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Production Potential of Rice-based Cropping System under Different Nutrient Management Practices

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ABSTRACT

Background: The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. The continuous application of inorganic fertilizers even in balanced form may not sustain soil fertility and productivity. However judicious use of chemical fertilizers in combination with organic manure is required to improve the soil health as well as to achieve sustainable crop production. Thus balanced fertilization and cropping system offers a great scope for increasing the productivity.

Methods: A field experiment was conducted during *kharif* season of 2019 and 2020 in the experimental farm, Department of Agronomy, Nagaland University, SAS, Medziphema campus to study the effect of cropping system and nutrient management practices on production potential of rice-based cropping system. The experiment was conducted in randomized block design with factorial concept with 3 replications. The treatment consisted of five cropping systems and three nutrient management practices.

Result: The result revealed that among intercropping system, rice + soybean (3:1) cropping system recorded highest plant height (cm), number of leaves plant^{-1}, number of panicles m^{-2}, grain yield, straw yield and rice equivalent yield. Among different nutrient management practices, application of 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed recorded significantly higher plant height (cm), number of leaves plant^{-1}, number of panicles m^{-2}, panicle length, grain yield and straw yield.

Key words: Cropping system, FYM, RDF, Rice-based.

INTRODUCTION

Rice (*Oryza sativa* L.) is the third most widely cultivated cereal in the world after wheat and maize. Roughly half of the world's population, rice is the most significant staple food. Rice makes up around 21% of the total calories consumed and is a staple food for more than half of the world's population, including India (Anonymous, 2009; Parameswari *et al.*, 2014). With the ever-increasing population, world food security has become a major issue. Alarming climate change causing monsoon deficit has further aggravated water scarcity, yielding and stagnant rice productivity (Choudhary *et al.*, 2010). There is an urgent need to design and develop innovative methods and techniques of crop production to meet the rising demand for food, feed and forage through optimal utilization of available agricultural input resources. These resources include arable land, irrigation water and energy. Small farmers are unable to meet their diverse household demands to maintain a reasonable lifestyle from their limited land, water and financial resources under the current system of solo cropping. Going for suitable alternative and more effective production techniques is therefore necessary. One such approach is multiple cropping (inter/relay cropping), which can ensure adequate resource usage to enhance production per unit area and time on a sustainable basis (Trenbath, 1986). The practice of planting two or more crops simultaneously on a single plot of land is known as intercropping (Willey, 1979).

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Maintaining soil fertility and long-term productivity for sustainable production is made possible by integrated nutrient management, which combines several nutrient sources and management techniques (Yadav *et al.*, 2016). INM primarily refers to combining traditional and contemporary approaches to nutrient management into an agricultural system that is both ecologically sound and economically optimal, utilising the advantages of all available sources of organic, inorganic and biological components-substances in a wise, effective and integrated way. It optimises all facets of the nutrient cycle, including macro and micronutrient inputs and outputs, with the aim of synchronizing nutrient demand by the crop and its release into the environment. INM techniques reduce losses due to leaching, runoff, volatilization, emissions and immobilisation while maximizing nutrient usage efficiency (Zhang *et al.*, 2012). By keeping above information in view, present investigation

was carried out to study the effect of cropping system and nutrient management practices on production potential of rice-based cropping system.

MATERIALS AND METHODS

A field experiment was carried out during *kharif* seasons of 2019 and 2020 at the Experimental Research Farm of School of Agricultural Sciences (SAS), Nagaland University, Medziphema Campus. The site was well drained sandy loam, low in available N, low in available P, medium in available K during 2019 and 2020 respectively. The experiment was conducted in randomized block design with factorial concept with 3 replications. The treatment consisted of five cropping system *viz*., C_1: Sole rice, C_2: Sole groundnut, C_3: Sole soybean, C_4: Rice + groundnut (3:1), C_5: Rice + soybean (3:1) and three nutrient management practices *viz*., N_1: 100% RDF + FYM @ 2.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed, N_2: 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed, N_3: 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed. The net plot size of 4m × 3m and a spacing of rice was done at 20 cm row to row and 10 cm plant to plant. In case of groundnut and soybean, planting was done by dibbling in furrows at the spacing of 40 cm row to row and 15 cm plant to plant for groundnut crop and 10 cm plant to plant for soybean crop. The groundnut and soybean as intercrop, were sown at row to row spacing of 20 cm for both the crops and plant to plant spacing of 15 cm for groundnut 10 cm for soybean intercrops in 3:1 method of planting. Both the base crop and components crops were sown on last week of June in all these years. The amount of FYM was calculated for each plot separately and applied three weeks before sowing of rice, groundnut and soybean as per treatment as mentioned earlier. Fertilizer requirement of the crops were met through urea (46% N), single super phosphate (16% P_2O_5) and Muriate of Potash (60% K_2O). Intercrop and sole crop of rice received different levels of fertilizer i.e. for 100% NPK- 60 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 20 kg ha^{-1} K_2O, for 75% NPK- 45 kg ha^{-1} N + 22.5 kg ha^{-1} P_2O_5 + 15 kg ha^{-1} K_2O and for 50% NPK- 30 kg ha^{-1} N + 15 kg ha^{-1} P_2O_5 + 10 kg ha^{-1} K_2O. The total quantity of P and K and one-third (2/3) of nitrogen at the time of sowing was applied and remaining two-third (1/3) of N in two equal doses at tillering and panicle initiation stage was applied as per treatment as mentioned earlier. No additional dose of fertilizer was given to groundnut and soybean in intercropping with rice. Sole crop of groundnut received different levels of fertilizer *i.e.* for 100% NPK-20 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O, for 75% NPK- 15 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 22.5 kg ha^{-1} K_2O and for 50% NPK- 10 kg ha^{-1} N + 20 kg ha^{-1} P_2O_5 + 15 kg ha^{-1} K_2O. Sole crop of soybean received different levels of fertilizer i.e. for 100% NPK-20 kg ha^{-1} N + 60 kg ha^{-1} P_2O_5 + 40 kg ha^{-1} K_2O, for 75% NPK- 15 kg ha^{-1} N + 45 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O and for 50% NPK- 10 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 20 kg ha^{-1} K_2O. In case of sole groundnut and soybean full dose of nitrogen, phosphorous and potassium respectively, were applied as basal dose at the time of sowing. The variety used in the study were: 'Sahbhagi Dhan' rice, 'ICGS 76' groundnut and 'JS 9752' soybean. The remaining agronomic practices were followed as per recommendations for the region.

The tagged plants in every plot were measured from ground level to the tip of the longest leaf and plant height was recorded at 90 DAS. The numbers of leaves of the five tagged plant leaves per plant were counted and mean value was calculated at 90 DAS. Total number of panicles was recorded from a quadrate of 1m^2 fixed randomly from each plot at harvest. Five random plants were selected in each plot and length of panicle was measured from the base to the tip of the panicle and average length was recorded. The rice equivalent yield was calculated by converting the seed yield of groundnut and soybean into rice yield on the basis of existing market price of the crops. The harvested crop was sun dried, threshed and winnowed properly. The grains/ seeds were packed separately for each plot and marked. The weight of the grains/seeds was taken, recorded and converted to t ha^{-1}. The straw/stover was sun dried properly for few days to reduce the moisture and weight was taken separately for each plot, recorded and converted to t ha^{-1}.

RESULTS AND DISCUSSION

Growth attributes of rice

From the pooled data of both the years on plant height and number of leaves plant^{-1} revealed that the highest plant height and number of leaves plant^{-1} was recorded in sole rice which was at par with rice + soybean intercropping system, while the minimum plant height and number of leaves plant^{-1}of rice was recorded from rice + groundnut (3:1) intercropping system (Table 1). This may be attributed to the presence of more available nutrients for individual crop without any competition. For intercropping system, the wastage of nutrients can be avoided, thus maximum utilization of resources is possible with a complementary relationship and also maximum absorption of light is possible which leads to production of more photosynthetic area and finally leads to more number of tillers and leaves. The result was supported by the findings of Wangiyana *et al.* (2018) who also reported that the presence of soybean plants growing together with those rice plants resulted in higher tiller number, leaf number and filled panicle number and greener leaves, indicating better nitrogen nutrition of the rice plants growing together with soybean plants compared with the rice plants in monocrop.

The pooled data of both the years also revealed a significant difference with the highest plant height and number of leaves plant^{-1}, when the crop was applied with 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed. The lowest plant height and number of leaves plant^{-1} was recorded, when the crop was applied with 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed (Table 1). The increase in plant height in response to application of organic and chemical fertilizers was probably

Table 1: Plant height at 90 DAS, number of leaves plant^{-1} at 90 DAS, number of panicles m^{-2}, panicle length (cm) of rice as influenced by cropping systems and nutrient management practices (pooled data over 2 years).

Treatments	Plant height (cm)	Number of leaves plant^{-1}	Number of panicles m^{-2}	Panicle length (cm)
Cropping system (C)				
C_1 - Sole rice	111.15	33.38	102.75	23.56
C_4 - Rice + groundnut (3:1)	99.00	26.41	80.12	22.82
C_5 - Rice + soybean (3:1)	108.24	31.44	95.54	23.23
SEm±	1.53	0.87	2.90	0.42
CD (P=0.05)	4.39	2.52	8.37	NS
Nutrient management (N)				
N_1- 100% RDF + FYM @ 2.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	105.84	31.42	89.23	22.98
N_2 - 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	113.80	36.50	112.82	25.14
N_3 - 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	98.75	23.32	76.37	21.49
SEm±	1.53	0.87	2.90	0.42
CD (P=0.05)	4.39	2.52	8.37	1.20
Interaction (C × N)	S	NS	NS	NS

due to enhanced availability of nutrients. Singh *et al.* (2012) reported a significant increase in plant height of rice due to the integrated application of biofertilizers and organic manure in combination with chemical fertilizer.

Yield attributes and yield of rice

Pooled result thus obtained compiled with the findings of both the years. The highest number of panicles m^{-2} was recorded in C_1 which was statically at par with rice along with soybean intercropping system. The lowest was recorded in rice intercropped with groundnut (Table 1). The higher values with respect to yield attributing parameters are attributed to lack of inter space competition under sole cropping that could otherwise happen in intercropping system. Above results are in conformity with the findings of Shri *et al.* (2014). The result revealed that different cropping system had non-significant effect on panicle length during both the years of experiment (Table 1).

Pooled result thus obtained recorded the highest number of panicles m^{-2} and panicle length with the application of 75% RDF along with FYM @ 5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed. The lowest was recorded in N_3 treatment (50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed) (Table 1). Increase in panicles m^{-2} through FYM was supported by Mirza *et al.* (2005) and Barik *et al.* (2006). Rahman *et al.* (2009) reported that increased panicle length in rice with the combine use of organic and inorganic fertilizer.

The highest grain and straw yield was sole rice treatment which was at par with rice intercropped with soybean (Table 2). The highest grain yield of rice was obtained in sole cropping of rice in all the intercropping system. This results confirm the findings Mandal *et al.* (1997) who obtained more yield of rice in sole cropping than inclusion of intercrop. Among intercropping system highest grain yield was registerd in rice + soybean (3:1) intercropping system.

The effect of nutrient management on grain and straw yield showed significant increase in yield. It was observed that application of 75% RDF along with FYM @ 5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed significantly increased the yield. The minimum value was registered at application of 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed (Table 2). The highest grain yield in FYM and fertilizer treatment plot might be due to higher value of yield attributing characters *viz* number of panicles m^{-2} and panicle length. Sravan and Singh (2019) also got similar result that application of recommended nutrients in integrated approach (75% RDF + 25% FYM) enhanced rice grain yield.

Practice of different cropping system did not show any significant effect on harvest index. The effect of different nutrient management practices did not bring significant impact on the harvest index of rice (Table 2).

There was marked influence of different crop management practices on rice equivalent yield. The significantly highest values of rice equivalent yield were reflected in C_5 treatment (Rice + soybean at 3:1 row ratio), which was followed by rice intercropped with groundnut. Significantly lowest was achieved in sole rice (Table 2). Similar finding was reported by Virdia and Mehata (2010).

The data indicated that the effect of different nutrient management on rice equivalent yield was found to be significant. Significantly highest rice equivalent was observed in N_2 (75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed) treatment. The lowest was registered in treatment N_3 (50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed) (Table 2). It may be

Table 2: Grain yield, straw yield, harvest index and rice equivalent yield of rice as influenced by cropping systems and nutrient management practices (pooled data over 2 years).

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Rice equivalent yield (t ha^{-1})
Cropping system (C)				
C_1 - Sole rice	3.08	5.05	37.87	3.08
C_4 - Rice + groundnut (3:1)	2.64	4.52	36.68	4.25
C_5 - Rice + soybean (3:1)	2.98	4.87	37.96	4.63
SEm±	0.04	0.08	0.51	0.05
CD (P=0.05)	0.11	0.24	NS	0.13
Nutrient management (N)				
N_1- 100% RDF + FYM @ 2.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	2.94	4.82	37.90	3.99
N_2 - 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	3.15	5.16	37.95	4.43
N_3 - 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	2.60	4.47	36.66	3.54
SEm±	0.04	0.08	0.51	0.05
CD (P=0.05)	0.11	0.24	NS	0.13
Interaction (C × N)	S	NS	NS	S

Table 3: Interaction effect of cropping systems and nutrient management practices on plant height and yield of rice (pooled data over 2 years).

Treatments	Plant height(cm)	Grain yield (t ha^{-1})	Rice equivalent yield (t ha^{-1})
C_1 N_1	106.90	3.07	3.07
C_4 N_1	104.30	2.76	4.32
C_5 N_1	106.32	2.98	4.57
C_1 N_2	124.75	3.25	3.25
C_4 N_2	103.29	3.05	4.89
C_5 N_2	113.35	3.16	5.15
C_1 N_3	101.81	2.92	2.92
C_4 N_3	89.41	2.10	3.53
C_5 N_3	105.03	2.79	4.18
SEm±	2.64	0.07	0.08
CD (P=0.05)	7.61	0.19	0.23

attributed to various yield attributes of component crops. It may be ascribed to assimilation and translocation of more pohotosynthates towards sink at integrated use of organic manures and chemical fertilizers application.

The interaction effect between cropping system and nutrient management show significant variation on plant height. The highest plant height was recorded in C_1N_2 (Sole rice +75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed) treatment combination and lowest plant height was recorded in C_4N_3 (Rice + groundnut at 3:1 row ratio + 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed) treatment combination at 90 DAS. Grain yield was significantly affected by the combine practice of cropping system and nutrient management. The perusal of the data revealed that the grain yield was highest in C_1N_2 (Sole rice +75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed) treatment combination, which was found to be comparable with plot assigned to C_5N_2 (Rice intercropped with soybean and application of 75% RDF along with FYM @ 5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed), (C_1N_1) sole rice along with 100% RDF + FYM @ 2.5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1}. The lowest was recorded in C_4N_3 (Rice intercropped with groundnut and application of 50% RDF along with FYM @ 7.5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed) treatment combination. The combine practice of cropping system and nutrient management significantly affected on rice equivalent yield. The data revealed that the yield was highest in C_5N_2 (Rice intercropped with soybean and application of 75% RDF along with FYM @ 5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed) treatment combination, which was followed by C_4N_2 (Rice intercropped with groundnut and application of 75% RDF along with FYM @ 5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed) treatment combination and significantly minimum was observed in C_1N_3 (Sole rice + 50% RDF along

with FYM @ 7.5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed) treatment combination (Table 3).

Growth and yield of groundnut

Pooled data revealed that there was a significant effect on plant height and number of branches plant^{-1} due to cropping systems. Significantly highest plant height, number of branches plant^{-1}, seed and stover yield was recorded in sole groundnut and the lowest was recorded in rice intercropped with groundnut. Sole groundnut recorded the tallest plant height and highest number of branches plant^{-1} in all the growth stages as compared to rice intercropped with groundnut (Table 4). This might be due to the reason of absence of intercrop competition in sole groundnut. Crop intensification with intercropping reduced the yield of main crop due to more interspecific competition (Singh *et al.,* 2008) and disturbance of the habitat (Banik *et al.,* 2000).

The pooled data of both the years also revealed a significant difference with the highest plant height and number of branches plant^{-1} when the crop was applied with 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed. The lowest plant height and number of branches plant^{-1} were recorded when the crop was applied with 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed (Table 4). This might be due to the fact that beneficial effect of FYM in conjunction with recommended dose of fertilizers and biofertilizers may be due to the effect of organic matter in improving physical, chemical and biological environment of

Table 4: Plant height, number of branches plant^{-1}, seed yield, stover yield and harvest index of groundnut as influenced by cropping systems and nutrient management practices (pooled data over 2 years).

Treatments	Plant height (cm)	Number of branches plant^{-1}	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Cropping system (C)					
C_2 - Sole groundnut	31.59	9.79	1.26	3.36	27.22
C_4- Rice + groundnut (3:1)	28.51	8.76	0.59	1.67	25.88
SEm±	0.57	0.16	0.02	0.04	0.41
CD (P=0.05)	1.67	0.47	0.04	0.12	NS
Nutrient management (N)					
N_1- 100% RDF + FYM @ 2.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	29.72	9.08	0.90	2.50	26.22
N_2- 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	33.76	10.20	1.05	2.73	27.59
N_3- 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	26.67	8.53	0.82	2.31	25.85
SEm±	0.69	0.19	0.02	0.05	0.51
CD (P=0.05)	2.05	0.57	0.05	0.15	NS
Interaction (C × N)	NS	NS	NS	NS	NS

Table 5: Plant height, number of branches plant^{-1}, seed yield, stover yield and harvest index of soybean as influenced by cropping systems and nutrient management practices (pooled data over 2 years).

Treatments	Plant height (cm)	No. of branches plant^{-1}	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Cropping system (C)					
C_3 - Sole soybean	55.56	10.41	1.77	3.61	32.86
C_5 - Rice + soybean (3:1)	51.86	9.42	0.83	1.77	31.78
SEm±	0.75	0.18	0.02	0.08	0.51
CD (P=0.05)	2.21	0.54	0.07	0.22	NS
Nutrient management (N)					
N_1- 100% RDF + FYM @ 2.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	52.21	9.72	1.26	2.58	32.55
N_2- 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	58.02	10.78	1.53	3.11	33.11
N_3- 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed	50.90	9.25	1.10	2.38	31.30
SEm±	0.92	0.22	0.03	0.09	0.62
CD (P=0.05)	2.70	0.66	0.09	0.27	NS
Interaction (C × N)	NS	NS	NS	NS	NS

soil conductive to better plant growth. Vala *et al.* (2017) reported that application of 75% RDF + 25% N through FYM + Biofertilizer recorded significantly taller plants at harvest, higher plant spread. The present findings are in close agreement with the results obtained by Zalate and Padmani (2010).

Application of different cropping system did not show any significant effect on harvest index of groundnut. The effect of different nutrient management did not bring significant impact on the harvest index of groundnut (Table 4).

Growth and yield of soybean

Significantly a taller plant height, number of branches plant^{-1}, seed and stover yield was recorded at sole soybean and the lowest was recorded at rice intercropped with soybean (Table 5). This may be due to absence of intercrop competition. The result corresponds with those of Kithan (2012) and Aye (2013). The significant reduction in yield observed from the intercrop plots may be attributed to inter specific competition among the plants for space, nutrients, light, water *etc*. Similar findings was reported by Pal *et al.* (1993).

The pooled data of both the years revealed a significant difference with the highest plant height, number of branches plant^{-1}, seed and stover yield when the crop was applied with 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed. The lowest plant height and number of branches plant^{-1} was recorded, when the crop was applied with 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed (Table 5). This increase in N_2 treatment might be due to greater availability of macro and micronutrients, form of organic and inorganic sources which helped in acceleration of various metabolic processes of N P and k which help in better absorption of nutrients coupled with proper distribution, these results are in conformity with the reports of Dash *et al.* (2005). These findings are in accordance with the results of Babalad (1999) who had also observed increased plant height, the number of trifoliate leaves plant^{-1} and the number of branches plant^{-1} in soybean due to the application of organic manure and inorganic fertilizers.

CONCLUSION

The present investigation revealed that among intercropping systems rice+ soybean intercropping system was found to be the most suitable. This system recorded highest grain yield and the highest rice equivalent yield. Among the different nutrient management adopted, N_2- 75% RDF along with FYM @ 5 t ha^{-1} and biofertilizer consortium @ 20 g kg^{-1} seed found to be most suitable as it recorded maximum production under the rainfed condition of Nagaland.

Conflict of interest: None.

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