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EFFECT OF CROP DIVERSIFICATION ON YIELD AND ITS ATTRIBUTES OF SCENTED RICE (*KONJOHA*) UNDER ORGANIC RICE ECOSYSTEM

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ABSTRACT

A field experiment on crop diversification in organic rice ecosystem was conducted considering scented rice (*Konjoha*) as main crop with eight treatments (*viz.* T1=Sole rice, T2= Rice + Swamp Taro (4:2), T3= Rice + Buffalo Spinach (4:2), T4= T2 + Pumpkin in bunds, T5= T2 + Marigold in bund, T6= T3 + Pumpkin in bund, T7= T3 + Marigold in bund and T8= Rice-relay Lathyrus) and three replications. Most of the rice growth and yield attributes found to be highest in T1. The highest value of yield attributes of rice *viz.*, no. of effective tillers/m^2 (13.67), no. of panicles/m^2 (309.67), weight of panicle (1.82 g), number of filled grains/panicle (95.34), test weight (14.35 g) was found in T1. However, the growth and yield attributes of component crops were not influenced significantly under different crop diversification modules. The highest grain yield (18.46 q/ha) was in T1 which was at par with T8 (18.44 q/ha). On the other hand, the lowest grain yield (8.58 q/ha) was recorded in T4. Highest straw yield (45.41 q/ha) was recorded with T1. While, lowest straw yield (19.96 q/ha) was recorded in T4. Highest value of harvest index (30.07%) was found in T4. On the other hand, lowest value of harvest index (28.05 %) was recorded in T7. Crop diversification exerted significant influence on land equivalent ratio and rice equivalent yield with the highest value of multiple cropping index (200) in rice-relay lathyrus (T8) and the lowest value (100) was recorded in sole rice (T1) and rice + buffalo spinach intercropping(T3). The highest diversity index (0.61) was recorded in T4 and T5. The highest land equivalent ratio of rice (1.00) was recorded in T1 and T8. Though intercropping reduced the rice grain and straw yield, it increased the total rice equivalent yield of the system and the highest rice equivalent yield (64.57q/ha) was recorded in T5. On the other hand, lowest rice equivalent yield (19.02q/ha) was recorded in T3. The highest B:C ratio of 3.10 was recorded in T5 and was closely followed by T4 (2.94). The study revealed that crop diversification module, rice + swamp taro intercropping + marigold in bund (T5) was the best option in respect of profitability.

***Keywords*:** Crop diversification, scented rice, organic, intercropping.

Introduction

Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. It imparts wider choice in the hand of farmers for production of a variety of crops in a given area. The shifting in traditional farming to diversified farming is mobilized by increasing demand for diverse nature of food items. With the advent of modern agricultural technology, especially during the period of the green revolution, there was a continuous surge for diversified agriculture in terms of crops. Diversified agriculture helps in improvement of resiliency and may be the best way to solve the problem of nutritional self-sufficiency and

poverty alleviation by generating employment. It also helps in buffering crop production from the effects of variation in climatic condition and extreme events (Lin, 2011). Crop diversification and inclusion of the new crops can be one of the important technologies in increasing the farmer's income to a greater extent and also beneficial for conserving natural resources (Khanam *et al.,* 2018). Presently, Assam is considered to be a rice mono-cropped state with a cropping intensity of 149% indicating less utilization of rich resources and poor crop diversification (Anon, 2017). The policy makers have considered crop intensification and diversification as the thrust areas for livelihood security of the farming community of Assam.

Rice is cultivated in 158.9 million hectares worldwide with a production of 759.6 million metric tonnes (MMT) in 2017 (FAO, 2018) where India contributes 110.15 MMT of rice from 43.19 million hectares of area with a productivity of 2550 kg/ha and has a large potential to become a major exporter of organic rice in the international market. Rice is also the principal food crop of Assam. In spite of its higher importance and market potentiality, it is grown under mono cropping system only, occupying about 2.49 lakh hectares which produces 5.13 lakh tonnes of rice grain. (Anon, 2018). Aromatic rice has a high demand in domestic market and the aromatic rice of Assam is a unique class under *sali* rice and is traditionally known as "*Joha*" and organic scented rice enjoys special demand and is highly valued in Assam. The area under *Joha* rice is however very less because of its poor productivity. The poor yield level and productivity of this class of rice make it less preferable among the farmers. So, there is a need to overcome these challenges and maximize the productivity and profitability of *Joha* rice in Assam through crop diversification with other commercial crops may open new avenue for higher productivity and profitability from rice ecosystem.

Traditionally, Assam is organic by default with heritage of rich bio-diversity. Organic farming is now on high focus for sustainability in Indian agriculture. The North-eastern region of India has already been declared as the organic hub of India. Modern intensive agriculture has led to increase in agricultural production mainly due to development of high yielding crop varieties, adoption of improved crop production technologies, use of synthetic agrochemicals like fertilizers, insecticides, fungicides, herbicides, growth regulators etc. But the extensive uses of these agro-chemicals are causing environmental hazards (Bhandari, 2014). To overcome these negative effects of modern agriculture, the concept of organic agriculture was developed for a sustainable way of production.

Crop grown on field bund works as a cover crop and provides some extra monetary income to the farmer. Planting of flowers and vegetable strips in rice bunds result in increase of land use efficiency with increase in productivity and profitability of rice growing farmers. Additionally, this also helps attract predators and parasitoids of the principal rice pests (Gurr *et al.,* 2016). Presently, scientific information and agro-techniques of diversified modules in organic rice ecosystem of Assam are limited. The crop intensification and diversification under organic ecosystem are the need of the hour for enhancing farm productivity and livelihood security of the farmers. So, emphasis may be given on enrichment of field level agro bio-diversity by intercropping rice with some other commercial crops, bund crops and relay crops by inclusion of a few crops *viz.,* buffalo spinach, swamp taro, pumpkin, marigold and lathyrus with rice. Intercropping buffalo spinach may be considered as a viable option to maximize productivity and minimize weed pressure through weed suppression. Similarly, Marigold is also a hardy annual flowering plant which can be grown effectively for quick income generation and as border trap crop. Growing pumpkin as mix crop with rice is a general practice in few districts of Assam. It is also grown in the barren bunds with a very little adjustment of the bund height and width which adds an extra income to the farmers. Also, the bright flowers of pumpkin attract some pollinators and a few natural enemies. Lathyrus, being a drought tolerant dual purpose (food and fodder) crop can be grown as relay crop with rice by utilizing residual soil moisture.

Materials and Methods

The field experiment was conducted at the organic block of Instructional-cum-Research (ICR) farm of Assam Agricultural University, Jorhat during *kharif* and *rabi* seasons to evaluate the effect of crop diversification in organic rice ecosystem. The experimental farm is situated at 26043/N latitude and 94012/E longitude and at an elevation of 86.6 meters above average mean sea level (AMSL). The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications. The main crop was scented rice (*Konjoha*) with different diversified modules. The experiment consisted of eight different treatments *viz.,* T1= sole rice, T2= rice + swamp taro intercropping (4:2), T3= rice + buffalo spinach intercropping (4:2), T4= T2 + pumpkin in bund, T5= T2 + marigold in bund, T6= T3 + pumpkin in bund, T7= T3 + marigold in bund and T8= rice – relay lathyrus. The land having homogenous

fertility and uniform textural makeup at certified organic block of ICR farm, Assam Agricultural University, Jorhat. The soil of the experimental site was clay loam in texture with pH 5.28, organic carbon (0.82%), CEC {6.48 c mole (p+)/ Kg}, medium in available N (272.45 kg/ha), available $P_2 0_5$ (28.11 kg/ha) and low in available K_2O (132.38 kg/ha). The total rainfall received during the cropping season was 2014.1 mm. The mean maximum and minimum temperature during the whole crop growing period ranged from 20.7 to 34.8 0C and 8.4 to 26.9 0C, respectively.

Results and Discussion

The results of the experiment on "Crop diversification in organic rice ecosystem" are presented in Table 1, 2 and 3 to study the influence of various treatments on growth, yield attributes, yield, diversity parameters and economics of Scented rice (*Konjoha*) under organic ecosystem. The phenological events of all crops under different diversification modules were observed to understand their growth and development behavior. All the crops received normal *kharif* environment to express their normal performance. The component crops took different durations as per their genetic makeup and environmental influence under the present experimental condition. On an average, rice, buffalo spinach, swamp taro, pumpkin, marigold and lathyrus took 130, 86.3, 240, 123, 91.5 and 122 days, respectively for harvest and completion of life span.

Growth parameters of rice

The growth parameters (table 1) revealed that though plant height of all the crops was negatively affected under diversification yet maximum plant height (146.89 cm) was acquired under sole rice (T1) followed by another module (T8) sole rice – relay lathyrus (146.78 cm). Crop diversification had significant effect on plant population and tillers/hill at harvest. The highest plant population (24.33) was recorded in (T1) sole rice and was *at par* with the module (T8) sole rice-relay lathyrus. On the other hand, intercropping decreased the plant population of rice because of replacement of rice row with intercrop. Significant influence of crop diversification was observed on number of tillers/hill and recorded the highest number of tillers/hill (14.63) in sole rice (T1) and rice + buffalo spinach intercropping + pumpkin in bund (T6) recorded the lowest number of tillers/hill (11.40). These results are in agreement with the works reported by Okonji *et al.* (2007) and Bordoloi *et al.* (2019). The variation in growth might be due to the variation in external environment or micro-climate created under the different establishment methods.

Yield attributes of rice

Yield attributes like panicle length and test weight did not differ significantly due to crop diversification (table 2). On the other hand, there was positive influence on no. of effective tillers/m^2, no. of panicles/m^2, weight of panicle, number of filled grains/panicle. The highest value of yield attributes of rice *viz.,* no. of effective tillers/m^2 (13.67), no. of panicles/m^2 (309.67), weight of panicle (1.82 g), number of filled grains/panicle (95.34), test weight (14.35 g) was found with sole cropping of rice (T1). In this module rice was grown as pure stand with optimum plant population. The microclimatic, biotic and abiotic conditions were favorable for rice cultivation. The maximum panicle length (21.89 cm) was observed in rice + swamp taro intercropping + pumpkin in bund (T4). It might be due to the modification of the microclimatic situation caused due to intercropping of rice with other component crops. These results are in agreement with the works reported by Rabeya *et al.* (2018).

Yield, diversity parameters and B:C ratio of rice

Data presented in table 3 revealed that intercropping of rice with swamp taro and buffalo spinach at 4:2 intercropping ratio reduced the grain and straw yield under this replacement series. The highest (18.46 q/ha) grain yield was recorded with sole rice (T1). It was at par with (T8) rice - relay lathyrus (18.44 q/ha). On the other hand, the lowest (8.58 q/ha) grain yield was recorded in rice + swamp taro intercropping + pumpkin in bund (T4). Highest straw yield (45.41 q/ha) was recorded with sole rice (T1). While, lowest straw yield (19.96 q/ha) was recorded in rice + swamp taro intercropping + pumpkin in bund (T4). Highest value of harvest index (30.07%) was found in rice + swamp taro intercropping+ pumpkin in the bund (T4). On the other hand, lowest value of harvest index (28.05 %) was recorded in rice + buffalo spinach intercropping + marigold in the bunds (T7) and was in agreement with the works reported by Rana *et al.* (2013), Xinru *et al.* (2016) and Meena *et al.* (2013).

Diversity parameters related to different crop diversification modules were analyzed in context to land equivalent ratio, multiple cropping index, diversity index and rice equivalent yield. Crop diversification exerted significant influence on land equivalent ratio and rice equivalent yield (Table 3). The highest value of multiple cropping index (200) was recorded in rice-relay lathyrus (T8) and the lowest value (100) was recorded in sole rice (T1) and rice + buffalo spinach intercropping (T3). The highest diversity index (0.61) was recorded in rice + swamp

taro intercropping + pumpkin in bund (T4) and rice + swamp taro intercropping + marigold in bund (T5). The highest value (1.00) of land equivalent ratio of rice was recorded in sole rice (T1) and rice - relay lathyrus (T8). Though intercropping reduced the rice grain and straw yield, it increased the total rice equivalent yield of the system. The highest rice equivalent yield (64.57q/ha) was recorded in rice + swamp taro intercropping + marigold in the bunds (T5). On the other hand, lowest rice equivalent yield (19.02q/ha) was recorded in rice + buffalo spinach intercropping (T3). Improvement in all these parameters might be because of the improvement in resource use efficiency of the system and changed nutrient use pattern. Such results were earlier reported by Liang *et al.* (2016), Rana *et al.* (2013) and Dusa and Stan (2013).

The highest B: C ratio of 3.10 was recorded in rice + swamp taro intercropping + marigold in bund (T5). It was closely followed by (T4) rice + swamp taro intercropping + pumpkin in bund (2.94). On the other hand, the lowest B: C ratio of 0.95 was found in rice + buffalo spinach intercropping (T3). Rabeya *et al.* (2018), Nazrul and Shaheb (2015) and Tiwari *et al.* (2002) also reported economic profitability of crop diversification.

Conclusion

Awareness on organic *Joha* rice cultivation is gaining momentum in Assam for health concerns and premium prices of organic *Joha* rice. Sole cultivation of organic *Joha* rice may not be profitable for farmers as productivity is poor and premium markets infrastructure are not yet developed to ensure premium price to farmers of Assam. This study revealed that crop diversification module, rice + swamp taro intercropping + marigold in bund was found to be the best diversified module in terms of rice equivalent yield, diversity index, multiple cropping index, land equivalent ratio and benefit: cost ratio. Crop diversification module, rice + swamp taro intercropping + pumpkin in bund also qualified as next best module in terms of above parameters. In general, the present study revealed that the productivity and profitability in organic rice ecosystem can be increased by efficient crop diversification modules. Crop diversification under lowland rice ecosystem may show new promise to fulfill diversified food need and extra farm income. The present study also highlighted the role of rice bunds for generating extra income. Proper testing of the efficient modules under on-farm situation may validate the feasibility before adoption by the farmers. This study may be taken as guideline to conduct further research for enhancing farmer's income.

Table 1 : Effect of crop diversification on growth of scented rice at harvest under organic rice ecosystem

Treatments	Plant height (g)	Plant population (hills/m^2)	Tillers/ hill
T1: Sole rice (Joha)	146.89	24.33	14.63
T2: Rice + Swamp Taro (4:2)	143.78	20.00	13.10
T3: Rice + Buffalo Spinach (4:2)	141.67	19.67	12.30
T4: T2 + Pumpkin in bunds	139.89	19.33	12.10
T5: T2 + Marigold in bund	141.89	20.00	12.87
T6: T3 + Pumpkin in bund	137.11	20.00	11.40
T7: T3 + Marigold in bund	138.78	20.00	11.50
T8: Rice- Lathyrus (Relay)	146.78	24.00	14.57
SEm (±)	2.18	0.34	0.24
CD (P=0.05)	NS	1.04	0.73

Table 2 : Effect of crop diversification on yield attributes of scented rice at harvest under organic rice ecosystem

Treatments	Panicle length (cm)	Panicle weight (g)	Panicles /m^2	Effective tillers /Hill	Filled grains / Panicle	1000 grain weight (g)
T1: Sole rice (Joha)	20.11	1.82	309.67	13.67	95.34	14.35
T2: Rice + Swamp Taro (4:2)	21.28	1.66	253.78	12.11	93.67	14.30
T3: Rice + Buffalo Spinach (4:2)	20.34	1.49	237.00	11.78	83.34	14.28
T4: T2 + Pumpkin in bund	21.89	1.46	224.11	11.44	82.67	14.20
T5: T2 + Marigold in bund	21.56	1.53	246.67	11.89	83.44	14.29
T6: T3 + Pumpkin in bund	21.00	1.16	233.67	11.11	71.67	13.90
T7: T3 + Marigold in bund	20.56	1.45	242.33	11.22	77.44	13.94

T8: Rice- Lathyrus (Relay)	20.11	1.76	305.91	13.33	95.33	14.34
SEm (±)	0.85	0.09	8.58	0.63	4.34	0.14
CD (P=0.05)	NS	0.26	26.03	1.91	18.18	NS

Table 3 : Effect of crop diversification on yield, diversity parameters and B:C ratio of scented rice under organic rice ecosystem

Treatments	Grain Yield (q/ha)	Straw yield (q/ha	Harvest Index (%)	Multiple cropping index	Diversity index	Land equivalent ratio of rice	Rice equivalent yield (q/ha)	B:C ratio
T1: Sole rice (*Joha*)	18.46	45.41	28.90	100	0.00	1.00	26.40	1.75
T2: Rice + Swamp Taro (4:2)	8.70	20.71	29.58	108	0.41	0.47	38.77	2.25
T3: Rice + Buffalo Spinach (4:2)	11.18	26.55	29.64	100	0.18	0.61	19.02	0.95
T4: T2 + Pumpkin in bund	8.58	19.96	30.07	140	0.61	0.47	62.61	2.94
T5: T2 + Marigold in bund	8.67	22.11	28.17	140	0.61	0.47	64.57	3.10
T6: T3 + Pumpkin in bund	10.99	26.07	29.65	132	0.48	0.60	42.63	2.11
T7: T3 + Marigold in bund	11.12	28.52	28.05	132	0.48	0.60	44.04	2.25
T8: Rice- Lathyrus (Relay)	18.44	45.35	28.91	200	0.00	1.00	33.15	1.92
SEm (±)	0.28	0.51	0.52	-	-	0.01	0.27	-
CD (P=0.05)	0.17	0.54	0.56	-	-	0.02	0.82	-

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