditional varieties

The DARE or BUCAP III project activities were continued in 2014 season at existing site of Drujeygang, Dagana with the objectives of strengthening the capacity of local communities in Plant Genetic Resources management, contribute to conservation of traditional cultivars, and improve food security through crop diversification. As the activities were spill over of previous year, rice and maize received the major attention.

Nabja and Shengana Maap are some of the most popular and preferred traditional paddy cultivars in Wangdue and Punakha Dzongkhags, not by the farmers themselves but among the consumers outside the Dzongkhags. They are known for better eating quality and taste and hence fetch a premium price in the local market. As Drujeygang share similar agro-ecological conditions with the rice ecosystem of Wangdue and Punakha and these varieties are currently not cultivated in the project site, a need was felt to introduce and evaluate these cultivars. Therefore, the main objective of this activity was to assess their adaptability and production potential leading to varietal diversification if found promising.

The seeds, to the interested farmers, were supported by the project. Crops were raised under farmers' management conditions. Research and extension technically backstopped the farmers during the critical stage.

During the harvest time, a field day was conducted where both the growers and non recipients jointed evaluated the varietal performance.

Considering the crop cut data, the new varieties did not produce higher grain yield than the existing local cultivar (Table 37). The obvious circumstances leading to this are unknown but possible factors could be due to poor soil fertility in the new site, poor agronomic management including external fertilization and/or its weak capacity to adapt to new environment. However, farmers really appreciated its grain size, the boldness, and such variety is reported to have high milling recovery. Owing to the grain boldness and also to re-assess, farmers (both project and non project) would like to continue in the 2015 season. Project is exploring to support the seed and evaluate for the second season.

Table 37: Grain yield of introduced and existing paddy cultivars at Drujeygang

Variety	Grain Yield (kg/ac)	Remarks
Shengana Maap	752	Introduced
Nabja	689	Introduced
Attey	1006	Existing

6.1.2 Introduction of local upland rice cultivars

The project site has a considerable area, both wetland and dry lands, which are compelled to be fallow mainly due to water scarcity. The reports in eastern Bhutan have claimed success in cultivating rice under rainfed conditions particularly in dry lands. This was encouraging given that rice can be grown even under rainfed conditions without needing assured irrigation.

Project farmers were also excited about such option, and hence wanted to evaluate in the site. Hence, Zanthil was introduced from eastern Bhutan with the project supporting the seeds cost. Farmers exercised their past experiences in sowing the seed, both in timing and rate. Some farmers have also reported of sowing seed in the wetland where there was no supplementary irrigation.

Farmers reported positive feedback of the variety as it could yield appreciably even under rainfed situation (Table 38). Similar performances were also observed in wetlands where there was no assured/supplementary irrigation. Given this success, farmers have demanded about 300 kgs of seed for the following season which would be cultivated in both dry and wetlands where irrigation water is not required. This is expected to contribute in strengthening the food security through horizontal rice production.

Table 38: Grain yield of upland and irrigated paddy cultivars

Variety	Grain Yield (kg/ac)	Remarks
Zangthi	940	Rainfed
Attey	1006	Irrigated

6.2 Maize

6.2.1 Community based seed production (CBSP) of released cultivars

Being a cross pollinated crop, maize seed production and quality maintenance is a greatest challenge. Because of this, crop is highly vulnerable to varietal deterioration and is one of the main concerns and feedbacks from the farming communities. In addition, the main attention to improve the seed replacement ratio particularly for crosses pollinated cereals such as maize, demand quality seed. Chaskarpa Ashom and Shafangma Ashom, the two recently released cultivars with high yield potential and disease resistant, were selected.

Farmers received improved package of practices during the critical crop stages. Major emphasis was during tasseling, cob selection at harvest and seed selection after harvesting. The following quantities of quality seed were produced (Table 39 which were purchased through various funding sources and promoted to newer areas in 2015 season.

Table 39: Quantity of Maize seed produced at CBSP sites in 2014 season

Dzongkhag	Site	Variety	Qty of seed produced (kg)
Dagana	Shamdolay	Chaskarpa Ashom	850
	Drujeygang	Shafangma Ashom	1000
	Total		**1850**

6.2.2 Seed Production and Maintenance of released and promising varieties

One of the major activities of the center is to maintain basic seed and adequate production of released and potential varieties. As mandated, the following quantities of seed were produced (Table 40) which will be exclusively used for promotional program in the potential maize growing areas.

Table 40: Quantity of Maize seed produced in 2014 season

Variety	Quantity (Kgs)	Remarks
Chaskarpa Ashom	720	Released
Ganesh-II	100	Pre-release

Total	**820**

*Data averaged of three observations

6.3 Wheat

6.3.1 Initial observation of BARI[1] Lines

The wheat coordinating center has received four recently released BARI lines through SAARC Agriculture Center, Dhaka. The main objectives of this introduction were to assess the adaptability, disease resistance and yield potential under our local farming conditions.

Being in early evaluation stage, trial was laid out in a single observation plot. The crops were nourished with recommended dose of inorganic fertilizers; and irrigations provided at critical/needy stages.

With exception to BARI GOM 27, the other 3 lines showed great susceptibility to yellow rust at vegetative stage (Figure 14). This could be justifiable as Bangladesh never experiences cool weather conditions during wheat season for yellow rust to develop. Our cool winter conditions, even at Bajo trial site, had favored the yellow rust development on susceptible host such as these three BARI lines. On the other hand, BARI GOM 27 showed good resistance as this is the CIMMYT material from Mexico which was widely and vigorously tested for yellow rust elsewhere; and have even been commercialized in a number of wheat growing countries

Figure 14: Yellow rust

Notwithstanding with the disease susceptibility, these three BARI lines have bolder grains and produced appreciable yield (Table 41). Therefore,

[1] BARI: Bangladesh Agricultural Research Institute

it is planned that these lines be tested in lower elevations of Bhutan in 2015 season where winter is not too harsh for yellow rust to develop. While other two rusts (brown and stem) may be favored by warmer conditions in lower areas, these lines are known to be resistant.

Table 41: Agronomic traits of BARI wheat lines in 2014 –15 season

Treatments	Days to 50% Heading	Days to Maturity	Plant Height (cm)	Grain Yield (t/ha)
BARI GOM- 25	94	151	96	3.8
BARI GOM - 26	94	151	88	3.8
BARI GOM 27	94	151	97	4
BARI GOM -28	94	151	98	3.6
Gumasokha kaa	82	151	96	4.3

6.3.2 Initial Observation of Bio-fortified Wheat

There is a growing concern of malnutrition in the developing countries through non-availability of required amount of iron and zinc. This is more so in countries where wheat is the main staple food. The attention, therefore, is to provide supplementation of these minerals through wheat which is enriched with the minerals.

Two advanced lines were introduced to assess their adaptability and yield potential. Trial was organized in a single observation plot; and required agronomic practices were provided for optimum plant growth and development.

Both the entries succumbed to stripe rust resulting into low yield (Table 42). In addition, the grains were smaller in size which is usually not preferred by the Bhutanese farmers. Therefore, these entries will not be advanced for further evaluation.

Table 42: Agronomic traits of biofortified wheat lines in 2014 – 2015 crop season

Treatments	Days to 50% Heading	Days to Maturity	Plant Height (cm)	Grain Yield (t/ha)
Bajo Zn - 3	94	151	97	2.6
Bajo Zn - 5	94	151	110	3.5
Gumasokha kaa	82	151	96	4.3

6.3.3 Disease survey and surveillance

Surveys were organized from March through June, 2015 to monitor the wheat rusts situation in Bhutan using the standard BGRI survey methodology. Eight major wheat growing districts (Punakha, Wangdue,

Paro, Haa, Trongsa, Bumthang, Tsirang and Dagana) were covered during the period. It is a good representation to understand the rusts scenario in Bhutan. In addition, aecia infections on *Berberis* and *Mahonia* sp. for the possibility of acting as alternate hosts for rust (yellow) were also monitored.

In the farmers' fields, yellow rust incidence was found to be much lower than the previous seasons. This was largely due to replacement of susceptible cultivar (Sonalika) by the newly released rust resistant varieties (Gumasokha Kaa and Bajosokha Kaa) particularly in the mid and low wheat growing areas. However, higher incidence and severity of stripe rust were observed only in the research plots in some of the elite BARI lines in the screening nurseries.

Leaf rust continued to be prevalent and was mostly confined in warmer wheat growing areas. However, the severity was low and appeared late in all the surveyed sites, which would not have caused significant damage. This disease development in a susceptible host is confounded by the early appearance of yellow rust. Stem rust was not spotted in any of the sites both during the early and late season visits. The previous scoutings had also not observed stem rust in Bhutan. Among the six sites, five had the *Berberis* with aecia infections which were closed to wheat fields. To assess their functionalities in the yellow rust epidemiology (in case of Bhutan), samples were dispatched to regional and international reference centers.

6.3.4 Participatory Varietal Selection cum Seed Production of dry land wheat

Following the selection of three lines by farmers in the previous season, further evaluation was done to narrow down the lines and provide the farmers with the best variety of their preference. As in the past years, crops were raised under dry land condition which was sowing after maize harvest.

In this season too, farmers were called for the selection at harvest time. Based on plant height and compactness of spikes, farmers have chosen NL 1073. The yield data also supported farmers' preference (Table 43). Seeds of this particular variety had been promoted to participating farmers and mass seed production is planned in the 2015-2016 season.

Table 43: Grain yield of three dry land wheat lines in 2014-2015 season

Line	Plant height (cm)	Grain Yield (t ha^{-1})
BL3235	70	1.2
BL3503	83	1.7
NL 1073	88	2.5

6.3.5 Basic seed maintenance of released and potential cultivars

With the developmental mandate assigned to Research Centres, adequate seed production is mandatory and pre-requisite too before wider on farm evaluations. Additionally, the releasing agency is also obliged to maintain basic seed for future use and production. Given these responsibilities, RNRRDC Bajo had produced the following quantities of seed of both released and pipeline varieties (Table 44). These varieties will be used for on farm evaluation and mass seed production for ensuing seasons use.

Table 44: Quantity of wheat seed produced in 2014 – 2015 season

Variety	Quantity (kgs)	Remarks
Bajoka 2014	45	Elite line and demonstrating huge potential in grain yield and disease resistance
NL 1054	65	Elite line and demonstrating huge potential in grain yield and disease resistance
NL 1073	255	Candidate for release under dry land, maize based system
BARI GOM 25	95	Elite line to be tested in lower elevations
BARI GOM 26	105	Elite line to be tested in lower elevations
BARI GOM 28	110	Elite line to be tested in lower elevations
Bumthang Kaa	280	Released as winter/facultative wheat in
Drukchu		2015
Gumasokha Kaa	35	Released as spring wheat in 2014
Bajosokha Kaa	40	Released as spring wheat in 2014
Total	**1030**	

6.3.6 PVS of wheat varieties

The project area is predominantly a rice area, and land after rice harvest is kept fallow. Irrigation water is not a major constraint to barren these lands. Thus, there is an immense opportunity to optimally utilize this fallow land through cultivation of second crop after rice.

Wheat is not a new crop to the farmers. They have the history of cultivating and consuming in the past. However, the trend has changed in a decade or so due to improvement in purchasing power of imported

products and changing dietary habits. Farmers still consider wheat as an easy crop both in raising and managing.

With their keen interest shown towards this crop, 500 kgs of wheat has been supported covering about 20 households over an area of 13 acres. The crop performance, however, was very poor yielding about 500 kgs per acre. This was mainly due to poor nutrition as farmers did not apply any urea because of unavailability and also have the preset notion of land degradation by urea.

6.4 BUCAP[2] Activities

6.4.1 Promotion or Revival of Mustard Cultivation

Mustard is an important oil crop which provides fat requirement to the farmers. The vegetative parts are also used as vegetables further signifying its importance. Though an important crop, its cultivation has been constrained by lack of quality seed, wild animals' damage, and cheaper imported products.

The project wanted to revert mustard cultivation in the communities to contribute in oil sufficiency, substitute import and diversify the farm at individual household level. Being the initial phase, 210 kgs of locally available seed were distributed to 12 farmers covering about 10 acres. The crop on an average yielded about 650 kgs per acre which is appreciable considering the low inputs and minimal management practices. Farmers in total could market 1000 kgs of mustard seed which inculcate the farmers on its potential as cash crop.

[22] Biodiversity Use and Conservation in Asia Program

7.0 RDSC Tsirang

7.1 Horticulture

7.1.1 Persimmon varietal (adaptation) evaluation trial

The persimmon is a new fruit in Tsirang region although the climatic conditions are congenial for its cultivation. The trial was set up at Mithun on station (1600 m asl) to study the adaptability, yield performance and provide diversification to the local farmers and market. The trial was established in 2007 planting the local persimmon rootstock (astringent type); and an improved variety non-astringent type (Fuyu) was grafted on these local rootstocks in 2009. The trial consists of 15 plants. The trial was layout maintaining 4mx4m plant to plant spacing.

The growth/development of the plants is slow which may be due to cold. However, no major pests and diseases were observed except for minor incidence of beetles. Adults feed on the upper surface of foliage, chewing out tissue between the veins. This gives the leaf a lacelike appearance if timely sprays are not done.

Out of 15 plants, only four plants had fruits in 2013. Since, there were only two to three fruits borne in the trees, no data was maintained. In 2014 season, seven trees had the bearing. The mean yield per tree was two and half kilograms. Total soluble solids (TSS) level recorded at the time of harvest was 12%.

In Damphu condition flushing starts from mid February and likewise flowering starts from first week of March. The fruits mature by last week of September.

Figure 15: Persimmon fruiting

7.1.2 Kiwi variety evaluation trial

Considering the potentiality of kiwi in cash generation, varietal evaluation was established in 2007 with three plants each of Thimphu 1, Thimphu 2 and Thimphu 3. These three collections are from Thimphu. In 2014, another collection from RNRRDC Wengkhar named as Wengkhar Yellow was added. The plants are laid following triangular system maintaining 5 x 5 m spacing. The vines are trained in permanent trellis framework adopting pergola system.

Though at recommended agro-ecological conditions, the growth of plants remained poor which may be due to poor soil condition and extreme climatic condition in the current testing site. Among the Thimphu lines, only Thimphu 1 has started fruiting since 2012. The average yield per plant was 1.13 kg. . Total soluble solids (TSS) level recorded was at 12.5% at the time of harvest on average.The non-bearing of other two lines could be because of male dominance; and the close examination of inflorescence of other two lines confirmed this. Top working has been organized in these two lines. The buds break starts by mid February and flower by April. Harvesting was done in mid of November in Damphu condition.

Figure 16 Kiwi on-station trial

7.1.3 Pecan adaptation trial

The pecan adaption trial was established in 2007 with 15 plants. It was planted un-grafted saplings of western Shelly varieties. Although the growth of the plants is quite good, fruiting is yet to start. This year two plants were found to flowering indicating that crop is attaining reproductive stage. No major pests or diseases were observed as of now.

7.1.4 Peach varietal trial

The peach varietal trial was established this year. The trial consists of five varieties: four varieties from RNRRDC Wengkhar (Beauty cream, Matsumori, Nonomewase, Kurataki) and a local check mostly grown around Damphu area. The purpose of the trial is to assess the performance of different varieties under the agro-climatic condition of Damphu, Tsirang. Eight plants each of six varieties are planted in the trial plot. The lay system followed is square system maintaining the spacing of 4m x 4m between row to row and plants to plant, respectively. The growth of plants is very fast and within a year it has almost attended two meters height.

7.1.5 Maintenance of released fruit and nut cultivars

The released fruit and nuts cultivars block was established in 2006 with the spacing of 3m x 3m plant to plant spacing. The Block consists of eight varieties of released fruit and nuts cultivars with five plants each. The variety are Pomegranate (Chowla), Peach (July Elberta & Shani Punjab), Pear (Chojuro, Hosui and Kosui) and Apple (Anna). In total the block consists of 40 plants.

The main objective of maintaining the block is to suffice the need of scion woods both on-station and on-farm propagation. Besides, the purpose of the block is to showcase the technology to the visitors such as farmers on study tours, students in the nearby area and local passerby. As envisage, scion wood collections are done yearly during top working exercise in Tsirang and Dagana regions.

7.1.6 On-farm fruit plants propagation program

Apart from mandarin, Tsirang and Dagana are also enriched with other diverse fruit crops. Most of these are local types from the self grown plants. In order to improve these local cultivars, hasten the fruiting, contribute to daily diet and earn cash income, top working program with different improved cultivars was carried out (Table 45). While the available scion woods from the center were fully utilized, the non available ones were sourced and topped up from RNR-RDC, Wengkhar.

Table 45: Numbers of assorted fruit plants top worked in 2014 - 2015

Dzongkhag	Geog	Total HHs	Qty. (No.) & fruit varieties				
Dagana			Peach	Plum	Apricot	Pear	Apple
	Drujeygang	54	135	86	0	27	4
	Tshangkha	35	151	47	0	16	11
	Tashiding	27	132	1	28	2	0
	Tshendeygang	11	39	25	18	5	8
Tsirang	Kikhrothang	3	10	0	0	3	0
	Rangthanling	27	57	31	14	11	0
	Total	**157**	**524**	**190**	**60**	**64**	**23**

Taking the advantage of the training materials and participating farmers, hands-on-training on propagation was also imparted to the farmers. Farmers were also briefed on the aftercare of the top worked trees.

7.1.7 Nursery management and propagation

With the developmental mandate, the centre has to promote and demonstrate varietal technologies to potential areas. In addition, Dzongkhags' and farmers' requests have to be entertained for which the seedlings are invariably required. Therefore, the following assorted fruit saplings were propagated and maintained.

Table 46: Number of assorted fruit seedlings produced and maintained

Variety	Nos. of seedlings produced	Nos. of grafted saplings
Avocado	300	40
Kiwi	300	-
Persimmon	200	-
Pear	2000	350
Peach	1000	250
Plum	-	100

7.1.8 Fruits and nut research outreach plantation at Sunkosh

In many of the remote villages, the research technology has not been reached. So, given the suitable agro-climatic condition of the villages and as a measure toward poverty alleviation, RDSC Tsirang initiated the fruits and nuts research outreach reach plantation at Sunkosh village under Rangthangling geog in 2012.

The Sunkosh village consists of in 26 households and it is one of the remotest villages in the geog. The plantation consists of Litchi, grafted mango and areca nut. The objectives are to enhance the rural livelihood

through the earning from sale of fruit crops and to improve the nutritional intake of the community.

The farmers training on planting, manure application, mulching and after-care of fruit crops were provided at the time of planting. The fruit tree planting was supervised jointly by researcher and geog extension agent until its completion. Constant monitoring and evaluation is currently on-going.

7.1.9 Assorted fruit outreach program at Lungshigang

Lungtsegang under Tsirang Dzongkhag is adopted as a research outreach site for assorted fruits in the year 2009. The fruits promoted in this area include mango, avocado, and guava as the citrus is not suitable in this area. Mango and avocado has already fruited since 2013. Avocado and mango can be seen at roadside sale during the season.

No major problem was reported initially for mango however in last season mango weevil reported on crop damage causing immature fruit drop. Also few trees of avocado trees were infected with phytophthora rot.

7.2 Cardamom Repository at RDSC, Tsirang

The Cardamom Repository at RDSC, Tsirang was established in 2012. A total of 2.8 acres land was marked for establishment of germplasm collection, evaluation and multiplication blocks. The cardamom repository was established with the following objectives.

- To maximize diversity of large cardamom germplasm by collecting both wild and domesticated varieties in Bhutan and from outside Bhutan.
- Comprehensive data recording on habitat, habit, disease resistance and other important characteristics like variability in the land races.
- Identify suitable varieties for different agro-ecological zones through trials in different location from the accessions collected.
- To generate the overall crop management package.
- To set up on-station demonstration block to show case the available management technology.
- Produce disease free planting materials of the popular varieties in the long run.

There are 26 large cardamom accession collected from Zhemgang, Chhukha and Sarpang Dzongkhags from 2012 to 2014. In 2015, additional accessions were collected from different nineteen locations from Samtse, Dagana, Sarpang, Chukha, Zhemgang and Tsirang. The details of collection in 2012 - 2014 and 2014 - 2015 are detailed in Table 47 below.

Table 47: Cardamom collection

Indigenous and wild	Exotic and cultivated	Total lines
Amomum aromaticum (2)	*Amomum subulatum* (7)	9 accession
Amomum dealbatum (2)	*Amomum subulatum* (6 nos)	8 accession
Amomum kingie (3)	*Amomum subulatum*	3 accession
Amomum aromaticum (6)	*Amomum subulatum*	6 accession
13	13	26

Name (Local)	Location	Total lines	Remarks
Golsai	Tashithang,Gesarling, Dagana	2 lines/6 sucker	
Golsai	Lalikaharka, Dunglagang, Tsirang	2 lines/6 suckers	
Barlange	Bichgoan,Dunglagang, Tsirang.	(2 lines/6 suckers)	
Chibesai.	Lalikaharka, Dunglagang Tsirang	2 lines/6 suckers)	
Girasai	Lalikaharka, Dunglagang, Tsirang	2 suckers	
Chekri Barlange	Surey,Gelephu, Sarpang	2 lines/6 suckers)	
Sreenma	RDC, Bhur, Gelephu	2 sucker	Sikkim in 2012
Barlange	Saureni, Samtse geog, Samtse.	2lines/5 suckers	
Sawney	Majuwa,Bara/Norgaygang geog, Samtse.	2 lines/5 suckers	
Ramsey	Bounadokka, Saureni, Samtse geog, Samtse	2 lines/ 5 suckers	
Golsey	Bounadokka, Saureni, Samtse geog, Samtse	2 lines/ 5 suckers	
Kali Barlange	Surey, Sarpang.	2 lines/6 suckers	
Chipasa	Surey, Sarpang	2 lines/6 suckers	
Sawney	Surey, Sarpang	2 lines/6 suckers	
Nilasai	Surey, Sarpang	2 lines/6 suckers	
Barshong collection	Barshong ,Tsirang	2 lines/6 suckers	
Patshaling collection	Patshalingmae, Tsirang	2 lines/6 suckers	
Shemjong collection	Shemjong, Tsirang	2 lines/6 suckers	
Barlange	Menchana,Dophuchen, Dorokha, Samtse	Mass plantation for different trials/study.	

It may be mentioned here that while collection and planting have been completed, systematic characterization and data collection is a challenge as the concerned researcher has no formal exposure or training on Cardamom. Notwithstanding the constraint, every effort is made to study and collect data through desktop studies.

8.0 Citrus Repository RDSC Tsirang

The citrus is one of the highest value export crop of Bhutan and the program activities in the financial year 2014-15 were guided by the strategy document "Strategies for Citrus Industry Development". The main objective of the program is to strengthen the citrus industry by increasing mandarin yield and quality through research and development activities which are solely grounded on the opportunities and challenges.

Objectives: To increase citrus production and productivity through sustainable research and development activities

Research Activities

1. ***Collection of germplasm and evaluation (varietal trials)***

   A total of 12 different types of citrus accessions from east were collected from RDC Wengkgar. The citrus accessions collected include wild species, landraces and some cultivated species from farmers' field. The accessions are currently propagated at Citrus Repository, RDSC Tsirang. A varietal evaluation trial established on station at RDSC Tsirang and Bajo for evaluation and identification of suitable varieties for different purposes will be terminated (As per directives of DoA). Also the research trial on assessing compatibility of local mandarin with introduced rootstock is on-going.

2. ***Dissemination of key management practices***

   To showcase technology at shelf with respect to key orchard management practices, two demonstration orchards were set up at farmers' field (Thangna and Tsirangtoe). Also, whole Drujaygang geog under Dagana Dzongkhag has been mobilized for taking up area wide citrus management approach to mitigate Citrus Greening disease. All the citrus growers from Pangna, Thangna and Pangserpo Chiwogs (about 320 households) are involved in the group. The technical support and monitoring on implementation of calendar of activities will be continued. A

technical report on assessment of orchard management technology adoption is under review in international peer review journal (Agriculture and Food Security).

3. Nursery technique for producing disease free planting materials

Graft transmissible diseases such as citrus greening, CTV, psorosis, etc. has been the main issue across the globe. Since the establishment of citrus nursery is demanding both in term of resources and technicalities, a repository is established to cater the needs of disease free scion/bud woods. RDSC Tsirang has collected locally promising varieties from fields for further evaluation and also the multiplication of already released citrus varieties from RDC Wengkhar. The harvesting of budwoods have begun and propagated. In addition, to assist researchers, nurserymen, extension officials etc, a technical guide on Nursery manage is published. We also evaluated physiochemical properties of locally available materials that is more rampantly used by nurseries in Bhutan. We also determined the media mix ratio and performance of citrus seedlings which is continued in this financial year. The outcome of the experiment will be published in peer reviewed article.

4. Disease testing and implementation of repository protocol

As per the repository protocol, two additional blocks were constructed using polyhouse and screen net.

a. Quarantine block

This is the first block that any planting materials will have to pass through this block. The material will be treated with chemical as per protocol and propagated. Minimum of 41 days will be kept under this block and scrutinized for presence of quarantine pests or diseases. Once the proper graft union is formed, it will be transferred to diagnostic block. All, the activities conducted with the planting material introduced will be recorded. Currently, this block contained rootstock seedlings raised for propagation of introduced accessions

b. Diagnostic block

The purpose of this block is to maintain different mother trees for indicator plants, positive controls (HLB, CTV and other graft transmissible diseases), and conduct biological indexing

as per the repository protocol. Currently, the blocks contain different rootstock seedlings (sterile) that can be used for graft inoculation. Also, two potting mix experiment was conducted in this block.

c. Increased Block

One of the main purposes of the repository is to produce high health status planting materials and daughter trees to nurseries. Currently, we have maintained mother trees 13 lines of which only three are local mandarins. We also maintained lime and lemon varieties (bears lime, acid lime a local from Shemshong). We have already started producing budsticks. Since we have limited number of mother trees (only 10 potted plant) for each promising lines, another (increased/daughter) block will be constructed to house more potted plants to increase the production of budwoods. With the financial support from ACIAR, we purchased both external (two polyhouse frames and polyethylene sheets, syntax) and internal components (irrigation, pots, etc).

Developmental Activities

National Rice Program

Introduction

The National Rice Program continued with the initiatives and support on farm mechanization, crop production and marketing including germplasm evaluations at RDCs. As part of the Department's crop intensification drive, introduction and evaluation of short duration rice have been carried out and few varieties were selected for further evaluations. Machinery hiring services initiated by AMC is continuing to make progress as more Dzongkhags (villages/geogs) were covered benefiting increased number of farmers. As package of support services, RDCs in collaboration with NSC was able to continue with promotion of improved seeds. Over 48 ton improved seeds comprising of 13 varieties were supplied to the rice potential Dzongkhags of Wangdue, Punakha, Tsirang, Dagana, Sarpang, Samtse and S/Jongkhar. Based on request and as special cases, the program was also able to provide over 3.4 ton improved seeds to the other Dzongkhags like Trongsa, Zhemgang and Pema Gatshel benefiting 246 farmers. On the post harvest and marketing front, tangible achievement has been made with about 7 fold increase in volume of paddy collection for domestic market(s). A whopping 386 ton paddy was collected by FCBL from the Dzongkhags of Wangdue, Punakha, Sarpang and S/Jongkhar. Considering a paltry collection of just 26.3 – 58 ton in the past five years, it was a huge achievement. Below given headings are the highlights of activities carried out in 2014-2015.

Promotion of improved seeds

As one of the interventions to enhance rice production in the country, the rice program continued to promote higher yielding (improved) varieties in potential areas. Vigorous promotion of higher yielding varieties is the only way to sustain rice production through increased yield as more and more rice areas are getting converted to other land uses and substantial area gets fallowed. In 2014-2015, 48 tons of HYV seeds were supplied to the rice potential Dzongkhags of Wangdue, Punakha, Tsirang, Dagana, Sarpang, Samtse and S/Jongkhar. The varieties included all those recommended ones for different agro-ecological zones. Additionally, the Dzongkhags like Trongsa, Zhemgang and Pema Gatshel also received 3.4 ton seeds (on request). As the rice commercialization program gains momentum, farmers are expected to increasingly use HYV seeds thereby improving rice yield. Dzongkhag wise details of seed supply are presented in the table below.

Table 48. Details of paddy seeds supplied in the 2014-2015

Var	Dzongkhags								Total
	P	W	Ts	D	Sp	St	S/J	Others	
IR 64	1600	1000	200	1050	0	0	500	330	4680
BM1	930	740	400	150	0	0	0	173	2393
BM2	2125	870	250	170	0	0	0	63	3478
BK1	50	0	320	150	0	0	0	38	558
BK2	50	0	300	140	0	0	0	0	490
No.11	670	1370	0	130	0	0	0	0	2170
Khangma Maap	740	500	35	590	0	0	0	50	1915
Yusiray Maap	1500	1000	100	1300	0	0	0	600	4500
IR20913	0	0	0	1600	208	0	0	0	1808
Bhur Kambja 1	0	0	0	1300	4640	3500	3400	500	13340
Bhur Kambja 2	0	0	0	1020	1060	4000	200	1000	7280
Bhur Ray Kaap1	0	0	0	900	1800	1000	1100	700	5500
Bhur Ray Kaap2	0	**0**	240		1000	1000	1380	0	3620
Total	7665	5480	1845	8500	8708	9500	6580	3454	51732

Note: P, W, T, D, Sp, St, S/J refers to Punakha, Wangdue, Tsirang, Dagana, Sarpang, Samtse and Samdrup jongkhar, respectively.

Rice double cropping

Rice double cropping (spring rice) is one of the most important initiatives of the DoA to enhance rice production in the 11th FYP. However, area under Spring rice continued to remain low despite tremendous efforts by both the Dzongkhags and RDCs. In the 2014-2015 financial year, Spring rice was cultivated on about 120 ac area though the plan was to do it on about 300 ac. The farmers of Rinchengang in Wangdue Dzongkhag are into rice double cropping since the last three years and currently cultivate about 50 ac benefiting 46 households. With the successful demonstration on a small scale last year, Spring rice area scaled up to about 70 ac under Dagana Dzongkhag (Kalikhola, Karmaling and Nichula and Lajab). Altogether, the projected production from 120 ac area is 185 ton (rough rice) worth approximately 0.6 to 0.8 M ngultrum (Table 49).

Table 49. Area, production and gross income from the Spring crop (Wangdue and Dagana Dzongkhag)

Sl.No	Site/Dzongkhag	Area (ac)	Production (t)	Estd. Gross Revenue (m)	Remarks
1	Rinchengang (Wangdue)	50	115	6.900	Rice from first crop is being sold at Nu. 100/kg
2	Nichula, Karmaling and Kalikhola, lajab (Dagana)	70	73.5	1.323	Base price considered is Nu.30/kg for IR 20913 variety

Farm mechanization

The mechanization component of rice commercialization is being taken up by the Agriculture Machinery Centre (AMC). Among all the interventions initiated under the rice commercialization program, farm mechanization is highly capital intensive. Much of the fund for mechanization was used for the procurement of machineries (power tillers, tractors, reapers and spare parts). One of the most noteworthy and very important initiatives under farm mechanization is machinery hiring services. It is reported to be gaining momentum and more and more area are reported to be brought under mechanization which helped in reducing drudgery of rice farming. As part of promoting mechanized rice farming, AMC continued to demonstrate use of machineries in different locations/Dzongkhags. AMC also continued to train machinery operators including extension personnel to improve service delivery. Data maintained at RDC Bajo showed that the area under mechanization is increasing which is a positive sign that rice farming is sustaining despite numerous challenges. In 2014-2015 season, the projected area under mechanization is over 9562 ac and with increased no of power tillers made available to the farmers, the area is only going to increase indicating increased benefit to the farmers. Table 50 below shows trends in area (ac) under mechanization from 2008-2009 to 2014-2015.

Table 50. Farm mechanization trend (area) over the years

Financial year	Area (ac)	Remarks
2008-2009	10	Successful demonstration of mechanization at Chuzargang geog, Sarpang Dzongkhag
2009-2010	380	Mechanized farming promotion began in the same geog involving more farmers
2010-2011	556	Farm mechanization promotion enhanced
2011-2012	1931	Other geogs like Umling, Dekiling, samtenling and Gelephu included
2012-2013	3123	Promotion of mechanized farming expanded started in Wangdue-Punakha, and Samtse Dzongkhag
2013-2014	5500	Covered more Dzongkhags like S/Jongkhar and other Dzongkhags
2014-2015	9562.5	Covered 15 Dzongkhags and catered by 4 regional Agri. Machinery Centres

As part of promoting farm mechanization in the country, AMC has procured additional fleet of machineries including spare parts. These machineries are being used in the machinery hiring system and farmers are greatly benefited. Nearly 100% of the approved budget under rice program is currently pumped into mechanization program. For machineries alone, AMC has used a whopping Nu. 32.9 M as detailed in the table below.

Table 51. Details of farm machineries procured by AMC and their cost implication

SL	Type of Machinery	Nos	Rate	Amount (Nu.)
1	Power tiller with rotary tiller	122	172,502.00	21,045,244.00
2	Bottom Plough	122	40,954.00	4,996,388.00
3	Paddy Wheel	122	7,400.00	902,800.00
4	Trailer for P/tiller	104	49,990.00	5,198,960.00
5	Hitch adapter for P/tiller	133	980.00	130,340.00
6	Crompton Moter Single Phase	10	7,999.90	79,999.00
7	Mini Tractor 13KW 18hp	1	387,171.00	387,171.00
8	Rotary tiller	1	114,543.00	114,543.00
9	Bottom Disc Plough	1	64,500.00	64,500.00
10	Board plough 2bottom	1	38,197.00	38,197.00
	Grand Total			**32,958,142.00**

Capacity building

Two batches of in-country staff trainings on basic rice production were conducted benefiting 36 extension agents working in the rice growing geogs of Sarpang, Samdrup Jongkhar, Shemgang, Chhukha, Thimphu, Paro and Haa and 7 research/technicians of RDCs and NSC. So far, 142 field staff have been trained covering the rice growing geogs in 14 Dzongkhags (Wangdue, Punakha, Tsirang, Dagana, Sarpang, Samtse, Samdrup Jongkhar, Trongsa, Zhemgang, Thimphu, Paro, Chhukha, Gasa and Bumthang). Such trainings are important not only to update our field staff on basic rice production technology but also to encourage them to work harder and more efficiently.

Apart from staff training, 57 farmers were trained on various aspects of rice production technologies such as improved nursery production and balanced fertilizer application in selected sites. A total of 36 farmers from the Dzongkhags of Samtse and Sarpang were trained on application of balanced fertilizers and the trainings were carried out as part of 'on the site' demonstration. To promote rice-rice cropping, 21 farmers were trained on poly tunnel nursery production at Kalikhola Dungkhag under Dagana Dzongkhag.

Paddy collection and marketing

In the 2014-2015 financial year, FCBL was able to collect 386 tons of paddy from Sarpang, Samdrup Jongkhar and Wangdue-Punakha valley (Figure 15). Maximum collection has been reported from Wangdue-Punakha valley recording roughly 200 ton. The 2014-2015's collection

saw about 7-fold increase in paddy collection as compared to the last five year's average collection. Currently, the FCBL has started paddy collection, milling and marketing of rice in Sarpang, Wangdue-Punakha valley and Samdrup Jongkhar. It included different varieties of rice produced and branded from these regions.

The milled rices were made available to the consumers at the FCBL outlets throughout the country. This is already a huge success and milestones are in the offing with strategic plans to ensure supply of adequate quantities of locally produced rice to the school feed program of the Ministry of Education.

Top ten popular domestically produced rice varieties hitting formalized market (through FCBL) are as follows:

1. Bhur Kambja 1
2. Bhur Ray Kaap 1
3. Khamtey
4. Champa
5. Choti Masino
6. IR-64
7. Bajo Maap
8. Tan Tsheri
9. Local Kaap
10. Local Maap

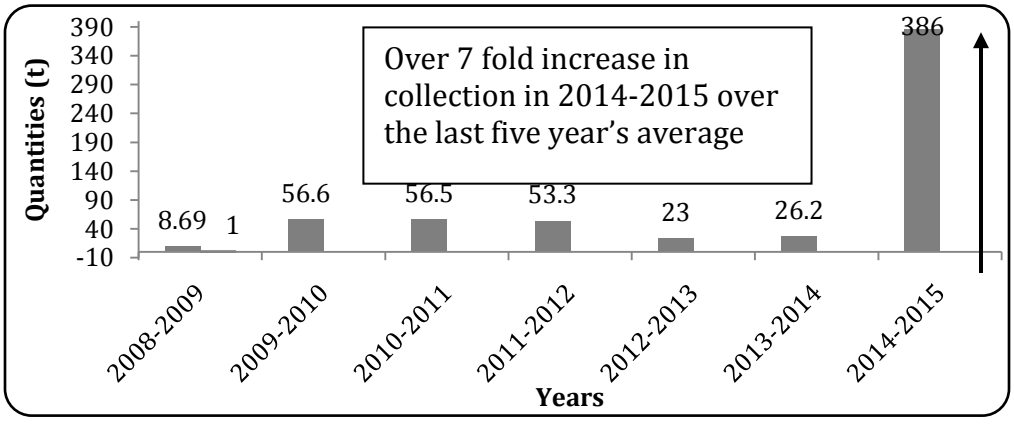

Figure 15. Record of Paddy collection trend as maintained by the Rice Program

Rice Research (Evaluation of varieties)

Hundreds of introductions are at various levels of evaluation at RDC Bajo, Bhur and Yusipang. As part of promoting rice-rice cropping in the mid altitude and southern Dzongkhags, evaluation of varieties for earliness is

also currently evaluated at Bajo and Bhur. In the last two years, twenty five improved short duration varieties were introduced from India and Bangladesh and the varieties were screened for yield, earliness, resistance to diseases and other agronomic traits. Among the Bangladeshi varieties, BRRI dhan 28, 26, 56, and 58 are doing well, a couple of Indian varieties have also observed to be promising for both Spring and main season crop in the Southern part of the country. However, all the evaluated short duration varieties were not earlier than our local check (IR-20913) which matures in about 110 days at Bhur condition as Spring crop.

Installation of electric transformer

At the Bhangtar rice mill, an electric transformer was installed since the BPC was not willing to share power supply to the rice mill citing some issues. An electric transformer was installed and it is hope that FCBL will be able to mill the paddy collections in Bhangtar area (Pemathang, Phuntshothang and Samrang geog). In absence of an assured power supply, FCBL had to transport paddy to Chuzargang in Sarpang for processing.

Annexures

Annexure 1: Trainings and workshops

Date	Name	Place	Purpose
02-03/07/2014	Mahesh Ghimiray	Bangkok, Thailand	Meeting on "Hybrid Rice Development in Asia assessment of limitations & Potentials".
02-09/07/2014	Thinley Gyamtsho	China	Study Tour Program organized by world Bank.
20-25/08/2014	Sangay Tshewang	Jabalpur, India	Addressing Abiotic and Biotic stresses to wheat production in Bhutan.
17/08 /2014 - 4/10/2014	Tanka M.Pulami	Japan	Planning and Designing of agriculture statistics for food security policy making.
8/9/2014	Sangay Tshewang	Nepal	Study Tour
23/9/2014 – 3/10/2014	Sangay Tshewang	KARI, Nijoro, Kenya	Training on standardization of stem rust field notes and germplasm evaluation with discussions on strip & leaf rust.
09-12/10/2014	Sangay Tshewang, Jigme, Ngawang Chhogyel	Varanasi, India	Attend consultative meeting on crops varietal selection.
26/10/2014 – 02/11/2014	Mahesh Ghimiray, dr. Yadunath Bajgai, Ngawang Chhogyel	Bangkok, Thailand	Participation in 4th international Rice conference at Bangkok
01-08/11/2014	Thinley Gyeltshen	Nepal	Training on Rainwater harvesting for coastal countries livelihood at Nepal.
01-05/11/2014	Purna Bdr.Gurung	Jhansi, India	Training on research methods on Agro-forestry.
15/12/2014	Dr. Yadunath Bajgai	Delhi, India	Workshop
23-30/12/2014 –	Mahesh Ghimiray	Kathmandu, Nepal	Workshop on PGRFA.
09-18/02/2015	Legjay	West Bengal, India, Dhaka, Bangladesh	Workshop understands the Progress made & discusses the future prospect of grain legumes.
25/02/2015 - 13/03/2015	Doley	Nepal	Study visit
3-5/4/2015	Dr. Yadunath Bajgai	Bangladesh	Climate change, disaster and human mobility in south Asian and Indian Ocean.
23/04/2015 –	Gyem Lham,	CMI,	Basic Dzongkha Unicode with

6/05/2015	Dorji Choden	Phuntsholing	official correspondences.
27 /04/2015 – 27/05/2015	Kinley Dorji	New South Wales Australia	Citrus Disease indexing and Diagnostic Laboratory skills.
4-8/05/2015	Ngawang	Bangkok, Thailand	Workshop on GIAHS.
11-23/06/2015	Thinley Norbu	RIM, Thimphu	Competency based training in Networking.
29-30/06/2015	Cheku Dorji	Bangkok, Thailand	Regional consultation on the promotion of pulses for the multiple benefits in Asia.

Annexure 2: List of the visitor to our Centre for July 2014– June 2015

Date	Name of the visitor	Address	Purpose of Visit
20/08/2014	8 Officials from the land Development Department	Bangkok, Thailand	Visit to study the various agriculture research and service facilities available in the country.
9/09/2014	Senior officials from the Department of Agricultural Extension.	Bangkok, Thailand	Official visit.
17/09/2014	2 member Thai Delegates	Bangkok, Thailand	Field visit
24/09/2014	9 Officials from Rice Department	Bangkok, Thailand	Exchange visit
31/10/2014	Dr. Udyog Subedi (Bhutan Consulting Associates)	Thimphu	Impact Assessment and Project completion reporting for Decentralized Rural Development Project.
3/11/2014	Graeme Paul Sanderson(ACIAR Australia team leader)	(New south wales DPI) Australia	Field Demonstration on managing Citrus Biosecurity Risk & Nursery Production.
	DR. Nerida J.Donovan (Pathologist)		
	Gary R Eyles (Eyles Nursery, Syndey)		
30/11/2014	Hon'ble minister	MoAF, Thimphu	Visit to Chimipang crown property site.
01/04/2015	8 member High delegation from Land Development Department	Bangkok, Thailand	Brief on the Research Division activities & trial sites.
14/04/2015	Dr. Richard H. Markham, (ACIAR Horticulture Manager)	ACIAR Australian	ACIAR activities and fruits & Nuts research programs at RDC-Bajo.
	Dr. George Andrew C Bealtie (University of western Sydney)		
	Mr. Graeme P Sanderson (ACIAR Australian Project Leader)		
26/04/2015	Zhemgang trainees (Educated Youth Training)	Rural Development Training centre, Zhemgang.	To learn about RNR-activities carried out by our centre.
20/05/2015	Team of 26 officials from Sikkim	Sikkim	To learn about Research & Development in Agriculture & Horticulture sector.
23/05/2015	EU-head of delegation	Thimphu	Visit RDC-Bajo & Rice mill.
03/06/201	Mr. Koa Tasaka, (Director	Japan	Field visit

5	of Asian Rural Institute.) Mr. Mitsukuni Inaba, (Chief Director of Japan)		
02/06/2015	28 Officials from the MoA, Bangladesh	MoA, Bangladesh	Visit various fruit production & processing Centre.
09/06/2015	28 Officials from the MoA, Bangladesh (second batch)	MoA, Bangladesh	Visit various fruit production & processing Centre.
18/06/2015	9 Officials from Bangladesh Agriculture Research Institute	Bangladesh (BARI)	Field visits & discussion

Annexure 3: Farmers study tour report for the year 2014-2015.

Sl.No	Type of visitor	Organization/Dzongkhag	Total
1	Community Forest Management group (CFMG) study tour.	Trashigang	20
2	Haa Farmers group	Haa	25
3	NWFP/CFMG (community Forest Management group) study tour	Monggar	17
4	RDTC (Rural Development Training centre) study tour.	Zhemgang	20
5	Trashiyangste Farmers study tour	Trashiyangste	6
6	BDBL farmers Groups I	Wangdue	22
7	BDBL farmers Groups II	wangdue	22
8	BSc Student of CNR study tour	Lobeasa Wangdue	21
9	Vegetable group under Kabjia Geog study tour	Punakha	25
10	Local elected leaders with RNR Extension workers under Dorokha Drungkhag study tour	Samtse	
11	BDBL Farmers group from eastern region		
12	Paro Dzongkhag farmers study tour	Paro	20
13	Samtengang School Agriculture Programme club student on study tour	Wangdue	20

Annexure 4: Financial Progress

RGoB contribution for RDC Bajo (Nu.)

Code	Particulars	Approved Budget	Expenditure
1.01	Pay and Allowances	16045000.00	16044840.00
2.01	Other personal emoluments	5460000.00	5459516.00
11.01	Travel- Incountry	5070000.00	5074481.00
12.01	Utilities-Telephones, Telex, Fax, Email, Internet	199000.00	198577.48
12.02	Utilities- Telegram, Wireless Transmission, postage	20000.00	19617.14
12.03	Utilities- Electricity, Water, Sewerage	111000.00	110910.93
14.01	S & M- Office supplies, printing, publications	310000.00	310000.00
14.02	S & M, Medicine and laboratory consumables	44000.00	43380.00
14.03	S & M Fertilizers, chemicals, manure and inoculants	95000.00	94910.00
14.04	S & M Seeds, Seedlings	232000.00	231310.00
14.06	S & M Uniforms, extension kits, linens	130000.00	129662.00
14.07	S & M- Text books, library books, stationeries and sports item	34000.00	33278.00

15.01	Maintenance of Property - Buildings	50000.00	49931.00
15.02	Maintenance of Property - Vehicles	1107000.00	1106542.98
15.05	Maintenance of Property - Equipments	38000.00	37683.00
15.06	Maintenance of Property – Plantations	21000.00	19701.00
15.07	Maintenance of Property- Computers	26000.00	25950.00
15.09	Maintenance of Property- Water supply, Sewerage, Playfield	21000.00	12672.00
17.01	Op. Exp- Advertising	134000.00	133135.00
17.02	OP. Exp- Taxes, Duties, Royalties, Handling Charges, Bank Charges	7000.00	66361.36
17.03	Op. Exp-Transportation	14000.00	13230.00
24.03	Contributions- Provident fund	1472000.00	1437803.00
	Total	**30640000**	**30653491.89**

RDC Bajo (Capital)

45.02	Training- Others	350000	349915.5
51.08	Exp on Structure- Others	307000	306744.50
52.05	Plant and Equipments	11300000	1129992.73
52.08	Plant and Equipt-General tools, Instrument	172000	171156
	Total	**12129000**	**1957808.73**

RDC Revenue Generation

Nu 204,055 were generated from the sale of agriculture produce and revenue collected from the transit collection charges.