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SUSTAINABLE AGRONOMIC APPROACHES FOR ENHANCING GROWTH AND YIELD OF RICE

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Abstract

Field experiment was conducted at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalainagar to evaluate the sustainable agronomic approaches for enhancing growth and yield of rice. The experiment was laid out in Randomized Block Design and replicated thrice. The results revealed that application of 75% N through urea + 25% N through vermicompost + $ZnSO_4$ @ 25 ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (T_9) recorded the maximum growth, yield attributes, yield, net return and benefit cost ratio.

Key words : Rice, vermicompost, nitrogen, zinc and iron.

Introduction

Rice (*Oryza sativa* L.) is one of the staple food crops in India. Rice is grown in 114 countries across the world with an area of 162.71 million hectares with the production of 741.48 million tonnes with the productivity of 4.55 t ha^{-1} (FAO, 2014). In Tamil Nadu, rice is grown in an area of 2.10 million hectares with a production of 7.12 million tonnes with the productivity of 3.4 t ha^{-1}. Highly intensified chemical agriculture with repeated application of fertilizers and pesticides has resulted in environmental pollution, soil degradation, depletion of soil fertility and decline the crop productivity. Though synthetic fertilizers have contributed more for enhancing agricultural production, their extensive use for longer period have contributed equally or more negatively in erosion of soil fertility and decline in productivity level (IRCN, 2001), environmental pollution with adverse effects on human health, biotic and ecosystem (IRRI, 2003).

Use of agricultural chemicals for increasing food production is necessary in the present context where food security and livelihood issues of the people have attained national priority. The only way out to this gloomy scenario is to develop sustainable and nutrient balanced technology packages, which would increase the food production sustainably without harming the precious environment. The prerequisite for a sustainable agriculture is the balanced supply of plant nutrients. This can be achieved through integrated nutrient management approach, which involves the use of high value organic manures along with inorganic nutrients for increasing the crop yield. Research evidences proved beyond doubt that the complementary use of organic and inorganic sources of plant nutrients can sustain the optimum crop yields and improve the soil health.

Application of organic manures in combination with inorganic fertilizers improves soil health and maximizes sustainable productivity through increased soil humic substances which leads to higher availability of macro and micronutrients to crops (Basha *et al*., 2017). In the recent years, vermicompost has been identified as one of the major gears to convert the biodegradable organic material into resourceful manure. It is rich in available nitrogen, phosphorus, potassium, calcium, vitamins, natural phytoregulators and microflora in balanced form that help in re-establishment of the natural fertility of the soil (Banik and Ranjita Bejbaruah, 2004).

Zinc is one of the first micronutrients recognized as

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essential for plants. It is the micronutrient that most commonly limiting crop yields in Indian soils. It aids in the synthesis of plant growth substances and enzyme systems and is essential for promoting certain metabolic reactions. It is also necessary for production of chlorophyll and carbohydrates. Zinc is essential for several biochemical processes in the rice plant, such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation, and membrane integrity (IRRI, 2000). Iron (Fe) is essential for plant growth and development (Curie and Briat, 2003). Iron deficiency is yield limiting factor with major implications for field crop production in many agricultural regions of the world (Hansen *et al*., 2006). Iron is an important component of enzymes, essential for chlorophyll synthesis and photosynthesis. Rice plants are susceptible to low Fe supply (Takahashi *et al*., 2001).

Materials and Methods

Field experiment was conducted in the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalainagar to evaluate the sustainable agronomic approaches for enhancing growth and yield of rice. The experimental site is situated at 11°24' N latitude and 79° 44' E longitude and at an altitude of +5.79 m above mean sea level. The weather of Annamalainagar is moderately warm with hot summer months. The mean maximum temperature fluctuates between 29.2°C and 37.3°C with a mean of 32.99°C while the minimum temperature ranges from 20.9°C to 26.6°C with a mean of 23.75°C. The relative humidity ranges from 76 to 96 percent with a mean of 86 per cent. The mean annual rainfall received was 1500 mm with a distribution of 1000 mm during North East Monsoon, 400 mm during the South West Monsoon and 100 mm during hot weather period spreaded over 60 rainy days. The mean hours of bright sunshine per day was 9.5. The soil of the experimental field was clay loam in texture with a pH of 7.5. The soil was low in available nitrogen, medium in available phosphorus and high in available potassium.

The experiments were laid out in randomized block design with three replication. Therewere altogether thirteen treatments *viz*., T_1 - Control, T_2 - Recommended dose of nitrogen (RDN) through urea, T_3 - 75% N through urea + 25% N through Vermicompost, T_4 - RDN through urea + $ZnSO_4$ @ 25 kg ha^{-1}, T_5 - 75% N through urea + 25% N through Vermicompost + $ZnSO_4$ @ 25 kg ha^{-1}, T_6 - RDN through urea + $FeSO_4$ @ 50 kg ha^{-1}, T_7 - 75% N through urea + 25% N through Vermicompost + $FeSO_4$ @ 50 kg ha^{-1}, T_8 - RDN through urea + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1}, T_9 - 75% N through urea + 25% N through Vermicompost + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1}. The fertilizers were applied to the experimental field as per the recommended manurial schedule of 120:38:38 kg N, P_2O_5 and K_2O ha^{-1}. Urea (46% N), Single super phosphate (16% P_2O_5) and Muriate of potash (60% K_2O) fertilizers were used to supply N, P and K nutrients, respectively. Nitrogen dose was increased or decreased as per the treatment schedule. Half dose of nitrogen and full dose of phosphorus and potassium were applied basally just before transplanting. The remaining nitrogen was top dressed in two equal splits during active tillering stage and panicle primordial initiation. Zinc sulphate @ 25 kg ha^{-1} and Ferrous sulphate @ 50 kg ha^{-1} were applied basally to the respective treatment plots.

Results and Discussion

Growth characters

Growth characters of rice were significantly influenced by the nutrient management practices (table 1). Among the different treatments tried, T_9 (75% N through urea + 25% N through vermicompost + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1}) recorded the maximum values of plant height (101.50 cm), number of tillers $hill^{-1}$ (434), LAI (6.25), DMP (13130 kg ha^{-1}) and CGR (20.12 g m^{-2} day^{-1}). Nitrogen is the prime element for growth of crop which is responsible for developing good vegetative frame. Substituting chemical nitrogen with vermicompost up to 25 per cent for obtaining a better response than 100 per cent N through chemical fertilizer. Favourable vegetative growth may be attributed to strong architecture of the plant adequately fed with N. Zinc is the precursor of tryptophan which is supposed to play decisive role in synthesis to auxins, the main factor behind apical dominance, growth and development (Anil *et al*., 2012). These ultimately led to improved plant height and tiller production in the treatment supplied with vermicompost, zinc and inorganic fertilizers. Higher LAI and CGR were registered with the application of 75% N through urea +25% N through vermicompost + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @50 kg ha^{-1} (T_9). Enhanced nutrient availability in rhizosphere could have favoured higher nutrient uptake resulting in better crop growth leading to higher LAI and crop growth rate by integration of inorganic nitrogen, vermicompost, zinc and iron. A similar finding was reported earlier by Suseendran (2011), Balasubramanian (2013) and Paul *et al*. (2013).

Yield attributes and yield

Nutrient management practices markedly increased the yield attributes and yield (table 2). The maximum

Table 1 : Effect of nutrient management practices on growth characters of rice.

Treatments	Plant height (cm) at harvest	Tillers (m^{-2}) at maximum tillering stage	LAI at flowering stage	DMP (kg ha^{-1}) at harvest	CGR (g m^{-2} day^{-1}) at flowering to harvest
T_1	82.56	276	5.29	8350	10.95
T_2	85.32	301	5.44	9310	13.06
T_3	88.05	324	5.58	10340	15.41
T_4	91.79	351	5.78	10870	15.97
T_5	95.12	383	5.96	12160	19.12
T_6	91.34	345	5.74	10800	15.88
T_7	94.98	376	5.93	12100	19.06
T_8	98.23	407	6.10	12730	19.93
T_9	101.50	434	6.25	13130	20.12
S.Ed	0.98	7.36	0.06	171.54	0.07
CD (P = 0.05)	2.09	15.63	0.13	363.66	0.15

Table 2 : Effect of nutrient management practices on yield attributes, yield and economics of rice.

Treatments	Number of panicles m^{-2}	Number of filled grains $panicle^{-1}$	Grain yield (t ha^{-1})	Netincome (Rs. ha^{-1})	Return $rupee^{-1}$ Invested
T_1	240	70.90	2.82	17650	1.61
T_2	268	80.14	3.61	28706	1.95
T_3	294	83.05	4.28	37277	2.15
T_4	324	85.77	4.69	45341	2.46
T_5	363	88.68	5.35	53782	2.62
T_6	316	85.04	4.58	42716	2.34
T_7	355	87.73	5.25	51307	2.51
T_8	388	90.68	5.51	56841	2.74
T_9	418	92.74	5.89	60880	2.76
S.Ed	6.23	0.92	0.06		
CD (P = 0.05)	13.21	1.95	0.13		

number of panicles m^{-2} (418), filled grains $panicle^{-1}$ (92.74), and grain yield (5.89 t ha^{-1}) were significantly registered with the application of 75% N through urea + 25% N through vermicompost + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (T_9). The higher yield attributes were due to the application of nitrogen through urea and vermicompost have been found to increase the activity of photosynthesis and enzymes, which are responsible for transformation of carbohydrates, fat metabolism and respiration of plant. Inorganic fertilizers in combination with vermicompost caused the greater translocation of photosynthates from source to sink site that resulted higher yield contributing characters of rice (Barik *et al*., 2008). The better performance of integrated supply of nutrient increased the availability and uptake of nutrients which could have favoured better translocation of photosynthates from source to sink resulting in higher panicle weight. In addition, higher number of filled grains in the aforesaid treatment might have also increased the panicle weight and fertility percentage. The results are similar to the finding of Sujathamma and Srinivasulu Reddy (2004). Application of 75% N through urea + 25% N through Vermicompost + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$@ 50 kg ha^{-1} (T_9) favoured better growth which might have resulted in better utilization of solar energy and intern led to enhanced values of yield attributing characters, which cumulatively resulted in realizing higher yield of rice. Economic efficiency and viability of crop cultivation are mainly referred to the outcome of the crop. In general, higher crop productivity resulted in better economic parameters like net return and benefit cost ratio. Among the different integrated nutrient management practices, application of 75% N through urea + 25% N through vermicompost + $ZnSO_4$ @ 25 ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (T_9) recorded the higher net return of Rs.60,880 ha^{-1} and return $rupee^{-1}$ invested of Rs. 2.76.

Conclusion

The application of nitrogen through chemical fertilizer along with vermicompost, zinc and iron registered the maximum values for most of the parameters like growth, yield attributes and grain yield of rice. Therefore application of 75% of recommended N through urea + 25% N through vermicompost + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} was found to be more effective for improving crop performance, productivity and economics.

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