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Organic Rice (*Oryza sativa* L.) Production for Sustainability of Hill Agro-ecosystem of North Eastern India

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ABSTRACT: The hilly farmers of North Eastern India are mostly practicing the chemical free farming with indigenous knowledge system from ages which can be considered as Organic Farming by default. But the productivity of crop is very low in this region due to low use of organic and inorganic fertilizers and pesticides along with soil acidity problem. The soils are also deteriorated day by day due to mono-cropping and imbalance fertilizer application. Introducing the location specific modern technologies, the challenges which hinders the development of Organic Farming in this region could be overcome which would be otherwise the boon for the farmers for increased the productivity of crop leading to economic development of the region. Rice is the major crop of this area and it is cultivated by imbalance fertilizer application. So, considering the above in view a Front Line Demonstration was conducted at the farmers' field of Ri-Bhoi District of Meghalaya of North Eastern Region of India during the year 2017-2018 and 2018-2019 to test the feasibility of the technology and to demonstrate the organic sources of nutrients for maintenance of soil health and to improve the productivity of rice (*Oryza sativa* L.). The results of the FLD reveals that the application of organic sources of nutrient *i.e.*, Vermicompost 5 t/ha + *Azospirillum* @ 3.5kg/ha + PSB @3.5kg/ha + 30 kg of cow-dung by root dip treatment had recorded significantly higher yield *i.e.*, 42 q/ ha with B:C ratio of 2.08 followed by farmers practice (32.5 q/ha yield with B:C ratio of 1.48). The nutrient content of soil was also recorded high after the treatment for both the years. Moreover, from the data of extension gap (9.5 q/ha), technology gap (8 q/ha) and the technology index (16) received after the implementation of the technology had reveals the feasibility of the demonstrated technology at the farmers' field and the suitability of the technology in the hill agro-ecosystem of North Eastern India.

Keywords: FLD, Organic Sources of Plant Nutrient, Paddy, Soil Health, Hill Agro-ecosystem, North Eastern India.

INTRODUCTION

North Eastern India is located at the extreme north east corner of India which is connected to rest of India via a narrow corridor. It has vast and varied landscape with extremely diverse tradition and rich cultural heritage. The farmers of this region are practicing mostly the chemical free farming with indigenous knowledge system from ages which can be considered as Organic Farming by default (Bordoloi 2021 a). Organic Farming is a viable component of agricultural production system which has the capacity of balancing the resource use efficiency and environmental protection while boosting up the crop productivity (Sanjay-Swami, 2020; Bordoloi, 2021 b). Organic Farming in North East India can be the boon for the farmers for increase the productivity of the crops which could be the major tool for improve the economy and prosperity of the Region. Making the Organic Farming successful in the Region, the challenges which hinders the development of organic farming should be addressed and required to overcome (Babu *et al*., 2015; Bordoloi, 2020 and Bhuyan, 2021).

The low use of organic and inorganic fertilizers coupled with soil acidity problem cause the low productivity of crop in North East India. The soils are also deteriorated day by day due to mono-cropping and imbalance fertilizer application (Sanjay-Swami and Singh, 2020; Bordoloi, 2020). Moreover, the favorability of use of chemical fertilizers and pesticides are also very limited in this region mainly because of unawareness, economic backwardness, unavailability of the product in proper time and proper place. Moreover, maximum of the farmers are afraid to use the chemicals and they are always tries to maintain their cultivation in natural ways (Bordoloi, 2021c). The organic manure and lime along with reduced dose of inorganic fertilizers recorded very successful results for improvement of the soil physical environment and recorded higher productivity of crop in North East hilly region of India (Bordoloi, 2021 d; Bordoloi 2021 e). In this disadvantaged area regarding crop productivity and soil sustainability the promotion of fertilizer application is very much essential. The

organic fertilizers can be utilized successfully to improve the soil physical and chemical properties and for productivity enhancement of crops (Kumar *et al.* 2020; Rajkhowa *et al.*, 2019; Bordoloi, 2021 f). So, considering the above in view the present study was carried out during 2017-2018 and 2018-2019 at Ri-Bhoi District of Meghalaya to test the feasibility of a technology and to demonstrate the organic sources of nutrients for maintaining the soil health and to increase the productivity of paddy to maintain the agricultural sustainability of hill agro-ecosystem of North Eastern India.

MATERIALS AND METHODS

The programme was conducted at the farmers' field of Ri-Bhoi District of Meghalaya of North Eastern Region of India during the year 2017-2018 and 2018-2019 as FLD to test the feasibility of the technology and to demonstrate the organic sources of nutrients for maintaining the soil health and to increase the productivity of Rice. The Ri-Bhoi District is lies between the North Latitudes 25.15′ and 26.15′ and East Longitudes 91.45′ and 92.15 with the geographical area of 2378 sq. km (Anonymous, 2011). The area is humid subtropical and average rainfall achieved between 1000 mm to 2500 mm. The villages taken for the experiment were namely Liarkhla, Kyrdem and Liarsluid and falls between the altitudes of 825 to 900 amsl. The soil of the experimental site was found as sandy loam and acidic in reaction. The area under each FLD was 0.4 ha. and rice variety taken was RCM 10. The treatments were comprised of Vermicompost@ 5 t/ha + *Azospirillum*@ 3.5kg/ha + PSB @3.5kg/ha + 30 kg of cow-dung by root dip treatment and Farmers Practice (Farmers' practice include imbalance fertilizer application of 30:25:15 NPK kg/ha). All the participating farmers were trained on all aspects of paddy cultivation and soil fertility management through organic fertilizer before implementing the FLDs at their field.

To study the impact of FLD, data from FLDs and Farmers' Practices were collected and analyzed. The soil fertility statuses were estimated by soil analysis of composite soil sample from each plot before transplanting and after harvesting of crop. The extension gap, technology gap and technology index along with benefit cost ratio were calculated using the formula as suggested by Samui *et al.*, (2000) as follows

Technology Gap = Potential yield – Demonstration Yield (q/ha)

Extension Gap = Demonstration Yield – Farmers Yield (q/ha)

Technology Index = Potential Yield – Demonstration Yield/ Potential Yield × 100

RESULTS AND DISCUSSION

Crop Yield and Economics Analysis. From the results of the FLD (Table 1 and Fig. 1), it was revealed that the application of Vermicompost 5 t/ha + Azospirillum @3.5kg/ha + PSB @3.5kg/ha + 30 kg of cow-dung by root dip treatment had recorded significantly higher yield *i.e.*, 42 q/ ha followed by Farmers' Practice (32.5 q/ha) (at 5% level of significance).There was a 129.32% yield improvement in T1 compared to T2 *i.e.*, Farmers' Practice where they used imbalanced fertilizers. Similar results of significantly higher rice yield and improved soil nutrient status were recorded by Bordoloi and Islam (2020) at the field of resource poor farmers of North Eastern India. The highest B:C ratio was recorded in the T1 *i.e.*, Vermicompost 5 t/ha + Azospirillum @ 3.5kg/ha + PSB @3.5kg/ha + 30 kg of cow-dung by root dip treatment (2.08) followed by T2 *i.e.*, Farmers' Practice (1.48). Similarly, the improved benefit-cost ratio was also observed by Kumar *et al.*, (2015) by the application of improved soil fertility management in crop.

Fig. 1. Implementation of FLD programme in the Farmers Field.

Gap Analysis. The data of extension gap, technology gap and the technology index received after the implementation of the technology had reveals the feasibility of the demonstrated technology at the farmers' field and the suitability of the technology in the hill agro-ecosystem of North Eastern India. The extension gap in the T1 *i.e.* 9.5 q/ha, emphasized the need to trained the farmers through demonstration and training for adoption of improved technology to reverse the trend of wide extension gap (Table 1). Technology gap of 8 q/ha reveals the farmer's cooperation in carrying out new demonstration with good results. The technology index of 16 showed the feasibility of the demonstrated technology at the farmers' field and suitability of the Technology in the region. Similar results also recorded by Bordoloi, (2021 g); Kumar *et al.* (2015).

Soil Fertility Status. From the Table 2, the improved soil nutrient status was seen for both the years. The soil sample were collected before the implementation of the FLD and after the harvesting of the crop. The soil fertility status was significantly increased with the application of organic combination of fertilizers from initial to final stage of the crop during both the years of experimentation. From Table 2 it is reveals that the soil is acidic in nature with high organic carbon content. The soil pH, organic carbon, available nitrogen, available phosphorus and available potassium status of soil after harvest of the crop significantly increased (at 5% level of significance) due to application of the Treatment. From the results of the experiment, it is seen that application of T1 *i.e.*, Vermicompost 5 t/ha + Azospirillum @3.5kg/ha + PSB @3.5kg/ha + 30 kg of cow-dung by root dip treatment significantly increased the nutrient content followed by T2 *i.e.*, Farmers' Practice. A total of 127.52% increased in organic Carbon, 129.89% Nitrogen, 159.58 % increased available Phosphorus and 163.81% increased in Potassium were recorded in the soil after the harvest of the crop as compare to initial stage of soil before the implementation of Treatment 1. Similar results of improved soil nutrient status after implementation of organic fertilizers were recorded by Bordoloi (2021 g) and Kumar *et al.*, (2015). So, the integrated use of Vermicompost, Azospirillum and PSB can be effectively used for increase the productivity of rice crop and for sustaining the soil nutrient status for improving the farmers' income.

Table 1: Effect of Organic Sources of Plant Nutrient on Yield and Economics of Paddy in Hill Agro-ecosystem of North Eastern India.

Treatments	Avg. yield (q/ha)	% increase/ change in avg. yield over local	Gross Cost (Rs/ha)/ (Rs./ unit)	Gross Return (Rs/ha) / (Rs./ unit)	Net Return (Rs/ha)/ (Rs./ Unit)	B:C Ratio (GR/GC)	Technology gap (q/ha)	Extension gap (q/ha)	Technology Index
T1	42	129.32	20,218	42,000	21782	2.08	8	9.5	16
T2	32.5		22,010	32500	10,490	1.48			
P<0.05	1.07								
%= % increase in yield over control									

Table 2: Effect of Organic Sources of Plant Nutrient on soil fertility status in Hill Agro-ecosystem of North Eastern India.

Treatments	pH		Organic Carbon (kg/ha)			Available Nitrogen (kg/ha)			Available Phosphorus (kg/ha)			Available potassium (kg/ha)		
	Before	After	Before	After	% Increased	Before	After	% Increased	Before	After	% Increased	Before	After	% Increased
T1	4.54	4.93	1.09	1.39	127.52	297.54	386.48	129.89	32.76	52.28	159.58	103.54	169.61	163.81
T2	4.48	4.67	0.98	1.12	114.29	298.21	318.35	106.75	32.24	41.24	127.92	102.56	121.54	118.51
P<0.05		0.09		0.08			8.76			3.12			1.56	
%= % increase in yield over control														

CONCLUSION

North East hilly region of India can be converted as a 'Hub of Organic Farming' with proper implementation of modern technologies and by overcoming the major challenges which hinders the development of agriculture in this region. As rice is the major crop of this area, so adopting the technology of organic rice production would help for maintain the sustainability of hill agro-ecosystem of North Eastern India. This soil test-based technology of application of vermicompost along with bio-fertilizer if adopt properly can lead to increase the rice productivity. Further researches and implementation of location specific technologies with organic packages and practices are required urgently for increase the productivity of crop and for socio economic development of this disadvantageous region of India.

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