


NATIONAL CENTRE FOR ORGANIC AGRICULTURE



ANNUAL REPORT 2020-2021

Copyright © NCOA -Yusipang, 2021

Published by:
National Centre for Organic Agriculture-Yusipang, Thimphu
Department of Agriculture
Ministry of Agriculture& Forests,
Royal Government of Bhutan
June 2021

Editors:
Chimi Rinzin and Editorial Board

Suggested Citation:
Research and Communication Section, TSS, RDC-Yusipang. **Annual Report 2019-2020**, Department of Agriculture, Ministry of Agriculture and Forests, Thimphu

Layout and design:
Chimi Rinzin

Reproduction:
This publication may be reproduced in part or whole in any form for educational and research purpose provided acknowledgement is made. NCOA-Yusipang would appreciate receiving copy of publications using the information from this document.

For a copy of the report, contact:
Programme Director
NCOA, Yusipang
Post Box: 212
Thimphu, Bhutan
Tel: +975 77191124
Email: ardcyusipang@moaf.gov.bt

ABOUT US

The National Centre for Organic Agriculture (NCOA) is located at Yusipang which is about 15 km from Thimphu city on the Thimphu-Punakha highway. The Centre falls under Chang Gewog of Thimphu Dzongkhag and is located at an altitude of 2700 m above sea level. The Centre has a very rich and dynamic history that dates back to Bhutan's second Five Year Plan.

VISION

A self-reliant, resilient and sustainable agriculture food system.

MISSION

Achieve food and nutrition security, agricultural transformation through innovative and sustainable technologies, diversified and competitive economic/production options, inclusive and sustainable policies and programs.

OBJECTIVES

1. *To increase crop production for enhancing food self-sufficiency, income and nutrition security*
2. *To generate and promote climate-resilient agriculture technologies*
3. *To promote organic farming for sustainable agriculture, safe food, and environment conservation*
4. *To develop functional farm infrastructures and facilities (irrigation channel, farm roads, post-harvest facilities, etc.)*
5. *To promote agriculture enterprise development*
6. *To enhance effective and efficient delivery of agricultural services*

FOREWORD

The National Center for Organic Agriculture (NCOA) Yusipang is pleased to bring out our Annual Report for the year 2020-21. As we bring this technical report, the auditing of the centers' financial status for 2019-20 has also been successfully completed by the Royal Audit Authority. The Annual Report serves as the most critical evidence for the Annual Performance Agreement (APA) of the Center.

In the 2020-21 financial year, the erstwhile Agriculture Research and Development Center (ARDC) Yusipang, has been designated and mandated as the apex national institution to regulate Bhutan Organic Guarantee System (BOGS). As the apex body on Organic Agriculture (OA), NCOA will operate under direct administrative management of DoA and policy/legislative guidance of the National Organic Board and National Working Group-Organic Agriculture. As the Bhutan Organic Standard (BOS) owner, NCOA will also be the scheme manager of Bhutan Organic Mark. In addition to being an apex body NCAO has also been assigned the national mandate to coordinate Organic research and development. These mandates have been endorsed by the Organizational Development (OD) exercise.

Some of the notable achievements of the NCOA Yusipang in the financial year 2020-21 are that it has registered 691households and 2090.26 acres across the country under Organic Agriculture. Accordingly, the cumulative registered households and farm land in the country is 1265 households and 10236.52 acres respectively. NCOA certified 746.67acres under the Local Organic Assurance Systems (LOAS) taking the cumulative figure of certified organic area to 3091.64acres. Similarly, 12 new products were certified during taking the cumulative certified organic product to 38. The products certified during the current financial year were rice, mustard green, radish, coriander, cauliflower, cabbage, dry chilli, bunching onion, buckwheat flour, wheat flour, garlic and potato. Further a total of 422 stakeholders (farmers and staff) were trained during the financial year 2020-21 on organic farming principles and practices and Internal Control System (ICS) to facilitate certification. Under GEF-LDCF project, two new Model Organic Villages , one each in Lhuentse and Thimphu Dzongkhag have been identified and supported. Support to existing Model Organic Village villages in Chudzom under Sarpang and Lull under Wangdue Dzongkhag has been strengthened. Through Resilient Mountain Solution (RMS) project, organic solutions and capacity building of farmers were supported in Longpa-Nobgang village under Haa Dzongkhag. The construction of conference hall and laboratory building worth Nu. 32 million is under progress with support from the National Organic Flagship Program. NCOA also reviewed and updated various organic policy, regulatory documents and manuals like BOGS, Bhutan Organic Standards (BOS), LOAS manual, Internal; Control System (ICS) manual and Bio-input framework .

The Horticulture Program of the Centre has successfully started Hydroponics farming using Nutrient Flow Techniques. The horticulture program also released four new hybrid vegetable varieties of Cauliflower, Tomato, and Radish. It has also initiated the concept of urban farming where 60 interested individuals from Thimphu Thromde were supported.

The Field Crops Program has initiated the Multi Environment Testing trial on Quinoa and Amaranth with support from the International Center for Biosaline Agriculture (ICBA).

The National Potato Program has implemented various activities such as demonstrations, promotions and trials in the main potato growing Dzongkhags to enhance crop productivity as a means to improve rural life. The main thrusts in 2020-2021 has been on carrying out multi-location evaluation of potato clones in Bumthang, Khangma and Yusipang followed by a series of technology demonstrations across main potato growing districts. The climate resilient potato clones imported from International Potato Centre in Peru and potato varieties imported from Nepal were under evaluated in multi-locations. Further, 50 biofortified (tetraploid) clones were multiplied in greenhouses into mini-tubers for introduction into the open-field conditions in the following year.

The Research Communication researcher focused on the packaging and advocating of technologies from NCOA. It prepared short video and uploaded in the NCOAs' Facebook page. This initiative was received very well by a wide range of audience which greatly increased the visibility of NCOA's interventions.

Some of the new initiative of the center include the Research Outreach Program- Organic, Permanent Organic Research and Demonstration plot in different ARDCs, Nationally Coordinated Trials on Organic Agriculture and neighbor first Program where the Centre first takes its proven technologies and development support to the community around the Centre. To support the consumer market and also the farming communities during the COVID -19 pandemic, the Centre successfully demonstrated low-cost tomato production technology in Dungna, Nalachong, and Bongo in Chhukha Dzongkhag. The Centre has also promoted and supported farmers to produce winter Chilli and Onion in Chhukha Dzongkhag. To improve the working environment for staff and Elementary Service Personnel (ESP), the Centre with support from UNDP and JICA has established a Crèche facility.

NCOA Yusipang, acknowledges the strong support from all the donor projects like NOFP, RMS, FSAPP, and GEF-LDC to out scale Organic research and developmental activities across the country. The Center is wholeheartedly committed to contributing towards realizing the national vision of becoming fully organic. We dedicate ourselves to serve the farmers, with our motto "Farmer First".

Tashi Delek and Happy Reading

Tirtha Bdr. Katwal
PROGRAMME DIRECTOR

Table of Contents

LISTS OF FIGURES

LISTS OF TABLES

1 NATIONAL POTATO PROGRAM

1.1 Summary of APA planned and achieved

The main thrusts in 2020-2021 has been on carrying out multi-location evaluation of potato clones in Bumthang, Khangma and Yusipang followed by a series of technology demonstrations across main potato growing districts. The climate resilient potato clones imported from International Potato Centre in Peru and potato varieties imported from Nepal were under evaluated in multi-locations. Further, 50 biofortified (tetraploid) clones were multiplied in greenhouses into mini-tubers for introduction into the open-field conditions in the following year. It is imperative re-emphasize that the activities were aimed at addressing the stagnation of yield due to degeneration the seed and varieties so as to contribute to food and nutrition security of the Bhutanese populace. The key development thrust of the program is to enhance potato production through by technology transfer through demonstration of late-blight resistant and nutrient-dense potato varieties, seed multiplication, demonstration of potato varieties, germplasm maintenance, farmers' capacity development and evaluation of different potato germplasm for generation of future varieties. Thus, National Potato Program has implemented various activities such as demonstrations, promotions and trials in the main potato growing Dzongkhags to enhance crop productivity as a means to improve rural life.

Table 1:APA targets and achievements in 2020-21 of National Potato Program, NCOA

Success indicators	Units	Target	Achievement	Achievement (%)	Remarks
Promoted & intensified new potato varieties through seed support	kg	2,500	2,800	112	Langpa Nobgang, Samar Gewog, Haa
Late-blight resistant and nutrient-dense potato varieties promoted	kg	2000	2050*	102.5	Trongsa, Bumthang, Wangdi, Gasa, Thimphu, Paro, Haa & Chhukha
Seed multiplication of newly released potato cultivars for technology transfer through demonstration	MT	6	8.952	149.2	Mongar, Tashigang, Haa, Paro, Thimphu & Bumthang
Demonstration through potato germplasm maintenance	Timeline	Sept. 2020	Sept. 2020	100	On-station
Increase potato production through Farmers' capacity development	Numbers	400	392	98	Due to COVID-19 restrictions, scheduled training were disrupted
Develop Potato knowledge management product	Date	Feb. 2021	Feb. 2021	100	Publication no. NCOA/BR-20-21/5 on Package of practices of potato
50 Biofortified tetraploid clones multiplied into mini- tubers (G0) in green house	Numbers	10,000	11732	117.32	Mini-tubers (G0) produced in vermiculite medium
Evaluate climate resilient potato G1 clones (Yusipag & Bumthang) through four observation trials	Timeline	Sept. 2020	Sept. 2020	100	Both organic and conventional
Conduct multi-location potato varietal trials on selected potato germ plasm (Yusipang, Khangma and Bumthang)	Number	4	4	100	First year under replicated evaluation
Conduct multi-location/ observation trial on imported potato varieties from Nepal at Yusipang, Khangma Bumthang & Chapcha	Number	4	4	100	First year under observation trial

excludes 10250 kg to WOW farm (Tang, Bumthang) and 1050 kg to Ramthankha Farm (Tshento, Paro) which were not unforeseen during APA preparation and came as instruction from MoAF and DoA.

1.2 Promoted & intensified new potato varieties through seed support

The APA target was 2,500 kg and achievement was 2,800 kg of potato seed of new variety Yusi Maap with 112% achievement. To support farmers in organic village of Langpa Nobgang, Samar Gewog under Haa Dzongkhag, 2,800 kg of potato seed of Yusi Maap were supplied with to enhance organic potato production. With this support, all 56 households of Langpa Nobgang were supplied with one bag (50 kg) each of the seed of the new potato variety so that farmers could replace degenerated seeds. A special approval was accorded by Dasho Secretary, MoAF for the direct purchase of new seed from farmer at Nagu village as the seeds of Yusi Maap was not available with the National Seed Centre. A sum of Nu. 126,000 (Nu.45/kg x 58,000 kg) was spent under the funding of GEF-LDCF project of NCOA, Yusipang to support the farmers. The potato production from the new seed is expected to replace their seed and also serve as a source of organic potato seed in future.

1.3 Late-blight resistant and nutrient-dense potato varieties promoted

The APA target was 2000 kg and achievement was 2050 kg of late-bight resistant and nutrient-dense potato varieties promoted with 102.5% achievement.

Table 2:Details of 12400 kg Yusi Maap and 950 kg Nasephey Kewa Kaap promoted in 18 Gewogs

SN	Location/Gewog	Dzongkhag	Sites/group	Yusi Maap (kg)	Nasephey Kewa Kaap
	Promotion through field demonstrations and comparative trials under farmers' managed conditions				
1	Chendabjee	Trongsa	1	50	0
2	Gangtey/Phobjikha/Sephu	Wangdue	3	150	150
3	Khaty / Khamey	Gasa	2	100	100
4	Laya	Gasa	1	50	50
4	Kawang/ Chang	Thimphu	4	200	100
5	Tshentoe	Paro	1	50	50
6	Eusu/ Samar/Katsho	Haa	3	150	150
7	Metakha/ Dungna/ Sampheling	Chhukha	3	150	150
8	Ura/Tang/Choekor/Chumae	Bumthang	4	200	200
				1100	**950**
	Potato seed village development				
9	Ramthangka Farm	Paro	1	1050	0
10	*Wobthang Organic Farm, Tang Gewog	Bumthang	1	10250	0
		Total		**12400**	**950**

**** Wobthang Organic Farm, Tang Gewog under Bumthang Dzongkhag was supported with a total of 10250 kg or 10.250 MTs of Yusi Maap seed with instruction from the Ministry of Agriculture and Forests to support for organic seed sector development in potato commodity. As such NPP sourced 7000 kgs and 3250 Kgs were supplied by NSC Nasephey farm. The seeds were provided on a seed back policy or on a seed returnable basis and hence Wobthang Organic Farm would return the 10250 kg Yusi Maap seeds to the Department after the crop harvest in September or October 2021. We have been able to achieve much higher percentile as compared to the target set mainly due to the support received from NOFP for Wobthang Organic Farm, which was not foreseen during formulation of APA target as the program came as an instruction from the Ministry of Agriculture and Forests. Further, 1050 kg Yusi Maap seeds were supplied and planted at Ramthangkha Royal farm, Tshento, Paro.***

1.4 Seed multiplication of newly released potato cultivars for technology transfer through demonstration

Of APA target of 6 MT (6000 kg), a total of 8,952 kg or 8.952 MT of seeds were produced of the newly released potato cultivar for technology transfer through demonstration in 2020-2021 financial year. The achievement was 149.2%. The demonstrations were in main potato growing Dzongkhags of Haa, Paro, Thimphu, Tashigang, Mongar and Bumthang. On an average, that seed: production ratio is 1:6. In other words, 1 kg of seed could produce 6 kg potato.

Table 3:Seed multiplication of newly released potato cultivars for technology transfer through demonstration (Yusi Maap and Nasephey Kewa Kaap (NKK).

SN	Name of farmer	Location/Gewog/ Dzongkhag	Seeds multiplied		Total production (Yusi Maap+NKK) (kg)
			Yusi Maap (kg)	NKK (kg)	
5	Pem Zangmo	Drametse, Mongar	50	50	440
6	Sanga	Drametse, Mongar	50	0	260
4	Phub Tshering	Sangkaree,Eusu, Haa	50	0	350
7	Tashi Yangzom	Narang, Tashigang	50	50	252
1	Tshencho	Nagu, Naja, Paro	200	0	1200
2	Tshewang Lhamo	Genekha,Thimphu	150	0	1010
3	Kipchu Tshering	Katsho, Haa	100	50	900
13	Pema Wangdi	Khaling, Tashigang	50	0	320
8	Ugyen Dorji	Choekhor, Bumthang	200	50	1500
9	Tshering Peldon	Choekhor, Bumthang	150	0	1050
10	Sonam Wangmo	Choekhor, Bumthang	100	0	720
11	Ugyen Wangmo	Ura, Bumthang	50	0	350
12	Jambay Lhamo	Chamkhar, Bumthang	100	0	600
		Total	1300	200	**8952**

1.5 Demonstration through potato germplasm maintenance

Demonstration through potato germplasm was completed by **targeted timeline of September 2020.** The germplasm of released varieties of Desiree, Khangma Kaap, Yusi Maap and Nasephey Kewa Kaap is being maintained through demonstration at RDC Yusipang. Further, two new varieties imported from Nepal, that are, Janakdev and Khumal Rato-2 are also conserved through demonstration. Besides, all twenty climate resilient clones, four released varieties, seven old clones are in the report are maintained through conventional demonstration. New clones of CIP308208.219, CIP398180.292, CIP398180.289 and CIP398192.213 which are selected for multi-location trial are maintained through demonstration in the organic block.

Figure 1:Potato plantation for germplasm maintenance at conventional block

To maintain important trait and information of various potato varieties, germplasm of old potato varieties as well as newly released potato varieties and new CIP clones were maintained through demonstration in both organic and inorganic blocks of NCOA-Yusipang.

Figure 2:Conventional germplasm maintenance under at NCOA-Yusipang

For the organic germplasm maintenance, new clones of CIP308208.219, CIP398180.292, CIP398180.289 and CIP398192.213, which are best known for its heat and drought tolerance with high resistant to blight disease along with released varieties Desiree was demonstrated as multi-location trial. Furthermore, old varieties Khangma Kaap and Desiree are maintained.

Figure 3:Organic potato germplasm maintenance at NCOA-Yusipang

Yusimaap and NKK along with two newly imported varieties from Nepal, Janak Dev and Khumal Rato-2 are conserved under organic management through demonstration.

Figure 4:Potato germplasm harvested and cured.

1.6 Increase potato production through Farmers' capacity development

A total of 392 farmers were trained out of the planned target of 400 farmers which is 98% achievement.

Table 4:Summary of farmers training conducted by National Potato Programin 2020-2021

SN	Topic	Location/Gewog	Dzongkhag	Female Farmers	Male Famers	Total Famers	Funding
1	Famers training of new Potato varieties on cultivation practices	Dungna	Chhukha	21	15	36	FSAPP
		Metikha	Chhukha	22	8	30	
		Sammar	Haa	13	17	30	
		Eusu	Haa	19	11	30	
		Katsho	Haa	24	6	30	
2	Famers training on Participatory Varietal Selection at Flowering stage for new potato varieties	Dungna	Chhukha	21	19	40	FSAPP
		Metikha	Chhukha	36	5	41	
		Eusu	Haa				
		Sammar	Haa				
		Katsho	Haa				
3	Organic Famers training for new Potato varieties on cultivation practices	Panzhi/Laya	Gasa	11	14	25	NOFP
		Neylu/Laya	Gasa	9	16	25	
		Toekor/Laya	Gasa	8	15	23	
		Chongra/Laya	Gasa	9	16	25	
		LongpaNobgang	Haa	44	13	57	
	Total					**392**	
	FSAPP= Food security and Agriculture Productivity Project						
	NOFP= National Organic Flagship Program						

In the means of achieving National food security and annual national potato production target of the Department of Agriculture for 2020-2021, National Potato Program under NCOA-Yusipang with fund support from Food Security and Agriculture Productivity project (FSAPP) had carried out farmers training at Haa and Chhukha. A total of 392 farmers (155 males and 237 females) were trained on improved production technologies including cultivation practices of new potato varieties. The skills and capacity building of farmers improved from training can help in increasing total production to enhance the national production and achieve the target cascaded from the DoA's target.

1.7 Develop Potato knowledge management product

As planned a 'Package of Practices of Potato' was completed and published by NCOA, Yusipang on February 2021 (targeted timeline) and publication series number NCOA/BR-20-21/5. The cover page is as shown in the figure 5.

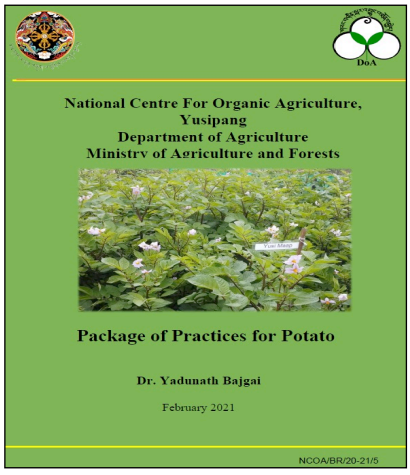

Figure 5:Package of Practices of Potato

1.8 50 Biofortified (CIP tetraploid) clones multiplied into mini-tubers (G0) in green houses

Table 5:Details of 50 Biofortified (CIP tetraploid) clones multiplied into mini-tubers (G0) in green houses. Of 10,000 minitubers targeted to produce, 11732 minitubers produced with achievement of 117.32%.

Sowing date: 6th April 2020 and harvesting on 12th October 2020			
SN	**Clone number & number of lines**	**Number of minitubers**	**Remarks**
1	312725.376, 10 lines	354	Red*
2	312609.252, 2 lines	34	Red
3	312725.036, 8 lines	367	Red
4	312595.053, 3 lines	153	White
5	312725.067, 6 lines	229	Red
6	312725.110, 2 lines	9	White
7	312682.011, 2 lines	73	White
8	312725.057, 5 lines	296	Red
9	312751.028, 4 lines	105	Light purple
10	312764.013, 7 lines	418	White
11	312721.029, 6 lines	255	White
12	3128271.043, 3 lines	56	Red
13	312721.245, 5 lines	250	White
14	312721.163, 4 lines	283	White
15	312686.05, 1 line	15	Dark red
16	312621.097, 4 lines	164	Red
17	312725.001, 5 lines	265	Muddy dark
18	312637.069, 10 lines	422	Red
19	312682.005, 7 lines	241	White
20	312725.062, 6 lines	421	Red
21	312721.169, 1 line	23	White
22	312721.038, 7 lines	277	White
23	312767.014, 2 lines	36	Red
24	312633.155, 9 lines	293	White
25	312735.051, 7 lines	69	White
26	312763.441, 10 lines	609	White
27	312721.286, 5 lines	192	White
28	312682.042, 6 lines	548	White
29	312609.247, 5 lines	294	White
30	312507.311, 4 lines	140	White
31	312751.025, 9 lines	386	White
32	312725.024, 4 lines	159	Red
33	312725.048, 9 lines	448	Red
34	312680.010, 5 lines	60	Red
35	312721.241, 6 lines	42	Red
36	312735.062, 5 lines	400	White**
37	312735.114, 4 lines	134	White
38	312721.004, 4 lines	262	White
39	312725.055, 5 lines	142	Red

40	312725.047, 9 lines	338	Red
41	312725.062, 6 lines	424	Red***
42	312747.056, 8 lines	460	White
43	312751.021, 6 lines	540	Red - high yield
44	312725.052, 13 lines	636	Red
45	312725.128, 9 lines	410	Red
46-50	312507.312, 312637.132, 312721.169, 312725.041 & 312735.105	0	No tuberization
	Total minitubers	**11732**	

1.8 Evaluate climate resilient potato G1 clones (Yusipag & Bumthang) through four observation trials (organic and conventional management).

.

Table 6: Four observation trials (G1) were completed on Sept. 2020, which is the targeted APA timeline

SN	Four observation trial (G1)
1	Yusipang 1 - Organic
2	Yusipang 2 - Conventional
3	Bumthang 1 - Organic
4	Bumthang 2 - Conventional

Table 7:Details of climate resilient potato G1 clones evaluated (Yusipag & Bumthang) through four observation trials (organic and conventional management).

SN	Accession No.	Production of G1 clones (kg)				Total per clone (kg)
		Yusipang 1 (Organic)	Yusipang 2 (Conven.)	Bumthang 1 (Organic)	Bumthang 2 (Conven.)	
1	CIP398180.289	17	17.9	10.9	11.4	57.2
2	CIP398192.592	9.5	12.8	16.1	13.3	51.7
3	CIP398190.605	13.2	14.3	11.8	12.4	51.7
4	CIP309103.85	16.0	14.3	15.2	12.8	58.3
5	CIP398192.213	13.6	18	10.7	12.4	54.7
6	CIP309074.129	1.5	6.4	3.4	1.3	12.6
7	CIP309041.1	15.1	19.6	14.2	16.7	65.6
8	CIP304079.10	11.3	13.5	12.6	10.8	48.2
9	CIP309017.101	7.5	13	3	4.5	28
10	CIP309028.56	8.5	12.1	10.4	14.3	45.3
11	CIP309087.23	9.5	7.7	10.3	12	39.5
12	CIP309036.2	6.2	7.2	5.2	3.9	22.5
13	CIP302535.3	19.1	19.8	16	13.6	68.5
14	CIP308208.219	30.3	24.1	20.5	18.8	93.7
15	CIP309041.1	10.5	6.8	8.3	7.7	33.3
16	CIP398098.203	20.5	21.6	15.7	17.2	75
17	CIP398180.292	24.3	27.2	21.3	26.2	99
18	CIP309121.6	11.2	13.8	8.4	10.1	43.5
19	CIP398192.553	9.3	12.6	11.7	7.4	41
20	CIP309077.116	12.8	17.6	9.8	13.3	53.5
	Total per site (kg)	266.9	300.3	235.5	240.1	

Across all clones, yields under conventional management showed 12.51% higher compared with that of organic management in Yusipang. However, that difference is only 1.95% under Bumthang conditions. In nutshell, the average yield of potato clones under conventional management is observed to be relatively higher. But the observation is across, all 20 clones and more precise and clearer information will be obtained upon conducting replicate trials under both conventional and organic management.

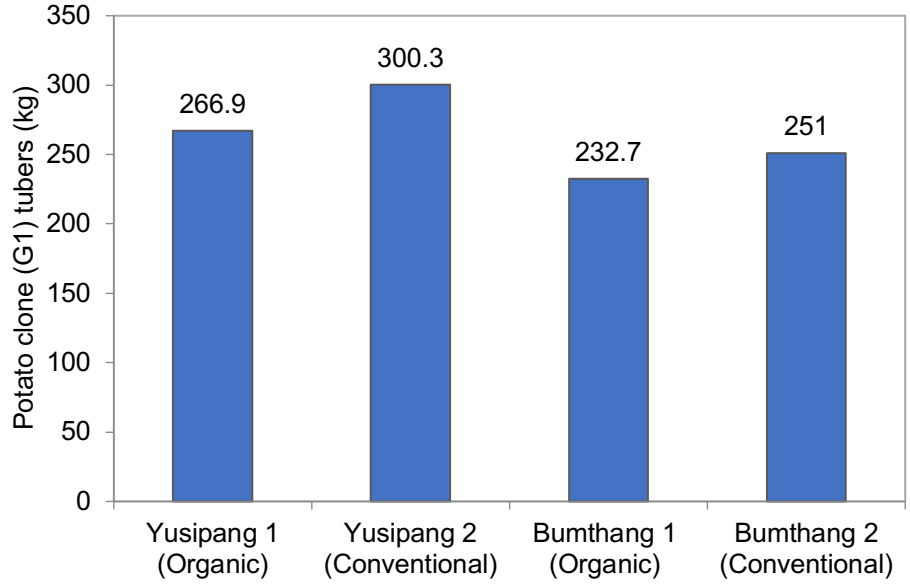

Figure 6:Four observation trials (organic and coventional) in Bumthang and Yusipang

1.9 Conduct multi-location potato varietal trials on selected potato germ plasm (Yusipang, Khangma and Bumthang)

***T*able 8:Four multi-location trials were conducted against APA target of in four multi-location trials as below**

SN	4 multi-location trials
1	Yusipang 1 - Organic
2	Yusipang 2 - Conventional
3	Khangma - Conventional
4	Bumthang - Conventional

Table 9:Characteristics of the selected clones for multi-location trial in 2020

SN	Accession No.	Skin colour	Tuber shape	Late blight resistance	Tolerance to heat	Tolerance to drought
1	CIP398180.289 (T1)	Cream	Oval	0.49	Tolerance	Tolerance
2	CIP398180.292 (T2)	Cream	Oblong	0.47	Tolerance	Tolerance
3	CIP398192.213 (T3)	Cream/Pink	Elliptic	1.13	Tolerance	Tolerance
4	CIP398208.219 (T4)	Cream/Russet	Elliptic	2.15	Tolerance	Tolerance

Table 10: Results of of multi-location on selected potato germ plasm in Yusipang under organic management (on-station trial). Mean potato yield and numbers harvested from 2.8 m2 area. The values presented are mean of three replicates.

Potato clones and treatment number	Potato tuber numbers			Potato tuber yield (kg/2.8 m²)		
	Table size	Seed size	Non-commercial	Table size	Seed size	Non-commercial
398180.289 (T1)	42.16	47.76	33.76	5.94	2.53	0.49
398180.292 (T2)	26.13	27.38	19.13	4.43	1.61	0.46
398192.213 (T3)	26.13	27.38	19.13	4.43	1.61	0.46
398208.219 (T4)	47.29	42.16	37.18	6.84	2.93	1.15
Desiree (T5)	23.80	28.62	19.29	1.90	0.96	0.37

Table size = >65g/tuber or >50 mm in diameter
Seed size = 35 to 65g/tuber or tuber diameter of 25 mm to 50 mm
Non-commercial = <35 g/tuber or <25 mm in diameter

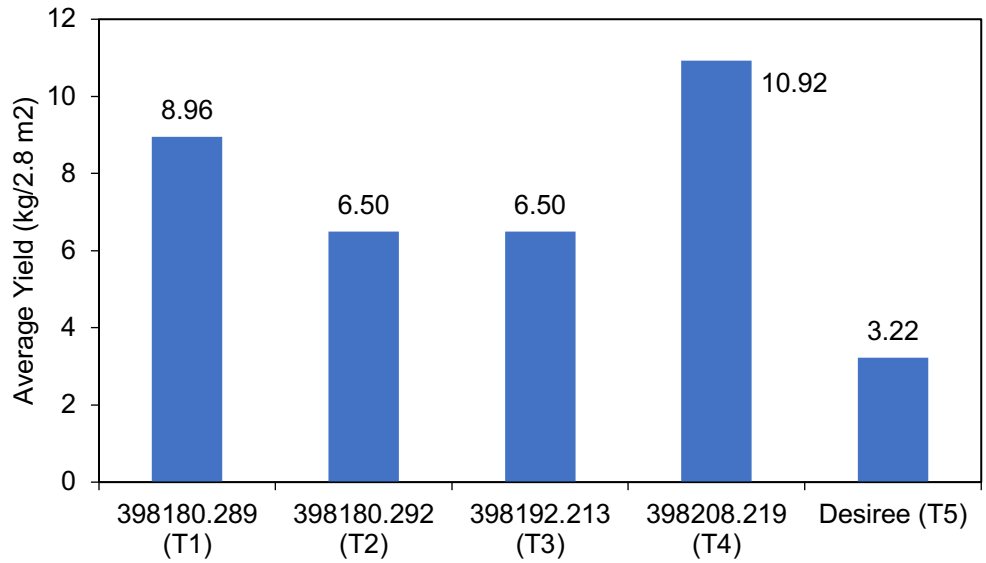

Figure 7:Climate resilient clones with Desiree in Yusipang (Organic

Average potato yield (combination of table size + seed size + non-commercial) for 2.8 m² trial area in Yusipang (organic). The values presented are mean of three replicates.

Table 11:Results of multi-location on selected potato germ plasm in Yusipang under conventional management (on-station trial). Mean potato yield and numbers harvested from 2.8 m2 area. The values presented are mean of three replicates.

Potato clones and treatment number	Potato tuber numbers			Potato tuber yield (kg/2.8 m²)		
	Table size	Seed size	Non-commercial	Table size	Seed size	Non-commercial
398180.289 (T1)	26.00	37.11	35.78	3.30	2.00	0.60
398180.292 (T2)	40.00	45.78	40.89	6.32	3.28	1.79
398192.213 (T3)	14.67	13.78	15.56	1.76	0.87	0.46
398208.219 (T4)	13.11	24.89	24.00	2.24	1.97	0.63
Desiree (T5)	8.22	38.44	60.89	0.72	1.50	0.84

Table size = >65g/tuber or >50 mm in diameter
Seed size = 35 to 65g/tuber or tuber diameter of 25 mm to 50 mm
Non-commercial = <35 g/tuber or <25 mm in diameter

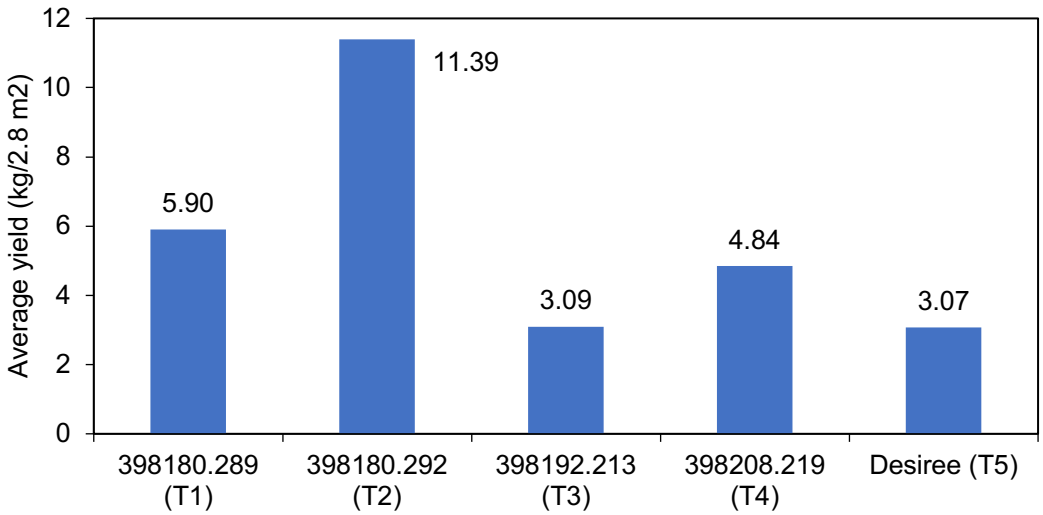

Figure 8:Climate resilient clones with Desiree in Yusipang (Conventional)

Average potato yield (combination of table size + seed size + non-commercial) for 2.8 m^2 trial area in Yusipang (conventional). The values presented are mean of three replicates.

Table 12:Results of of multi-location on selected potato germ plasm in Khangma (on-station trial). Mean potato yield and numbers harvested from 2.8 m2 area. The values presented are mean of three replicates.

Potato clones and treatment number	Potato tuber numbers			Potato tuber yield (kg/2.8 m^2)		
	Table size	Seed size	Non-commercial	Table size	Seed size	Non-commercial
398180.289 (T1)	23.67	48.67	31.00	2.60	2.27	0.57
398180.292 (T2)	33.33	40.00	31.33	3.53	1.93	0.59
398192.213 (T3)	20.67	38.00	42.00	2.40	1.88	0.76
398208.219 (T4)	25.33	26.33	13.00	2.77	1.14	0.45
Desiree (T5)	20.00	39.00	67.00	1.53	1.48	0.91

Table size = >65g/tuber or >50 mm in diameter
Seed size = 35 to 65g/tuber or tuber diameter of 25 mm to 50 mm
Non-commercial = <35 g/tuber or <25 mm in diameter

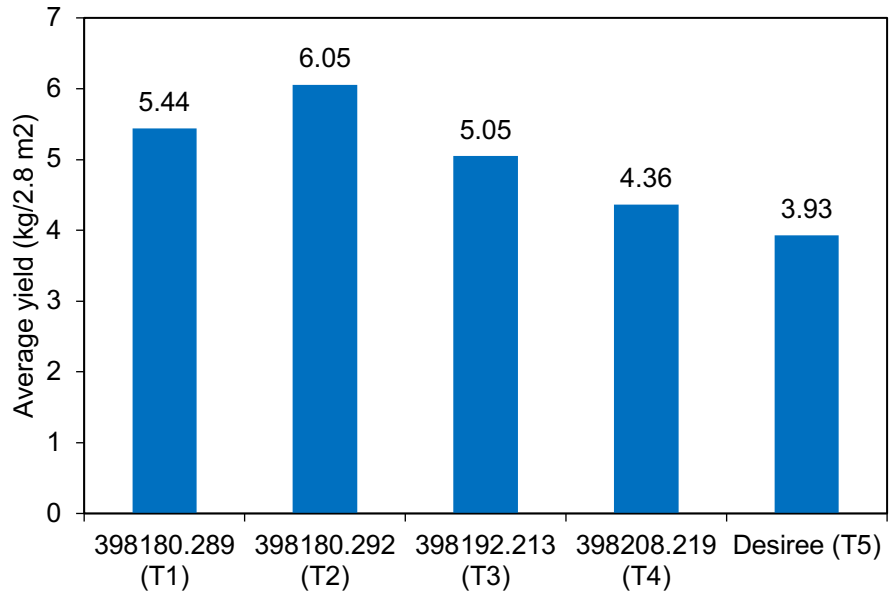

Figure 9:Climate resilient clones with Desiree as check in Khangma

Average potato yield (combination of table size + seed size + non-commercial) for 2.8 m^2 trial area in Khangma. The values presented are mean of three replicates.

Table 13:Results of of multi-location on selected potato germ plasm in Bumthang (on-station trial). Mean potato yield and numbers harvested from 2.8 m2 area. The values presented are mean of three replicates.

Potato clones and treatment number	Potato tuber numbers			Potato tuber yield (kg/2.8 m^2)		
	Table size	Seed size	Non-commercial	Table size	Seed size	Non-commercial
398180.289 (T1)	26.67	85.33	30.00	4.80	5.50	0.55
398180.292 (T2)	21.67	47.33	30.00	3.70	2.70	0.33
398192.213 (T3)	17.67	68.33	28.33	2.42	3.47	0.40
398208.219 (T4)	1.00	41.33	34.67	0.08	1.37	0.37
Desiree (T5)	6.00	59.00	46.67	0.63	2.37	0.52

Table size = >65g/tuber or >50 mm in diameter
Seed size = 35 to 65g/tuber or tuber diameter of 25 mm to 50 mm
Non-commercial = <35 g/tuber or <25 mm in diameter

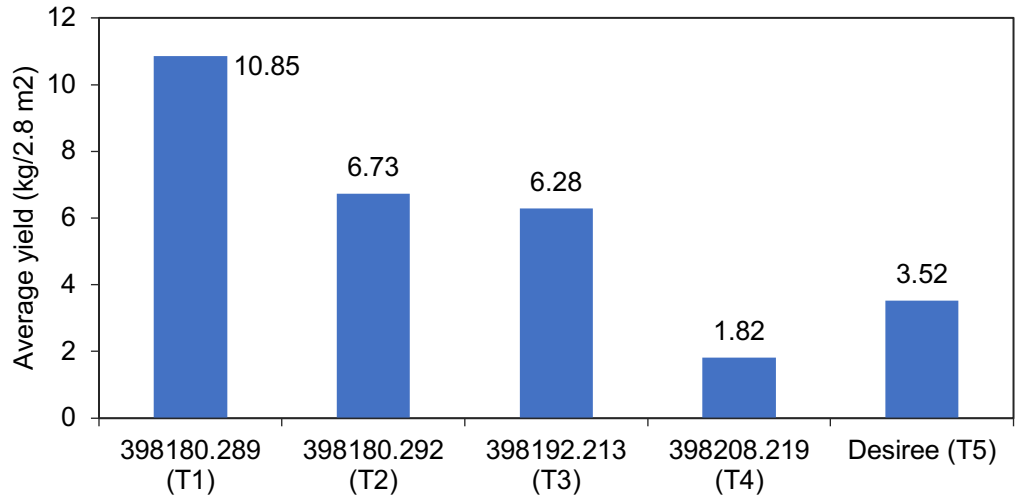

Figure 10:Climate resilient clones with Desiree as check in Bumthang

Average potato yield (combination of table size + seed size + non-commercial) for 2.8 m² trial area in Bumthang. The values presented are mean of three replicates.

1.10 Conduct multi-location/ observation trial on imported potato varieties from Nepal at Yusipang, Khangma Bumthang & Chapcha.

Four multi-location/ observation trials completed against APA target of Four multi-location/ observation trials in in Yusipang, Khangma, Bumthang & Chapcha. Tuber sizes and yields of imported potato varieties from Nepal were under four multi-location/ observation trials at four locations in Yusipang, Khangma, Bumthang & Chapcha. Two local varieties of Yusi Maap and Desiree were used as standard check.

Location		Yields (kg/16.8 m²)				Yield (kg/ha)
	Variety	Table size	Seed size	Non-commercial	Total	
Bumthang	K. Rato-2	0	2.8	2.15	4.95	2946
	Janak Dev	3.7	18.1	3.65	25.45	15149
	Desiree	1.6	10.15	2.15	13.9	8274
	Yusi Maap	3.25	15.60	4.80	23.65	14077
Chapcha	K.Rato-2	0	0	0.76	0.76	452
	Janak Dev	7.18	21.14	2.73	31.05	18482
	Desiree	1.3	6.5	2	9.8	5833
	Yusi Maap	3	4.5	4	11.5	6845
Khangma	K.Rato-2	0	5.6	4	9.6	5714
	Janak Dev	6	7.4	1.8	15.2	9048
	Desiree	8.7	10.3	5.85	24.85	14792
	Yusi Maap	8.2	5.3	2	15.5	9226
Yusipang	K. Rato-2	11.22	28.31	14.1	53.63	31923
	Janak Dev	32.63	26.95	2	61.58	36655
	Desiree	1.08	2.25	1.27	4.60	2740
	Yusi Maap	8.17	7.96	3.34	19.47	11589
	K. Rato-2	0	2.8	2.15	4.95	2946

Table size = >65g/tuber or >50 mm in diameter
Seed size = 35 to 65g/tuber or tuber diameter of 25 mm to 50 mm
Non-commercial = <35 g/tuber or <25 mm in diameter
K. Rato-2 = Khumal Rato-2. The highlighted in shade are two varieties imported from Nepal and the other two are local varieties of Bhutan.

Assuming the four locations as replicates mean yield is calculated and presented in Figure to better understand the overall performance of the varieties. The mean yield of four potato varieties ranges from 7.91 to 19.83 tons/ha. The lowest mean yield was observed in Desiree and the highest in Janak Dev. The mean yield of Yusi Maap was slightly higher than to that of Khumal Rato-2.

On an average, the imported Janak Dev yielded 90.07% higher than Yusi Maap and Janak Dev's yield was 2.5 times more compared to that of Desiree. However, Khumal Rato-2 yielded 1.68% higher in comparison to that of Yusi Maap and other words the yields of the two varieties were close to each other, on average. The average yield of Khumal Rato-2 was 29.70% higher to that of Desiree, when the yields were compared with each other.

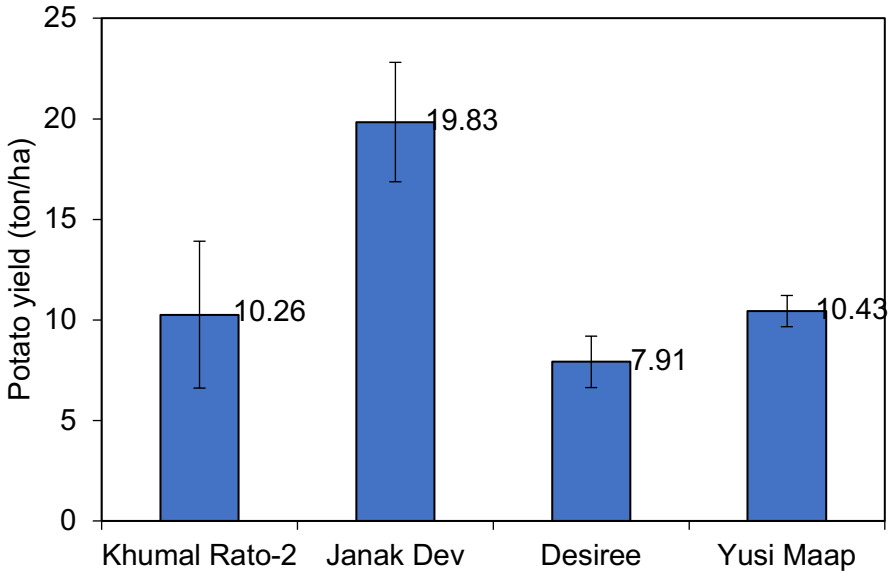

Figure 11:Potato varieties (two each from Nepal and Bhutan)

The mean yield of four potato varieties calculated assuming the locations as replicates and the error bars indicate the standard errors of the means.

Other Highlights

1. Published an article entitled: 'Productivity and preferences of new potato varieties an their relationships in five districts of Bhutan' in the Bhutanese Journal of Agriculture, Volume 4, Issue 1 pages 11-27.
2. Completed a vulnerability assessment survey in the seven Dzongkhags of Tashigang, Mongar, Bumthang, Gasa, Wangdue, Chhukha and Haa under FSAPP funding. Agricultural risks and vulnerability of potato growing farmers particularly with regard to livehihood means in the face of changing climate is being assessed.
3. Contributed produce the DoA's Crop-Cut Manual for Field and Horticulture as one of the authors, which is now widely available for MoAF users.
4. Contributed to DoA's Food Security assessment on major food and cash crops in Bhutan as a board member.
5. Published a paper entitled "Farmers applaud the Varietal Technolgy of Yusi Maap: a new potato variety" in Sanam Drupdrey to share the success stories for wider reach.
6. Contributed in editing and rewriting the four research articles from NCOA, Yusipang (quinoa, chirayita, tomato and rice) three of which are now published in BJA
7. Contributed as a reviewer and Editor-in-Chief in publishing BJA volume 4 (Issue 1)
8. PO of NPP reviewed, evaluated and screened all research prototols of the centre before sending to DoA
9. Contributed as resource person on Research methodology and scientific paper writing training to young agriculture officers.

1.10.1 Initiated field experiment with silicon fertilizer as an option to substitute inorganic fertilizer (Key aspects presented below).

Effect of silicon fertilizer (di-atomaceous earth) on performance on potato productivity and its protentional on reduction of NPK requirement

Rationale

In Bhutan, Potato ranked second highest in export value after orange and first in volume with 26075 MT of potato exported alone in 2019 which valued almost Nu.521 million. However, continuous monocropping and intensifying potato cultivation without proper nutrient management has led to yield stagnation in many potato growing areas. On other hand, poor soil nutrient status such as low nitrogen and phosphate and increase in purchasing price of chemical fertilizer is another concern.Also, most of potato plantation in Bhutan are rainfed where rainfall pattern is unpredictable and erratic. Therefore, to enhance potato yield, reduce the cost of cultivationof potato and risk of unpredictable weather, silicon which is known to reduce biotic and abiotic stress of as well said to have synergistic effect on NPK uptake of plants can be alternate solution. However, silicon fertilizer being fairly new to Bhutanese farming system, National Potato Program
under NCOA-Yusipang in collaboration with National Soil Service Centre has conducted research on the silicon fertilizer to see his efficacy on potato yield and productivity.

Figure 12:Field layout of silicon fertilizer trial

Objectives

1. To assess the benefits/efficacy of silicon fertilizer (Diatomaceous earth) on potato productivity.
2. To evaluate and analyze the best combination of silicon with NPK fertilizer.

Methodology

The field laid out was donewith Yusimaap potato variety in Randomized complete block design (RCBD). 5 different levels of NPK and silicon fertilizers was used as treatment with each replicated 5. Distance between blocks and treatments was maintained 50 cm with plant to plant and row to row distance as 15 cm x 60 cm.

Treatment	N:P: K (kg/ha)	Silicon (kg/ha)
T1 (1 NPK+ 0 Si)	150:100:100 (1 of NPK)	0 (0 of silicon)
T2 (1/2 NPK+1/2 Si)	75:50:50 (1/2 of NPK)	150 (1/2 of silicon)
T3 (1/4 NPK+3/4 Si)	37.5:25:25 (1/4 of NPK)	225 (3/4 of silicon)
T4 (0 NPK+1 Si)	0 (0 of NPK)	300 (1 of silicon)
T5 Control (0 NPK+0 Si)	0 (0 of NPK)	0 (0 of silicon)

For NPK fertilization Urea (in split dosage) and Suphala was used. For treatment application entire dosage of Potassium (K) and phosphorus (P) was be applied as basal dose. For Nitrogen (N) only 2/3 was applied as basal and remaining 1/3 was be applied at initial stage of tuber initiation. However, initial trial conducted at NCOA-Yusipang will be continued for 2 year with multi-location trial at Bumthang and analysis and outcome will be presented after completion of trial period.

Table 14:Average yield data of Yusimaap potato from first trial at NCOA-Yusipang

	T1(1 NPK+ 0 Si)	T2(1/2 NPK+1/2 Si)	T3(1/4 NPK+3/4 Si)	T4(0 NPK+1 Si)	T5/C (0 NPK+0 Si)
	(kg/3.6m2)	(kg/3.6m2)	(kg/3.6m2)	(kg/3.6m2)	(kg/3.6m2)
Rep 1	3.1	5.4	4	4.2	4
Rep 2	3.5	3.2	3.3	2.9	4.2
Rep 3	5.4	5.8	4.9	4.5	4.3
Rep 4	4	2.97	3.3	4.1	4.185
Rep 5	3.7	4.6	4.02	3.28	3.98

1.10.2 Silicon fertilizer as potential new Fertilizer in Bhutanese farming system-Review

Background

Silicon is the second most abundant element after oxygen in the crust of earth, with an average content of 28.8% weight with enormous potential for mitigating a wide range of biotic and abiotic stresses. The fertilization of silicon has a dual effect on the soil-plant system where silicon strengthens plant protective properties against diseases, insect attacks, and adverse climatic conditions such as toxicity to drought, salt, heavy metals or hydrocarbons. moreover, soil treatment with biogeochemically active Si substances optimizes soil fertility by improving the properties of water, physical and chemical soil and by maintaining nutrients in plant-available forms. It was said that silicon can reduce the application of pesticides (by 40-70%), traditional mineral fertilizers (by 10-40%), irrigation water (by 30-40%) can be reduced by Si fertilization without reduction in the yield of cultivated plant. However, concept of silicon (Diatomaceous earth) fertilizer was new to Bhutanese farming system and research on its benefit and outcome was not done as of 2020.Therefore, to evaluate the various aspect of silicon and its benefit on plant before introducing into Bhutanese farming system, review on silicon fertilizer was done through literature review from different journal article.

Objectives

1. To see the potentially of silicon fertilizer benefit on plant.
2. To substantiate the beneficial role of silicon prior to carrying out field research.

Summary of review

Antoine Lavoisier, a French chemist, was the first to identified silicon (Si) in 1787. However, Jöns Berzelius was credited with discovering silicon in 1824, when he was able to validate Lavoisier's theory by isolating silicon in Sweden(Cahn, 2009).Si is mainly translocated through the xylem in rice (Oryza sativa) in the form of monosilicic acid and mostly accumulates in leaves since it is distributed via transpiration stream(Aston & Jones, 1976).Soil concentrations of silicon range from 0.1 to 0.6mMand it primarily exist in soil in the form of Monosilicic acid(Epstein, 1994). It is deposit in the epidermal cells of leaves, stems and roots in the form of biogenic opals(phytolith) which act as mechanical barriers for the insects to chew, penetrate and digest plant tissues effectively(Alhousari & Greger, 2018).According to Takahashi, Ma, and Miyake (1990)silicon uptake in plants can possibility occur through active, passive and rejective types in relation to water uptake. And two different types of silicon (Si) transporter, influx and efflux, are involved in the Si-transport process of higher plants. The silicon transporter Lsi1(influx) and Lsi2(efflux) are responsible for Si uptake by roots and an influx transporter (Lsi6) is involved in xylem unloading of Si (Liang, Nikolic, Bélanger, Gong, & Song, 2015).

The history of use of silicon in agriculture possibly dates back to more than 2000 years ago in China, when the emperor ordered farmers to integrate rice (Oryza sativa) straw with Manure to improve plant productivity and yield as reported in(Liang et al., 2015). Silicon (Si) fertilizers in the form of plant ash were also used in ancient Roman agriculture to improve plant Si nutrition and restore depleted soils(Datnoff & Rodrigues, 2015).Silicon fertilizer in the form of sodium silicate fertilizer was first proposed by Liebig. He also conducted research on sugar beet (Beta vulgaris) production in greenhouse conditions using this silicon source(von Liebig & Playfair, 1841).In 1952, the Ministry of Agriculture, Forestry, and Fisheries of Japan started conducting slag field trials at national agricultural experimental stations. The findings of these studies illustrated the beneficial effects of slag in various locations, leading the Ministry of Agriculture, Forestry, and Fisheries to add Silicon to the list of fertilizers in 1955 (Ma & Takahashi, 2002)

Of numerous benefits,the economic benefit of silicon is known for its enormous potential in mitigating a wide range of biotic and abiotic stresses (Epstein, 1994). Additionally, it is claimed that silicon can reduce pesticide application by 40-70 percent, conventional mineral fertilizer application by 10-40 percent, and irrigation water application by 30-40 percent without reducing cultivated plant yield (Bocharnikova & Matichenkov, 2014). Silicon also strengthens plant protective properties against diseases, insect attacks, and adverse climatic conditions such as toxicity to drought, salt, heavy metals or hydrocarbons. Moreover, soil treatment with biogeochemically active Si substances optimizes soil fertility by improving the properties of water, physical and chemical soil and by maintaining nutrients in plant-available forms(Meena et al., 2014).It is reported that Silicon can increase quantity of mobile phosphate in thesoil as applied silicon rich substance can adsorb phosphorus and reduce P leaching by 40-70% (Meena et al., 2014).Additionally, Si has the ability to increase photosynthesis, minimize transpiration loss, and improve plant tolerance to a variety of abiotic and biotic stresses, all of which support plant growth (Souri, Khanna, Karimi, & Ahmad, 2020). Therefore, in variety of plants silicon can have a significant impact on plant growth and development(Epstein, 1994).

References

Alhousari, F., & Greger, M. J. P. (2018). Silicon and mechanisms of plant resistance to insect pests. *7*(2), 33.

Aston, M., & Jones, M. M. (1976). A study of the transpiration surfaces of Avena sterilis L. var. Algerian leaves using monosilicic acid as a tracer for water movement. *Planta, 130*(2), 121-129.

Bocharnikova, E., & Matichenkov, V. (2014). Silicon fertilizers: agricultural and environmental impacts. In *Fertilizers: Components, uses in agriculture and environmental impacts* (pp. 183-198).

Cahn, R. (2009). Silicon: child and progenitor of revolution. In *Into the Nano Era* (pp. 3-10): Springer.

Datnoff, L., & Rodrigues, F. (2015). History of Silicon and Plant Disease. In (pp. 1-5).

Epstein, E. (1994). The anomaly of silicon in plant biology. *Annals of applied Biology, 91*(1), 11-17.

Liang, Y., Nikolic, M., Bélanger, R., Gong, H., & Song, A. (2015). *Silicon in Agriculture: From Theory to Practice*.

Ma, J. F., & Takahashi, E. (2002). *Soil, fertilizer, and plant silicon research in Japan*: Elsevier.

Meena, V., Dotaniya, M., Coumar, V., Rajendiran, S., Kundu, S., & Rao, A. S. (2014). A case for silicon fertilization to improve crop yields in tropical soils. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 84*(3), 505-518.

Souri, Z., Khanna, K., Karimi, N., & Ahmad, P. (2020). Silicon and Plants: Current Knowledge and Future Prospects. *Journal of Plant Growth Regulation*. doi:10.1007/s00344-020-10172-7

Takahashi, E., Ma, J., & Miyake, Y. (1990). The possibility of silicon as an essential element for higher plants. *Comments on AgriculturalFood Chemistry, 2*(2), 99-102.

von Liebig, J. F., & Playfair, L. P. B. (1841). *Organic chemistry in its applications to agriculture and physiology*: J. Owen.

1.10.3 Initiated a pot experiment to assess effect of hilling on the yield of potato three potato varieties of NKK, Desiree and Yusi Maap (Key aspects presented below)

Introduction

Traditionally, commercially grown potatoes are hilled in the production cycle betweenemergence and closure of the canopy. Hilling is usually accomplished with disks, sweep shovels, or similar tools that lift soil from between rows and deposit it beside and on top of the row. Reasons for hilling may include: improved weed control, improved drainage, minimization of greening of tubers, and raising of soil temperatures. Proper management of each of these factors may result in an increase

in quality and quantity of tuber yield.Negative aspects of hilling have also been noted. It reported that waterdistribution was uneven under potato hills, resulting in uneven availability of water to plants and increased loss of fertilizer due to leaching. Hilling operations may also damage potato plants, and significant reductions in yield are known to result from hilling and other types of cultivation. Many commercial growers wait until vines are 12 or more inches tall before hilling. This scheduling is preferred because at this time the danger of covering plants is minimal. However, the vines of larger plants may sustain greater damage from hilling than smaller plants. Also, the possibility of damaging roots and stolon'sincreases as the plants increase in size, so there may be advantages to hilling when plants are younger and smaller.

Objective

1. To determine the best hilling height for potato
2. To determine effect of hilling on potato growth and yield

Material and Methods

The on-station trial is laid out in Split Plot(RCBD) using STAR (Statistical Tool for Agriculture research) with three different potato varieties. Single tuber of three different was planted in poly pot and hilled at 4 different height (0 cm, 5 cm, 10 cm and 15 cm) with no hill or 0 cm hill as standard check.

The **ANOVA**indicate that the hilling height has significant effect on tuber number at $F(3,6)=6.95, P=0.02$. However, varieties and combination of varieties has no significant effect on the tuber number. As indicated in table the mean tuber on hilling height 10 cm is significantly higher than the rest of treatment except 0 cm hilling height. Tuber number in 0 cm hilling hieght is silightly greater than 5 cm hilling height but there is no significance difference in tuber number between 5 cm and 15 cm. The hilling height and vareities has however no significant difference on tuber weight as indicated by ANOVA.

2 HORTICULTURE PROGRAMME

2.1 Highlights

Substantial progress in terms of both on-station, on-farm, strategizing and the conduct of a number of activities were made during the year 2020-2021 some of which were as below which are over and above the planned activities:

- Streamlined vegetables Research and development along with mandates across Research and development Centres
- Notified four hybrid varieties of Cauliflower, Tomato, and Radish.
- Research on low cost protected cultivation initiated
- Research on Tomato lines under the AFACI project with breeding objectives
- Research initiatives on winter chilli production
- Research on hydroponics initiated.
- Organic methods of apple orchard management trials initiated

Table 15:APA targets and achievements in 2020-2021 of Horticulture Research Program

Programme	Success indicators	Units	Target	Achievement	Achievement (%)	Remarks
Horticulture Production Enhanced	Produce basic vegetable seeds	Nos	6	8	133 %	Varieties of Lettuce,Chilli, Bean, Onion, Ground Apple, Garlic, Saag, Pumpkin species were produced
	Promote Winter Vegetable Production	Acres	10	10.25	102.5 %	13 villages under Chhukha Dzongkhag were covered
	Promote commercial Vegetable production sites in the region	Numbers	5	5	100%	5 villages under Thimphu, Chhukha and Haa Dzongkhags were covered
Agriculture research conducted	Collection and Evaluate indigenous vegetable varieties	Timeline	Dec 2020	Completed	100%	Completed
	Collection and establishment of MAP germplasm in the herb garden	Numbers	5	24	480 %	24 varieties of MAPS collected & established
	Initiate the Evaluation and development of organic management technology for MAPs	Numbers	6	6	100%	Completed
	Evaluate Fruits and Nuts-6 citrus varieties	Timeline	March, 2021	March 2021	100%	Completed
	Conduct trials on improved production and management practices of fruits and Nuts	Timeline	April, 2021	April, 2021	100%	Completed

	Conduct trials on propagation of seedlings from stone fruits	Timeline	Nov 2020	November 2020	100%	Completed
	Established Persimmon Germplasm Block	Timeline	March 2021	March	100%	Completed:
Agriculture Technologies Generated	Release/Notify high yielding vegetable varieties through VRC/TRC	Numbers	4	4	100%	Completed
Enhanced adoption of agriculture technologies	Promote fruits and nuts -strawberry varieties	Household numbers	10	10	100%	Completed
	Technology transfer on POP of Newly released cultivars in farmers field	Timeline	April, 2021	March 2021	100%	Completed
Climate smart technologies released and adopted	Evaluate climate resilient tomato varieties from AFACI	Numbers	28	28	100%	Completed

2.2 Produce basic vegetable seeds

Background

In view of National Center for Organic agriculture (NCOA) mandate, the center has been carrying out organic production of various vegetables. However, one of the main challenges the center faces is the fewer availability of organic breeder seeds. Thus, production of breeder seeds is one of the main focuses of the Horticulture sector. This report gives an overview of the activities undertaken for the production of organic breeder seed with the objectives to: Produce enough organic seeds for research purposes, distribute of excess organic seeds to other research institutions and interested organic grower and Maintain pure lines of seeds

Table 16:Table providing an update of the activities undertaken for the organic seed production

Crop Type	Varieties	Sowing Date	Harvesting Date	Seeds produced (kg/gm)
Lettuce	Butteroak, green-oak leaf, flashy trout, visiarosa, and red-mix	7/2/2020 nursery raising. 10/4/2020 transplanting	Sept-Oct, 2020	50 gm seed for each variety has been maintained
Chilli	Khasadrapchu, Nubi, Tamchoe, Yangtse and Haa locality name	29/01/2020, nursery raising, 22/04/2020 transplanting	1st week of Oct, 2020	In total 1.5kg seeds have been extracted from five chilli varieties: 1.Khasadrapchu : 0.236 kg 2.Nubi: 0.420 kgs 3.Tamchoe: 0.333 kgs 4.Yangtsipa: 0.694 5.Haa local: 0.157

Beans	local white, local brown, local creamy, local Chakharpa, local yellowish, local Punakha, local Dagani dwarf, local Gew Bori, Local khenkharpa Shepen, Local Kalo Bori	13/04/2020	End September 2020	Around 30kgs of seeds have been harvested from twelve local bean varieties as detailed here: 1.Local white: 6.9 kgs 2.Local brown: 2.8 kgs 3.local creamy: 1.7 kgs 4.chakharpa local: 6.5kgs 5.Punakha local: 2.0 kgs 6.Mukha shepen: 3.4 kgs 7.Gew bori: 0.7 kgs 8.Daganey: 0.6 kgs 9.Pangbey local: 0.5 kgs 10.Kalo bori: 6.3 kgs 11. Khengkharpa: 2.7 kgs 12.Local pink: 6.2 kgs
Ground Apple	Yusiyacon 1	10/03/2020	mid to end March, 2021	20 kgs ground apple rhizome maintained
Spring onion	Tsirang Local	Nov-2019	July 2020	60 kgs spring onion bulb cured for seed for on-station and on-farm trials.
Garlic	Yusipang Local	Nov-2019	July 2020	120 kgs of fresh garlic produced and cured for seed
Saag	Local (Yusipang)	6/03/2020	End Sep-Oct 2020	300 gms.
Pumpkin	Local green (: NBC)	10/03/2020	End Oct-2020	200 gms
cucumber	Local Yellow/green: (NBC)	10/03/2020	End 0ct-2020	400gms

Figure 13: Basic Vegetable Seed Produced

2.3 Promote Winter Vegetable Production

Production and therefore sufficiency of vegetables during the winter months has been a challenge. Except for Chhukha Dzongkhag, the Western region of Thimphu, Paro, and Haa mostly fall under the temperate agro-ecological zone where the main production season is in summer. Ten acres of winter vegetables were supported by the centre to promote production as summarized below.

Table 17:Summary of winter vegetable production supported in the region

Dzongkhag : Chhukha					
Gewog and village	**Crop**	**Sowing/planting date**	**Harvesting date**	**Intervention**	**Area (acres)**
Samphelling: Pekarshi	Winter Chilli	Aug	Dec- April	Training, Seedlings , seeds	2
Bongo: Beuri village	Winter chilli	Aug	Dec- April	Seeds, seedlings and trainings	0.5
Samphelling :Gurungdara& Rangaythung	Onion	Sept	March	Seeds, seedlings and trainings	2
Dungna: Dukdhingsha Ngalachung Lokchina: Jachu	Winter tomato	Aug	March	Seedlings, seeds, Training on low cost rain shelter, Training on Pruning, Plastics, GI wire and Jute rope	1(rain shelter)
Phuentsholing : Adeykha Bongo: Jigmechu Darla: Peeping	Winter tomato	Aug	March	Seedlings, seeds, Training on low cost rain shelter, Training on Pruning, Plastics, GI wire and Jute rope	1(open field)
Bongo : Beri	Cole crops (cabbage, cauliflower)	Sept	Dec	Seeds and training and green houses	2.25
Bongo:Jigmechu Darla: Peeping	Cole crops and legumes	Sept	Dec	Seeds and demonstration and trainings	0.5
Bongo: Meritshimo village and laga village	Cole crops, onion and tomato	Sept	Feb	Seeds and demonstration and trainings.	0.75
					10.25

Chilli (hybrid variety, SV 2319HA) seedlings was raised at NCOA Yusipang and grown in Pekarshi village, an organic village in Sampheling gewog, Chhukha Dzongkhag on 2 acres and Beuri village on 0.5 acres. Seeds were sown under poly-tunnels on 7 August 2020 and transplanted by 18 September - 42 days from the date of sowing.

Figure 14: Winter Chili Production

Winter chilli nursery at Yusipang(left) and famers pack chilli for market(right)

Farmers practiced either tethering of cattle or applied Farm Yard Manure. Pest and diseases (leaf curl and blight) affected the crop in the month of January. Neem oil and cow urine was applied to

address the problem. Harvests started on 7 December. Farmers sold their winter chilli at Phuntsholing town at Nu. 400-450/kg earning about Nu.238, 000 as of April 2021.

Samphelling gewog was supported with onion seeds to cultivate on 2 acres. Demonstrations of nursery raising and transplanting techniques were conducted.
Likewise, two acres of winter tomato production under protected cultivation (1 ac) and open field (1 ac) was supported to Gewogs of Dungna, Lokchina, Phuentsholing, Bongo and Darla gewogs. Production under rain shelter was promoted at Peeping, Darla gewog, Jigmichu, Bongo, Dukdhingsa, Ngalachung, Adaykha, and Jhachu village. Trainings on low cost rain shelter installation, transplanting, mulching, pruning were imparted besides providing with plastic sheets, GI wires and jute ropes.
Cole crops (cabbage, cauliflower and broccoli) were promoted on an area of 2.5 acres through seeds and training at Beri village, Bongo with 14 farmers, who were also provided with a polyhouse of size 10mx5m for the purpose of raising seedlings jointly.

Figure 16:Onion Production at Dungna

Figure 15: Tomato production in Rain shelter and open field

Legumes and cole crops were promoted on 0.5 acre of land as winter crops in Jigmechu. At Meritsimo and Laga villages of Bongo gewog, Cole crops, onion and tomato were promoted through seeds, demonstration and trainings to 14 farmers on 0.75 acre.

2.4 Promote commercial Vegetable production sites in the region

In line with the 12 FYP, the centre promoted commercial vegetable production sites at five locations as detailed in table below.

Table 18:Table summarizing promotion of commercial Vegetable production sites in the region

Sl no	Dzongkhag and (Village)	Number of beneficiaries	Crops promoted	Area (Acres)
1	Haa, (Langpa Nobgang)	20	Garlic	3
2	Thimphu, (Genekha)	15	Onion, Tomato	2.5
3	Chhukha, (Ngalachung and Dukdhingsha)	40	Tomato, cabbage, cauliflower	3
4	Chhukha, (Jigmechu and Meritsimo)	15	Beans and Onion	3
5	Chhukha, (Darla)	12	Onion	1

2.4.1 Haa Dzongkhag: Nobgang village, Samar gewog

Garlic production was initiated at Langpa Nobgang, Haa Dzongkhag through demonstration of planting techniques and distribution of seeds/garlic cloves. More than 600kgs of garlic seeds were distributed to 20 farmers of Langpa Nobgang village covering an area of 3 acres in total. Garlic cloves were sown during the Month of February 2021 and will be harvested in August 2021 and expected to produce 2400kg (2 MT) at a yield of 800 kg /ac.

Figure 17:Garlic seed delivery

2.4.2 Dzongkhag: Thimphu: Gewog : Genekha

Two acres of commercial onion and tomato production was supported to Genekha Gewog through demonstration, training and seed supply. Intensive training was conducted with 40 households. Six kgs of onion seed were provided to the farmers which will cover two acres, tomato seed of hybrid variety "cosmic" was provided to the farmers to cover 20 protected existing structures and nursery was also raised during the training.

Figure 18: Onion Production

2.4.3 Dzongkhag: Chhukha: Gewog: Dungna

Commercial production of cabbage, cauliflower and tomato was promoted at Dungna Gewog through training and seed supply. Tomato seeds of cosmic variety were provided to farmer's vegetable group of Dukdhingsha and Ngalachong. 3 Tomato growers' group were formed and provided with seeds in upper Ngalachung, lower Ngalachung and Dukdhingsha.

Figure 19: Tomato Production Training and tomato Produced

2.4.4 Dzongkhag : Chhukha: Gewog: Bongo

Beans and onion crops were promoted in Bongo Gewog, Chhukha Dzongkhag. Seeds of onion and beans were provided to the farmers of Jigmechu and Meritsimo village for commercial production. Trainings on vegetable production with focus on onion, tomato and chilli cultivation were imparted.

Figure 20:Trainings on vegetable production with focus on onion, tomato and chilli

2.4.5 Dzongkhag : Chhukha, Gewog: Darla

Figure 21: Onion Production at Darla

At Darla gewog, seeds of onion were provided to the onion group for mass cultivation. Seeds were provided to the growers. Seed sowing and planting techniques were demonstrated. Seeds were distributed to fourteen small holder farmers for a total area of 2 acres

2.5 Collection and Evaluate indigenous vegetable varieties

Modern varieties are outcomes of scientific breeding while traditional varieties or landraces (farmer's varieties) are the product of selection carried out by farmers. Traditional varieties help to provide stability to farming system at local, national and regional levels by leveling yield variability, through the cultivation of wide range of crops and intra-crop diversity. Pepper (*Capsicum spp.)* is one of the most important crops in Bhutan. The inadequacy of basic information has hindered a rational production planning and promotion of suitable high yielding open pollinated varieties. Further, the erosion and decline of traditional varieties of chili in Bhutan has been reported as a prominent issue. This further exacerbated by a lack of research and extension efforts in characterization and maintenance of local genetic resources. NCOA Yusipang collected five different traditional varieties of chilli which were evaluated for their characteristics and potential.

Materials and Methods

Five accessions of chilli from NCOA Yusipang (western region) with Sha ema as local check were evaluated on station at Yusipang (2600masl) in a randomized block design (RCBD) with four replications on bed size of 5mx1 m

Table 19: Treatments(chilli lines)

	Name	Landrace origin
1	Yangstipa	Tashiyantsi
2	Nubi ema	Nubi , Trongsa
3	Begup	Khachadrapchu and Begana
4	Haa local	Mixed of Haa, Thimphu and Paro
5	Sha ema	Wangdue
6	Tamchu	Tamchu Lhakhag,Paro

Beds were mulched with black plastic. Seeds were sown in February 2020 under poly tunnels and transplanted on 22 April 2020 at a spacing of 45PP X 60 RR**. Data from total of two harvests of 8th and 18th September were collected.** Data was analyzed using SPSS software package. Comparison between the varieties was made by Tukey HSD All-Pairwise Comparisons. Data on morphological characteristics was collected as per the International Union for Protection or new Varieties of Plants (UPOV) guidelines

Results & Discussions

Table 20: Plant characteristics of six varieties of traditional chilli lines

	F	Sig.
Plant height (cm)	7.073	.000
Plant width(cm)	1.657	.154
No. of fruits /plant	2.049	.080
Fruit wt/plant	2.256	.056
Yield/plot	7.940	.002

Statistical analysis conducted using one-way ANOVA, showed significant differences between the varieties for plant height and yield at P<0.05 level but no significant differences between the varieties for plant width, number of fruits per plant and fruit weight

Table 21:Comparative analysis on plant height, plant width, Fruits per plant, fruit weight and yield per plot

	Plant Height (Cms)	Plant Width (Cms)	Fruits per plant (nos)	Yield per plant (gms)	Yield per plot(Kgs)
Yangtsepa	58.4_{c}	49.9_{a}	21.0_{a}	456.7_{a}	11.0_{a}
Nubi ema	85.7_{a}	58.0_{a}	30.7_{a}	306.7_{a}	4.4_{c}
Khasadrapchu	67.4_{bc}	54.5_{a}	22.1_{a}	440.0_{a}	10.5_{ab}
Haa local	67.9_{bc}	52.2_{a}	28.5_{a}	435.3_{a}	6.3_{abc}
Sha ema	84.1_{ab}	56.9_{a}	22.9_{a}	293.3_{a}	3.9_{c}
Tamchoe	79.3_{ab}	51.7_{a}	22.7_{a}	320.0_{a}	5.5_{bc}

Each subscript letter denotes that the parameter (plant height, plant width, fruit per plant, fruit weight per plant and yield per plot) whose column proportions do not differ significantly from each other at the P<0.05 level.

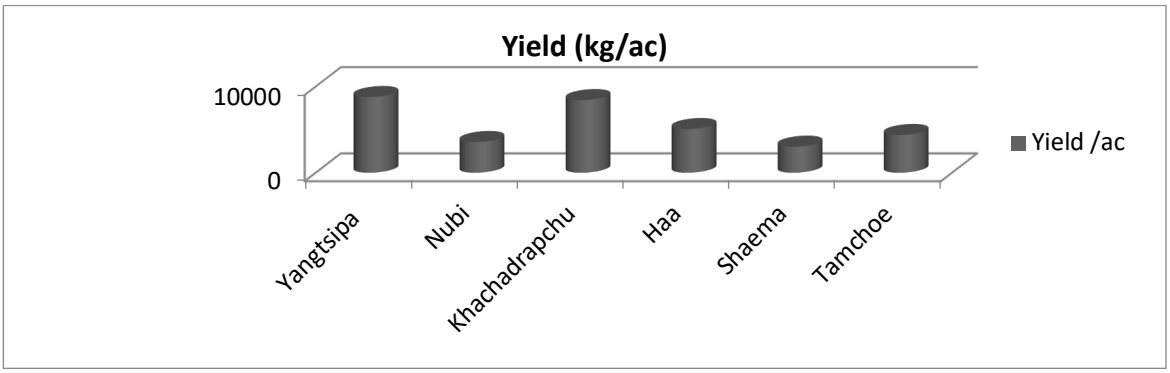

Figure 22: Yield per acer

Yangstipa ema had the highest yield at 8784kg/acre followed by Khasadrapchu (Begup) at 8424.kg/acre, Haa local at 5064 kg/acre, Tamchoe at 4376 kg/acre) , Nubi at 3560kg/acre and Sha Ema(3024kg/acre). There was no significant differences between the yield of Yangtsipa and Begup chilli. However, these two varieties performed significantly better compared to others.

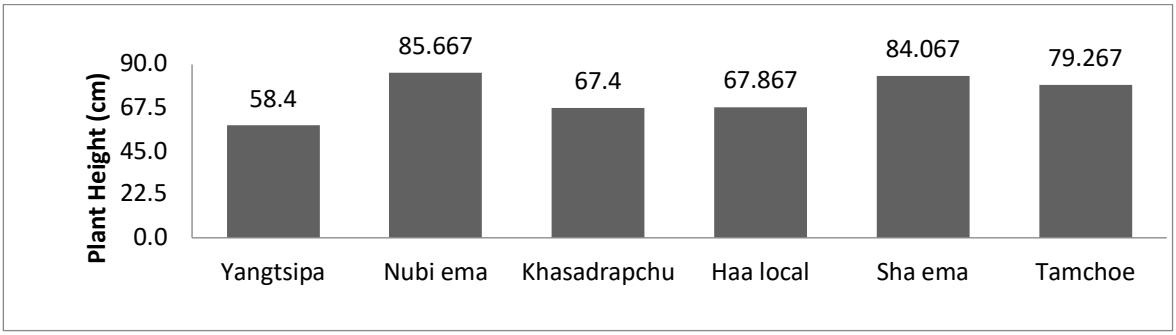

Figure 23:Figure showing Plant height of different chilli varieties.

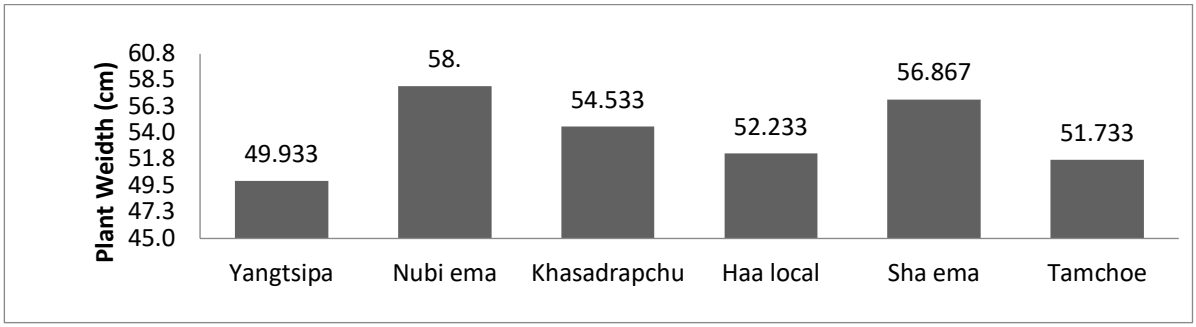

Figure 24: Figure showing plant width of the varieties.

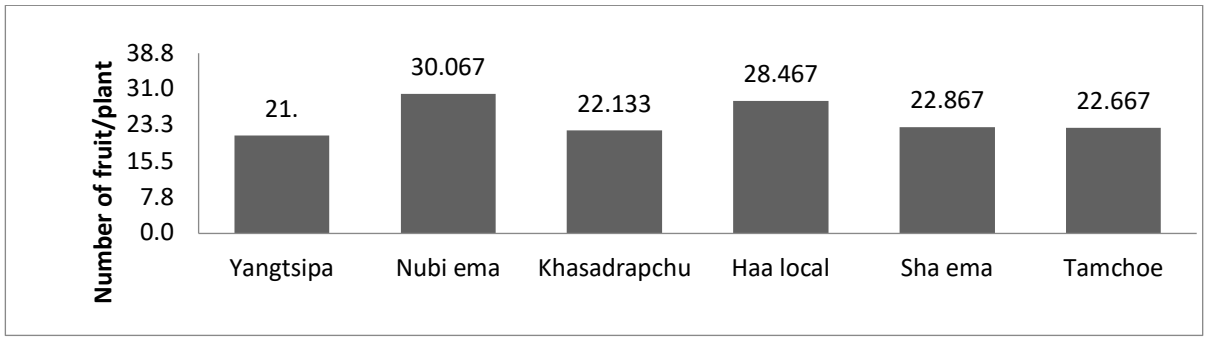

Figure 25:Figure showing number of fruits per plant.

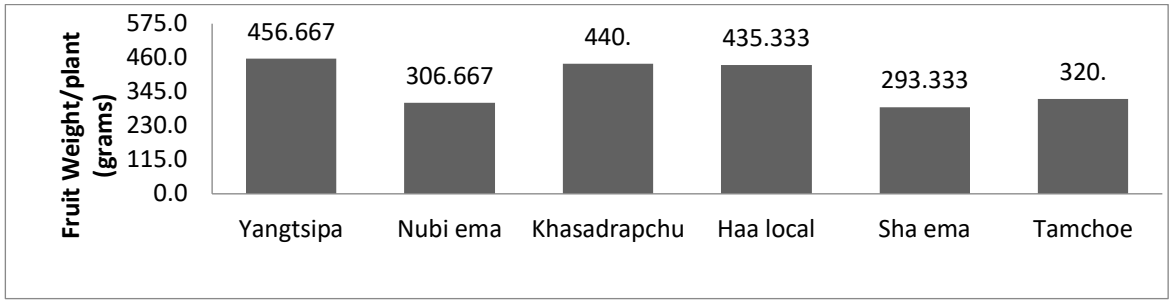

Figure 26: Figure showing fruit weight per plant of the varieties

Yangtsipa ema weighed the heaviest at 456.7 gram per plant and Sha ema the lightest at 293.3 gram. Plant height of Nubi ema at 85.7 cm was the tallest while Yangtsipa ema was the shortest (58.4 cm). Canopy width was widest in Nubi ema (58.cm) and smallest in Yangtsipa (49.9 cm). Nubi ema had the maximum number of average fruits per plant (30.1) and Yangtsipa had the minimum number of fruit per plant (21 numbers). The results of the evaluation clearly indicated that two promising variety under the traditional lines are Yanstsipa ema and Begup ema. The varieties were also distributed to other ARDCs (Samtelling and Bajo), the results of which are yet to be received. A comparative data for more comprehensive results and further recommendation needs to be carried out.

2.5.1 Traditional Bean Variety Evaluation

Green beans are consumed as vegetables and in Bhutan its production and consumption has increased over the years. NBC has recorded 51 traditional varieties of beans**.** NCOA Yusipang has collected eleven varieties of traditional varieties of beans out of which seven varieties were evaluated in 2020 with the objectives to evaluate for their yielding traits and propose for release

Materials and method

Trial was established at NCOA Yusipang with seven accessions as in table below. Seeds were sown on 30/3/2020 and harvested **from July 2020 till September 2020.** Data from two harvests were recorded.

Table 22: Name of Traditional beans varieties, source and characteristics

Sl.no	Name/ accession	String/stringless Source	Source	Indeterminate/ determinate
1	Punakha local	stringless	Punakha	Indeterminate
2	Pangbisa	stringless	Mongar	Indeterminate
3	Muka	stringless	Mongar	Indeterminate
4	Daganay	string	Dagana	Indeterminate
5	Khenkharpa		NBC	
6	Chakarpa	string	NBC	Indeterminate
7	Gew bori	string	Dagana	Indeterminate

The experiment was laid out in a randomized block design with four replications, which makes a total (7 treatments x 4 replications) of 28 beds each measuring 5m x 1m at a spacing of 45cm (PP) and 80cm Row to Row (RR)
Data was analyzed using SPSS software package. Comparisons were made by one-way ANOVA method. Data on morphological characteristics was collected as per the international Union for Protection or new Varieties of Plants (UPOV) guidelines

Result and Discussions

Out of the seven varieties, germination of evaluated two varieties Daganay and Pangbisa (determinate varieties) was poor and was affected by leaf spot and anthracnose diseases. Yield data of one variety Chakarpa was discarded and screened out as the pods were not edible. Only seeds were consumable and comparison for pods yield was not made

Table 23: Results of yield of four traditional beans are as follows

Varieties	No of Pod/plant	Pod weight	Yield
Geu bori	39.93_{a}	463.33_{a}	3.83_{a}
Kengkhar shepen	20.66_{b}	350.40_{a}	2.69_{ab}
Mukha shepen	18.06_{bc}	260.00_{ab}	1.70_{ab}
Punakha local	3.35_{c}	57.00_{b}	0.83_{ab}

Statistical analysis conducted using one-way ANOVA, showed that there is significant difference between the varieties for all three parameters i.e. number of pod per plant, Pod weight and yield. Each subscript letter denotes that the parameter (number of pod per plant, Pod weight and yield) whose column proportions do not differ significantly from each other at the P<0.05 level.

Comparison between the varieties done by Tukey HSD All-Pairwise Comparisons. Geu bori yielded maximum with 3064kg/acre, significantly higher than the others followed by Khenkhar shepen with 2158 kg/acre, Mukha Shepen with 1364kg/acre and Punakha local with 665.6kg per acre.

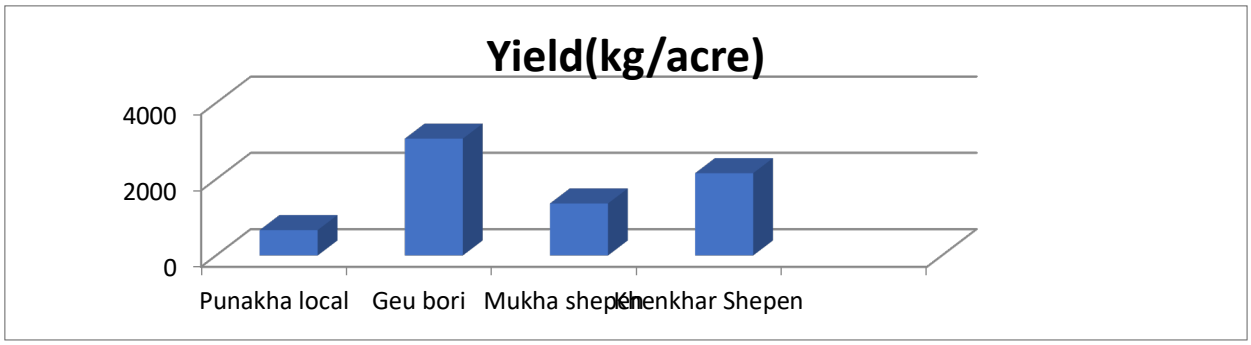

Figure 27: Yield Figures

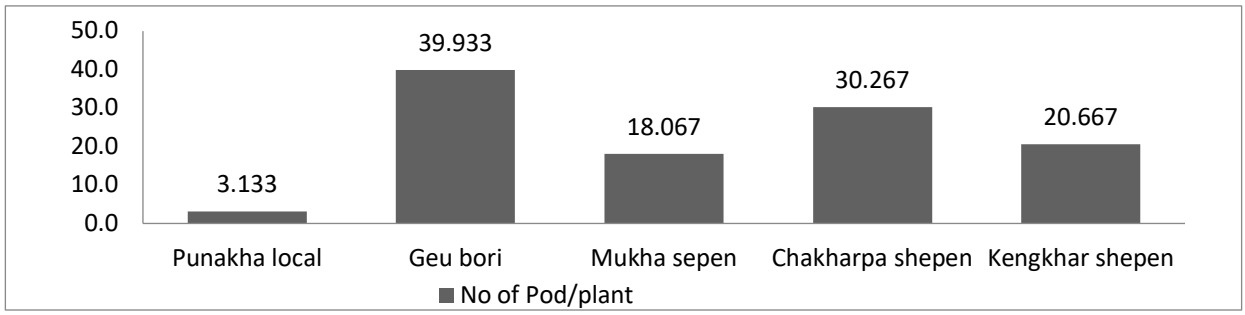

Figure 28:Figure showing no of pods per plant

Maximum number of pods per plant was 39.9 in Geu bori and minimum in Punakha local with 3.1 pods per plant.

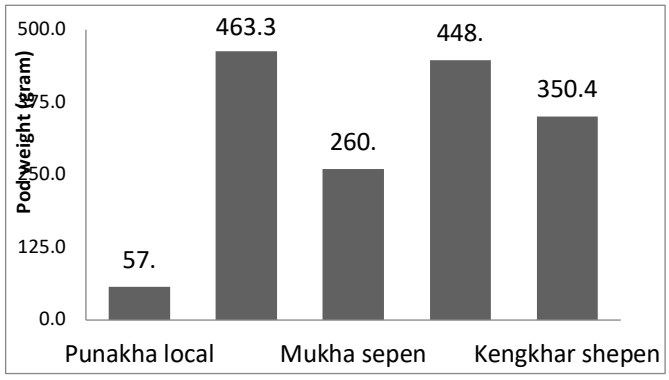

Figure 29:Figure showing pod weight per plant.

Maximum weight of pod/plant was 463.3 gms for Geu bori and minimum was in Punakha local with 57 g pod weight. The result of the evaluation shows promising yield from geu bori however further evalatuion needs to be conducted to compare yields other open pollinated varieties.

2.6 Collection and establishment of MAP germplasm in the herb garden

Introduction

Medicinal plants and traditional medicine play an important role in the health care system of Bhutan where both traditional medicine and modern medicine are followed. Bhutanese traditional medicine uses about 300 species of medicinal plants which are mostly collected from wild. However, of recent years, the

community's engagement in illegal collection and trade is one of the main factors resulting in depletion and endangerment of medicinal plant species from the wild. In an attempt to conserve medicinal plants through domestication research, generation and promotion of sustainable collection and cultivation packages, the MAP Section annually collects endangered, potential medicinal plants and maintain in the herb garden for observation and demonstration purpose.

Objectives

1. To understand the characteristics of endangered medicinal plants and to explore the possibility of its domestication
2. To demonstrate medicinal plant germplasm to students, farmers, conservationists and visitors.

Methodology

The germplasms were collected from Chelela and Sagala hills under Haa Dzongkhag between 5thto 18th October 2020. The elevation of the collection site ranges from 2500 to 4000 meters above mean sea level. The collections were done after the plants have completed their life cycle, seeds set and matured to ensure regeneration in the next season. The collected materials are wrapped in the mosses and brought to MAP Office at NCOA Yusipang. Then the plants were potted in the ploy pots with the media mixture of soil, sand and forest soil at 50:25:25 ratio respectively. The potted plants were regularly watered and weeded.

22 accessions of 13 different medicinal plant species were collected from Chelela and Sagala under Haa Dzongkhag from an altitude ranging from 2500 to 4000 masl

Accession Number	Collection Date	Common Name	Scientific name	Place of Collection	Altitude (masl)	Soil Type	Soil pH	Habitat
1	05-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3676 masl	Sandy loam	6.4	Under shade
2	06-10-20	Emong karpo	*Clematis Montana*	Chelela	3729 masl	Sandy loam	6.4	Under shade
3	06-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3764 masl	Sandy loam	6	Under shade
4	06-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3848 masl	Sandy loam	6.3	Open space
5	06-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3879 masl	Sandy loam	5.2	Open space
6	06-10-20	Lagiop	*Allium sp.*	Chelela	3878 masl	Loamy	6	Open space but on rocks & cliffs mostly
7	06-10-20	Pangpoe or Zappoe	*Valeriana sp.*	Chelela	3876 masl	Loamy moist soil	6	Open space but on rocks & cliffs mostly
8	07-10-20	Ngo-Bashaka	*Corydalis stracheyii/crispa*	Chelela	4046 masl	Moist loamy soil	6.2	Open space
8	07-10-20	Ngo-Bashaka	*Corydalis stracheyii/crispa*	Chelela	4096 masl	Moist loamy soil	6	Open space
9	06-10-20	Risho	*Ligularia virgaurea* (MaXIM) ex. Rehd	Chelela	3878 masl	Loamy moist soil	5.4	Open space

10	06-10-20	Wangla	*Dactylorhza hatagera*	Chelela	3897 masl	Loamy moist soil	6.4	Open space
11	07-10-20	Wangla	*Dactylorhza hatagera*	Chelela	4082 masl	Loamy moist soil	5.4	Open space
12	07-10-20		*Picrorhiza kurroa*	Sagala	4057 masl	Loamy moist soil	6.4	Open space
13	07-10-20	Wangla	*Dactylorhza hatagera*	Chelela	4080 masl	Rocky area	5.4	Open space
14	07-10-20	Changser Loma	*Acanthocalyx nepalenses*	Chelela	4034 masl	Loamy moist soil	6.8	Open space
15	07-10-20	Wangla	*Dactylorhza hatagera*	Chelela	4080 masl	Rocky area	6	Open space
16	08-10-20	Ngo-Bashaka	*Corydalis stracheyii/crispa*	Chelela	4046 masl	Moist loamy soil	6.2	Open space
17	09-10-20	Bashaka	*Corydalis stracheyii/crispa*	Sagala	3878 masl	Moist loamy soil	7	Open space
18	09-10-20	Bashaka	*Corydalis stracheyii/crispa*	Sagala	4043 masl	Moist loamy soil	6.4	Open space
19	08-10-20	Khensey	*Ajania sp*	Chelela	4012 masl	Moist loamy soil	4.8	Open space
20	09-10-20	Pantse Daw	*Pterocephalus hookeri (C.B.Calarke*	Sagala	4028 masl	Moist loamy soil	5.8	Open space
21	09-10-20	Pantse Daw	*Pterocephalus hookeri* (C.B.Calarke	Sagala	4037 masl	Moist loamy soil	6	Open space
22	06-10-20	Chushung wombu	*Myricaria germanica* (L.)	Mesi zam	2514 masl	Sandy	6.6	Open space
23	09-10-20	Tarbu Namtar	*Hypophae rhamnoide*	Chelela	2513 masl	Sandy	6.8	Open space

The surrounding vegetations were dominated by *Rhodio* species, *Jatamansi* species, *Pleurospermum* species, *Juniper* species, *Aconite* species, *Primula* species, *Cassiope* species, *Fritillaria* species, *Polygonum* species, *Potenylla* species, *Cassiope* species, *Berberis* species, Ferns, *Morina* species, and *Aster* species. It was found that the wild medicinal plants are grown dominantly on loamy type of soils and on the rocky areas with slightly acidic soil with pH ranging from 4.8 to 6.8. It was found that except for Udpal and Emong Karpo, all medicinal plants are found to be growing in open space. The medicinal plants collected are maintained in the herb garden for observation purpose.

22 accessions of 13 different medicinal plant species were collected from Chelela and Sagala under Haa Dzongkhag from an altitude ranging from 2500 to 4000 masl (Table 24). The surrounding vegetations were dominated by *Rhodio* species, *Jatamansi* species, *Pleurospermum* species, *Juniper* species, *Aconite* species, *Primula* species, *Cassiope* species, *Fritillaria* species, *Polygonum* species, *Potenylla* species, *Cassiope* species, *Berberis* species, Ferns, *Morina* species, and *Aster* species. It was found that the wild medicinal plants are grown dominantly on loamy type of soils and on the rocky areas with slightly acidic soil with pH ranging from 4.8 to 6.8. It was found that except for Udpal and Emong Karpo, all medicinal plants are found to be growing in open space. The medicinal plants collected are maintained in the herb garden for observation purpose.

Table 24:MAPs collected and maintained

Accession Number	Collection Date	Common Name	Scientific name	Place of Collection	Altitude (masl)	Soil Type	Soil pH	Habitat
1	05-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3676 masl	Sandy loam	6.4	Under shade
2	06-10-20	Emong karpo	*Clematis Montana*	Chelela	3729 masl	Sandy loam	6.4	Under shade
3	06-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3764 masl	Sandy loam	6	Under shade
4	06-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3848 masl	Sandy loam	6.3	Open space
5	06-10-20	Udpal	*Meconopsis simplicifolia*	Chelela	3879 masl	Sandy loam	5.2	Open space
6	06-10-20	Lagiop	*Allium sp.*	Chelela	3878 masl	Loamy	6	Open space but on rocks & cliffs mostly
7	06-10-20	Pangpoe or Zappoe	*Valeriana sp.*	Chelela	3876 masl	Loamy moist soil	6	Open space but on rocks & cliffs mostly
8	07-10-20	Ngo-Bashaka	*Corydalis stracheyii/crispa*	Chelela	4046 masl	Moist loamy soil	6.2	Open space
8	07-10-20	Ngo-Bashaka	*Corydalis stracheyii/crispa*	Chelela	4096 masl	Moist loamy soil	6	Open space
9	06-10-20	Risho	*Ligularia virgaurea* (MaXIM) ex. Rehd	Chelela	3878 masl	Loamy moist soil	5.4	Open space
10	06-10-20	Wangla	*Dactylorhza hatagera*	Chelela	3897 masl	Loamy moist soil	6.4	Open space
11	07-10-20	Wangla	*Dactylorhza hatagera*	Chelela	4082 masl	Loamy moist soil	5.4	Open space
12	07-10-20		*Picrorhiza kurroa*	Sagala	4057 masl	Loamy moist soil	6.4	Open space
13	07-10-20	Wangla	*Dactylorhza hatagera*	Chelela	4080 masl	Rocky area	5.4	Open space
14	07-10-20	Changser Loma	*Acanthocalyx nepalenses*	Chelela	4034 masl	Loamy moist soil	6.8	Open space
15	07-10-20	Wangla	*Dactylorhza hatagera*	Chelela	4080 masl	Rocky area	6	Open space
16	08-10-20	Ngo-Bashaka	*Corydalis stracheyii/crispa*	Chelela	4046 masl	Moist loamy soil	6.2	Open space
17	09-10-20	Bashaka	*Corydalis stracheyii/crispa*	Sagala	3878 masl	Moist loamy soil	7	Open space
18	09-10-20	Bashaka	*Corydalis stracheyii/crispa*	Sagala	4043 masl	Moist loamy soil	6.4	Open space
19	08-10-20	Khensey	*Ajania sp*	Chelela	4012 masl	Moist loamy soil	4.8	Open space
20	09-10-20	Pantse Daw	*Pterocephalus hookeri (C.B.Calarke*	Sagala	4028 masl	Moist loamy soil	5.8	Open space
21	09-10-20	Pantse Daw	*Pterocephalus hookeri* (C.B.Calarke	Sagala	4037 masl	Moist loamy soil	6	Open space
22	06-10-20	Chushung wombu	*Myricaria germanica* (L.)	Mesi zam	2514 masl	Sandy	6.6	Open space
23	09-10-20	Tarbu Namtar	*Hypophae rhamnoide*	Chelela	2513 masl	Sandy	6.8	Open space

2.7 Initiate the Evaluation and development of organic management technology for MAPs

To streamline research on organic management and technology generation for medicinal and aromatic plants, six research trials were established during the reporting period as detailed in **Error! R eference source not found.** below.

Table 25:: Research trials established

Sl. No.	Research Topics	Research Objectives	Research Design Treatment details	Status
1.	Evaluate the effect of different dosages of organic manures on the yield of Ruta (*Saussurea lappa*).	To find out the right manure and right dosage for Ruta cultivation.	Split-plot RCBD	Trial established in July, 2020
2.	Effect of altitude and manure application rates on the yield and yield parameters of *Swertia Chirata* in Bhutan	To study the performance of chirata in different altitudes and generate package of practices	RCBD	Nursery established
3.	Effect of different manure rates and irrigation intervals on the fresh yield and yield parameters of parsley under different agro-ecological zones of Bhutan.	To evaluate adaptability and yield of parsley	Split-plot RCBD	Trials on-going at Wengkhar, Bajo and NCOA
4.	Effect of different manure rates and irrigation intervals on yield parameters of dill under different agro-ecological zones of Bhutan.	To evaluate adaptability and yield of dill	Split-plot RCBD	Trials on-going at Wengkhar, Bajo and NCOA
5.	Effect of Organic Matter and spacing on the yield of Ti-Yangku (C*arum Carvi)*	To generate optimum recommendation of Organic Matter and spacing	Split-plot RCBD	Trial established
6.	Effect of Organic Manure and spacing on yield of *parpata*	To generate optimum yielding recommendation of OM and spacing	Split-plot RCBD	Trial established

2.8 Evaluate Fruits and Nuts-6 citrus varieties

Introduction

Mandarin orchards are declining due to several factors including climatic and environmental conditions. The livelihoods of citrus farmers are threatened because of decline in production and non-availability of other optional citrus varieties. The National Citrus Repository (NCR) has varieties of citrus germ-plasm collection of both local and exotic. The repository has developed planting materials of Public Access Varieties (PAVs) which are introduced and promising. Varietal trials were established in two locations of different elevations in Chhukha with five of these PAVs to evaluate and identify suitable new citrus varieties for different agro-ecological zones. The trials were established in Pakshikha (1500masl), Gamana (1000 masl), and Alay (500 masl) villages. **In Pakshikha, two trials with different sets of varieties were established, one with 6 varieties, and the other with 3 new varieties.**

Methods

Randomized Complete Block Design (RCBD) with each block replicated 5 times with the PAV varieties as the treatments with a total of 30 plants in a plot was established in Mid-March, 2021. The five new varieties are Tarocco Ippolito grafted on local, Cant Star Ruby grafted on local, Parson Brown grafted on Swingle, Caffin grafted on local, Afourer grafted on Swingle and the check variety Dorokha Local grafted on Trifoliate

The other trials at Alay (500 masl), Gamana (1000 masl) and Pakshikha (1500) comprises of three varieties Hayaka grafted on local, Okitsu grafted on Swingle, and Mcmohan grafted on Rangpur lime with 3 plants/treatments and a total of 15 plants in each trial plot. Data on Plant height, No. of branches and Stem girth were recorded after planting. Data on Crop phenology, pest and diseases, Adaptability, Fruit quality and Yield will be recorded during the course of the research. Variety evaluations on fruits are long-term and will take at least a few years to generate information and data.

2.9 Conduct trials on important production and management practices of fruits and nuts

Background
Farmers in general give more attention and investment in vegetable cultivation compared to fruits. Since testing the effects of management and production practices in standing perennial fruit crops require a number of years, a trial was initiated to identify the best method of a low-cost and easily available mulch material on strawberry. Strawberry is one fruit crop that has a higher market value and corresponding demand in the domestic market.

Methodology
A trial was established on station at **NCOA Yusipang in mid-April, 2021** to assess the effect of different types of mulch on yield and fruit quality of organically grown strawberry. Trial was laid out in Randomized Complete Block Design with four treatments viz: clear plastic mulch, black plastic mulch, straw mulch, and bare ground as control, replicated four times. Variety Sweet Charlie was planted as the test material. 15 runners were planted per treatment numbering 60 runners per replication and totaling 240 runners. All plots will be managed uniformly organically. Fruits will be harvested weekly from the first flush up until August. Data will be collected from 7 plants in each treatment plot. Parameters such as yield per plant, fruit quality, phenology, marketability, number of runners per plant, and pest and disease incidence will be recorded.
Identification of a suitable, labor saving, low-cost mulch material that the farmers of Bhutan can adopt easily will be possible through this trial.

2.10 Conduct trials on propagation of seedlings from stone fruits

Background
Stone fruits grown commercially in Bhutan are peach, plums, apricots, and cherries. Stone fruit seeds do not germinate immediately after harvest and require a period of after ripening for certain chemical and other changes to take place in the seed and for dormant embryo to grow. Two independent dormancies; physical (external) and embryo (internal) dormancy that are essential for better survival and establishment of seedlings in the field exist in seeds of stone fruit (Garcia *et al.,* 2004). There are various methods to break the dormancy of stone fruits. Stratification is one traditionally popular method used to break seed dormancy in *Prunus* sp. Mechanical removal of endocarp is a method used to reduce the time taken for germination of stratified seeds. Plant growth regulators and chemicals are also employed to promote initiation of seed germination and seedling growth.

Propagation through seeds is usually used to produce seedlings, or in breeding new fruit varieties. Although producing clonal rootstock is easier than growing rootstock from seed, sexually produced rootstocks are desirable because seedlings tend to have a deeper, more anchored root system than

clonal rootstocks (Hartmann, Kester, Davies, & Geneve, 2002). Seedlings will also have a lower probability of virus transmission from parent to progeny. Hence, there is a need to identify an efficient method to grow seedlings from seed for rootstock purposes.
A trial on the Efficacy of Different Methods of Breaking Dormancy in Stone Fruit Seeds was established on station with the objectives to assess different methods of breaking dormancy and assess the quality of seedlings raised

Materials and Methods
A two-factorial experiment was established in a Randomized Complete Block Design in November, 2020. Different methods of breaking dormancy were treated as the primary treatments and types of stone fruits as the secondary treatments. The primary treatments were i) outdoor stratification, ii) autumn sowing, iii) mechanical scarification, and iv) control (sowing in spring with no stratification or scarification). Each block comprised of 4 primary and 3 secondary treatments. 150 seeds (50 seeds of each type of stone fruit) were sown in each block. Each block was replicated three times. Seeds were collected from mature fruits. Collected seeds were cleaned and placed in cool, dry place to prevent rotting or early germination. Seeds were planted at 1 ½ to 3 inches depth to ensure planting depth consistency and increase germination uniformity. Seeds were treated as described for each treatment;

a. **Treatment 1** – **Outdoor Stratification**: Seeds were sown in alternate layers of sand to provide low temperature and proper aeration in a pit of 2ft deep and 1ft wide in winter. The pit was then covered with Sphagnum moss to maintain moisture level. The pit was irrigated at regular intervals to maintain appropriate moisture.
b. **Treatment 2 – Planting after harvest**: Seeds were sown on 14th October, a week after harvest without any treatment.
c. **Treatment 3 – Mechanical Scarification** – The hard coat of the seeds were slightly cracked with a hammer before sowing in November, 2020.
d. **Treatment 4** – The seeds were stored in cool dry place and sown directly in the field on **30th November, 2021.**

Data on date of germination, plant vigour, height, percentage of germination will be recorded. The method that gives the best germination and vigour of the seedlings will be promoted as a better nursery technology for adoption

2.11 Establish Persimmon Germplasm Block

Background
The center has 11 varieties of persimmon introduced through the support of a Thai project. The usual practice of propagation has been to raise rootstocks through the seeds of date plum (*Diospyros lotus*) and graft the scion of desired cultivar on it. However, most of the varieties here are Asian persimmons and are not readily compatible with the local date plum seedlings. In order to encourage better growth, the scions and the rootstocks should be highly compatible. Hence, a germplasm block of Asian persimmons commonly used for raising seedlings was established at NCOA, Yusipang.

Method
Scionwood of six varieties of Asian persimmons viz; Thimphu Local, Japan local, Zenjimaru, Japan persimmon 1, Japan persimmon 2, and Nepal local were procured from ARDC-Wengkhar. 3ft^3 pits were dug in the month of January, 2021 at a plant to plant spacing of 4m. The pits were then filled with a mixture of farmyard manure and soil in February, 2021 after which a total of 18 local

persimmon seedlings were planted. **The scionwood of the six varieties was grafted onto local persimmon seedlings in March, 2021.** For each variety, three grafted plants were established which will be used as mother block for the production of seeds of these varieties. The seeds produced will then be used to produce seedlings to be used as rootstocks on which good persimmon cultivars will be propagated. This block will be trained to central leader system and fruiting will be allowed only after 4 years following which the mature fruits will be harvested for extraction of seeds for raising seedlings. The seedlings will then be used for grafting any Asian persimmon cultivars.

2.12 Release/Notify high yielding vegetable varieties through VRC/TRC

ARDC-Yusipang as the national coordinating centre for vegetables coordinates fast track evaluation of hybrid vegetables for release for commercial cultivation. During the reporting year, four hybrids of three vegetable species cauliflower, radish and tomato were released which are**:** hybrid radish "YR white spring", cauliflower hybrid variety "Suhasini", Tomato hybrid variety "Cosmic". Characters of each of the variety notified are described below

2.12.1 Cauliflower variety: Suhasini

- Yield: 6.5 to 8.8 t/ acre (farmers fields)
- Plant height :60 cm
- Early variety, vigorous Plants with dark green leaves.
- Self-blanched, snow white Curd well protected by leaves.
- Compact and dome shaped Curd.
- Curd Weight: 1.0- 1.5 kg.
- Tolerant to Black rot (*Xanthomonas campestris* pv. *campestris*)
- Crop Duration: Harvest after 80 days after transplanting under cold temperate areas
- Recommended ecology/agro-ecological zones: (1) Cool Temperate and Warm Temperate AEZ (High altitude zone): Early Spring to late Autumn (February to October). (2) Dry Sub-tropical and Humid Sub-tropical AEZ: Throughout the Year (Mid altitude zone) (3) Wet Sub-tropical AEZ: September to March (Low altitudes zone).

Figure 30:Suhasini cauliflower hybrid curd

2.12.2 Cauliflower variety:“ CANDID CHARM”

- Yield: 16-20t/acre (research stations) and 6-10 t/acre (farmers fields)
- Days to maturity (sowing-harvest): 140-150 days
- No major disease incidence even under organic management.
- Reaction to major pests: Satisfactory; though susceptible to DBM in peak summer seasons.
- Cold tolerant
- Suitable for early production under poly-tunnel nurseries.
- Good market preference and extended shelf life due to the self-blanching nature of the inward curling leaves that provide protective environment to the fragile curds inside.

Figure 31:Sample curd of Candid Charm cauliflower hybrid

2.12.3 Radish variety “YR White spring hybrid

YR white spring is a popular hybrid radish among the farmers due to its prolonged shelf life, frost and heat tolerant, resistant to turnip mosaic virus and fusarium yellow, suitable for all the seasons, fetches higher market price, higher demand among the customers and retailers. It is grown by farmers of Hongtsho and Yusipang for about 3 years.

A fast track evaluation trial was conducted at (I) NCOA: on station, (ii) ARDC Samtenling (iii) ARDC Bajo. Three varieties of radish Minowasi, SPTN, and YR white spring were tested in a RCBD design with four replications at spacing of RR 15cmx PP10cm. Sowing was done on 26/6/2020 and harvested on 31/8/2020 taking about 66 days to mature.

The P value of root girth is >0.05%, showing no significant difference between the root girth of YR white spring variety and other released varieties. The P value of root length is <0.05%, therefore, there is significant difference between root length of SPTN and the other two variety (Minowasi and YR white spring).The P value of plot yield is <0.05% showing significant difference in yield per acre between YR white spring and the other two varieties. The plot yield of YR white spring under organic management in NCOA-Yusipang was 38.2mt, followed by SPTN with 24.9mt yield per acre and Minowasi with17.7mt per acre. The hybrid is therefore a better yielder than the existing varieties and justified for cultivation

Figure 32:Pictures of Minowasi, STPN and YR White Spring Respectively

Table 26:Result and discussion

Variety	Root girth (cm)	Root length (cm)	Root weight (g)	Plot Yield (kg)	Yield per acre (mt)
Minowasi	4.21	30.09 b	428.12	21.92[c]	17.7
SPTN	4.52	33.54 a	482.12	30.85[b]	24.9
YR White spring	4.55	30.62 b	533.62	47.22[a]	38.2
P value	0.145	0.032	0.08	0.008	
F value	2.71	6.36	3.90	29.43	
CV(%)	5.08	4.69	11.10	14.19	

2.12.4 Tomato variety "Cosmic "

Figure 33:Cosmic hybrid tomato sample fruits

- Yield: 25-35t/acre
- Days to maturity: 140 days
- Reaction to major diseases: Moderately tolerant to blight
- Reaction to major pests: Satisfactory
- Tolerant to climatic factors such as drought, high temperatures and cold: Tolerates high temperatures under protected conditions but succumbs to frost injury in early November.
- Suitability for early or late production: Suitable for late and prolonged duration of production due to its indeterminate nature.
- Marketability : Prolonged shelf life compared to existing varieties and good market preference; suitable for long distance marketing.
- Recommended ecology/ agro-ecological zones and cropping calendar by agro-ecological, the hybrid can be grown successfully in the altitude range of 2000-2700masl.

2.13 Promote fruits and nuts -strawberry varieties

Background

Farmers in Bhutan generally consume less fruits. For instance, in terms of fruit cultivation, farmers in Haa prefer growing apple. However, the decline in apple productivity and with it, the declining interest in cultivation may result in exclusion of fruit in their daily diet entirely. Promoting nutrition security and diversity along with food security is important. The growing season in Haa is relatively shorter with the earlier onset of frost and delayed spring season. Hence, strawberry, which is a short duration fruit crop tolerant to low temperatures was promoted among 10 farmers from Eusu and Samar gewogs with the objective to enhance household dietary diversity and nutrition security.

Method

Three released varieties of strawberry viz., Sweet Charlie, Chandler, and Camarosa were potted in October, 2020. With support from Gewog Extension staff, ten households were identified as in table here . In the third week of March 2021, these farmers were provided with 50 strawberry runners and $10m^2$ of black plastic mulch each. Method of mulching, preparation of raised beds, planting and after care was demonstrated to the farmers.

Table 27:Beneficiary list of strawberry promotion

Sl.no	Farmer's name	Village/ Gewog	CID
1	Pelden	LongpaNobgang/Samar	10504001412
2	Penjor Tshering	LongpaNobgang/Samar	10504001450
3	Lham Tshering	LongpaNobgang/Samar	10504001210
4	Passang Gyem	LongpaNobgang/Samar	10504001227
5	Kiba Lham	LongpaNobgang/Samar	10504001214
6	Thinley zam	LongpaNobgang/Samar	10504000363
7	Sangay	LongpaNobgang/Samar	10504001493
8	Kinley Bidha	Bangayna/Eusu	10504000035
9	Pema Thungzom	Tshelungkha/Eusu	12003002651
10	Pema Wangmo	Tshelungkha/Eusu	10504000785

Since, runner production per plant is high; these farmers can further multiply and expand the production to a larger scale gradually.

2.14 Technology transfer on POP of newly released cultivars in farmers field

Background

A European plum variety, Stanley was released as Yusiprune-1 during the 22nd Variety Release Committee Meeting in 2020 by the Center. This variety is self-fertile and late-maturing suited for planting in mass or as stand-alone crop for nutrition. It is also extremely cold hardy unlike Japanese plums that thrive in lower altitudes of the temperate zone. This variety is principally grown for drying to make prunes although it can also be consumed fresh. Hence the program promoted the crop variety through the establishment of a demonstration orchard.

Method

An interested farmer was identified at Longpa, Nobgang (2800 masl), Haa where fruit cultivation is non-existent due to extreme cold. This variety may create opportunities for farmers to cultivate fruit crops. Plants were planted in, $3ft^3$ pit size incorporated with farmyard manure **in March, 2021** at a spacing of 4m. Basic yield data will be collected once the trees start bearing. The trees will be trained to a central leader system since European plums have more erect growth. Any flowers developed before the tree becomes three years old will be pinched off to encourage vegetative growth. Monitoring and technical assistance will be provided annually by the centre

2.15 Evaluate climate resilient tomato varieties from AFACI

Introduction

Bhutan has two open pollinated varieties of tomatoes; Ratan and Roma which are both susceptible to blight, possess shorter shelf life and are not high yielders. The National vegetable program is in the process of importing and evaluating hybrid tomatoes from external sources for adaptability and performance. However, the sustainability as well as the cost of such hybrids is a serious concern, which needs to be addressed at the earliest possible.

Furthermore, Bhutan doesn't have a vegetable breeding programme. Thus, we have not been able to improve the varieties to make them more tolerant and suited to our growing conditions. The AFACI project for Bhutan aims to address the issues related to tomato in Bhutan through the introduction of tomato varieties and build the capacity of our researchers on evaluations and breeding as outlined below.

Objective

- ✓ To evaluate the lines for blight resistance, other diseases and yield.
- ✓ To develop suitable tomato varieties/hybrids best adapted to the Bhutanese conditions through capacity building on breeding technology facilitated by the project.
- ✓ To contribute to sustainable vegetable production and augment income generation by making good varieties available to the farming population in the medium term.

Materials and Methods

The trial was carried out in National Center of Organic Agriculture (NCOA), Thimphu, Bhutan. The experimental site is located at 27.46410 N latitude, 89.70750 E longitude with an altitude of 2600 masl. 23 tomato lines from the World vegetable Center lines and 5 local lines were evaluated as listed in this table.

*T*able 28:23 tomato lines from the World vegetable Center lines and 5 local lines evaluated

T1: AVTO1288	T5: AVTO1702	T9: AVTO1306	T13: AVTO1716	T17: AVTO0301	T21: AVTO1707	T25: Ratan
T2: AVTO1314	T6: AVTO1705	T10: AVTO1711	T14: AVTO1717	T18: AVTO1616	T22: AVTO1424	T26: Black cherry
T3: AVTO1315	T7: AVTO1706	T11: AVTO1712	T15: AVTO1718	T19: AVTO1219	T23: AVTO1713	T27: Beams Yellow Pear
T4: AVTO1464	T8: AVTO1409	T12: AVTO1715	T16: AVTO1719	T20: AVTO1429	T24: Roma	T28: Local Cherry (KT)

Figure 34:Trial field in the initial vegetative stage and Blight infected plants under open field

Figure 35:Tomato screening for blight resistance or disease resistance, yield and other desirable traits.

The experiment was laid out in Randomized Complete Block Design (RCBD), with three replications. Seeds were sown on 3rd March,2020 and transplanted on 4th April,2020.

Fruits were first harvested on 20th August 20,2020.Plants were grown on a two-row, 4.8 m long and 1 m wide plot with furrows (ditches) 50 cm wide on each side. Distance of 60 cm RR and 40 cm PP was maintained with each plot containing 24 plants. Data was collected from 10 randomly selected plants i.e., 42% of the total plant population.

Result and Discussion

The main topic of interest in the study was to screen for blight resistance or disease resistance, yield and other desirable traits. This is because farmers cannot afford protected structures and the cultivation of tomatoes is confined mostly under open field conditions. Under open field, the productivity is affected greatly due to the incidence of rampant blight disease. The biotic stress rating for the lines was done with major impetus on blight occurrence. Of the total 28 lines, almost all the lines exhibited severe incidence of blight with the disease incidence hindering the plants from attaining its first harvestable maturity. Only 4 lines exhibited some degree of resistance to blight in the vegetative stage to early fruiting stage.

The aforementioned 4 lines with some degree of resistance to blight also could not reach its full maturity. Hence the true yield potential of the lines could not be determined as the plants died after second harvest on 9th September, 2020. Therefore, complete data on yield and yield attributes could not be obtained. However, whatever derivations that can be made from the first and second consecutive harvests has been made as follows:

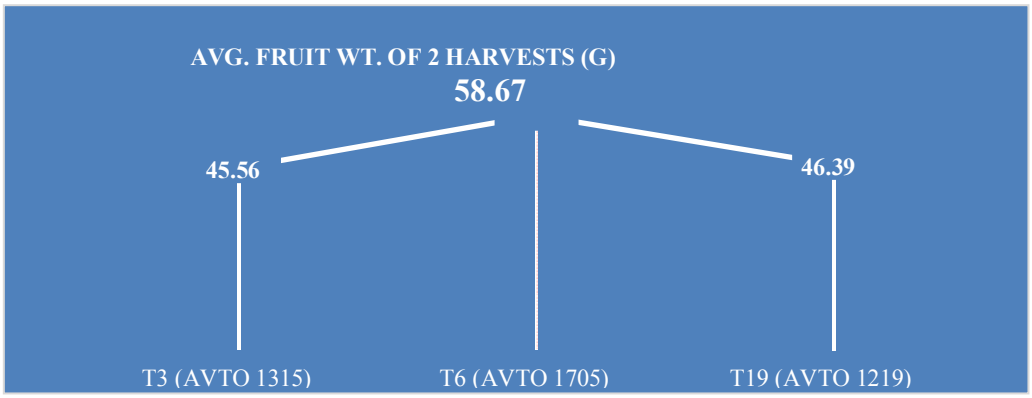

Figure 36:Graph comparing the average fruit weight of the blight resistant lines

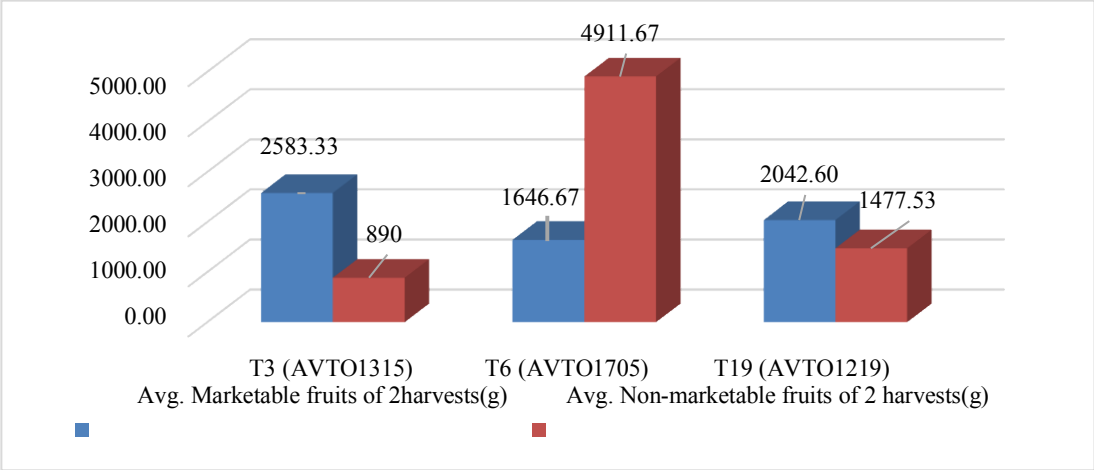

Figure 37:Comparison of marketable & non-marketable yield between the treatment

Of the total 4 showing resistance to blight, the local selection wasn't considered while comparing the yield attributes as it is cherry type and the fruit size non-comparable. However, the cherry type was included in the study with the intention of using it for breeding purpose in future. As evident from the graph, AVTO 1705 yielded the highest average fruit weight of 58.67g and the average fruit weight of AVTO 1315 and AVTO 1219 stands at par with 45g & 46g respectively. Thus, AVTO 1705 produced comparatively bigger sized fruits compared to the other 2 lines.

A simple analysis on the lines producing the highest number of marketable as well as non-marketable (blight infected, blemished, bruised, etc.) was done as depicted in figure 2. AVTO 1315 produced the highest number of marketable fruits and correspondingly the lowest number of non-marketable fruits, followed by AVTO 1219. On contrary, AVTO 1705 exhibited heavy bearing but the ratio of non-marketable fruits far exceeded the marketable volume.

Figure 38:Segregation of marketable & non-marketable fruits

Seed extraction

As per the advice of the World Vegetable Center, the seeds of all the lines have been saved. A separate seed production block under protected structure made this possible as the lines in the open field condition couldn't reach maturity or the fruit quality wasn't good for seed extraction. For seed extraction, fully matured red ripe fruits with uniform shape, size and blemish-free were selected and subjected to fermentation method. The seeds were extracted after fermentation. The usual practice of fermenting the entire fruit took longer as well as damaged the quality of the seeds. Some seeds germinated while some turned little dark in color upon longer duration of fermentation. Therefore, the extraction of only the fruit pulp along with seeds by cutting the fruits apart was done later as recommended by the World Vegetable Expert team. This not only reduced the duration of fermentation to just 3 days but also retained the seed quality. The seeds of the lines will be used for further works on varietal development in the coming years or the future.

Figure 40:Fully matured fruits for seed extraction

Figure 39:Fermentation of fruits

Figure 42:shade drying of seeds

Figure 41:Dried seeds

Figure 43: Storage seeds

2.16 Gender Disaggregated Data

Apart from researches undertaken to test or develop new technologies, National Center for Organic Agriculture also carries out various developmental and capacity building activities. While carrying out trainings, demonstrations, and awareness programs, it is mandatory for all programs in the center to encourage equal participation from all genders. This year, 571 female and 360 males participated in various trainings, awareness programs, and surveys. The details of the male and female participants for various activities are reflected in the following table and the figures were submitted in the month of May 2021.

Table 29:Details of the male and female participants for various activities

	Activity title	Male	Female	Location	Funding
1	Capacity building for Bama Sanam Chithuen Detchen on herb cultivation, management and post-harvest management	4		Genekha	RGoB
2	Input support for Tashicholing ginger cooperative (women group)	2	10	Sipsoo	Kanchenjunga Landscape Development Initiative
3	Training on organic farming principle	15	15	Paro	NOFP
4	Demonstration and technology dissemination of improved technologies in citrus orchard	20	18	Gakiling	FSAPP
5	Participatory varietal selection (Potato (cultivation time)	15	21	Dungna	FSAPP
6	Participatory varietal selection (Potato (cultivation time)	8	22	Metekha	FSAPP
	Participatory varietal selection (Potato (cultivation time)	17	13	Samar	FSAPP
8	Participatory varietal selection (Potato (cultivation time)	6	24	Katsho	FSAPP
9	Participatory varietal selection (Potato (cultivation time)	11	19	Eusu	FSAPP
10	Participatory varietal selection (Potato (flowering stage)	19	21	Dungna	FSAPP
11	Participatory varietal selection (Potato (flowering stage)	5	36	Metekha	FSAPP
12	Awareness program on Nutrition and Food diversity (including gender)	4	21	Nobgang	RMS
13	Focus group discussions on livelihood survey	16	9	Gangtey	FSAPP
14	Focus group discussions on livelihood survey	6	19	Phojikha	FSAPP
15	Focus group discussions on livelihood survey	10	15	Khatoe	FSAPP
16	Focus group discussions on livelihood survey	9	16	Damji	FSAPP
17	Focus group discussions on livelihood survey	11	14	Drametse	FSAPP
18	Focus group discussions on livelihood survey	9	16	Narang	FSAPP
19	Focus group discussions on livelihood survey	7	18	Kanglung	FSAPP
20	Focus group discussions on livelihood survey	4	21	Khaling	FSAPP
21	Focus group discussions on livelihood survey	4	21	Tang	FSAPP
22	Focus group discussions on livelihood survey	5	20	Chumig	FSAPP
23	Training on vegetable production and climate resilient technology	3	26	Meritsemo	FSAPP
24	Advocacy and consultative meeting for Langpa-Nobgang organic model village	18	41	Nobgang	RMS

25	Vegetable Nursery Management	16	44	Nobgang	RMS
26	Awareness Training and Consultation with New Organic Model Village at Nang-Nye, Jarey Gewog, Lhuntse)	5	15	Jarey Gewog Centre	GEF/RMS
	Implementation of ICS and general organic farming	54	38	Sergithang and Thakorling geog, Tsirang	NOFP
	Implementation of ICS and general organic farming	42	8	Goongring, Sarpang	GEF-LDCF
	Implementation of ICS and general organic farming	15	10	Lull, Kazhi geog, Wangduephodrang	GEF-LDCF
	Total	360	571		
	Activity title	**Male**	**Female**	**Location**	**Funding**
1	Capacity building for BamaSanamChithuenDetchen on herb cultivation, management and post-harvest management	4		Genekha	RGoB
2	Input support for Tashicholing ginger cooperative (women group)	2	10	Sipsoo	Kanchenjunga Landscape Development Initiative
3	Training on organic farming principle	15	15	Paro	NOFP
4	Demonstration and technology dissemination of improved technologies in citrus orchard	20	18	Gakiling	FSAPP
5	Participatory varietal selection (Potato (cultivation time)	15	21	Dungna	FSAPP
6	Participatory varietal selection (Potato (cultivation time)	8	22	Metekha	FSAPP
	Participatory varietal selection (Potato (cultivation time)	17	13	Samar	FSAPP
8	Participatory varietal selection (Potato (cultivation time)	6	24	Katsho	FSAPP
9	Participatory varietal selection (Potato (cultivation time)	11	19	Eusu	FSAPP
10	Participatory varietal selection (Potato (flowering stage)	19	21	Dungna	FSAPP
11	Participatory varietal selection (Potato (flowering stage)	5	36	Metekha	FSAPP
12	Awareness program on Nutrition and Food diversity (including gender)	4	21	Nobgang	RMS
13	Focus group discussions on livelihood survey	16	9	Gangtey	FSAPP
14	Focus group discussions on livelihood survey	6	19	Phojikha	FSAPP
15	Focus group discussions on livelihood survey	10	15	Khatoe	FSAPP
16	Focus group discussions on livelihood survey	9	16	Damji	FSAPP
17	Focus group discussions on livelihood survey	11	14	Drametse	FSAPP
18	Focus group discussions on livelihood survey	9	16	Narang	FSAPP
19	Focus group discussions on livelihood survey	7	18	Kanglung	FSAPP
20	Focus group discussions on livelihood survey	4	21	Khaling	FSAPP
21	Focus group discussions on livelihood survey	4	21	Tang	FSAPP
22	Focus group discussions on livelihood survey	5	20	Chumig	FSAPP
23	Training on vegetable production and climate resilient technology	3	26	Meritsemo	FSAPP
	Total	**210**	**415**		

2.17 Other activities conducted but not reflected in the APA:

2.17.1 Year-round vegetable production under protected structure/greenhouse

Background

Any protected structures are highly expensive and maximizing its utilization for crop production is very important to offset its costs. The two most prominent advantages of protected structures are that they are Climate Proof and can be 100% organic as external confirmation can be controlled. Crop intensification through a properly designed cropping sequence can help to maximize its utilization, produce fresh organic vegetables and also maximize farmer's income. This will contribute to household food and nutritional security and cash income generation.

A production trial was conducted at Yusipang with the objective to Maximize the use of protected structure and returns from such facility in cool temperate agro-ecology through crop intensification and see feasibility of off Season production of fresh, organic vegetables in protected structures in cool temperate agro-ecology.

Materials and methods

The study was carried out on-station in a single 20x5 sq.m plastic house.

Result and discussion

Total yield of crops grown under 3 green houses are as follows:

Table 30:Yield of crops grown in 10mx5m greenhouse(no.1)

Bed no	Summer crops	Total yield(kg)	Winter crops	yield(kg)
1	Tomato	52.96	Broccoli	1.75
2	Chilli	16.55	cabbage	24.72
3	Tomato	108.95	cauliflower	2.5

Table 31:Yield of crops grown in 10mx5m greenhouse (no.2)

Bed no	Summer crops	Total yield(kg)	Winter crops	yield(kg)
1	Tomato	79.47	Cauliflower	5
2	Tomato	94.78	Broccoli	6.75
3	Tomato	63.16	Cabbage	10

Table 32:Yield of crops grown in 20mx5m green house (no.3)

Bed no	Summer crops	Total yield(kg)	Winter crops	yield(bundle)
1	Chilli	26.25	Mustard green	70
2	Tomato	107.84	Mustard green	7
3	Tomato	118.54	Coriander	10

For winter crops, the total yield could not be obtained because the structures were dismantled to create space for constructing conference hall / laboratory.

2.17.2 Demonstration of Low-cost structures for vegetable production in NCOA, Yusipang

It is presumed that good quality tomatoes can only be produced in a conventional plastic green house. The National Center for Organic Agriculture (NCOA) Yusipang has adapted and demonstrated that a very simple rain shelter can be used to produce high quality tomatoes. In the 2019 season vegetable researchers at NCOA designed and evaluated two types of simple low-cost

rain shelters using bamboos and polythene sheet for successful tomato production at Yusipang which is at an altitude of 2600 masl.

Three critical factors which hamper the production of high-quality tomatoes are heavy rainfall, warm temperature, and high incidence of tomato blight diseases. Heavy rainfall and warm temperature make it conducive for the incidence of late blight disease which cause the rotting of leaves and fruits. It is therefore very important to avoid the direct exposure of tomato plants to rain. Simple rain shelters (Fig. 44) of different shapes have been proven to be very effective to reduce the incidence of late blight allowing production of high-quality tomatoes. Rain shelter generally consists of a frame covered with polyethylene plastic on the top with sides and ends open for air circulation and entrance of light which are critical for photosynthesis. Ordinary wood and bamboo are the most commonly used materials to make the rain shelter frames (Fig.45)

Figure 44:Dome shaped rain- shelter & *sloop roof rain-shelter*

Figure 45:Two types of rain shelter frames constructed with bamboos

Result and discussion

Rain shelters with dome shaped roof and sloped roof were very effective. The rain shelter with dome-shaped roof was 16 m long and 1.5 m wide with a growing area of 24 m^2.This rain shelter accommodated 64 plants which were planted at a plant to plant and row to row distance of 0.50 m. Under this shelter open-pollinated tomato lines received from Asian Food and Agriculture Cooperation Initiative (AFACI) was planted (Fig. 44). A total of six harvests were carried with a total yield of 72.53 Kg which can be estimated at 12224 Kg/acre.

The size of the shelter with sloped roof was slightly bigger. The support in the front side was 2 m tall while the back support was 1.5 m tall to create the slope for allowing the rain water to slide down. The shelter was 26 m long and 1.5 m wide with a planting area of 39 m^2.This rain shelter accommodated 153 plants which were planted at a plant to plant and row to row distance of 0.50 m. A total of 13 harvests were carried out from this rain shelter. The total yield obtained was 198.62

Kgs which is estimated as 20371 Kg/acre. The tomato variety planted in this case was cosmic hybrid from Japan (Fig.45). The higher total production in the sloped roof type rain shelter is attributed to the variety and larger planting area. NCOA Yusipang has promoted this simple technology for tomato production in the farmer's field.

Figure 46:Open pollinated tomatoes under the dome shaped rain shelter

Figure 47:Cosmic Hybrid tomatoes under sloped roof rain shelter

2.17.3 Demonstration of low-cost bamboo green houses in NCOA, Yusipang

In the temperate regions where the climatic conditions are extremely adverse and no crops can be grown, green house can provide protection from the excessive cold, wind, precipitation, excessive radiation, extreme temperature, insect and diseases. It is also of vital importance to create an ideal micro climate around the plants. This is possible by erecting greenhouse (low-cost or prefabricated), where the environmental conditions are modified so that plants can be grown in any place and at any time. Bamboo polyhouse are cheap in cost, provides other occupation in the villages, spreads greenery, free from subsidy, can be done hilly areas, as well as easy insect management. This technique has been developed with the welfare of farmer, consumer as well as nature.

NCOA Yusipang has adapted and demonstrated that low-cost greenhouse can be used to produce high quality tomatoes, eggplant, bottle gourd and cucumber. Vegetable researchers at NCOA designed and evaluated low-cost greenhouse using bamboos and polythene sheet for successful vegetable production at Yusipang (2600 masl).

Figure 48: Layout of bed inside the low cost greenhouse and bed prepared for transplanting

Figure 49: External structure of low-cost green house and types of low cost greenhouse

low-cost green house was 10x 5m wide with a growing area of 24 m^2.The spacing between the main frame was placed at 0.5 m, similar to that of pre-fabricated green house. A total of 50 nos of bamboos were required to construct each low-cost green house. Low-cost greenhouse 1(LCG 1) was fully covered with white plastic sheet, low-cost greenhouse 2(LCG 2) was half covered by plastic sheet and low-cost greenhouse 3(LCG 3) was partially covered with plastic sheet to check the difference in yield of crops grown under different types of low-cost greenhouses.

Result and Discussion

Table 33:The total yield of crops grown under different types of low-cost greenhouses are enlisted below:

Crop	Total yield in Fully covered LCG (kg)	Total yield in Half covered LCG (kg)	Total yield in Partially Covered LCG (kg)
Eggplant	10.84	20.26	-
Tomato	32.49	33.09	119.115
Bottle gourd	45.20	22.32	-

Yield of Eggplant grown in half covered low-cost greenhouse in an area of 18 $m^2$was comparatively higher than that of eggplants grown in fully covered low-cost greenhouse in an area of 18m^2. Likewise yield of tomato grown in an area of 9 m^2in half covered LCG was higher than yield of tomato grown in an area of 9m^2. However, in case of bottle gourd grown in an area of 9m^2, yield was higher in fully covered low-cost greenhouse than half covered greenhouse. The total yield of tomato grown under partially covered LCG in an area of 36$m^2$was 119.16kg.

2.17.4 Evaluation of winter vegetable production in double layer poly-house

In the temperate conditions (2000-3000 masl), it is difficult to grow vegetables during winter season. A single layer poly house is not enough to protect crops from frost. Cole crops which are cool season crops also get damaged by frost during the month of November to March. Greenhouse plastic on its own has very little insulation value, however, inflating the air in between two layers of greenhouse plastic provides additional insulation and improve structures ability to retain temperatures through cold nights. In addition to better insulating the greenhouse, a double layer

inflation system has structural benefits, as it helps protect against strong winds and sheds snow during snow events. A prototype of double layer poly house which is developed by Agriculture

Machinery Centre (AMC) was tested at NCOA, Yusipang on station during the month of October 2020 to March 2021 with the objective to**:**

1. Evaluate the performance of Cole crops (cabbage, broccoli and cauliflower) and Solanaceous vegetable crops (tomato and chili) in the double layer poly-house during winter season in Yusipang condition (2600 masl)

Methods

The test was conducted in a 10mx5m poly house which was covered with double (two) layers of plastics sheets (200micron)). A blower heater which was connected to electric point which was used to fill in hot air in between these two layers of plastic cover. In order to absorb heat during day and conduct heat at night, black painted stone wall measuring height of 1.5 m, 0.61m width and 10m long was installed. In addition, 20 numbers of jerry cans painted with black colour was placed at one side to increase the poly-house temperature.

Figure 50:Double layer house at NCOA Yusipang

Crops of cabbage, cauliflower and broccoli was transplanted on 7 October 2020 in a bed size (plot) measuring 1.5mx 2m. Two beds each of these crops were transplanted at the distance of 35cm RR and 45 PP. Tomato and Chilli was transplanted on 10 December 2020 at a spacing of 45mx45m.

Weeding and hoeing was done 2-3 times and plants were irrigated every morning hour (9-10am). Compost was applied at the rate of 2 kg per bed (2.7MT/ac)

Table 34:Performance of crops under double layer

	Activities	*Date of sowing*	*Date of Germination*	*Transplanting date*	*Harvesting date*	*Total yield/plot(kg)Plot size=3m2*	*Kg./ac*
1	Cabbage	3.9.20	15.9.20	7.10.20	21.1.21	5	6666kg/ac
2.	Broccoli	-do-	-do-	-do-	18.2.21	3	4000kg/ac
3	C/ Flower	-do-	-do-	-do-	26.1.21	4	5333kg/ac
4	Chilli: SV2319HA &Tomato:Roma	10.11.20	9.12.2020	-	-	Damaged by Frost	No harvest
5	Sag *	26.12.20	10.1.21	2.2.21	20.2.21	20 bundles.	-

It was evident that cole crops could be grown successfully in the double layer during winter season. Average yield/ acre of cabbage was 6.7 MT/ac , broccoli was 4 MT/ac and cauliflower was 5.33Mt/acre. The production of cabbage, cauliflower and broccoli in open condition during normal season (summer) is 25-30 MT, 7MT and 5 MT per acre respectively with good management practices (www.dao.gov.bt). Since the study was not compared with single layer poly-house the result could not be compared to analyze its economic benefit. Further study using comparison to study economic returns is required.

Table 35:Average maximum and minimum temperature of double layer and open conditions

Months	**Inside poly house(^oC)**		**Open condition(^oC)**		**Temp difference(^0C)**	
	Max.	Min.	Max.	Min.	Max.	Min.
Dec.2020	18.76	2.25	14.1	-5.9	4.66	7
Jan.2021	21.88	1.23	13.9	-7.2	8	9
Feb.2021	22.08	1.27	16.7	-5.6	5.38	7
March 2021	23.33	3.67	13.3	0	10	3.8
	Recording by Max&Min Thermometer		Source: Data logger (Horticulture)			

Tomato and chilli plants died after one week of transplanting. The lowest temperature during this time was recorded at 2.25^{o}C, the drop in temperature must have damaged the plant .The temperature requirement for chilli production is between 15^{0}Cto 28^{0}C and for tomato it requires 18^{0}C to 22^{0}C for optimum production. Further study and modification of the poly-house will be required for production of warm season such as tomato and chilli during winter season in temperate climatic areas.

2.17.5 Production of lettuce, basil, parsley and strawberry under hydroponics system.

Introduction

Hydroponics is the method for growing plants in nutrient solution with or without the use of a medium (sand, gravel, vermiculite, rockwool, perlite, peat moss, coir, oasis form or saw dust) to provide mechanical support . A study was conducted on a manually operated, insulated polycarbonate to see its feasibility of production of various herbs and strawberry under the cold climatic conditions

Materials and Methods

A study of lettuce, basil, parsley and strawberry production was conducted in a hydroponic structure sized 12.3m*10.3m installed with Nutrient Film Technique (NFT)system. The system consists of four vertical A-frame NFT growth chambers with 10 uPVC rectangular channels. The growth chambers were set up in such a way that the nutrient solution flows in a single direction through gravitational force which is collected back to the nutrient solution reservoir by a common outlet pipe. The nutrients are pumped into the system from the reservoir tank of 3000 liters using 1hp water pump (company-Kirloskar brother limited, model-KIRLOSKAR MEGA-54S 1.5HP 1P).The reservoir was installed under a simple shed and covered with normal shade net to protect from sunlight, algae growth and frost.

The study was conducted from November, 2020 to February, 2021. The pH, electrical conductivity (EC) and total dissolved salts (TDS) were maintained at the range of 5.8-6.5, 1.1-1.3 dS m^{-1} and 812-935 ppm respectively throughout the experiment as per recommendations by the Indian company "Enviro Agritech". The stock nutrient solution was prepared by mixing 2 kg of Part-A nutrient in 16 liters of water and 2 kg of Part-B nutrient mixed in 16 liters of water separately. The stock solution was added to the reservoir tank and diluted with tap water until the required EC, pH, and TDS was attained. The EC, pH and TDS of the nutrient solution was calibrated using HANNA Instruments *(model specifications: pH range: 0.0-14.0, EC: 0.00-4.00 mS/cm, TDS: 0-1999 ppm)*.

The seedlings of parsley, basil and lettuce were raised using oasis cubes manufactured from water-absorbent foam, while the runners for strawberry were prepared by uprooting from the field and washing thoroughly using tap water and was stored in the fridge for a month at 5^0C to get the 700 hours chilling requirement. Two seeds were sown in each water-soaked oasis cube and the diluted nutrient solution sprayed on a regular basis to keep the cube moist depending on the requirement. The nutrient solution was prepared by mixing equal ratio of Part A and B stock solution and diluting with water at 1:200 ratio. The nutrient solution was then stored in a cool place in an airtight container. Seedlings were transplanted when they attained 3-5 true leaves into the netted cups in the grow channel.

To measure representative data for crop yield and agronomic parameters, 20 plants each (50% of plant population) for all the crop grown were tagged by giving a unique number after transplanting. The low temperature *(Figure 52)* and mismatch of required EC significantly affected the growth and development of basil which led to failure of the crop, therefore, no data available. The mean yield of sample plants was used to estimate the crop yield for a structure by multiplying with the total number of growing space holes (1600) in the system. The crop yield per acre was estimated using a unitary method. The days to transplanting (DAT) is the number of days taken from seeding to transplanting, while days to harvesting (DAH) was calculated based on the number of days taken by the crop for the first harvest from the date of transplanting. The crop duration (CPD) was estimated based on the number of days taken by the crops from date of seeding to days to harvesting.

However, the same parameters for strawberry were calculated from the date of transplanting till first fruiting. All the estimates yield and other parameters reported in this report are solely based on the data from winter season.

Result and discussion

The nutrient temperature ranged from 10.3 ^{0}C to 15.3 ^{0}C during the study period. The mean temperature inside and outside the hydroponic are presented in Figure 52. The temperature inside the hydroponic was maintained manually from 13 to 28^{0}C using four heaters *(Greenfarming solutions, specification: Electric heat convertor with blowers for uniform heat circulation- 2.5 Kw output)*.

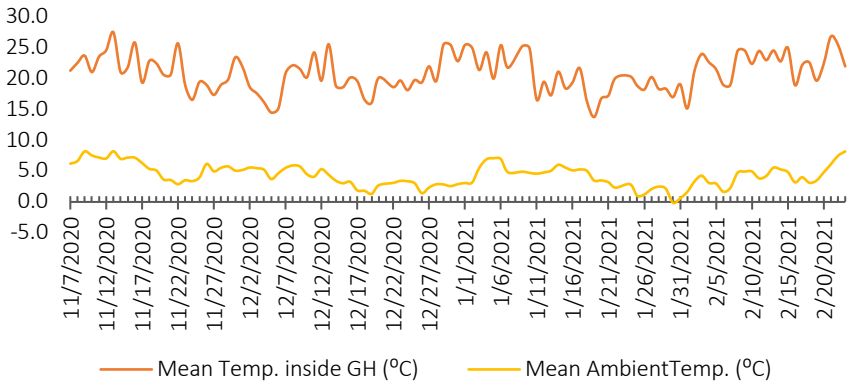

Figure 51:: Mean ambient temperature and temperature inside hydroponic greenhouse

Crop yield and production estimates

The yield data for crops under current investigation is presented in Table 39. The study found that the fresh weight of both the lettuce varieties were not comparable to similar research findings from an experiment conducted in Kashmir, India with a mean yield of more than 1 kg per plant (Majid et al., 2021). The significantly lower yield could be due to varietal difference and yielding potentials. We recommend future research on high yielding lettuce varieties having market potential for economic sustainability of hydroponics lettuce farming. The per acre yield of both the lettuce varieties cultivated under hydroponic system is significantly higher than all the released lettuce varieties by the Department of Agriculture indicating the advantage of vertical spaces in increasing the yield per unit area compared to the horizontal conventional system. Our findings corroborate with Barbosa et al. (2015) where they claimed that the vertical farming of lettuce can yield 11 times higher compared to conventional soil-based farming systems.

Yield per plant for parsley is comparable to that obtained under hydroponics (DiNev &Mitova, 2014) and under organic management (Peyvast, Olfati, Madeni, Forghani, &Samizadeh, 2008). The findings indicate that parsley grown under hydroponics in winter performed well.

The yield of strawberries under the current study was very negligible and not comparable to findings from high density vertical growing systems for strawberries by Linsley-Noakes, Wilken, and Villiers (2006). The yield compromise could be due to the wrong media used as strawberries cultivation in substrate-based hydroponics is widely practiced. However, the study found that the fruiting of strawberries started 51days after transplanting indicating that the strawberries could be grown during the off-season in winter if a climate controlled hydroponic system is used.

Table 36: Crop yield and estimated yield

Crops	Yield/Plant (g)	Yield/Structure (kg)	Yield/Acre (kg)
Parsley	41 (2.81)	65 (4.50)	2085 (144)
Biscia Rosa	120 (12.24)	101 (19.59)	6107 (626)
Blush butter oak	181 (30.02)	290 (48.02)	9254 (1534)
Strawberry	28 (2.71)	45 (3.12)	1431 (100)

Calculations based on the area of existing structure which is 12.3*10.3m

Labor and cost

The labor requirement was very low (table 40) since the hydroponics system does not require operations such as weeding and watering.

Table 37:Labor and cost detail

Particulars	Unit	Number of labors	Unit Cost (Nu.)	Amount (Nu.)
Nursery	Man-days	1.73	215.00	371.77
Solution Preparation	Man-days	0.17	215.00	35.83
Transplanting	Man-days	0.17	215.00	35.83
Daily management	Man-days	1.74	215.00	374.91
Harvesting	Man-days	1.08	215.00	232.92
Total		**4.89**		**1,051.26**

1 man day is assumed to be 8 hours of labor, ** Cost is based on national workforce wage rates 2015

Nursery duration, crop duration and harvest

Details of crop duration concerning days to transplanting, days to maturity, crop duration, and number of estimated seasons per year are presented in Table 39. There are noticeable differences in the amount of time taken by different crops to reach a harvestable stage. The days to transplanting for all the crops except strawberry (used runners) was 41 days since the seedlings were raised on the same day. Parsley took the longest day to reach the harvestable stage while the lettuce (*Biscia rosa*) took the shortest duration with the highest number of estimated seasons per year, and indications that the strawberry can be grown three seasons per year.

Table 38:Estimation of Crop calendar and durations

Crop	DAT	DAH	CPD	Seasons/Year
Parsley (Triple curled)	41	85	126 to 148	6
Lettuce (*Biscia Rosa*)	41	44	85	8
Lettuce (Blush Butter Oak)	41	65	106	5
Strawberry*	-	51	51 to 120	3

**** Propagated through runners***

Scale and Economics of hydroponics

The total cost incurred in the production of crops in the 2020 winter season at NCOA Yusipang was Nu. 231,979.49. This high cost is attributed by fixed asset (structural cost) cost at 72%,and variable cost at(27.6%) while labor cost (0.5%) was minimal. Amongst the variable cost, the heating cost is the major contributor amounting to about 17% of the total cost incurred in current research.

The total revenue generated in the current research covers only 5.4% of the total cost incurred. This indicates that for the hydroponics farming to be economically viable, the scale and the size of the

farm is important. It is also known that the crop choice should be made based on the market scenario and only high value, high demand crops should be grown for the success of the business.

Conclusion

The NFT system is adaptable to a wide range of crops like leafy greens, herbs and strawberry characterized by producing high quality crops. The minimal use of water and nutrients has made it highly desirable in arid climates or non-arable land. The main disadvantage of the system is the failure of pump and algae growth but neither of these has proved to be serious if sanitization is maintained regularly.

Although production of lettuce, parsley, and strawberry were successful in the hydroponics system during winter at NCOA, crop duration and production was comparatively less than research conducted elsewhere. This may be due to the varietal differences and degree of system automation. The return and market for fresh leafy vegetables in the hydroponics system currently in Bhutan is not satisfactory due to less demand and preference of the leafy greens in the Bhutanese market. Likewise, for herbs, the demand for fresh herbs in the market is less. Therefore, for herbs, it is recommended to explore alternatives through value addition that could be exported to other countries. Growing strawberries inside the expensive NFT hydroponics structure is not recommended as well, since it takes longer time to reach maturity and the return may not justify the investment.

Hence, in order for the system to be profitable, the scale of cultivation should be on a larger scale focused on short duration, high value crops with an assured market.

2.17.6 Establishment of Pear Demo-Orchard

Two demonstration orchards of two Asian pear Pear varieties Niitaka and Hakuri released by NCOA-Yusipang in 2018 were established in farmers' fields in Kana and Jemina villages under Haa and Thimphu Dzongkhags respectively. These varieties are suited at altitude of 1700-2600 masl. Twenty five grafted plants of each variety that were raised on-station were planted in both the orchards at a distance of 4m X 4m in a triangular system layout. All technical advice and supports were provided and will be monitored annually since they will serve as an example to other farmers of the Dzongkhags.

2.17.7 Technology demonstration in Mandarin, under Gakiling Gewog, Haa Dzongkhag

The national average yield of citrus mandarin at 32 kg/tree or approximately 3.5 Mt/acre is comparatively lower than that of India with an average of 5.08 Mt/acre and China with 6.76 Mt/acre (FAOSTAT). This can be mainly attributed to minimal management of mandarin orchards and low adoption of improved technologies by the farmers.

A demonstration cum farmers training was conducted for 45 farmers of Gakiling Gewog under Haa Dzongkhag with the objective to increase the number of farmers' adoption of improved mandarin orchard management practices. They were trained on pruning methods and techniques, irrigation, basin maintenance and pests and disease control measures. They were trained to prepare Bordeaux paste and Bordeaux mixture from Copper Sulphate and lime powder as fungicide. Application methods of Bordeaux paste on the tree trunks spraying Bordeaux mixture on the foliages using power spray machine to control powdery mildew and other fungal diseases were also imparted. Fertilizer application in trenches to enhance soil nutrient content were also demonstrated in theory and practical.

2.17.8 Propagation trial using four different grafting methods in persimmon established in NCOA Yusipang

Introduction

Persimmon (*Diospyros kaki* L.) can be propagated by seed, grafting, and micro propagation with propagation from seeds used for the production of rootstocks. Improved persimmon varieties are also mostly seedless or with very few seeds. Demand for improved varieties has been increasing over the years but due to shortage of rootstocks, very low rate of seed germination and low grafting success, both private and government agencies are not able to meet the demand. Further challenges associated with persimmon cultivation include poor seed germination due to seed dormancy and long durations for stratification (60-90 days). A trial has been established at NCOA Yusipang in March 2021 with the objective to study the compatibility of rootstock and scion using four different grafting methods in persimmon.
Two-year old date plum (*Diospyros lotus* L.) seedlings having uniform diameter (between 8.0–10.0 mm) were used as rootstocks were grafted with Scion wood of *Diospyros kaki* L 'Fuyu' cultivar was used. There are 5 replications with 4 treatments with 5 plants in each treatment

2.17.9 Propagation of Temperate fruit crops

The following temperate fruit crops have been propagated on-station**.** They will be distributed for promotions and for clients in the coming season.

Table 39:fruit crops propagated on-station

Sl #	Fruit Crops	Numbers Propagated
1	Pear	160
2	Apple	200
3	Chestnut	30
4	Persimmon	50
5	Prune	50
6	Cherry	60
7	Walnut	20

2.17.10Technical Advisory on fruit crops to VIP clients

Table 40:Technical feasibility study and advisories were given to the following clients

Sl #	Client	Location	Technical Support provided
1	Gyaltshab Jigme Dorji Wangchuck	Lango, Paro	• Top working of 20 nos. of apple trees with pollinizer varieties. • Planted 40 nos of mixed varieties of apple
2	Gyalyum Tshering Pem Wangchuck	Motithang Palace, Thimphu	• Site visit and provided with 10 nos. of mixed temperate fruit plants
3	Gyalyum Sangay Choden Wangchuck	Motithang Palace, Thimphu	• Provided with 25 nos of released pear varieties

4	HH Rabjam Rinpoche	Tsento, Paro	• Site visit and feasibility study report submitted on establishment of apple orchard
5	HH Chung Trilku Rinpoche	Shari, Paro	• Site visited and technical advised recommended

2.17.11Floriculture and landscaping

Flowers play a very important role in organic farming, it not only provides aesthetic beauty to the surrounding, but they provide nectar for bees and beneficial insects, drawing them in so they are there when we need to pollinate or combat pest on our crops. They are also a part of the agriculture ecosystem. Since, the center is fully operated as organic research center the establishment of the flower gardens will benefit in organic agriculture system as whole.

Two flower gardens, an annual flower garden and an ornamental cherry garden (permanent) were established on-station. The annual flower garden mainly consists of annual flowers, while the cherry garden is established with Japanese ornamental cherry variety (Sakura) grafted on rootstock variety Colt. In addition to the gardens established, ornamental cherry trees were planted along the roadside and the border fencing of the center.

Such activities is expected to enhance the diversity and aesthetics around the farm but also benefit both bees and beneficial insects that are crucial in an organic farm

2.17.12Development of Kiwi germplasm block in NCOA, Yusipang.

Kiwi fruits are vigorous, deciduous, climbing plants that need plenty of space and a sheltered, sunny position to thrive. Only one plant is needed if a self-fertile cultivar is selected - otherwise male and female cultivars are required to ensure a crop. Kiwi fruit has a high nutritive and medicinal value. It is a rich source of vitamin B & C and minerals like phosphorus, potassium and calcium. A kiwi demonstration block was established March 202 with 5 female varieties and one male variety to demonstrate technology and maintain germplasm. The recommended ratio of 1:5 male to female is kept and planted on a triangular layout at 4 m spacing. Pergola also known as overhead system was made for the support of kiwi climbers at a height of 1.5m (4 ft) from ground. GI wire of 8mm was used as the width across the path between the uprights. The space between GI wire within each of the two parallel is 91.44 cm (3ft).

2.17.13Greenhouse Solar Dryer

Background

The women farmers of Bangayna village in Eusu gewog, Haa grow tomatoes in greenhouses to earn some extra income by selling them. Alongside tomatoes vegetables such as leafy vegetables, chilli, strawberry, and cucumbers are also grown in the greenhouse. Since many farmers grow tomatoes in greenhouses, there is a glut of tomatoes in the local market during summer in Haa. With limited buyers in the local market and inadequate facilitations for marketing in other Dzongkhags, farmers face difficulty selling their surplus produce.

With the intention to reduce the post-harvest losses and also to demonstrate to farmers on hygienic practice of drying the surplus vegetables, NCOA, Yusipang installed a solar dryer using the conventional greenhouse which was originally designed by the Agriculture Research and Development Center, Wengkhar. The technology was also promoted as a gender-responsive technology as it will aid in reducing the time consumed in sun drying vegetables

for both male and female members of the household. The dryer will also enable the farmers to produce hygienically dried vegetables.

Materials and Methods

Inside a 10X5M greenhouse two rows of drying shelves were made using wood and plastic net. A two layered T-bar trellis was also made using GI wires on which turnip leaves will be dried. An exhaust fan was installed to vent out hot air and moisture from the greenhouse. A 50% shading green shade net was curtained below the roof of the greenhouse to lower the temperature in the summer and to conserve the colour of the vegetables while drying.

The solar dryer was installed at Aum kinley Bidha's farm in Bangeyna village. Aum kinley Bidha grows an assortment of vegetables in her homestead of which tomatoes, chilli, leafy vegetables, and turnips are grown for selling in the local market. Chilli and turnips (both leaves and root) are chiefly dried and sold.

The solar dryer was installed on a cost-sharing basis with the farmer bearing the cost for the woods, labour, and wires. The greenhouse, exhaust fan, and green shade net were supported by NCOA with budgetary support from FSAPP.

The solar dryer will be used to create awareness to farmers on the availability of such technologies and the ease with which any farmers can replicate in their own greenhouses. The dryer will also be used to train farmers on the different methods of dehydrating vegetables and fruits for value addition and food preservation.

2.17.14Demonstration and multiplication of cape gooseberry

Cape gooseberry, also known as golden berry, is the fruit of the plant *Physalis peruviana* L. that belongs to Solanaceae family and genus Physalis. This plant is native from the Andean Region and is cultivated currently in South American countries, especially Colombia, Peru and Ecuador. Cape gooseberry is a fruit with approximately 1.25 – 2.50 cm of diameter, 4 -10 g of weight, orange yellow skin and juicy pulp containing numerous small yellowish seeds. Consumption of fruits and vegetables is inversely associated to the risk of cardiovascular (CVD), respiratory and digestive diseases and certain cancers. Anti-tumor, anti-diabetic, anti-inflammatory, anti-hypertension activities and cardio-protective effects have been associated with the consumption of berry fruits such as strawberries, blueberries, blackberries, raspberries and cranberries and have also been 49 related to the plant *Physalis Peruviana* (leaf and stems) and cape gooseberry.

The germplasm was introduced into Bhutan from Thailand by the researchers of MAP, NCOA during their study visit and shared with the National Biodiversity Centre. However, a scientific adaptation research to document its adaptability and package of practices couldn't be initiated as the crop failed to give fruiting in the financial year 2019-2020. To this end, MAP section has recovered germplasm from National Biodiversity Centre, Serbithang and planted in the MAP Block for observation and seed multiplication.The activity was initiated in January, 2021 with nursery raising and transplanted in March, 2020.

2.17.15Capacity development of culinary herb farmers on herb cultivation technology and also periodical visit to be made.

The MAP Section has imparted hands on capacity development program to the members of Bama Sanam Chithuen Detchen venturing into the culinary herbs farming on cultivation, management and post-harvest practices of culinary herbs. The farmer capacity development program was conducted in collaboration with the Dzongkhag administration, Thimphu and Agriculture Extension Officer of the Ganey gewog on 19th February, 2021.In addition, the

awareness programs on Local Organic Assurance System were also provide and the group will process for registration of their farm in organic herb production.

Figure 52: Capacity development of culinary herb farmers

2.17.16Publications

As per the annual workplan, the MAP Section has made a significant contribution in publication of package of practices of MAPS,

Table 41: List of Publication by MAP

Sl. No.	Topic	Remarks
1.	Assessment of Nursery Methods and Manures for Cultivation of Chirayita (*Swertia chirayita* Buch-Ham.) in Lauri Gewog, Bhutan	Published in BJA
2.	Lauri farmers successfully domesticates Swertia chirayita	Published in Sanam drupdrey
3.	Culinary herbs cultivation	Published in Sanam drupdrey
4.	Package of practices for Goned (*Carum carvi* Linn.)	Submitted to ARED
5.	Package of practices for Manupatra (*Inula racemosa* Hook. f.)	Submitted to ARED
6.	Package of practices for Ruta (*Saussurea lappa* Clarke)	Submitted to ARED
7.	Package of Practices forTi-yangkhu (*Dracocephalum tanguticum*)	Submitted to ARED
8.	Seed production manual for ginger	Submitted to ARED
9.	Seed production manual for turmeric	Submitted to ARED
10.	Seed production manual for large cardamom	Submitted to ARED
11.	Leaflets on cultivated MAPs	Draft completed

2.17.17Research on formulation of organic pesticide from medicinal plants

Management of pests in agriculture over the past half century has been largely dependent on the synthetic chemical pesticides. Potential problems associated with continued long-term use of toxic insecticide include pest resistance and negative impact on natural enemies. In addition, increasing documentation of negative environmental and health impact of synthetic toxic insecticides and increasingly stringent environmental regulation of pesticides have resulted in renewed interest in the development and use of botanical pest management products by agrochemical companies. Not only might certain secondary metabolites of the plant's origin be source of new pesticides, but also botanical derivatives may be more environmentally benign than synthetic chemicals. Extensive surveys and report on plants used as insecticides can be found in the literatures and over 2000 species of plants are known to possess some

insecticidal properties. Recently some of the researchers have reported the bioactivity of extracts/essential oils from various plants against important agricultural insect pests and mites.

Bhutan is endowed with a wide range of promising flora known for their medicinal values and many have a history of usage, either to kill or to repel insects. Plants with known medicinal properties may be screened for insecticidal activities particularly in Bhutan. However, studies on pesticidal activity of medicinal plants are scanty and no quantitative report is available. Against this backdrop, the MAP Section, NCOA in collaboration with NPPC, NBC and NPRP of NCOA has initiated studies to discover potential pesticide from six promising medicinal plants (Ruta, Zanthoxylum, Garlic, Manupatra, Khen nap, Khen kar) either grown abundantly in the country or cultivated by the farmers, were selected to evaluate their insecticidal activity against some agriculturally important pests. In this research, we used extract as well as essential oils from these plants totaling 12 types of formulations. Next step will be to conduct research using these formulations on vegetables, fruits, Field Crops. aiming at the development of new agent for pest control based on natural products in Bhutan.

2.17.18Other minor activities

In addition to major research activities, MAP Section implemented following regular and minor on-station activities.

Sl. No.	Activity	Remarks
1.	Herb Garden Maintenance	Initiated in February, 2021
2.	Observation trial and seed multiplication of Ti-yangku	Completed in March, 2021
3.	Observation trial and seed multiplication of goned	Completed in March, 2021
4.	Seed multiplication of culinary herbs	Completed in April, 2021
5.	Maintenance of demonstration blocks (culinary herb and medicinal plants in core area)	Completed in March, 2021
6.	Research on culinary herb production in hydroponic system	On-going
7.	Management of long-term turmeric trial	On-going
8.	Management of long-term trials of water wasabi	On-going
9.	Management of long-term zanthoxylum trial	On-going
10.	Management of long-term manupatra trial	On-going
11.	Observation trial on wild allium (Lagop)	Completed in April, 2021
12.	Multiplication of Parpata planting materials	Completed in April, 2021

3 FIELD CROP PROGRAM

3.1 Summary of APA planned and achieved

The FY 2020-2021 marks yet another stepping stone to the success of Field Crop Program. The main thrust of the program for the reporting year have been to facilitate up-scaling of quinoa production in the country, promote quinoa in highland agriculture farming, produce high yielding variety paddy seed, initiate agriculture production research in high altitude rice and the Quinoa as bestowed with national mandates of coordinating national quinoa commodity program and the high altitude rice research and development program.

The program prepares its Annual Performance Agreement (APA) target in line with the annual target set by the Department of Agriculture (DoA). The APA targets are then translated into the Individual Work Plan.

Table 42: APA targets and achievement in FY 2020-2021 of Field Crop Program, NCOA

Success Indicator	Unit	Target	Achievement	Achievement (%)	Remarks
Upscaling Quinoa production in the country	Mt	188	34.59	18.40	Refer details in table 43.
Paddy Production	Kg	500	2500	500	2500 kg paddy seed produced from 2020 rice harvest from 7 released varieties, 2 pipeline varieties and 5 traditional varieties.
Quinoa Promotion	Ac	22	158	718.18	Promoted through the supply of 316.5 kgs of Quinoa seed to Punkha, Zhemgang, Samtshe, Chhukha, ARDC Bajo and Wengkhar.
Agriculture production research in high altitude rice	No	4	7	150	4 independently conducted by NCOA Yusipang and 3 collaborative trials were implemented and successfully completed in 2020 rice season. The data collected will be analyzed.
Agriculture production research initiated in Quinoa	No	4	4	100	(1) Multi Environmental Trail on Quinoa which is under implementation (2) 5 NCT on Evaluation of new Quinoa entries- under implementation (3) Evaluation of different bio-manures on the growth and yield of Quinoa - to be initiated in the coming season (4) Evaluation of different.

3.2 Up scaling Quinoa production in the country

This activity on up-scaling Quinoa production in the country has been tagged with National Centre for Organic Agriculture, Yusipang for the entire period of 12th FYP merely to maintain the statistics at national level production of Quinoa in the county. This is imperative to have been assigned to any other ARDCs if not NCOA without which annual consolidated of statistics of Quinoa would not have known. However, NCOA in its capacity as the Quinoa commodity coordinating Centre, have been facilitating production in close collaboration with ARDCs through supply of basic seeds as and when we receive the request for supports.

Quinoa research and development marked six years since its introduction into the country in 2015. It has now been adapted in 20 Dzongkhag covering all agro-ecological zones. The DoA aims to upscale quinoa cultivation to enhance household food and nutritional security as well as diversify farmers' cropping systems to adapt this versatile climate resilient crop. The consolidated total 12th FYP target for quinoa is 630 acres with an expected production of 310.50 MT.

Observing from the past production records the annual production of quinoa annually has been significantly low giving a factual conclusion of difficulty in achieving the annual targets if marketing issues remains constant and unexplored. The recommendation to reducing the target has been put forth to Department during APA review. The region wise production data of Quinoa for FY 2020-2021 is as given below:

Table 43:Region wise Quinoa production in FY 2020-2021 through up-scaling program

Region	**Production (MT)**
Wengkhar	22.1
Samtenling	5.81
Bajo	1.65
NCOA	5.03
Total	**34.59**

3.3 Paddy production

3.3.1 Basic seed production and maintenance of released and pipeline varieties

Introduction

Different varieties are being evaluated for their performance at rice research station at Tsento-Shari. The varieties undergo evaluation for several years after which it is proposed for release. Yusiray Maap-1, Yusiray Maap-2, Yusiray kaap-2, Yusiray kaap-3, YusirayKathramathra, KhangmaMaap and Jakar Ray Naab are the released varieties which are popularly grown in high altitude areas. Bulk-20, Sticky rice, Chandanath-1 and Sasanishiki are four varieties which are still in pipeline and has reached advanced evaluation stage. Among four pipeline varieties, Bulk-20 in particular has been performing very well and will be proposed for varietal release in 2021.

Objective:

Released varieties main grown to supply seed to the farmers as seed replacement in the fields. Pipeline varieties are evaluated for their performance in yield and other parameters and proposed for released if they perform very well and are preferred by the farmers.

Materials and methods:

The nursery was raised from 7th to 10th of March, 2020 at Tsento-Shari rice research station. The transplantation for seed production was done from 3rd June, 2020 to 10th June, 2020. Each variety is grown in different terraces to maintain purity of seed. The seed production plots were harvested from 20th October, 2020 to 28th October 2020. Fertilizer was applied at the rate of 32:20:8 NPK kg/acre. Half of N and entire dosage of P and K were applied as basal dose at the time of transplantation. The remaining N dosage was top dressed at tillering stage. To suppress weeds, Butachlor was applied at 12 kg/acre.

The field was also monitored regularly and voluntary or off-type panicles were rouged. Panicle selection was also done to obtain quality and pure seeds which are used for seed production and seed supply to the farmers.

Result and Discussion:

The seed production is targeted based on the demand and seed request by the farmers. Farmers have their own preference for variety like kernel colour, straw yield, threshability of the grain, cold and blast resistance, resistant to lodging, grain size and presence of awn etc.

Table 44:Production of released and pipeline varieties

Sl.No	Variety Name	Amount Produced (kg)	Remarks
Released varieties			
1	Yusiray Maap-1	370	The seed produced were supplied to high altitude areas based on farmers demand, supplied to NSC for seed replacement and maintained for seed production and trials for next season
2	Yusiray Maap-2	300	
3	Yusiray Kaap-2	230	
4	Yusiray Kaap-3	300	
5	YusirayKathramathra	250	
6	KhangmaMaap	350	
7	Jakar Ray Naab	250	
Pipeline Varieties			
1	Bulk-20	350	Bulk-20 will be proposed for release in 2021 while other two are still under evaluation
2	Chandanath-1	100	
3	Sticky rice	100	
	Total Production	**2600 kg**	

Figure 53:Rice seed production at rice research station, Tsento-Shari, Paro

3.4 Quinoa Promotion

Since its introduction in 2015, quinoa has been aggressively promoted in all 20 Dzongkhags. Regional ARDCs and Dzongkhags have coordinated the production of 34.59 MT in FY 2020-2021. In fulfilling the usual demand for Quinoa seeds, NCOA Yusipang continues to provide support not only in terms of technical backstopping but also in production and supply of seeds. The center had supplied 200 kg of basic seed to ARDCs for further promotion to Dzongkhags.

Table 45:Quinoa promoted by NCOA, Yusipang through supply of seeds

Sl.No	Dzongkhag/ARDCs	Qty supplied(kg)	Area (acre)
1	ARDC-Wengkhar	150	75
2	ARDC Bajo	50	25
3	Zhemgang	30	15
4	Samtshe	25	12.5
5	Chhukha	45	22.5
6	ARDC-SC Tsirang	150	75
7	OGOP	5	2.5
8	Punakha	10	5
	Total	**465**	**232.5**

3.5 Agriculture production research in high altitude rice

Introduction

National Centre for Organic Agriculture conducts high altitude rice researches at Tsento-Shari under Tsento Gewog in Paro in about 2.84 acres of land leased from FMCL in 2017. The centre pays an annual rant of Nu.76, 000 (Seventy Six Thousand) for the land. Locating under warm temperate agro ecological zone with an elevation of 2450 masl makes the site technically suitable for conducting high-altitude rice researches. The overarching objectives of the rice research by the centre are to:

- Conduct rice research on emerging technologies in rice for the benefit for rice growers
- Evaluate rice varieties suitable for high altitude rice growing areas and propose the better performing varieties for varietal release
- Maintain the basic seeds of released high altitude varieties, popular high-altitude varieties and local germplasm
- Produce seeds of released varieties for replacement in high altitude rice growing areas
- Produce and supply basic seed as source seed to the National Seed Center.

Rice Research /Trials:

Six rice trials were implemented in the 2020 rice season as follow:

- Establish Agromomic Parameters for popular high altitude rice varieties
- Production Evaluation Trial
- Evolutionary Plant Breeding Trial
- Rehabilitation of Dumbja
- Trial on Efficacy of aquobiota on rice

3.5.1 Establish Agronomic Parameters for popular high-altitude rice varieties

Introduction

The trial was implemented for the second year in 2020. Climate change has become a very pertinent issue throughout the world. The rainfall and temperature pattern has become very unpredictable which largely impacts the production of crops. Since, rice is a very important cropin our country, studying the temperature and rainfall pattern at different growing stages of rice to accordingly aligning the management practices has become very pertinent.

Objective:

The research was aimed at studying the agronomic parameters for popular released high altitude rice varieties and their relation with temperature at different growth stages which could serve as baseline for future germplasm selection for warm temperate or high altitude rice agro-ecology.

Materials and methods:

The nursery was raised on 7th march, 2020 and the trial was transplanted on 5th June, 2020. Weather data for 10 years (2009-2018) were also collected from National Centre for Hydrology and Meteorology to examine weather parameters like temperature temp rainfall pattern. 8 popular high altitude rice varieties were selected for the trial to examine and establish the agronomic parameters.

The treatments were: Yusirey Maap-1, Yusirey Maap-2, Yusirey Kaap-2, KhangmaMaap, JakarRayNaab, YusirayKathramathra, Yusiray Kaap-3 and Janam which is a traditional variety was kept as standardard check.

The trial was laid out in Randomized Complete Block Design (RCBD) which was replicated 3 times. The plot size was 10 m^2 (5m x 2m) and the plant to plant spacing of 20 cm x 20 cm was kept. Fertilizer dosage of 80:40:20 kg ha^{-1} were applied. The sources of NPK were Urea, Single Super Phosphate (P_2O_5) and Muriate of Potash (MoP) respectively. Half of N and whole of P and K were used applied as basal dose while other half of N was top dressed at panicle initiation stage. Butachlor was applied was applied at 1 kg a.i ha^{-1} right after transplanting and once 3 weeks after transplanting to suppress the weeds like pondweed/shochum (Potamogetondistinctus), baynyard grass (Echinochloacrusgalli), knotgrass (Paspalum distichum) etc.

The data was collected during different stages of rice. The traits collected were: plant height, number of tillers per hill, 1000 grain weight, panicle length, number of grains per panicle, plot yield. The trial was harvested from an area of 5.04 cm^2 after borders were removed and the grain yield was calculated by standardizing the moisture content to 14%.The trial was harvested on 25th October, 2020. The data was analyzed by December 2020 and a journal article was published in Bhutanese Journal of Agriculture in February 2021.

Result and discussion

The data collected were analyzed using STAR software and the analyzed data are summarized in the table below.

Table 46:Different agronomic traits from the trail (2020 season)

Variety	Plant height (cm)	Tiller No.	1000 GW	Filled Grains/panicle	Unfilled Grains/panicle	Panicle length (cm)	Yield (t/acre)
Jakar Ray Naab	101.00^{ef}	13.27	22.47^{cd}	81.00^{d}	9.22^{ab}	16.37^{c}	1.92^{ab}
Janam	145.03^{a}	14.13	19.67^{d}	172.45^{ab}	21.11^{a}	21.52^{ab}	1.61^{b}
Khangma Maap	118.67^{bc}	12.07	27.53^{ab}	140.11^{bc}	5.22^{b}	22.56^{a}	2.45^{ab}
Yusiray Kaap-2	122.07^{b}	13.33	23.87^{c}	137.33^{bc}	18.33^{ab}	20.90^{ab}	2.00^{ab}
Yusiray Kaap-3	96.20^{f}	12.93	29.47^{a}	126.11^{cd}	7.00^{ab}	20.05^{ab}	2.58^{a}
Yusiray Kathramathra	107.67^{de}	15.87	24.80^{bc}	139.00^{bc}	14.67^{ab}	19.00^{bc}	2.60^{a}
Yusiray Maap-1	120.14^{bc}	11.93	27.20^{ab}	137.45^{bc}	13.89^{ab}	20.93^{ab}	2.45^{ab}
Yusiray Maap-2	113.37^{cd}	13.8	22.60^{c}	191.34^{a}	18.56^{ab}	22.95^{a}	2.17^{ab}
P Value	0	0.1247	0	0.0001	0.013	0.0001	0.0184
SE±	2.13	1.24	0.81	13.08	4.11	0.8912	0.26
CV (%)	2.25	11.36	4.03	11.39	37.32	5.32	14.5

Values in columns followed by different letters in subscript are significantly different at 0.05 % level of significance.

The result showed that Yusiray Kathramathra (2.6 t/acre) followed by Yusiray Kaap-3 (2.58 t/acre) while standard check Janam (1.61 t/acre) had the lowest yield. Janam (145.03 cm) was tallest of all the variety while Yusiray Kaap-3 (96.20 cm) was the shortest. In terms of tiller numbers, though Yusiray Kathramathra had the highest numbers of tillers, there was no significant difference all the varieties.

3.5.2 Production Evaluation Trial

Introduction

Varieties which are still under evaluation (pipeline varieties) are compared with released and traditional varieties to evaluate the performance of yield and other parameters. Currently, three pipeline varieties i.e. Bulk-20, Chandanath-1 and Sticky rice are under initial evaluation phase. PET was implemented to compare the agronomic performance of these pipeline varieties with the released and traditional varieties. The treatments were Chandanath-1, Janam, Sticky rice, Bulk-20, Yusiray Kaap-2, Yusiray Kaap-3, YusirayKathamatha and Yusiray Maap-1.

Objective

Evaluation of yield and other agronomic parameters of pipeline varieties with released and traditional varieties for varietal diversification in high-altitude areas

Materials and methods

The nursery for this trial was raised on 7th March, 2020 and the trial was transplanted on 5th June, 2020. The trial was laid out in a Randomized Complete Block Design with 3 replications. The plot size was 10 m^2 (5 m x 2 m) and the seedlings were transplanted by keeping a spacing of 20 cm x 20 cm. Fertilizer dosages were kept same as the first trial since the trial locations are same.

At maturity the trial was harvested from 5.04 m^2 plot size after removing the borders. The trial site was at Tsento-Shari rice research station. The trial was harvested on 25th October, 2020 and data entry and analysis was completed by December 2020

Result and Discussion

The results were analyzed using STAR software and the traits collected and analyzed are presented in the table below.

Table 47:Traits collected from production evaluation trial (2020)

Variety	Plant Height (cm)	Tiller No.	Plot Yield (5.04 m^2)	Yield (t/acre)
Chandanath-1	94.07^{c}	9.67^{ab}	2.22^{abc}	1.89^{abc}
Janam	139.07^{a}	11.87^{a}	2.14^{bc}	1.73^{bc}
Sticky Rice	115.07^{b}	8.07^{b}	2.61^{ab}	2.10^{ab}
Bulk-20	116.33^{b}	8.27^{b}	2.66^{a}	2.13^{a}
Yusiray Kaap-2	112.87^{b}	10.20^{ab}	2.01^{c}	1.64^{c}
Yusiray kaap-3	90.33^{c}	8.73^{b}	2.25^{abc}	1.80^{abc}
Yusiray kathramathra	99.00^{c}	11.33^{a}	2.59^{ab}	2.06^{ab}
Yusiray Maap-1	112.33^{b}	9.73^{ab}	2.48^{abc}	2.00^{abc}
P Value	0.3404	0.0008	0.0025	0.0033
SE±	3.34	0.7189	0.1429	0.1129
CV(%)	3.73	9.05	7.38	7.24

Values in columns followed by different letters in subscript are significantly different at 0.05 % level of significance.

The experiment showed that Bulk-20 had the highest yield followed by Sticky rice which are both pipeline varieties while Yusiray Kaap-2 had the lowest yield. However, except Yusiray Kaap-2, no significant difference was observed among all other treatments. It was a clear

indication that pipeline varieties have an equal potential with the released varieties which would largely add in varietal diversification in farmers' fields.

3.5.3 Evolutionary Plant Breeding Trial

Introduction

Evolutionary Plant Breeding (EPB) is a new concept in the field of plant breeding whose principle is subjecting a crop population with a high genetic diversity to the forces of natural selection year after year. The concept of diversity in the Evolutionary Plant Breeding has a number of beneficial effects. When crops of different genotype are grown together, each one of them has different ability to intake the limited resources and hence the plant to plant competition can be largely reduced. Having a diversity within a population allows sufficient Genetic-environmental (GE) interaction within an evolving population.

Diversity also means that plants can complement each other in terms of inducing resistance in the lesser resistant cultivars. Moreover, in the phase of changing climate, if some genotypes fail to survive, others can survive which ensures a continuity within a population. Thus, the population is expected to adapt with the changing and unpredictable climatic condition, an issue which is globally raised and discussed. EPB therefore is a very holistic approach to generate a climate resilient technology.

Funded by Bioversity International and coordinated by the National Biodiversity Centre in collaboration with four Agriculture Research and Development Centres (ARDC) and Gewog agriculture extension supervisors of respective regions, Evolutionary Plant Breeding Project was implemented at the beginning of 2019. The project will be funded for a duration of four years and the crops chosen for implementation in Bhutan are beans and rice.

Objective

To evaluate and develop Evolutionary Population (EP) in rice which is expected to be climate resilient and adaptive to a particular micro-climate.

Materials and Method

The trial was established at Tsento-Shari rice research station and was laid out in a Randomized Complete Block Design (RCBD) with three replications. The nursery for this trial was raised on 10th March, 2020 and the trial was transplanted on 5th June, 2020. The plot size was maintained at 10 m^2 (5 m x 2 m) with spacing of 20 x 20 cm both row to row and plant to plant.The fertilizer rate was 80:40:20 NPK. Half of N and whole of N and P were applied as basal dosage while half N was applied at panicle initiation stage. Butachlor at 1 kg a.i ha^{-1} to suppress the weeds.

The trial was collected from 5.04 m^2 after removing the borders. The data collected were: Plant height, tiller number, panicle length, 1000 grain weight and plot yield from 5.04 m^2. The trial was harvested on 21st October, 2020 and the data was sent to EPB experts for analysis by December, 2020.

Result and discussion

A special component of EPB trial is the mixture which is allowed to evolve over the years under the influence of changing climate and weather pattern. It was observed from the experiment that the yield of the mixture was significantly lower than Khangma Maap and Yusiray Kaap-3. The yield of EPB mixture was however higher comparing to Dumbja and Jakar Ray Naab though there was no significant difference.

Table 48: Traits collected from EPB trial (2020)

Variety	Plant Height (cm)	Tiller No.	Panicle Length	1000 GW	Yield (t/acre)
Dumbja	146.75^{a}	8.47^{b}	23.19^{ab}	18.87^{c}	1.68^{c}
EPB Mixture	146.83^{a}	11.20^{ab}	24.45^{a}	21.40^{bc}	1.97^{bc}
Jakar Ray Naab	101.25^{c}	13.27^{aa}	16.36^{c}	22.47^{bc}	1.92^{c}
Khangma Maap	114.42^{b}	13.40^{a}	20.71^{b}	25.33^{ab}	2.40^{a}
Yusiray kaap-3	89.50^{d}	10.13^{ab}	17.51^{c}	29.47^{a}	2.44^{a}
Yusiray Maap-1	118.17^{b}	11.27^{ab}	20.77^{b}	25.40^{ab}	2.30^{ab}
P Value	0.000	0.0053	0.00	0.0004	0.0002
SE±	3.17	1.02	0.8151	1.47	0.1099
CV(%)	3.25	11.09	4.87	7.56	6.35

Values in columns followed by different letters in subscript are significantly different at 0.05 % level of significance.

The trial will be repeated for the third year in 2021 rice season at Tsento-Shari village. However, the trial site will be changed to a different farmer as per the requirement of the EPB principle.

3.5.4 Rehabilitating Aroma of Traditional Rice Dumbja

Introduction

Dumbja is a traditional rice variety popularly cultivated in warm temperate region. This variety is popular due to its special aroma. Farmers use this variety to make bitten rice locally called ***Sip*** used commonly for offering to guest and also during rituals as an offering**.** Dumbjais the only traditional variety that is found to be cultivated by the farmers even to this day. According to farmers of Paro, the seeds were first introduced in the past from Dungnavillage under Chhukha Dzongkhag.However, over time farmers and consumers have aroma of Dumbja has largely deteriorated. Therefore, there is a strong desire and proposal from the community to rehabilitate the aroma of this variety through appropriate research interventions.

Objective

Rehabilitate the aroma of Dumbja through farmers' participatory selection

Materials and Methods

The trial was therefore carried out by making a collection Dumbja from different locations. 10 accessions of Dumbja were collected from different farmers of Dungna village, 6 accessions from the Gene Bank (National Biodiversity Centre and one line was maintained by RDC Yusipang. We used Yusiray Kaap-3 as the standard check.

The nursery was raise on 8thMarch 2020 and the trials was transplanted on 4th June, 2020. The trial was laid out in a Partially Balanced Incomplete Block Design (PBIBD). The plot size was 10 m^{2} (5 m x 2 m) with spacing of 20 cm x 20 cm.

The treatment D-3 was excluded in 2020 trial as it didn't mature in 2019. A farmers' field daywas conducted when the crop attained its maturity stage and farmers were allowed to tag the variety which phenotypically resembled the original Dumbja. The trials was harvested on 22nd October, 2020 and the data was sent for analysis to experts by December 2020.

Result and Discussion

The trial was harvested at its maturity and the data were collected as detailed in the table below and the results are discussed accordingly.

Table 49: Agronomic traits of different accessions of Dumja

ENTRY No.	Accession Name	Plant Height (cm)	Tiller Number	1000 GW (g)	Grain Yield (t/ha)
1	Dungna Collection - 1	124.6	12.3	21.9	4.839
2	Dungna Collection - 2	124.6	10.2	21.9	4.848
3	Dungna Collection - 3	130.1	9.6	*	*
4	Dungna Collection - 4	134.0	8.6	21.8	2.627
5	Dungna Collection - 5	126.7	11.0	22.4	4.498
6	Dungna Collection - 6	134.0	11.5	21.5	4.991
7	Dungna Collection - 7	141.4	9.3	21.7	3.051
8	Dungna Collection - 8	131.7	13.0	22.6	4.967
9	Dungna Collection - 9	128.0	12.6	21.8	4.931
10	Dungna Collection - 10	123.8	11.0	22.3	5.316
11	NBC Collections/National Gene Bank Collection_1	137.9	5.8	21.3	5.203
12	NBC Collections/National Gene Bank Collection_2	134.7	7.8	21.3	5.197
13	NBC Collections/National Gene Bank Collection_3	142.6	7.6	22.3	4.487
14	NBC Collections/National Gene Bank Collection_4	133.9	7.1	21.3	5.157
15	NBC Collections/National Gene Bank Collection_5	138.5	8.1	21.5	4.141
16	NBC Collections/National Gene Bank Collection_6	131.2	6.2	20.4	5.048
17	ARDC Yusipang = 1	148.9	6.2	22.4	4.753
18	Standard Check - Yusiray Kaap 3	96.4	8.6	30.1	5.855
	$LSD_{0.05}$	5.343	1.466		0.6606
	CV %	6.54	25.86		10.27

During the field day, 3 accessions i.e Yusipang Dumbja, NBC Collection-2 and NBC Collection-3 were selected or tagged most by the farmers. NBC Collection-2 and NBC Collection-3 were also found to possess prominent aroma than Yusipang Dumbja while making beaten rice.

The mean plant height of all accessions of Dumbja from the trial in 2020 was found to be 129.2 while mean tiller number was 8.92. The mean 1000 grain weight was 23.2 g while the yield was 4.639 t/ha. The same trial will be repeated for 2021 season and additional findings like organoleptic test will be carried out to further assess and confirm the aroma of Dumbja.

3.5.5 Diversifying climate resilient rice varieties in Metsi village, Tsento gewog, Paro

Introduction

The selection and access to climate resilient rice varieties have become an urgency for high altitude rice farmers of Tsento Gewog, Paro. Metsi and Zamsa villages are located at some 2600 masl and currently only two varieties i.e Jakar Ray Naab and Khangma Maap are prominently grown in these villages. However, farmers have claimed that the existing two varieties are deteriorating fast in terms of disease tolerance and productivity.

Cold temperature, incidence of fungal diseases such as Rice Blast and very short growing season are the three most critical constraints faced by rice farmers in this region. Farmers have selected many traditional varieties that are well adapted to such a challenging environment but many of the traditional rice varieties were devastated by rice blast disease epidemic in 1995.

Objectives

Diversification of cold tolerant and climate resilient rice varieties in high altitude areas

Materials and Methods

To diversify rice varieties in Metsi and Zamsa villages, an on-farm trial was implemented at Metsi village for 2020 rice season. Six varieties (Jakar Ray Naab, KhangmaMaap, Yusiray Maap-1, Yusiray Kaap-3, Chandanath-1 and Bulk-20) which are popular throughout lower part of Tsento Gewog were selected for on-farm demonstration. The nursery was raised on 5th March, 2020 and the demonstration plots were transplanted on 7th June, 2020. The plots were harvested on 14th October, 2020.

Result and Discussion

On 14th October, 2020, a farmers' field day was organized to assess the performance of different varieties through participatory varietal selection by the farmers.The participants (farmers) were made to select and tag the varieties they preferred to grow in the coming rice season. The best performing variety was made to be tagged with red ribbon while the one which showed little lower in its yield performance was tagged with yellow ribbon. Chandanath-1 was the variety which was chosen as the best performing varieties in Metsi village followed by Bulk-20. Both are pipeline varieties which are still under evaluation and soon be proposed for variety release in coming years. The seeds of the two varieties were supplied to farmers of Zamsa and Metsi villages to be grown in 2021 rice season for which the nursery raising will start from February 2021.

Figure 54:supplementation on the growth and yield of rice

3.5.6 Effect of AQUABIOTA

Introduction Varietal selection and tagging the best performing variety

Plants are exposed to diverse biotic and abiotic factors during their lifetime. The whole system consisting of plants, their environments, and all organisms in those environments is called the phytobiome. Abiotic and biotic factors of a phytobiome interact dynamically, influencing natural ecosystems and agro ecosystems. Among biotic factors, the microbial com munities associated with plants are referred to as the plant microbiome or microbiota. The microbiome is defined as both the composition of a microbial community in a specific environmental niche (microbiota) and its collective genome.

The microbiota can be profiled using marker genes suited to specific environment and use in agriculture. One such example is aquabiota. Aquabiota is a complex of microbiota selected amongst 200 strains for their properties to benefits plant growth. Studies have shown that the use of aquabiota improved soil fertility, reduced diseases and pest, increased crop yield, reduced the need of chemical fertilizers and increased the concentration of bioactive in the rice. Therefore, exploration of the use of aquabiota in rice is of considerable interest with respect to both productivity and human health.

This trial was led by National Soil Services Centre (NSSC) in collaboration with NCOA-Yusipang and other ARDCs.

Objective

Assess the effect of aquabiota on growth, yield and nutrient content of rice in Bhutan.

Material & Method

The trial was established at Tsento-Shari rice research station, Paro on 7th March, 2020 and transplanted on 10th June, 2020. Trial was laid out in an Randomized Complete Block Design (RCBD). The plot size was 5 m x 2 m (10m^2) with plant-to-plant and row-to-row distance of 20 cm. The trial was harvested on 27th October, 2020 and analysed data with report was shared by February 2021. The variety used for the trial was Yusiray Maap-1 and the treatments were as follows:

Table 50: Treatments and the rate of application

Treatment	Rate of application
T1 control	No application
T2 Aquabiota	Broadcasted Aquabiota R 0.3 kg/plot before immersion of field in water Mixed 60 gram of Aquabiota J88 in water and dispersed on the field at 30, 60 and 90 days after transplanting (DAT)
T3 Effective microorgasm (EM)	Diluted 0.5 lit of EM to 50 lit of water and sprayed 206 ml and water the field After rice transplanting sprayed 206 ml of EM to the field Repeated the same application rate of EM at 30, 60 and 90 DAT Where spraying was not possible due to flowering or milking stage, poured or driped EM at the side of the rice field
T4 Biochar	Applied 1 kg biochar in the form of fine powder one week before transplanting. It was thoroughly mixed with the soil to prevent floating on the water surface
T5 Bio-fertilizer (*Azotobacter sp*)	Mixed 2.5 ml bio-fertilizer in 500 ml water and apply 0.5 ml per field one week before transplantation

Result and Discussion

The result showed that there was no significant difference between the treatments in yield and other parameters. The no of spikelet/panicle per hill increased and the no of hollow spikelet decreased with aquabiota application. The trial was also carried out at Chimipang, Punakha

and Lingmithang, Mongar and similar results were also found from the two sites. The trial will be repeated for 2021 season.

Table 51 Effect of aqua biota supplementation on yield and yield parameters of rice

Treatment	Plant height (cm)	No of tillers per hill	No of fertile tillers per hill	No. of spikelet/panicle per hill	No. of hollow spikelet/panicle per hill	No of panicle per m^2	Grain yield/ha (kg)	Biological yield/ha (kg)
1	97.1333	7.0467	6.7533	118.6250	6.3750	158.3333	3190.0853	11975.3406
2	94.8700	7.3800	7.2967	170.0250	5.1667	196.3333	4284.7442	13931.2946
3	96.5033	6.4200	6.2100	135.2917	5.9583	178.3333	3161.6667	9568.3333
4	94.7467	7.0033	6.8367	128.1250	5.8333	189.6667	3667.0581	11690.3915
5	97.7567	6.6700	6.5833	135.9167	6.6250	194.6667	3477.4186	13204.0853
F value	**0.533**	**0.402**	**0.535**	**1.750**	**0.707**	**1.347**	**4.150**	**3.787**
P value	**> 0.05**	**> 0.05**	**> 0.05**	**> 0.05**	**> 0.05**	**> 0.05**	**< 0.05**	**< 0.05**
Sig	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	*****	*****

In general, the application of aquabiota positively affected some of the growth and yield-related traits of rice. However, most of the parameters were statistically non-significant. More research is needed to scrutinize and validate the above findings.

3.6 Agriculture production research initiated in Quinoa

3.6.1 Multi Environment Trial on Quinoa and Amaranth

Introduction

Bhutan represented by Gross national Happiness and Department of Agriculture signed a two year project on Multi Environment Trial on Evaluating the adaptation of Quinoa and Amaranth genotypes across the different ecologies and identification and use of beneficial microbes to enhance stress tolerance and yield in crop plants with The International Center for Biosaline Agriculture (ICBA**),** Dubai, United Arab Emirates. For the first party ICBA, the long term pursue is to address the major major impediment in the progress in breeding for yield and key economic traits due to the complex genotype x environment (GxE) interactions that reduce trait heritability thus weaken the chances to identify and select superior genotypes. Through this high-quality multi-environment testing (MET) system it is expected to provide understanding and effectively exploit GxE interaction. The second party Bhutan, The project implementation is guided by ICBA through its Principal Investigator with a carefully designed MET to allow for the accurate estimation of the true genetic worth of breeding lines early in the variety development cycle, strengthen the ability to develop marker-trait association and enable the identification of genotypes with consistent performance across as well as in specific target environments and markets.

For Bhutan, the primary objective of the trail is to diversify the existing Quinoa germplasm in the country. Currently there are four released Quinoa varieties in the country. Bhutan received accessions 186 (180 entries and 6 checks) of Quinoa from ICBA each of five gram to be tested in the country.

Figure 55: Quinoa Field

Research aim and objectives

- Phenotypically evaluate Quinoa and Amaranth genotypes through multi-environment testing (MET)
- Explore the variability of the microbial populations in the rhizosphere of studied areas and their possible use to enhance crop productivity under the marginal environmental stresses.

The objectives are to:

- Identify candidate genes/loci's/QTLs and markers associated with them for agronomically and biochemically important traits by genome-wide association study in quinoa and Amaranth
- Speed up the breeding program for genetic improvement of quinoa and Amaranth through marker assisted breeding
- Strengthen the outputs by deducing G x E interactions besides QTL x E interactions.
- Understand the structure, the diversity and the abundance of soil microbial populationsusing next-generation DNA technology
- Extract microbial strains, identify, characterize and selection of elite endophytes strains to be tested in the field.
- Evaluation of the characterized endophytes strains for their capability to enhance crop productivity under abiotic stress (heat, drought, salinity).

Research Methodology

Bhutan received 186 quinoa genotypes from ICBA which includes 180 entries and 6 checks for 1st year sowing. The trail required over 0.8 Acres of land and was generously approved by ARDC Bajo to conduct at ARDC- Sub Centre Tsirang. The first year trail on Quinoa trail establishment started from 12th, 13th and 14th of October 2020. The plots that attained harvesting stage and measurement of parameter was carried out on 22nd -24th February 2020. The harvesting of remaining plots that attained harvesting stage and measurement of parameters were done from 19th March to 26th March 2021. Six plots still remain with delayed crop maturity.

Study Design and data analysis

The MET design was developed and received from ICBA so called Augmented Randomised Complete Block design. Each of six Checks had 5 replications and 180 entries with single plot design. A total of over 9000 parameters have been started measuring that continues from harvesting to curing/drying and threshing. The data will be submitted to ICBA for analysis.

Outcome

While fulfilling the ICBA's Objective, it is expected that superior varieties are identified that best fit in the Bhutanese agro ecological conditions. First year trail on Quinoa has been successfully completed with data to be entered in data sheet provided by ICBA. First year trial on Amaranth is yet to be established.

3.6.2 Evaluation of Different Bio-pesticides in Controlling Leaf-miners on Quinoa

Introduction

Quinoa (*Chenopodium quinoa*) has been recognized as a strategic crop that can contribute to global food security because of its high nutritional quality, genetic variability, adaptability to adverse climate and soil conditions, and low production cost (FAO, 2011). Quinoa production in Bhutan has been increasing dramatically, but the infestation by leaf-miners is common in all quinoa growing areas and it damagesthe plants at its juvenile stagecausing serious yield losses in the crop. Even though there are several bio-pesticides, no research has been carried out to control leaf-miners on quinoa.

Objective

1. To evaluate different types of bio-pesticides in controlling leaf miners in quinoa under organic practice.
2. To document natural enemies associated with leaf miner.

Materials and Methods

The trial is initiated in NCOA, Yusipang on 8th April, 2021 situated at an elevation of 2690 masl.It is a quantitative research involving field trials. Randomizedblock design with 5 treatments including control and 4 replications was used to design the research field. The treatments are; i. Neem oil (4 ml/liter of water), ii. Artemisia Extract (1 liter/ 10 liter of water),iii. Jholmol (1 liter/liter of water), iv. Jeevumruth(1 liter/liter of water) and v. Control. The variety of seed used is *Amarallia marangan.*The treatments will be applied @ 15 liters per plot ones every weekly. The randomization was done by using Statical Tool for Agriculture Research (STAR).The plotswere8 m^2(4m X 2m). The variety of seed used is *Amarilla Marangani* was sown in line at row to row spacing of 50cm. 10 kg of vermicompost was applied in lines during sowing.Data collection will be a day before and after each spray on a weekly interval.A total of 10 plants will be selected and tagged in the middle row (visual counting of mines). In each of the treatment plots whole sampled plants will be sampled for leaf mines. The total number of leaves on the plant and the total number infested leaves with leaf miners will be recorded for percentage infested leaves and total infected plants will also be recorded for percentage infested plants before and after 48 hours of treatment application.

The presence of natural enemies such as coccinellids, syrphid flies will be recorded from these plants through visual inspection. The growth parameter data will be collected during harvesting. The trial will be completed by September, 2021.

3.6.3 Evaluation of types and rates of bio manures on quinoa yield

Figure 56: Biopesticides Trial Set up

Introduction

Quinoa is mostly grown in a marginal land with very less of external inputs. However, quinoa is quite responsive to Farm yard manure application which increases the crop yield. Considering the approved Organic Flagship and quinoa being one of the commodities, there is urgent need to identify organic manure which would increase the yield of quinoa. Growing quinoa under organic regime would further augment the health benefits of the crop. Currently there are different types of organic manure present which are obtained from various animal sources. The organic manure includes FYM, Chicken manure, Vermi-compost and bio-slurry. There is a need to identify the best manure and the rate which could give the highest yield of quinoa when grown under organic regime.

Objective

To evaluate different types and application rates of bio manures on quinoa yield under organic regime.

Materials and Method

The trial was initiated on 14th April, 2021. It is a quantitative research involving a field trial. The design is split plot in a randomized block design with three replications. The main factor are types of manure and the sub plot factor are application rate. The main plot is 32 m^2(8m X 4m) and the sub plot will be 8m^2 (4m X 2m). The variety of seed used is *Amarallia maranganiand* the seeds are sown in line at row to row spacing of 50cm.The randomization was donusing STAR. The data will be collected for days to 50% flowering, days to maturity, plant height, plant biomass, yield per plot and 1000 grain weight. The trial will be completed by September, 2021.

Treatments

Main Plot	Sub plots
T_1- Vermi-compost	S_1=0T/a
T_2- Bio slurry	S_2=2T/a
T_3-Chicken manure	S_3=5T/a
T_4-Local Farm Yard Manure	S_4=7T/a

3.6.4 Evaluation of Quinoa germplasm at different agro ecological zones

Introduction

National Centre for Organic Agriculture received 20 Quinoa germplasm of each 5 gram from ICBA Dubai in February 2019. The Centre evaluated the germplasm and came up with eight best performing germplasm at Yusipang location. The second season trail of these selections was continued in the 2020 in a larger area for seed multiplication.

Having obtained a good amount of seed from the first adaptation trail, the center planned to carry an evaluation through Nationally Coordinated Trial. The NCT protocol was formulated and distributed to ARDCs and their Sub Centers along with quinoa seeds on 25th September 2020. NCOA initiated and established the trail in ARDC Sub Centre Tsirang on 14/10/2020 and was harvested on 19th March 2021. The trail at Yusipang has been initiated and established on 6 April 2021 and other ARDCs have reported to have established.

Objectives

i. To evaluate the performance and adaptation of new quinoa germplasm under different agro-ecological zone
ii. To identify additional suitable & promising Quinoa varieties in different ago ecological zones.

Figure 57: BioManure Trial Set up

Materials and Methods
Research protocols were sent to ARDCs and their sub centres along with 0.5 kg each of seven new accessions adapted at Yusipang and two released varieties Amarilla Marangani and DOA. ARDC Samtenling and ARDC-Sub Centre Tsirang had reported to have harvested the trail while ARDC Bajo and Wengkhar reported to have established the trail using the Randomized Complete Block Design with replication- 3 in plot size of 4m X 2.5 m = 10 m^2, 50 cm between rows and row length of 4 m.

Treatments/Conditions

i.	Amarallia Maragani	control	vi.	ICBA-13256
ii.	DoA-PMB-1- 2015	control	vii.	ICBA-12673
iii.	Quinoa Real		viii.	ICBA-12695
iv.	ICBA-13315		ix.	ICBA-12632
v.	ICBA-12994			

Outcome

The trail data will be submitted by collaborating researchers form ARDCs and ARDC Sub Centre. The data will be analyzed and potential varieties will be proposed for new Quinoa variety release.

3.7 Other Additional Research & Development Initiated by Field Crop Program

3.7.1 Implementation of Neglected and Underutilized Species Project

Introduction
The Neglected and Underutilized Species project is coordinated by National Biodiversity Centre (NBC) in collaboration with different Agriculture Research and Development Centres (ARDCs). The project is mainly aimed at enhancing the minor cereals which are otherwise nutritious but is neglected and less consumed across the world. In Bhutan, NUS project focuses on millets which has been playing a very important role in the lives of different communities across country. Millets are not commonly cultivated and consumed like other major cereals like rice, wheat and maize but it has lots of nutritional benefits and cultural benefits. Zamsa and Phasuma village under Chhukha district which are very popular for cultivation of millet were chosen as the project sites which were monitored by National Centre for Organic Agriculture. Through NUS project, we could bring to light the importance of different millets cultivated under these two villages.

Objective
Conservation of indigenous millet varieties grown in project sites and support in value chain management of millets

Materials and Method
The objectives of the project were planned according to the need of the community and also to provide some value addition to the existing practices of the farmers. A survey to assess the

diversity of millet and its importance in the livelihood under Zamsa and Phasuma villages was carried out in 2019 during the first year of project implementation. There were total of 54 farmers (one from each household) who participated in the survey. It was raised by the farmers in the focal group discussion that the main challenge faced by them was milling of millet. The project is planning to support farmers with milling machine which is expected help them in efficient milling of millet.

Since Phasuma and Zamsa villages have the potential to grow diverse range of cereals, vegetables and fruits, NCOA-Yusipang has also found the potential to register and certify the two villages as model organic villages under Chhukha Dzongkhag. a consultation meeting was held by officials from NCOA with the farmers of Phasuma and Zamsa on 8th and 9th April, 2021 to create awareness on organic agriculture and discuss on farmers interest to go organic. The farmers positively responded about their interest to get registered and certified as organic villages. The two villages also have no history of using any inorganic fertilizers and pesticides. Different types of foxtail millet with their local names popularly grown in Zamsa and Phasuma villages are given below.

Figure 58: Karchum and Napcham Respectively

Figure 59: Lingphub & Machum Respectivley

Result and Discussion

A group of officials will soon visit Zamsa and Phasuma villages to create awareness on procedures in getting registered as organic village and the importance of organic agriculture. Farmers will also be trained on preparation of organic manures and pesticides like compost, biodigester, jevamrut, jholmol etc. New crops like quinoa and adzuki beans will be given special importance due to the nutritional importance and assured markets of these two crops. One millet milling machines each will also be procured from FMCL and supplied to Zamsa and Phasuma villages. Through this intervention, we expect to go beyond the targeted crop and goals of Neglected and Underutilized Species (NUS) project by certifying the two villages as model organic villages and also supporting farmers in generating income for their livelihood.

.

Figure 60: Consultation Meeting at Zumsa and Phasuma Village

3.7.2 Evaluation of growth and yield of six highland traditional buckwheat accessions

Introduction

Cropping system above 2500 masl are dominated by buckwheat, barley, wheat, mustard and potatoes. Buckwheat, although a minor crop at present is an indispensable food for the Bhutanese people, particularly in non-rice growing areas and other highland where people have limited access to growing other cereals due to diverse agro-ecological zones of the country. Over 70% of the marginal farmers depend on buckwheat. Considering that the crop is a subsistence crop, research related to crop and yield improvement of buckwheat and its characteristics has not been properly carried out. Therefore, this research trial will be experimented to evaluate the growth and yield of traditional buckwheat in highland area.

Objective

To evaluate the performance of six buckwheat accessions under high altitude rainfed dryland production system under organic regime.

Material and Method

The study is a quantitative research involving a field trial. The trial initiatedon 15th April, 2021 at National Centre for Organic Agriculture, Yusipang**.** The design used is completely randomized block design with 6 treatments and 4 replications. The plot size is5m × 2m. The seed requested from National Biodiversity Centre and it was sown with row to row spacing of 25 cm at rate 35 kg/ha. Vermicompost was applied during seed sowing in lines at rate 10 kg

per plot. The data will be collected for days to 50% germination, days to 50% flowering, days to maturity, plant height, plant biomass, yield per plot and 1000 grain weight. The trial will be completed by September, 2021.

Table 52 : Details of treatments

		Collection Location			
TMT	Accession	Village	Gewog	Dzongkhag	Altitude (masl)
T_1	BTNC128	Khorlam Tag	Dogar	Paro	2620
T_2	BTNC1513	Chanachen	Geling	Chhukha	2359
T_3	BTNC1355	Wangdicholing	Chhoekhor	Bumthang	2680
T_4	BTNC762	Kinga Rabten	Dragteng	Trongsa	1825
T_5	BTNC2213	Kusumphel	Menbi	Lhuentse	1797
T_6	BTNC898	Yongra	Menbi	Lhuentse	2117

3.7.3 Organic seed production of wheat and barley

Introduction

The Field Crop Sector has initiated organic seed production of winter local wheat and barley on-station. The seeds were sown on 12/12/2020. The seed production is aimed to sustain the livelihood through organic farming and enhance the organic seeds availability in the country. Wheat and barley are among the crops which are predominantly grown in most of the farming system in Bhutan.

Objective

To produce 100 kg organic seeds each for winter local wheat and barley

Material and Method

Land preparation was done 2-3 weeks before seed sowing.Seed was sown in lines and also broadcasted.FYM was applied at rate 15 tons per acre during sowing.Seed was sown at the rate35kg per acre.The crop was rainfed and no irrigation was provided unless it was very critical. Both wheat and barley are at grain formation stage. The seeds will be harvested by May, 2021 and will be dried and stored for distribution to farmers during the next season.

Figure 61: Wheat and Barley Seed Production

it

4 POLICY, REGULATION AND COORDINATION PROGRAMME

Introduction

During the financial year 2020-21, in accordance with the implementation of Organizational Development Exercise 2020 recommendations, the erstwhile National Organic Programme (NOP) was renamed as Policy, Regulation and Coordination Program's (PRCP) and merged with Technical Support Programme of the National Centre for Organic Agriculture (NCOA). The primary mandate for PRCP is to coordinate/facilitate registration and certification of organic operators to access organic mark under Local Organic Assurance System (LOAS). Further PRCP also has the overarching role to uphold policies and regulations related to organic sector development in the country. In line with this mandate, PRCP regularly review and revise the existing documents, formulate new strategies, guidelines and forms to strengthen and address ground issues. Other important mandate for PRCP is to creating awareness on organic farming, capacity building of stakeholders and support promotion of organic concepts and technologies.

During the financial year 2020-21, PRCP's activities were funded by National Organic Flagship (NOFP), Global Environment Facilities & Least Developed Country Fund (GEF-LDCF) and Resilient Mountain Solution (RMS) project supported by ICIMOD. NOFP supports the development and commercialization of organic sector in the country with emphasis on bio-input production, organic technology promotion, certification and commerce. GEF-LDCF project on Enhancing Sustainability and Climate Resilient Forest and Agriculture Landscape and Community Livelihoods in Bhutan supported promotion of organic farming as climate resilient livelihood option. Similarly, RMS is a joint initiative between ICIMOD and RGOB to enhance resilience of mountain community to socioeconomic and environmental changes including climate change through organic farming and product promotion.

4.1 Key Highlights

2.1 During the financial year 2020-21 a total of 691 households and 2090.26 acres of farm land were registered across the country. Accordingly, the cumulative registered households and farm land is 1265 households and 1023.65 acres respectively

2.2 PRCP during the FY-20-21 certified 746.67 acres under LOAS taking the cumulative figure to 3091.64acres.

2.3. Similarly, 12 new products were certified during FY 20-21 taking the cumulative certified organic product to 38. The products certified during the current FY are:

i. Rice, ii. Mustard Green, iii. Radish, iv. Coriander, v. Cauliflower, vi. Cabbage, vii. Dry Chilli, viii. Bunching Onion, ix. Buckwheat flour, x. Wheat flour, xi. Garlic and xii. Potato.

2.4 Total of 472 stakeholders (farmers and staff) were trained during the financial year 2020-21 on organic farming principles and practices and internal control system to facilitate certification.

2.5 Under GEF-LDCF project, 2 additional model villages, one each in Lhuntse and Thimphu Dzongkhag has been identified and supported. Support to existing model farms in Chudzom under Sarpang and Lull under Wangdue Dzongkhag has been strengthened.

2.6 Through Resilient Mountain Solution (RMS) project, organic solutions and capacity building of farmers were supported in Longpa-Nobgang village under Haa Dzongkhag. The joint project between ICIMOD and RGOB is funded by ICIMOD.

2.7 The construction of conference hall and laboratory building worth 32 million is under progress. It is support by NOFP and expected to complete by March 2022.

2.8 During the reporting period, a total of 405.7 mt of organic production was achieved in the region for target for export and domestic market. The production was mainly from Buckwheat, cardamom, ginger, turmeric, quinoa and chilli.

2.9 Various organic policy, regulatory documents and manuals like BOGS, BOS, LOAS manual, ICS manual Bio-input framework were reviewed and revised.

4.2 Overview of APA Target and achievements

Policy Regulation and Certification Programme's (PRCP) APA target and Success Indicators (SI) for the FY- 20-21 was primarily adopted from the NOFP's APA which is also aligned to 12th FYP organic SI assigned to NCOA (erstwhile ARDC) Yusipang .

There were ten success indicators for PRCP during the FY 20-21, out of which seven indicators were that mandate of PRCP and whereas the remaining three indicators related with organic crop production and technology generation were linked to technical programmes under NCOA such as Horticulture, Field crops and Technical Support Programme (TSP). Activities related to these three indicators were implemented and coordinated by technical programmes but only the report is put together under PRCP considering the organic nature of the activities and fund provided through NOFP.

The table 53 below shows the target and achievement status of Annual Performance Agreement (APA) for financial year 2020-21. All the APA targets and achievements reflected in the table below are cumulative. However, this report also contains the achievements made specifically during this final year.

Table 53:APA targets and achievements for FY 2020-2021.

SN	Key indicator	Unit	Target	Achievement	Remark
1	Area under organic agriculture	Acre	7060	1023.52	
2	Area of land certified for organic *agriculture* production	Acre	1000	746.67	
3	Individuals, FG, and cooperatives registered under LOAS for production and marketing increased (basic organic principles and production systems)	HH	1000	1265	
4	Organic Product certified	Nos	12	38	
5	Technology generated and promoted		1	5	Three trials on pest and nutrient management and promotion of Jeevamrut and Jholmal.
6	Construction of laboratory and Multipurpose conference hall	Timeline	Dec, 2020	Dec, 2020	Tender initiated in Dec 2020 but award of work was delayed due to retendering and COVID-19 lock down in January 2021.
7	Production of selected organic commodities for export market increased	MT	251.3	349	
8	Production of selected organic commodities for domestic market increased	MT	88	56.7	Target revised to 49 mt in mid-term APA review.
9	Stakeholders training (Farmers, staff, enterprise, processors, institute)	No	100	472	
10	Reporting of NOFP progress	Timeline	27th of every month	Reported on time	
8	Production of selected organic commodities for domestic market increased	MT	88	56.7	Target revised to 49 mt in mid-term APA review.
9	Stakeholders training (Farmers, staff, enterprise, processors, institute)	No	100	422	
10	Reporting of NOFP progress	Timeline	27th of every month	Reported on time	

4.3 Area under organic Agriculture

Area under organic agriculture is calculated from the farm land formally registered with PRCP. During the reporting period, PRCP registered a total of 2090.26 ac of farm land across the country taking the cumulative achievement to 10236.52 ac against the APA target of 7060. Maximum agriculture area registered during the reporting period in from Samtse, Sarpang, Samdrupjongkhar, Zhemgang, Paro and Tsirang. The large area registered under Paro Dzongkhag is a virgin land which is yet brought under cultivation.

The registered area mentioned above belongs to farmers operating individually or in groups from selected Dzongkhags, Youth groups cultivating state land with LUC, commercial farms and institutional land.

PRCP also received and reviewed another 192 applications including 14 from schools for registration but could not be registered due to incomplete documentation/information. Details of area registered is given in table 54 below.

4.4 Area of land certified for organic agriculture production

Following the registration of farm lands to adopt organic management for crop production, the land is certified if it is following the Bhutan Organic Standards (BOS) requirements. Generally, after registration, the registered operators have to observe a conversion period of 12 and 18 for annual and perennial crops respectively. However, if the land is virgin or not cultivated and/or lying fallow for the last three years, certification could be fast-tracked and certificate could be awarded after six months or one crop season, whichever is earlier provided the farm operations are properly recorded in farm diary and organic standards are met. PRCP basically provide certification under Local Organic Certification System (LOAS) and provide access to use Bhutan Organic Mark. However, operator/farmers have option to take third party certification from BAFRA or international certifying body if they wish to do so.

Certification requires timely inspection and monitoring of registered farms. To accomplish the timely monitoring and inspection of farms, PRCP was supported by other technical programmes under NCOA. Field inspection and monitoring was conducted to check whether the operators follow the Bhutan Organic Standards (BOS) and verify that they have adopted organic production practices and following organic principles.

During the FY 20-21, PRCP team support by other programmes and Dzongkhags' organic focal person and field extension carried out inspection and monitoring of all eligible registered farms. But huge registered area (approximately 640 acres) under Samtse and Samdrupjongkhar Dzongkhags could not be inspected for certification due to travel restriction imposed by the government in view of the COVID-19 pandemic.

Figure 62:Monitoring and Inspection for certification

However, despite some challenges experienced due COVID- 19 protocol, PRCP managed to monitor/inspect and certify total of **746.67 ac** of registered land under LOAS against the APA Target of 1000 ac. Details of certified area is given in table 54 below.

4.5 Individuals, FG, and cooperatives registered under LOAS for production and marketing increased (basic organic principles and production systems)

During the FY 20-21, total of 691 households were registered for Local Organic Assurance System (LOAS) with PRCP taking the cumulative achievement to **1265 households** which is above the target of 1000 households. Out of the total households mentioned above, 32 households operate individual farms, 5 households operates state land under LUC provision, 9 households operate commercial farm and other households operates in 13 different groups across the country. Two institutions (NCOA and NSC) were also registered with PRCP.

The maximum households registered was from Samdrupjongkhar, Sarpang, Tsirang and Samtse. The details of households registered under LOAS is shown in table 54 below.

Table 54:Area and households registered and certified during FY 2020-21

Sl. No.	Dzongkhag	Registered area (Ac)	Registered HH	Area certified (Ac)	Certified HH
1	Thimphu	35.885	49	46	46
2	Chhukha	208.98	62	118.58	33
3	Haa	23.755	23	60.77	79
4	Paro	828.31	36	36.38	35
5	Samtse	300.091	137		
6	Sarpang	17.55	16	239.8	186
7	Samdrupjongkhar	193.75	141		
8	Zhemgang	147.015	58		
9	Tsirang	126.114	98	136.23	76
10	Punakha	23.84	10	29.04	10
11	Monger	21	27		
12	Trashigang	0.7	5		
	Lhuntse	4	13		
13	LUC	10	5		
14	Commercial farms	79.87	9	79.87	9
15	Institution (NCOA 68.12+NSC 1.4)	69.4	2		
	Total FY 20-21	**2090.26**	**691**	**746.67**	**474**
	Cumulative achievement	**10236.52**	**1265**	**3091.64**	**759**

4.6 Organic products certified:

During the FY 20-21 twelve new products were certified under LOAS and launched in an event organized by NCOA in collaboration with ARDC, Bajo and Wangdue Dzongkhag at Lull on 25th February, 2021. The event was graced by Director, Department of Agriculture as Chief Guest and attended by Dasho Dzongrab, NOFP Project Manager, Senior officials from ARDC, Bajo, NCOA-Yusipang and Wangdue Dzongkhag. Such event provides a platform for organic operators to showcase their products, explore marketing opportunities and to create awareness and encourage other organic operators to take-up organic farming.

The products certified from Lull and Chimakha are:

i. Rice, ii. Mustard Green, iii. Radish, iv. Coriander, v. Cauliflower, vi. Cabbage, vii. Dry Chilli, viii. Bunching Onion, ix. Buckwheat flour, x. Wheat flour, xi. Garlic and xii. Potato.

Rice was certified from Chimakha organic farm, Paro and whereas all other products were certified from model organic village, Lull under Kazhi Gewog, Wangdue. Both Lull Model Organic Village and Chimakha farm were certified under LOAS in 2020. With certification of

12 new products, cumulative number of organic commodities certified under LOAS is 38 which is more than the APA target.

Figure 63:LOAS certified products during launching

4.7 Technology generated and promoted

Trials to generate organic technologies are implemented by technical programmes like Horticulture, Field Crops and Technical Support Programme.

During the financial year 2020-21 Horticulture programme including MAP conducted three trials mainly to generate technologies to address the pressing field issue of organic pest and nutrient management. The trials conducted were

i. Formulate organic pesticides from medicinal plant,
ii. Evaluate effectiveness bio- pesticides on control of cabbage white butterfly & aphids in Cauliflower and
iii. Efficacy of organic fertilizer on the yield of cauliflower.

4.7.1 Research on the formulation of organic pesticide from medicinal plants

Management of pests in agriculture over the past half century has been largely dependent on the synthetic chemical pesticides. Potential problems associated with continued long-term use of toxic insecticide include pest resistance and negative impact on natural enemies. In addition, increasing documentation of negative environmental and health impact of synthetic toxic insecticides and increasingly stringent environmental regulation of pesticides have resulted in renewed interest in the development and use of botanical pest management products by agrochemical companies. Not only might certain secondary metabolites of the plant's origin be source of new pesticides, but also botanical derivatives may be more environmentally benign than synthetic chemicals. Extensive surveys and report on plants used as insecticides can be found in the literatures and over 2000 species of plants are known to possess some insecticidal properties. Recently some of the researchers have reported the bioactivity of extracts/essential oils from various plants against important agricultural insect pests and mites.

Bhutan is endowed with a wide range of promising flora known for their medicinal values and many have a history of usage, either to kill or to repel insects. Plants with known medicinal properties may be screened for insecticidal activities particularly in Bhutan. However, studies on pesticidal activity of medicinal plants are scanty and no quantitative report is available. Against this backdrop, the MAP Section, NCOA in collaboration with NPPC, NBC and PRCP of NCOA has initiated studies to discover potential pesticide from five promising medicinal plants (Ruta, Zanthoxylum, Garlic, Manupatra, Khen nap, Khen kar) either grown abundantly in the country or cultivated by the farmers, were selected to evaluate their insecticidal activity

against some agriculturally important pests. In this research, we used extract as well as essential oils from these plants. The results of the present study would be useful in promoting research aiming at the development of new agent for pest control based on natural products in Bhutan.

4.7.2 Evaluation of bio-pesticide for control of cabbage white butterfly and aphids in Cauliflower

Bio-pesticides trials was conducted to evaluate the effectiveness of four bio-pesticides namely neem oil, Jholmal, Artimesia extract and BT for the control of cabbage white butterfly and aphids. The trial was established at NCOA, Yusipang in collaboration with NPPC.

The initiate finding suggest that neem oil, artemisia extract and BT can be used as alternative to chemical insecticides to manage cabbage white butter fly and aphids. However, the finding is just an outcome of one season trial and similar trials need to repeated to make final recommendation.

4.7.3 Evaluate the efficacy of Organic Fertilizer on yield of Cauliflower (*B. Oleracea*)

The trial to evaluate the efficacy of different organic fertilizers on yield of cauliflower was conducted at NCOA, Yusipang in collaboration with NSSC. The organic fertilizer evaluated were vermicompost, bio-slurry, Jholmal, FYM and Bhu-organic compost.

Figure 64:Application of different fertilizer in the experiment plot

The result found that the untreated plot recorded highest yield compared to treated plot. It could be due to the slopy gradient which could have led to leaching of nutrients and high nutrient content from the previous cropping season. The trial needs to be repeated for further validation of the result.

During the reporting period, Technical Support Programme and Horticulture jointly promoted Jeevamrut and Jholmal in the organic crop production sites. These two products were evaluated in on-farm trials and also demonstrated in the farmers field. Jholmal and Jeevamrut are organic products which can be used to enhance soil fertility and manage pest and disease in crop.

4.8 Construction of conference hall and laboratory

With the funding through NOFP, the construction of two storied conference hall and laboratory building has been started and progressing as scheduled *(figure iv)*. The tendering process and award of work was slightly delayed due to uncertainty of the fund due to re-prioritization of activities owing to outbreak of COVID-19 pandemic. The first tendering process was completed in **December 2020** but the work was not awarded as the price quoted by lowest evaluated bidder was observed to quite high. Tender awarding committee chaired by the director, DoA decided to call for second tender which completed in **February 2021** as there was completed lockdown during January due to COVID-19 outbreak.

After the evaluation and assessment of the 2nd tender bids, the construction work was awarded to M/S PKC Construction Private Limited, Thimphu on 5 March, 2021. Currently the work is in progress and expected to complete by the time period given as per the contract award.

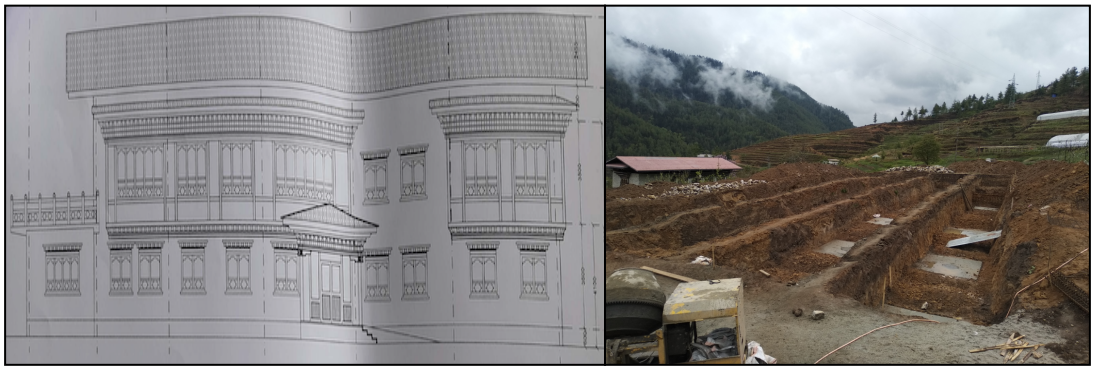

Figure 65: Construction of conference hall and labortoury

4.9 Production of selected organic commodities for export market increased

As reported by the Field Crop programme, the production of organic commodities for export market has been achieved. A total of 349 mt of different export commodities were produced during the reporting period which is above the APA target of 251.3 mt. Details of production are shown in table 3 below:

To achieve the targeted production, farmers were provided with inputs such as improved planting materials, organic manures, irrigation pipes, sintex water tank, mulching plastics and electric fencing. Farmers were also sensitized and trained on organic farming principles, requirements and crop production practices.

Table 55: Details of export commodity production

Sl	Commodity	Qty (mt)	Location
1	Buckwheat	126	Chhuka (Getena, Dhungna & Metekha); Haa (Gakiling, Langpa-Nobgang (samar), Sanbaykha)
2	Cardamom	122	Chhukha (Gelling, Bongo, Metekha) Haa (Sanbaykha & Gakilling)
3	Ginger	80	Chhukha (Logchina)
4	Turmeric	16	Chhukha (Logchina)
	Quinoa	5	Chhukha (Sampheling, Gelling, P/ling, Bango) Thimphu (Kawang, Genekha) Paro (Chubjakha)
	Total	**349**	

Figure 66:Production of export commodities

Figure 67:Inputs provided to farmers to support production

4.10 Production of selected organic commodities for domestic market increased

The domestic production of vegetables was prioritized and focus was given to organic chilli production considering the import restriction and high market demand. Accordingly, horticulture programme who implemented/coordinated the activities in the field reported that 56.7mt of chillies were harvested during the reporting period from four western Dzongkhags. Maximum production was reported from Paro Dzongkhag. Production details are given in table 56 below:

Figure 68: Chilli Production for domestic market

Table 56:Winter chilli production

SN	Location	Qty Produce (Mt)	Remark
1	Thimphu	5.5	The initial APA target of 88 mt was revised and brought down to 49 mt during the mid-year APA review.
2	Haa	5	
3	Paro	29	
4	Chhukha	17.2	
	Total	**56.7**	

The annual target for chilli production was revised and brought down to 49 mt during the mid-year APA review. The initial target was 88 mt.

Beside the support for production of NOFP priority commodities mentioned above for domestic and export market, Horticulture team also promoted and supported production of organic tomato , a nationally prioritized commodity under low-cost rain shelter in the regional Dzongkhags with the fund provided through organic flagship progamme. Low-cost rain-shelter is basically designed to protect the tomato crop from rain thereby preventing the blight infestation which is major issue when tomato is planted in open field.

Farmers in the production sites were trained on construction of low-cost rain-shelter, seedling production and organic management of crop. Farmers were also provided with planting material, plastic sheet, GI wire and thread. Total of 51 household were supported in four regional Dzongkhags of Thimphu, Paro, Haa and Chhukha. Harvest of tomato from rain-shelter is expected from the month of August 2021 onwards.

Figure 69:Promotion of low-cost rain-shelter for tomato production

4.11 Stakeholders training (Farmers, staff, enterprise, processors, institute)

Stakeholders (farmers, staff, entrepreneurs, processors and institution) training is another important mandate for PRCP. Stakeholders are trained on various aspect of organic farming such organic principles & production practices, Organic Standards, Organic Registration & Certification process, roles and responsibilities. Stakeholders were also trained on instituting Internal Control System (ICS) in the group which would facilitate faster and cost-effective certification. Farmers were also sensitized on benefits of consuming organic product, preparing healthy food and gender empowerment.

During the reporting period total of 472 farmers were trained on different aspects of organic agriculture in collaboration with concerned stakeholders. The achievement of this financial year is APA target of 100 numbers given to PRCP. Details of stakeholders trained during the FY 20-21 is given in table 57 below:

Table 57:Details of stakeholders training during the FY 2020-21

Sl.No	Topic	Location	No. of participant	Description of training
1	ToT on BOGS and ICS for Organic focal persons and researchers	NCOA, Yusipang; ARDC, Bajo and ARDC Wengkhar	54	Two days training each was organized in 3 regions to create awareness and capacity of the organic focal persons and researchers on BOGS, BOS, LOAS and ICS. Participants were also engaged in field exercise such a feasibility study and filling forms related to registration and certification of organic farms. Participants from region: Western Region – 26 West Central Region – 13 Eastern Region – 15 Fund Support from NOFP and GEF-LDCF
2	Instituting Internal Control System (ICS) for farmers group	Gasa, Tsirang and Sarpang	168	PRCP organized training to institute ICS in three Dzongkhags covering 5 groups. ICS facilitates faster and cost-effective certification. Gasa:16 participants Tsirang (3 Groups): 102 participants Sarpang: 50 participants. Fund support from NOFP and GEF-LDCF
3	Farmers training on Organic principles and practices, crop production	Paro, Sarpang,	86	As planned during the RRPW, PRCP conducted farmers training at Paro in collaboration with Dzongkhag. Farmers were made aware on organic principles and crop production practices. They were particularly trained in soil fertility management and organic plant protection measures. Similar training was also organized in Sarpang model organic villages. Paro Dz:50 participants Sarpang: 36 participants Fund support from NOFP, and GEF-LCDF

4	Enhancing soil fertility , plant protection and crop diversity	Lull, Kazi, Wangdue	25	Training was basically aimed at imparting knowledge and demonstrating new soil fertility management measures. Bio-char, Bokashi, Jholmal. Jeevamrut production were introduced. New crops such a Adzuki bean, upland rice, soybean, maize and quinoa were also introduced. 10 HHs of nearby village Sill were also included in the training. Fund Support GEF-LDCF
5	Vegetable Nursery Management	Langpa-Nobgang, Haa	60	One of the important activities identified during the activity planning was vegetable nursery management. Farmers were trained on site selection, bed preparation, poly tunnel preparation, seed sowing depth, water management. Fund supported by RMS
6	Awareness training on safe and nutritional food diversity (including gender)	Langpa-Nobgang, Haa	25	An awareness training on safe and nutritional food diversity including gender empowerment was organized in Langpa Nobgang, Haa. The training focused on food security, gender empowerment, organic agriculture, nutritional garden, importance of nutritional crops like quinoa and food preparation and on overall human nutrition. Fund supported by RMS.
7	Organic farming and enterprise development	Punakha	4	A group of youth operating organic farm (Othbar) in Geonshari, Punakha were trained on organic principles, production practices, and organic regulation and standards. Field attachment for 3 days Fund support from NOFP
8	ICS implementation	Goongring, Sarpang	50	
	Total		**472**	

In addition to above trainings, PRCP also coordinated and organized advocacy/awareness on benefits of organic farming as sustainable production system amongst farmers of existing and proposed new model organic villages in Langpa-Nobgang, Haa, Yusipang, Thimphu and Nganney, Jarey, Khuntse. Total of 99 farming households were sensitized. Combined with advocacy, consultative meeting were also organized to draft activity plan and crop prioritization in the above location. Details of advocacy and consultations are provided in table 58 below:

Table 58:Advocacy & Consultation on organic farming

Sl.No	Topic	Location	No. of participant	Description of training
1	Advocacy and consultative meeting for Langpa-Nobgang Organic Model Village	Langpa- Nobgang, Haa	59	PRCP in collaboration with NPPC, NSSC and Haa Dz organized awareness on organic principles, practices and policies & standards in Langpa-Nobgang, Organic Model Village. Activities planning and crop prioritization were also completed. Fund supported by RMS.
2	Awareness training and consultation with New model organic Village	Yusipang/Thimphu and Ngangney, Jarey, Lhuntse	40	PRCP in collaboration with ARDC Wengkhar and Lhuntse Dz organized awareness on organic principles, practices and policies & standards in Ngangney, Jarey, newly identified Organic Model Village. Activities planning and crop prioritization were also completed. Similar awareness and consultation were also carried out in Yusipang village, under Thimphu Dzongkahg. Yusipang 20 farmers Nganney/Jarey 20 farmers Fund support from GEF – LDCF and RMS
	Total		**99**	

Figure 70:Glimpses of various training coordinated by PRCP

Reporting of NOFP progress

PRCP is the focal points for coordination of NOFP activities in the western region consisting of four Dzongkhags. Besides coordinating the planning and implementation of NOFP activities, PRCP is also mandated to collate and compile the monthly progress report and submit to NOFP- CU. The NOFP focal person in PRCP had regularly collected, reviewed and compiled the field progress report submitted by Dzongkhags and commodity coordination and submitted to NOFP- coordinating unit by 27th of every month. In order to support the field reporting and authenticate the progress the commodity coordinators, technical staff and Dzongkhag officials made regular field monitoring and provided guidance to field staff. Focal person also prepared and submitted the annual report of NOFP activities for the region and submitted to NOFP- CU.

4.12 Review and revision of documents

In an effort to strengthen and improve organic registration and certification process and thereby facilitate/support promotion of organic farming, PRCP during the reporting financial year reviewed and revised existing policy documents, standards, bio-input framework, manuals and

forms. Similarly, new guidelines and awareness materials were also developed. Details of the document review and formulated are given below.

4.12.1 Bhutan Organic Guarantee System (BOGS)

BOGS is the umbrella document guiding the development of organic sector in the country particularly with respect to registration and certification. The review of BOGS was necessary to incorporate the changes made in the other subsidiary document such as LOAS, BOS and ICS. The review was done in consultation with relevant stakeholders particularly BAFRA and NOFP.

4.12.2 Bhutan Organic Standard (BOS)

BOS provide the standards for organic operations in the country which the registered/certified organic operators have to comply with to get access to Bhutan Organic Mark. Further, to facilitate international trade and to get international recognition of BOS, an effort is being made to incorporate the BOS in the IFOAM family of standards. PRCP in consultation with all the stakeholders and expert's advice, reviewed and revised the existing standards and submitted to IFOAM which is currently being reviewed by IFOAM.

4.12.3 Review of Local Organic Assurance System (LOAS) manual

While implementing the existing process of registration and certification as per the provision of LOAS**,** lots of issues were raised by the organic operators and implementers (extension staff) on forms and other procedure of registration and certification. Therefore, in order to address the implementation issues and make registration and certification process clear and simply, the manual was revised and improved. New provision on fast tracking of registered land for certification and implementation of ICS has also been incorporated.

Along with the revision of registration/certification processes, the associated forms for registration and monitoring/inspection were also revised with an introduction of a new form for registration of organic institutional farms, processor and aggregators. PRCP also revised the registration and certification certificates. Further stakeholder consultation for registration and certification of organic food processors and aggregators is also underway.

4.12.4 Review and revision of farm diary

The farm diary, an important document for operator to record all the operations was reviewed and revised to capture the required information. Maintaining all the record of farm operations in farm diary is a mandatory process for certification. The diary is to be furnished to the organic field inspectors during inspection with record of all the activities undertaken on the registered organic farm. A total of 2000 copies of revised farm diary was printed for distribution to registered organic operators.

4.12.5 Fast tracking guideline

To facilitate and support the fast tracking of LOAS certification of virgin new farm land, fallow land and farms with no history of any chemical use, a guideline was developed in consultation in BAFRA and other relevant stakeholders. The guideline consists of criteria and roles & responsibilities of stakeholders for fast-tracking of registered land for LOAS certification. Currently the guideline is being reviewed by the Ministry for approval.

4.12.6 Guidelines for non-compliance in Organic Agriculture

With the start of registration and certification system, there is always the probability that case of non-compliance by organic operator might occur in the future, therefore in order to guide,

correct and to learn degree of non-compliance, the guidelines has been developed. These guidelines will serve as basis to identify the degree of compliance by certifying bodies and guide organic operators to correct the non-compliance.

4.12.7 Review and revision of Internal Control System (ICS)

The existing ICS manual was reviewed in consultation with BAFRA. This manual will serve as the guiding document for the purpose of group certification. It specifies the purpose, roles and responsibilities of the office bearers and the monitoring process. Few copies the manual was printed with supported by BAFRA. Establishing ICS within the group will facilitate fast and cost effective certification.

4.12.8 Review of framework and guidelines on bio-Inputs

In view of the increasing demand for bio-inputs, the Third National Working Group (NWG) on Organic Agriculture directed the NPPC, NSSC, and National Center for Organic Agriculture (NCOA) and BAFRA to review and update the first Framework and Guidelines for Supply of Bio-pesticides and Bio-fertilizers in the Country, 2015.Based on the directives, NCOA coordinated the review process in consultation/collaboration with technical agencies like NPPC, NSSC and BAFRA. The revised document clearly specifies the roles and responsibilities of all the concerned agencies, updated the list of approved bio-inputs permitted for import and use in the country.

The revised document is submitted to Legal section, MoAF for their review and legal comments and feedback. After their review, the bio-input framework will be officially circulated for implementation.

4.13 Establishment of model organic villages

4.13.1 Support to existing model organic village

During the FY 20-21, PRCP continued to support the three existing model organic villages namely Lull Model Organic Village, Kazhi Gewog under Wangdue Dzongkhag, Goongring Model Organic Village, Chudzom Gewog under Sarpang Dzongkhag and Langpa-nobgang Model Village, Samar Gewog under Haa Dzongkhag. Further in line with the landscape approach of promoting organic farming, 14 new households have been included in the existing Goongring Model Organic Village under Samtenling region. These villages will be showcased as hub for organic technologies for nearby villages and Dzongkhags. Lull and Goongring village is support by GEF-LDCF fund while the langpa-Nobgang was supported through RMS, a joint initiative of ICIMOD and Department of Agriculture.

Farmers in the model organic villages were supported with training on organic crop production and management. New organic technologies such as bio-char, EM-bokashi, Jholmal, Jeevamrut were introduced through demonstration and farmers were also trained to produce it locally. Beside the introduction of new technologies and capacity development of farmers, PRCP also provided the farmers in the model village with inputs to enhance their crop production and build resilient to climate change and improve socioeconomic condition. Details of input provided to three model organic village during FY 20-21 are shown in table 59 below.

Table 59:List of inputs provided to model organic villages

Sl.No	Activities/Items	Quantity	Beneficiary (HHs)
Goongring Model Organic Village, Chudzom, Sarpang			
1	Low-cost poly house	10 nos	10
2	Mulching plastic	20 nos	20
3	Green shed Net2	2 nos	2
4	Plastic sprinklers	60 nos	36
5	Neem oil	200 bottles	36
6	Knapsack sprayer	36 nos	36
7	Vegetable crate	36 nos	36
8	Yellow sticky Trap	17 pkts	36
Lull Model Organic Village, Kazhi, Wangdue			
1	Organic manure	1000kg	5
2	Fabricated green house	1 nos	5
3	Yellow sticky Trap	3	5
Langpa-Nobgang Model Organic Village, Samar, Haa			
1	Fabricated green house (20m x5m)	2 Nos.	2
2	Drip Irrigation sets	2 Nos.	2
3	Sintex Tank (1000L)	2Nos.	2
4	Threaded flexible pipes	4 rolls	2
5	Garlic seeds	200 kg	57
6	Buckwheat seeds	495kg	57
7	Yusimaap (potato)	2800kg	57
8	Vermicompost	1300kg	57
9	Chicken Manure	1300kg	57
10	Flour milling machine	1 No	1

Farmers is Langpa-Nobgang, where also provided with flour milling machine and buckwheat seeds were supported by NOFP and potato seeds through GEF-LDCF.

With the support from the project, the Goongring Model Organic Village has produced about 12MT of beans and Lull Model Organic Village has produced about 6.7 MT of garlic, 3.75MT of chilli, 6.25MT of wheat and13.75MT of potatoes. The model village has been certified as

organic on 21st May, 2020. Langpa-Nobgang Model Village will be certified soon as the inspection for certification has been completed.

4.14.2. Initiate the development of new model organic village in east and western region

The PRCP, NCOA is upscaling organic agriculture through concept of Model Organic Village in close collaboration with ARDCs. The initiative is support by GEF-LDCF and RMS, ICIMOD. In the Eastern Region, one new model village in Ngang-Nye, Jarey Gewog under Lhuentse has been identified, this village consists of 25 households and an area of approximately 20 acres where they cultivate vegetables and fruit trees. PRCP, NCOA has completed awareness on organic farming and planning consultation with support from Dzongkhag, ARCD, Wengkhar and ICIMOD.

Similarly, in the Western Region, coordinated by NCOA, Yusipang village under Chang Gewog, Thimphu Dzongkhag has been identified as model organic village. Awareness and consultation have been completed and GEF-LDCF will support the village to promote organic farming. The village consists of 40 households, however only a youth group engaged in fruit processing will be registered under LOAS at initial stage for organic farming. Further, PRCP, NCOA has identified Tashiding village under Dogar Gewog, Paro and Zamsa & Phasuma village under Bongo Gewog, Chhukha Dzongkhags to out-scale the organic farming initiative which will be supported through Research Outreach Program- Organic.

4.15. Development of Permanent Organic Demonstration Plot

As a part of development of NCOA research and demonstration farm as permanent organic demonstration plot, PRCP supported and coordinated the improvement/establishment of some basic structures such as bokashi shed, compost shed, floriculture and land-scaping. PRCP also supported and coordinated the construction of six bio-directors, two utility sheds and procurement of lawn mower/weeder.

Figure 71:Basic facilities provided for permanent plot (NCOA farm)

PRCP also coordinated and supported the establishment of Resilient Model Farm o carry out long term research of organic farming system within NCOA. Around two acres of land above the existing farm was identified and developed to establish long term study on zero tillage, crop rotation, soil health etc.

These facilities will greatly facilitate and enhance organic research and demonstration of technologies to farmers and visitors. The financial supports to above activities were provided through NOFP and GEF-LDCF fund.

4.14 Documentation and publication

4.14.1 Success story on Model Organic Villages

Two success stories on Goongring Model Organic Village and Lull Model Organic Village have been produced. This success stories documented how these two villages were identified as model villages, what activities has been taken up in these villages and how has the livelihood of this village have been improved after intervention from the project. These two-success stories of the model village will serve as inspiration for other organic operators to take up organic farming and improve their livelihood.

4.14.2 Concept note on model villages

Organic model village is an approach to showcase and demonstrate organic farming principles and technologies for upscaling/promoting organic farming. The concept note outlines the importance, process and roles & responsibilities of different stakeholders including farmers in establishing and managing model organic village.

4.14.3 Posters and definition

PRCP with support and inputs from technical programmes developed a poster on the National Organic Registration and Certification System. The poster depicts the structural linkages of agencies and committees with their roles in implementing/facilitating organic registration and certification.

Similarly, poster on registration process was also developed which shows the steps involved in registration procedure and the function of different offices in the process. Further, PRCP also developed a poster to define commonly used organic terms in our local context to have a uniform understanding of the terms by all the stakeholders. All these posters are being made available to stakeholders.

4.15 Online registration and certification system

NCOA-Yusipang and ICTD, MoAF has initiated the development of online registration and certification system with support from RMS Project. The concept note on the online system will be finalized and submitted to Department of Information and Technology for clearance.

4.16 Meetings and workshops

During the reporting period, PRCP organized /coordinated various consultative meetings and discussion to facilitate promotion and adoption of organic farming especially in identified model organic villages and Research Outreach Programme- Organic (ROP-O) sites . Similar consultation/discussion was also organized to review and formulate documents, guidelines, forms as highlighted above to facilitate registration and certification of organic operators.

4.17 Support/collaboration provided to other programmes

During the reporting period PRCP through the funding from GEF-LDCF, RMS and NOFP support other technical program like National Potato Programm, Horticulture Progamme and Technical Support Programme to conduct research on organic aspects and promote organic crop production and technologies. The details of support provided by PRCP to other programmes is shown in table 60 below:

Table 60: Support provided to other Programme

SN	Activity Supported	Brief Description	Source of Fund
Horticulture Programme			
1	Promotion of the newly notified tomato variety	The PRCP supported vegetable sector to promote newly released tomato variety (Cosmic) among the Yusipang farmers under the NCOA initiatives of neighbourhood first programme. The support was provided to procured seeds, poly-tunnel plastic, black mulching plastic, jute rope and binding wire.	GEF
2	Evaluation of winter vegetable production in double layer poly-house	Supported the establishment of double layer poly house for vegetable sector to evaluate of winter cole crop production and early spring production of chilli and tomato.	GEF
3	Procurement of fabricated poly house	Supported fruits and floriculture section, Horticulture programme to procure one fabricated poly house(20x5m). The poly house will be used for nursery raising of flowers.	GEF-LDCF
National Potato Programme			
4	Organic Potato demonstration in Nobgang and Laya	Supported National Potato Programme (NPP), to promote organic production of nutrient rich potato variety (Yusimap) in Langpa-Nobgang Model Organic Village in Haa. Support was provided to procure and transport 2.8MT potato seed and supply to 56 Hhs PRCP also support training and demonstration of new potato varieties in Laya, Gasa. Almost 100 farmers attended training and demonstration	GEF-LDCF and RMS
Technical Support Programme			
5	Supply and transportation of organic manures	Supported procurement and transportation of organic fertilizer for research at NCOA farm	NOFP
6	On-farm trials bio-pesticides	Supported biopesticide trial and demonstration in Langpa-Nobgang	RMS
7	Procurement of leaf mould for NCOA	Supported procurement of 5 truck loads leaf-mold for research purpose. It was used by different sectors for their respective activity.	GEF-LDCF
8	CNR research support	College of Natural Resources through the RMS funding started a research on "Comparison of effect of different organic manures on cauliflower growth, yield and soil chemical properties." The research is aimed to compare the effect of different organic fertilizers on the yield of cauliflower and to analyze the impact of different organic fertilizers on soil properties in cauliflower field.	RMS

5 TECHNICAL SUPPORT SERVICES PROGRAMME

The Technical Support Services Programme is the one of the important Programme under the National Centre For Organic Agriculture. It consists of Soil and Land Management section, Plant Protection Section, Research and Communication Section and Socioeconomic Section. The Summarized activities in the APA for financial Year 2020-21 is as shown below.

Table 61: TSS APA for the FY 20-21

#	Sector	Indicators	Unit	Target	Weight
5	TSS	Generate PoP for plant protection and nutrient management of soil	Number	May 1st week	2
		Conduct study on vermi compost technologies using different Raw Materials	Time line	2nd week may	2.5
		Conduct Soil fertility, survey, land and nutrient management research	Number	4	2.5
		Natural pesticides formulation based on locally materials available	Number	4	2.5
		Publish annual report of the Centre	Timeline	July 1st Week	2

5.1 Generate POP for plant protection and nutrient management of soil

The proposal for Jeevamrut and Jholmal technology was developed and will be proposed for release to Technology Release Committee in June 2021. Jeevamrut and Jholmal Brochure has been already prepared and kept ready for printing. **It was published by the end of April 2021.**

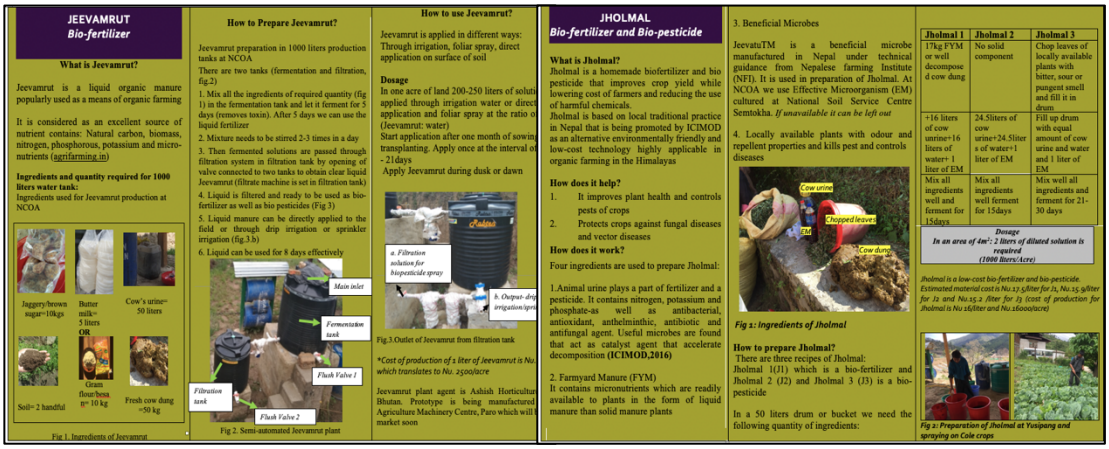

Figure 72:POP for plant protection and nutrient management of soil

5.2 Conduct study on vermicompost technologies using different raw materials

5.2.1 Evaluate vermicomposting of different substrates using *Eisenia foetida* at center

Background

Vermicomposting is the process of producing compost by utilizing earthworms to turn the organic waste into high-quality compost. Vermicomposting helps to convert the organic wastes (agro-wastes, animal manure and domestic refuse) into highly nutrient fertilizers for plant and soil. The technology of vermi-composting plays an important role in organic farming as it is an environmentally friendly source of plant nutrient that have the ability to produce healthy crop and higher yield. Vermicompost helps to reduce the need for chemical fertilizer and decrease the amount of waste entering the landfill as the wastes from agriculture activities are converted into value added product that improves our soil/environment.

The common materials that are used to feed earthworm are cow dung and some kitchen waste. Till date no research has been carried out on vermicompost using different animal waste and biomass/kitchen waste. Thus, there is need to explore and study on vermicompost using different raw materials to obtain good quality compost.

Materials and Methods

The trial was laid in randomized block design with four treatments and five replications. The substrates used for the trial were cow dung, kitchen waste, dry waste and combination of cow dung, kitchen waste and dry waste. For the worm bin the old vehicle tyres was used.

Figure 73:Vermicompost trial using different substrates

Result and Discussion

The trial was initiated on 21st April, 2021 and the result will be reported.

5.3 Conduct Soil fertility, Survey, Land and Nutrient management research

5.3.1 Kitchen waste Compost

Background

Disposal of kitchen waste to landfill causes putrefaction, offensive odor and pollution of ground and surface water thereby causing adverse impact on environment. Thus, composting of kitchen waste can be an effective method to reduce waste in landfill, impact on environment and human health.

Materials and Methods

Kitchen waste compost was prepared by using dry waste, kitchen waste and Effective Microorganism. At the basal layer gravel stones were spread for drainage of liquid manure and a nylon mesh was laid to serve as filtration. Kitchen waste collected from the canteen was chopped into smaller sizes for faster decomposition. On top of kitchen waste, a layer of rice husk, dry grass was spread and EM was sprinkled followed by a layer of soil. This continued till the bucket was full and the bucket was covered with lid. The compost was turned biweekly for uniform decomposition of materials.

Figure 74:Kitchen waste compost

160 kg of kitchen waste compost was produced till March. We are expected to produce 200 kg of kitchen waste compost till June, 2021.

5.3.2 Heap Compost

Background

Composting is one of the best technologies to turn waste into nutrient rich substances that improves soil fertility, structure and maintains moisture content of the soil and improves the physical properties of the soil such as drainage, aeration and ability to retain water. Composting is an environmentally friendly economical procedure of organic waste disposal.

Figure 75: Heap Compost Prepared

Materials and Methods

Heap compost was produced using the dry waste and biomass available in the field in the compost shade. Dung slurry was prepared by mixing 30 kg dung with 10 L of cow urine in 100 L water. A layer of dry grass was uniformly spread and on top, a layer of soil was added and moistened with Jeevamrut solution and cow slurry. After addition of each layer, it was moistened with water. Alternately layer of dry biomass, soil, Jeevamrut solution and cow slurry were laid till the desired height,

Result and Discussion

Total of 12 tons of heap compost was produced till March, 2020. The compost was applied in vegetables and fruits tress.

Figure 76: Preparation of Jholmal at Centre

5.3.3 Jeevamrut and Jholmal

Jeevamrut and Jholmal 1 are liquid manure which are used as biofertilizer. Jeevamrut and Jholmal was applied in biofertilizer trial.

5.3.4 Farmers Training on Jholmal and heap compost at Longpa Nobgang Village, Haa (ROP sites)

Background

Since the issue of non-compliance was on soil fertility management in model village, Haa where farmer have been found applying Urea and Suphala on Potato. To solve the issues, Resilient Mountain Solution Project in collaboration with National Center for Organic Agriculture had decided to give farmer's training on soil fertility management on 5^{t} -9th July, 2020.

Materials and Methods

The training was imparted to farmers on how to prepare Jholmol 1, 2 and 3, and heap compost. Both theoretical and hand on training were given to the farmers.

Figure 77:Heap compost and Jholmal demonstration

Result and Discussion

All the Participants learned how to prepare Jholmal and heap compost and application rate on vegetables.

5.3.5 Efficacy of Jeevamrut solution on Cauliflower production

The data collection was done from May to July, 2020. The data were analyzed in SPPS and results were reported.

Result and Discussion

Plant height and Number of leaves

There was no significant difference in plant height ($p > .05$) and number of leaves at different growth stages of plants among the treatments**.** At 15, 30 and 45 days the plot applied with dosage of 5:5 (T4) produced highest plant height (5.7 cm, 8.2 cm and 17.7 cm respectively) and number of leaves (5.6, 8.3 and 9.7). The shortest plant height was recorded in T2 at 15 days, T1 at 30 days and T3 at 45 days. The minimum number of leaves were recorded in T1 at 15 days and 45 days and T2 at 30 days.

The highest plant height and number of leaves in T4 could be due to same dilution rate of Jeevamrut and water (1:1) compared to other treatments. As reported by Palekar (2006), Vasanthkumar (2006) and Devakumar et al., (2008) the application of Jeevamrut could have attributed to higher microbial load and growth hormones which might have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately resulted in better growth and yield of crops. The shortest plant height in T2 and T3 could be due to less quantity of Jeevamrut compared to T4 which has same quantity of Jeevamrut and water and T1 could be due to sole application of FYM as FYM (solid manure) has slow releases of nutrients compared to liquid manure (Jeevamrut).

Curd weight and Curd diameter

Significant difference was observed ($p > .05$) in curd weight and curd diameter of cauliflower. The highest curd weight and dimeter was recorded in T4 with 772 kg and 140.26 mm and lowest in T3 with 558 kg and 112.2 mm. The highest curd weight and diameter in T4 could be due to the contain of cow urine in Jeevamrut which is a good source of plant nutrients besides having antifungal properties. Some of the beneficial organisms in Jeevamrut (liquid manure) are helpful in phosphate solubilization, nitrogen fixation etc. Application of these organic liquid formulations could have enhanced the soil microbial activity and population to a larger extent which led to a positive effect on growth and yield of crops. The lowest curd weight and diameter in T3 could be due to less quantity of Jeevamrut application compared to T4.

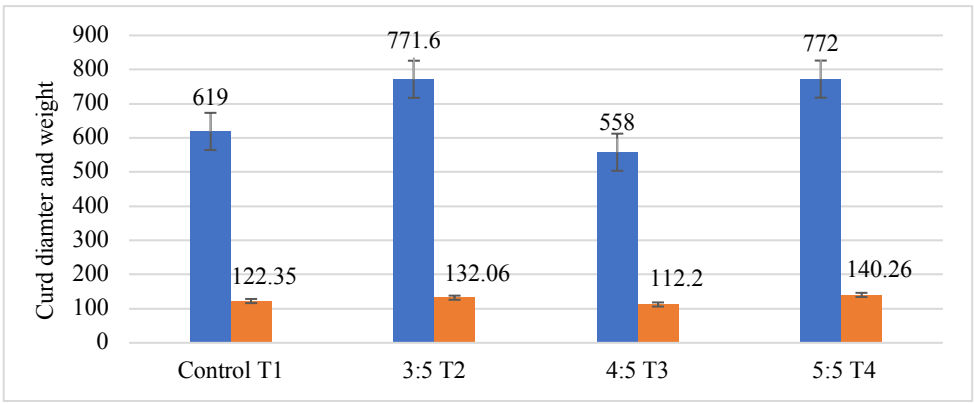

Figure 78:Effect of treatments on curd weight and diameter of cauliflower

Yield(kg/acre)

There was significant difference ($p > .05$) in yield among the treatments in terms of yield. The highest yield was recorded in T4 with 12497 kg and lowest in T3 with 9032 kg. The highest yield in T4 could be due to high soil biological activity because of the combined application of liquid manure with FYM that led to availability of nutrients throughout crops.

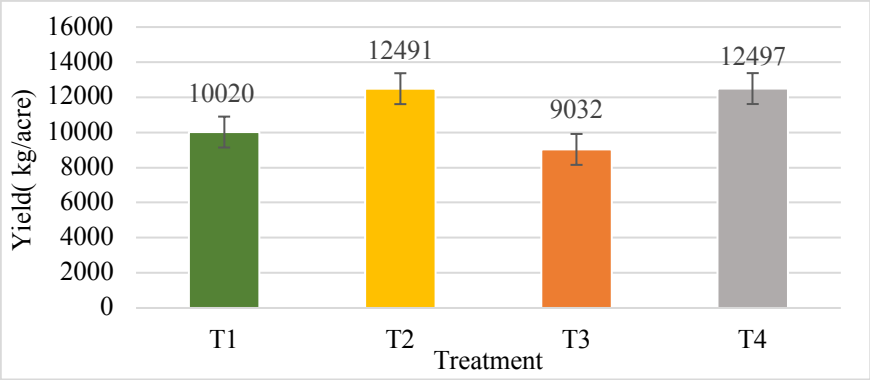

Figure 79:Effect of treatments on yield of cauliflower

Conclusion

Treatment 4(5 L of Jeevamrut:5 L of water) was found better higher yield, curd weight and growth attributes compared to other treatments at fortnightly interval. Therefore, the study concludes that 5 L of Jeevamrut with 5 L of water (T4) was effective and has potential to enhance the growth and yield of cauliflower.

The second trial was initiated on 24th April, 2021 and result will be reported.

5.4 Natural pesticide formulation based on locally materials available

5.4.1 Wood vinegar Production

Background

Wood vinegar or pyroligneous acid/wood acid is a dark liquid produced by distillation of wood and other plant materials. Wood vinegar is a byproduct from charcoal production. It is a liquid generated from the gas and combustion of fresh wood burning in airless condition. When the gas is cooled, it is condensed into liquid. Wood vinegar is an excellent pesticide and fertilizer that improves soil quality, helps elimination of pest and assist in the plant growth.

Material and Method

About 20-30 cm diameter hole was dug and the woods/log were piled in the holes. The hole was further covered with soil. The chimney was attached to the perpendicular holes which was further attached with metal pole whereby the wood vinegar was allowed to dip out later on in the process from the end of the metal.

Figure 80: Wood Vinegar Production

Result and Discussion

The production of wood vinegar was started in December and till February total of 500 L of wood vinegar was produced. The wood vinegar will be applied on vegetables and cereals and will be one of the treatments in the biopesticide trial of vegetable and Quinoa.

5.4.2 Formulation of Jholmal and artemisia extract

Background

Jholmal is a homemade biofertilizer and biopesticides that helps to improve crop yields while lowering costs for farmers and reducing the use of harmful chemicals. It is prepared by mixing and fermenting locally available material such as animal urine, water, microorganisms, farmyard manure and plants that can be used as pesticides and repellent in a defined ratio.

Three types of Jholmal- Jholmal 1, 2 and 3. Jholmal 1 is biofertilizer and Jholmal 2 and Jholmal 3(artemisia extract) are biopesticide.

Materials and Methods

Jholmal was prepared in 50 L bucket. Jholmol 1- 17 kg of well-decomposed cow dung/farm yard manure, 16 L of cow urine, 16 L of water and 1 litre of EM were added for the preparation of Jholmol 1. The mixture was mixed well and kept for two weeks to get fermented. Jholmol 2-16 L of cow urine, 24.5 L of water and 1 L of EM were added for the preparation of Jholmol 2. The mixture was mixed well and kept for two weeks to get fermented.

Figure 81:Ingredients of Jholmal and types of Jholmal

Result and Discussion

Jholmal 2 is one of the treatments for biopesticide trial while Jholmal 1 for biofertilizer trial. Jholmal technology will be proposed for technology release which will happen in June 2021. We are expected to produce 300 L of Jholmal till June 2020.

5.4.3 Artemisia extract/Jholmal 3

Background

Plants with pungent, sour odor and repellent properties that could kill pest such as artemisia, stinging nettle were used as botanical extract.

Materials and Methods

Artemisia extract was prepared in 50 L bucket. 5 kg of chopped Artemisia, 16 litres cow urine, 16 litres water and 1 litre of EM were added for the preparation of artemisia extract. The mixture was mixed well and kept for 21 to 30

Figure 82:Artemisia Extract/Jholmal 3

days to get fermented. Cotton cloth was used to filter liquid extraction.

Result and Discussion

Artemisia extract is one of the treatments for biopesticide trial. We are expected to produce 200 L of artemisia extract till June 2021.

5.4.4 Jeevamrut production in 1000 L tank

Background

Jeevamrut is a liquid organic fertilizer which is an excellent source of nitrogen, phosphorous, potassium and lot of other micro nutrients required for the crops. Jeevamrut is applied in different ways- irrigation, foliar spray on plants increases the process of photosynthesis and direct application on the surface of soil increases the activity of microbes leading to an increase in soil fertility. In one acre of land 200-250 litres of solution is applied through irrigation water or direct soil application. For a liquid foliar spray apply 5% to 10% in water. Jeevamrut should be applied once at the interval of 7-15 days according to the growth of crop.

Materials and Methods

Jeevamrut production plant has filtration system and fermentation chamber in built. Jeevamrut was prepared in 1000 L tank- ingredients such as 1000 L water, 50 kg fresh cow dung, 50 L cow urine, 10 kg Brown sugar, 10 L buttermilk and a handful of soil are filled in the chamber and fermented for 5-6 days. The fermented solutions are passed through filtration system to obtain crystal clear liquid called Jeevamrut. The manure was further filtered to be used as bio pesticides.

Result and Discussion

Jeevamrut is one of the treatments in biofertilizer trial of cauliflower. We are expected to produce 3000 L of Jeevamrut till June, 2021 Jeevamrut technology will be also proposed for technology release.

5.4.5 Demonstration of Jeevamrut and Jholmal technology to the farmers of Chang Gewog at NCOA, Yusipang

On 25th March, 2021 National Center of Organic Agriculture has coordinated an awareness program on organic farming, registration and certification to the farmers of Chang Gewog, Yusipang whereby the farmers were imparted with both theoretical and practical knowledge on soil fertility and plant protection management and registration and certification of land. Total of twenty farmers were given training on preparation of heap compost, kitchen waste compost, vermicompost and Jholmal, Jeevamrut and wood vinegar.

Figure 83:Farmer's training on organic technology

5.5 Others

5.5.1 Evaluation of bio pesticides and botanical extracts against major insect pests in organic Cole crops

Background

Bio pesticides are derivatives of plants, microorganisms and insects. Botanical pesticides are derivatives of plant that repel, inhibit growth or kill pests. Most plants produce chemicals that deter pests, often producing a mixture of compounds that repel and stop from feeding. Plants with pesticidal properties also possess compounds that have effects on plant pathogens such as bacteria, fungi, viruses as well as nematodes. Botanical pesticides are highly biodegradable, have varied modes of action, are less toxic to humans, are non-pollutant and they are readily available in the environment. Under the NOFP, the use of bio pesticides and botanicals are being promoted as an alternative to synthetic pesticides.

This experiment was established with the main goal of identifying natural enemies and major insect pests infesting Cole crops, understand their population dynamics. It also aims to evaluate the effectiveness of bio-pesticides for the control of Cole crop pests. This paper discusses the population dynamics of Major Cole crop pests and their natural enemies. It will also evaluate the effectiveness of different biopesticides against these pests.

Materials and Methods

The trial was conducted in collaboration with National Plant Protection Center at Yusipang on 29th July, 2020. The trial was laid in RCBD with plot size of 2x2 m and spacing of 45*45 cm was maintained. The trial was conducted on Cole crops which comprised of five treatments such as neem oil (5ml/1 l of water), Jholmal (1 L Jholmal: 1 L Water), artemisia (1;1), All Bio and control. Each treatment had four replications. Snow mystic cauliflower was used for this trial.

The population count of pest was recorded from six randomly selected plants in each treatment through visual counting one day before every spray which served as pre-treatment observation and the subsequent counts were taken two days after each spray (post treatment data). The data collection was done from July till October, 2020.

The data obtained were subjected to analysis through ANOVA by using SPSS version 22.0. Significant differences among treatment means were tested at 5% significant level.

Figure 84: Spray of treatments and data collection

Results and Discussion

Cabbage aphids, looper egg, Diamond back moth and Looper larva

A one-way ANOVA showed a significant difference in the total number of cabbage aphids, looper egg, DBM and looper larva between the treatments. A post-hoc comparison showed a significantly higher number of aphids, looper egg, DBM and looper larva in the control plots compared to plots treated with Jholmol 2, neem oil and artemisia.

A Study reported reduction in number of aphids (48%) in plot treated with cow urine (Jholmol) and mixture of plant extract (artemisia) due to their photochemical and action of bio constituent inserted on insect development and survival (Patel et al., 2019).

Azadirachtin in neem has been reported to produce varied effects, including insecticidal activity, oviposition deterrent, antifeedant, growth retardant, moulting inhibitor, sterilant (Prakash and Rao, 1997).

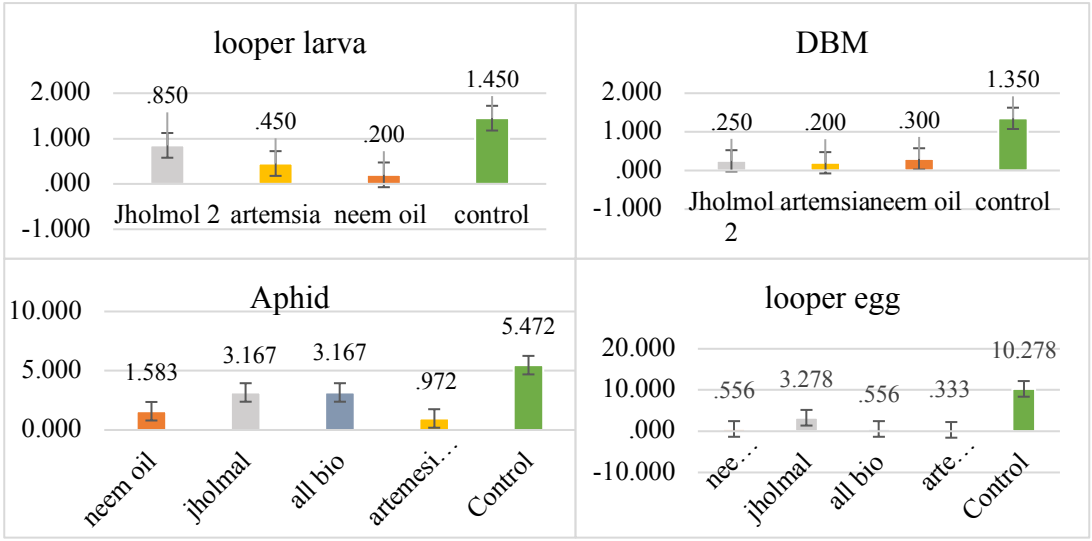

Figure 85:Effect of treatments against Aphids, looper egg, Looper larva and DBM

Conclusion

Cabbage semi-looper, aphids, cabbage white butterfly and DBM are the major insect pest attacking Cole crops. In both the trial, artemisia and neem oil was effective in keeping the number of aphids, looper eggs, looper larva, CWB and DBM at a rate which was significantly lower than the untreated plots. Neem oil and artemisia showed similar efficacy. Neem and artemisia acts as a repellent and the results obtained here indicate that it was effective in keeping the looper moths from laying its eggs.

The second trial was initiated on 8th April, 2021 and result will be reported.

5.5.2 Efficacy of bio pesticides and fungicide on control of Apple scab *(Venturia inaequalis)*

The data collection was done during the harvest of the apple on 29th September, 2020. The data collected were analyzed in SPSS and the result are reported below.

Result and Discussion

Apple scab lesion

A one-way ANOVA showed a significant difference in the total number of lesions on fruit and leaves. A post-hoc comparison showed a significantly higher number of lesions in the control plots compared to plots treated with Bordeaux mixture, Jeevamrut (1:5) and Jeevamrut (1:10). A significantly lower number of lesions was observed in plots treated with Bordeaux mixture followed by Jeevamrut treatments. There were no significant differences on different dosage used (1L Jeevamrut:5 L water and 1 L Jeevamrut:10 L water) on the reduction of scab disease lesions both on fruits and leaves. Therefore, the results showed that 1 liter of Jeevamrut mixed with 10 liters of water indicated reduction of lesions on fruits and leaves.

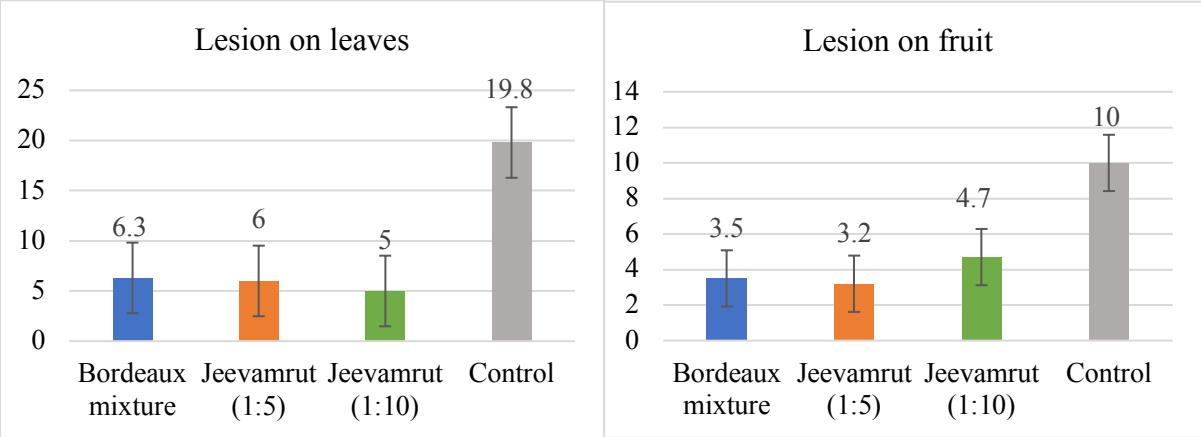

Figure 86:Effect of treatments on lesion of fruit and leave

Weight of apple

No significant difference was observed in weight of apple among the treatments. However, the highest weight of apple was recorded in Jeevamrut (1:10) followed by Bordeaux mixture treatment.

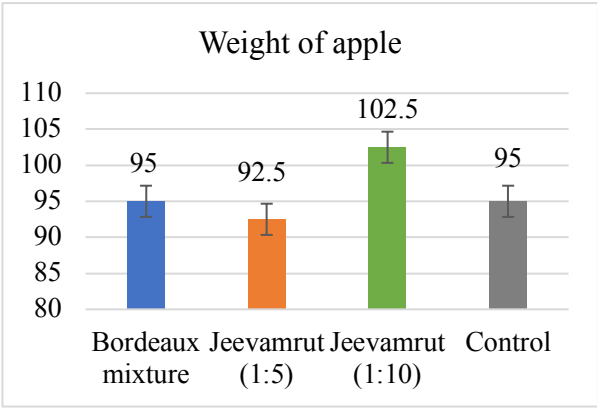

Figure 87:Effect of treatments on weight of apple

Conclusion

The different dosage used for Jeevamrut solution and Bordeaux mixture were significantly differences as compared to untreated treatment. Therefore, the study recommends using dosage of one liter of Jeevamrut solution mixing with 10 liters of water can be on apple trees for the control of apple scab in the Bhutan.

5.5.3 Assessment of local earth worm species collected from different sources for vermicomposting at center

Background

Vermicomposting is the process of producing compost by utilizing earthworms to turn the organic waste into high-quality compost. Vermicomposting helps to convert the organic wastes (agro-wastes, animal manure and domestic refuse) into highly nutrient fertilizers for plant and soil.

The technology of vermi-composting plays an important role in organic farming as it is an environmentally friendly source of plant nutrient that have the ability to produce healthy crop and higher yield. The most widely used worm is *Eisenia foetida* which is known as **red wigglers** or manure worms. It reproduces prolifically and survive in variety of feeding conditions. Till date no research has been carried out on worm culture using local species. Therefore, there is need to study and evaluate local earthworm species collected from different sources for vermi-composting.

Materials and Methods

Worm culture

The collected earthworm from different source (Yusipang, Tsirang, Dagana and Samtse) were cultured in wooden boxes with the sizes of 50cm x 50cm x 40cm. Before incorporating the earthworms in the worm bin, the dry and wet waste were pre decomposed for two weeks. A basal layer of vermi bed comprised of layer of sand to facilitate the drainage of water. On top of sand 15 kg cow dung was laid followed by 15 cm layer of soil. The bed was watered and covered by gunny bags for 15 days to decompose the contents. After pre-decomposition 100 locally collected earthworms was placed in the bed. They were fed thrice-April, August and December, 2020.

Figure 88:Worm culture in wooden boxes

Vermicompost production

The biomass available in the center such as grass and left-over plant from trial were used as bedding materials for worms. At the base of the bed a layer of sand was placed followed by 500 kg of chopped grasses then 10 kg soil. On top of soil 10 kg cow dung was added followed by 50 kg saw dust. The bed was watered and covered by gunny bags for 15 days to decompose

the contents. After pre decomposed the worms were incorporated in each bed and the compost materials were turned once in a month.

Figure 89:Vermicompost production in concrete bed

Data collection

Number of earthworms and mortality

Total of 100 worms from different sources were placed in each worm bin. After the trial has been completed (April, 2021) the number of earthworm population and mortality was counted in each bin.

Length and weight of earthworm

Ten earthworms from each treatment were randomly picked and measured its length and weight.

Length of earthworm was measured using measuring scale and weight of earthworm was weighed using digital weighing balance.

Weight of biomass

Before incorporating the biomass in the bin, the biomass was weighed using spring balance. After the trial has been completed, the vermicompost harvested were weighed using spring balance.

Figure 90:Data collection

Result and Discussion

Till March 3000 kg of vermicompost was produced from the sixteen concrete beds and we are expected to harvest another 3000 kg of vermicompost till June, 2021.

5.5.4 Evaluate the efficacy of Organic Fertilizer on yield of Cauliflower (*B. Oleracea*)

Background

Growing organic vegetables is rapidly growing industry and the concerns over the pesticides residues in food and the environment has resulted to increase in demand for organic food. Organically grown foods are perceived as better quality, healthier and more nutritious than conventional counterparts. On the other hand, the relatively slow mineralization of the composts and other organic fertilizers limits the effective nitrogen utilization. The low availability of nitrogen in organic fertilizers is the main underlying factor for contributing to the low yield in organic farming.

The Royal Government of Bhutan approved the National Organic Flagship program in 12th FYP which identifies the importance of organic fertilizer to take forward the program. With the support of the Government, it is expected that production and usage of organic fertilizer will rapidly increase. More usage of organic fertilizer puts pressure on Department of Agriculture for organic fertilizer recommendation of various agriculture and horticulture crops. Considering the above important points, the research aims of this study and evaluate the efficacy of locally available organic fertilizers on cauliflower yield.

Material and Method

The research was conducted in collaboration with National Soil Service Center at Yusipang on 21st April, 2020. The research was laid out in RCBD (Randomized Complete Block Design) with three replications. The bed size of 6m*1m was prepared and planting distance between row and plants was maintained at 45 cm x 50 cm accommodating 25 plants in each bed. Treatments evaluated were FYM, Vermi-compost, Bio-slurry, Jholmal, Bhu-organic compost and control.

Soil samples were taken before and after the trial to determine soil nutrient content. The yield parameter such as curd weight and diameter and yield per plot were recorded. The data collection was started from May till July, 2020.

The second trial was initiated on 29thApril, 2021 and result will be reported.

5.5.5 Demonstration of Organic technologies at Organic model village of Haa and on station of National Centre for Organic Agriculture

Background

After the issue of non-compliance letter, the model village has to undergo conversion period for a year from June 2020 till June 2021. Since the issue of non-compliance was on plant protection and soil nutrient management Longpa Nobgang being one of the sites of research outreach Program farmers training has been given to fifty households in mid-July, 2020. Jeevamrut and Jholmol are the two promising technologies to manage soil nutrient and pest and disease issue. Jholmal is a low cost homemade biofertilizer and biopesticide that improves crop yield while lowering cost of farmers and reducing the use of harmful chemicals. Jeevamrut is a liquid organic manure which is an excellent source of nutrient contains and can be used as biopesticide as well.

The National Centre for Organic Agriculture has proposed to replicate the technology of soil nutrient and plant protection management at organic model village, Longpa Nobgang, Haa as a part of research outreach program whereby Jholmol and Jeevamrut technology was installed and demonstrated at two households. With the support from Resilient Mountain Solution Project, the materials required for demonstration and installation of technology were purchased and will be given to identified households. Beside installation of technology practical implementation will be also carried out on Cole crops at identified households to know the efficacy of Jholmal and Jeevamrut and to showcase the farmers about these two technologies. The Centre will be also replicating biopesticide trial using biopesticide and botanical extracts on farm as well as on station.

Table 62:Materials purchased through RMS budget

Sl.no	Particulars	Quantity (nos)
1.	Bucket (20 L)	10
2.	Bucket (100 L)	10
3.	Knap sack sprayer (15 L)	3
4.	Digital weighing balance (50 kg)	2
5.	Spring weighing balance (50 kg)	2
6.	Flexible pipe threaded (25 mm)	5
7.	Plastic crate	12
9.	Jug (1 L)	6
10.	Cole crop seed (Cabbage, Cauliflower and Broccoli seed)	30 packets (10 packets each crop)
11.	Tomato Seed	20 packets
12.	Measuring Tape (100 m)	2

5.5.6 Farmer's training on Organic Pest and Disease management at model village of Haa

Background

Since the issue of non-compliance of Organic model village was on plant protection the famers training on organic pest and disease management was finalized to be conducted in first quarter of the fiscal year. Accordingly, the framers training was conducted on 5th July till 9th July, 2020 at the Longpa/ Nobgang model village. The training was a part of outreach program of National Center for Organic Agriculture, Yusipang and RMS work plan.

Materials and Methods

Before imparting farmers training, pest and disease inventory was conducted by randomly visiting few vegetable gardens at Longpa/ Nobgang model village. The main objective for the inventory was to know the pest and disease that are common for the vegetable and to give training based on the inventory's finding.

Figure 91:Pest and Disease inventory

The two days farmer's training was on how to manage pest and disease organically. The theoretical and hands on training was imparted to farmers on how to prepare botanical extracts of garlic and chill, Jholmol 1, 2 and 3, liquid manure for biopesticide use. The theoretical session covered three different topics- harmful effect of pesticides, common pest of vegetable at model village and organic management on pest and disease of vegetable. The main objective of the training was to create awareness on above mentioned topics and to be able to recognize the pests by farmers in the field.

Figure 92:Farmer training on botanical plant extract- chilli and garlic extract

Result and Discussion

All the participants learnt how to prepare botanical extract, biopesticides, liquid manure and application rate on the crops.

Conclusion

The participants thanked the trainers and expressed their appreciation in providing them with such useful and important training.

5.5.7 Maintenance of Azolla in Low-Cost Poly house

Background

Azolla is an aquatic fern consisting of a short, branched, floating stem, bearing roots which hang down in the water that gives the appearance of dark green to reddish carpet and are in triangular and polygonal shape. It has a symbiotic relationship with the nitrogen-fixing blue-green alga (cyanobacterium). Azolla must be grown in fresh water or wet mud in order for plant to thrive and it doubles the biomass in 3-10 days in right conditions.

Azolla is grown as livestock feed as it has higher protein content. It can be also used as a biofertilizer and green manure for the rice crop due to its Nitrogen fixing abilities. Besides biofertilizer it can also use as weed control as azolla suppresses the growth of some aquatic weeds in paddy cultivation.

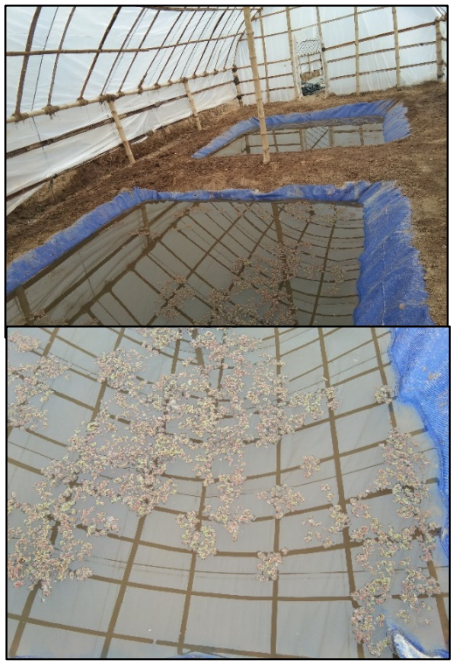

Figure 93:Azolla in green house

Materials and Method

Two Pond size of 3.5m* 3m was dug and covered with blue silpaulin. At the base a layer of soil was added followed by filling of water and application of nutrients.

Materials required for establishment of azolla:

1. Cow dung- 500 g
2. Rock Phosphate-250 g
3. Azolla culture
4. Silpaulin (blue)
5. Water-3/4 of the pond

Result and Discussion

Azolla is growing well and need to add nutrient such as rock phosphate and cow dung at fortnight intervals.

5.5.8 Dzongkhag Language Promotion in the Centre

Dzongkhag language is the National and official language of Bhutan. With modernization, it's been observed that the use of language in the office forum has been minimum. In order to promote the language development and enhancement, the Centre has put up it as one of the mandatory indicators in its Annual Performance Activity. Following were some of the activities carried out till May 2021 as a part of Dzongkhag Language Development Programme.

#	Activity	Dateline
1	Videos Production using Dzongkhag Language	Till May 2021. Reference Facebook NCOA Page
2	TA Forms in Dzongkhag	Developed and in official use
3	Offtg. Orders	Developed and in official use
4	Vehicle Requisition form	Developed and in official use
5	Field Boards	Developed and in use

Figure 94: TA & Vehicle requisition form in Dzongkhag Language