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RESEARCH ARTICLE :

Growth and yield response of lowland rice to different application methods of zinc with green leaf manuring

P. PRAKASH, M. HEMALATHA, A. VELAYUTHAM, R. AMUTHA AND M. JOSEPH

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SUMMARY : A field experiment was conducted to study the response of rice to different methods of zinc application with incorporation of green leaf manure at Agricultural College and Research Institute, Killikulam, TNAU, Tamil Nadu, during *late Pishanam* season (November - March) of 2015 – 2016. The field experiment was laid out in Randomized Block Design with three replication using rice ADT (R) 45 as a test variety. The treatment consists of twelve treatments, control (RDF alone), two method of application (as basal and foliar spray) of zinc with / without incorporation of green leaf manure *Glyricidia maculata*. Application of $ZnSO_4$ as basal @ 12.5, 25 and 37.5 kg/ha and foliar spray was given at two different levels 0.5 and 1 per cent at tillering and at panicle initiation stage, respectively. The recommended dose of NPK (150:50:50) was applied to all the treatment plots. There are significant difference was noticed in the growth parameters and yield of rice. The growth parameters (plant height, number of tillers, dry matter production), growth analysis (leaf area index and crop growth rate) and yield (grain and straw) were recorded. Among the different treatments, the higher growth parameters was recorded with application of 100% RDF + GLM @ 6.25 t / ha + $ZnSO_4$ @ 12.5 kg / ha as basal + Foliar spray of $ZnSO_4$ @ 1.0% (T_{12}). Maximum grain and straw yield was achieved in the same treatment. The lowest growth parameters and yield (grain and straw) was noticed in the control plot.

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Author for correspondence :
P. PRAKASH
Agricultural College and Research Institute (T.N.A.U.), MADURAI (T.N.) INDIA

See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

Rice (*Oryza sativa* L.) is the most important and major food grain for more than one third of the world's population (Zhao *et al.*, 2011). Rice accounts for about 52 per cent of the total food grain production and 55 per cent of the total cereal production. Even though the area under rice cultivation is large, the productivity is very low when compared to state average due to various factors (Duraisami and Mani, 2002). The continuous use of high analysis fertilizers in an imbalanced manner has aggravated and resulted in additional problems of soil fertility. This

progressively impoverished the soils of their native nutrient reserves, leading to the multiple nutrient deficiencies, in particular the micronutrient deficiencies (Reddy and Reddy, 1999). Among the micronutrients, Zn and Fe considered to be an important element for rice growth. However, in lowland condition availability of zinc alone reduced due to redox potential of puddled soil and higher clay content thereby fixed in the soil. The variation in availability of macro and micro nutrient usage is one of the main factors responsible for the low productivity. This may be eliminated by application of zinc by different methods. Globally, more than 30 per cent of soils are low in plant-available Zn (Hajiboland *et al*.,2003). Zinc application methods are aimed at improving Zn availability for plant uptake. Selection of appropriate method of application is considered to be an alternative strategy to improve plant availability of Zn under lowland conditions (Ghoneim, 2016). Soil application of zinc as basal an effective method to meet earlier requirement of the crop growth. Foliar application is one of the most effective and safest approaches to enrich essential micronutrients in crop grain. Foliar applied nutrient substances can enter the leaf either by penetration of the cuticle or via the stomatal pathway. Foliar application is increasingly used to alleviate micronutrient deficiencies (Fang *et al*., 2008). In situ incorporation of green manuring is one of the effective method to enhance the availability of nutrients macro as well as micro nutrients. It increases the organic matter content and fastened the mobilization of nutrients thereby nutrient availability is higher in incorporated field.

RESOURCES AND METHODS

The proposed research study was conducted at Agricultural College and Research Institute, Killikulam, TNAU, during *late Pishanam* season (November – March) of 2015-2016. The farm is geographically located in the southern part of Tamil Nadu at 8°46' N latitude and 77°42'E longitude at an altitude of 400 m above mean sea level.

The experimental site is situated in semi-arid tropical region**.** The mean annual rainfall is 786.6 mm received in 40 rainy days. The mean maximum and minimum temperature of the location were 33.4 °C and 23.6 °C, respectively. The soil of the experimental field is sandy clay loam in texture. The fertility status was low in available nitrogen (237 kg ha^{-1}), medium in available phosphorus (18 kg ha^{-1}), medium in available potassium (240 kg ha^{-1}), Organic carbon (0.64 %), pH (1:2 soil water suspension) (7.4) and diethylenetriaminepenta acetic acid (DTPA) extractable Zn in soil was 0.8 mg kg^{-1} of soil.

The experiment was laid out in Randomized Block Design, replicated thrice using ADT (R) 45 as the test variety. The experiment was carried out with the following treatments *i.e.* 100% RDF alone (T_1) and it was in combination with $ZnSO_4$ @ 25.0 kg / ha as basal (T_2), 37.5 kg / ha as basal (T_3), $ZnSO_4$ @ 0.5% as foliar spray (T_4), 1.0% as foliar spray (T_5). The treatment T_6 to T_8 consist of 100% RDF + GLM @ 6.25 t / ha + $ZnSO_4$ @ 12.5 kg / ha as basal (T_6), 25.0 kg / ha as basal (T_7) and 37.5 kg / ha as basal (T_8). For treatment T_9 and T_{10} instead of basal application, the $ZnSO_4$ was given as 0.5% foliar spray (T_9) and 1.0% foliar spray (T_{10}) with 100% RDF + GLM @ 6.25 t/ha. The treatment T_{11} and T_{12} consist of all combination in 100% RDF + GLM @ 6.25 t / ha + $ZnSO_4$ @ 12.5 kg as basal + 0.5% $ZnSO_4$ as foliar spray (T_{11}) and 1.0% foliar spray (T_{12}).

The recommended dose of fertilizer *viz.*, 150:50:50 kg N, P_2O_5 and K_2O ha^{-1} was applied to all the plots. The entire P fertilizer was applied as basal in the form of Diammonium phosphate (18 % N and 46 % P_2O_5). The N fertilizer was applied in the form of urea (46 % N) and applied in four equal splits*viz.*,one at basal and remaining at activetillering, panicle initiation and heading stages. The K fertilizer was applied in the form of Muriate of Potash (60 % K_2O) in four equal splits *viz.*,one at basal and remaining at active tillering, panicle initiation and heading stages along with N.

Leaves and twigs of *Glyricidia maculate* @ 6.25 t ha^{-1} was collected from the farm and incorporated in the respective plots at ten days before transplanting. After incorporation the field was puddled two times and leveled two days prior to planting. Zinc sulphate 12.5, 25, 37.5 kg/ha was mixed with sand to uniform distribution and applied as basal before the transplanting to the respective plots as per the treatment. Zinc sulphate at 0.5 and 1 per cent foliar spray was given in two times *viz.*, at active tillering and panicle initiation. Data on growth parameters (plant height, number of tillers $hill^{-1}$ and dry matter production, leaf area index and crop growth rate) were recorded at tillering and panicle initiation and at harvest stage, respectively. The grain and straw yield were also recorded.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Growth parameters of rice:

In the present study, the growth parameters *viz.*, plant height, total number of tillers hill^{-1} and dry matter production are greatly influenced by different methods of zinc nutrition and green leaf manure application at various stages of observation. Among the different treatments the higher growth parameters were recorded with the application of 100% RDF + GLM @ 6.25 t / ha + $ZnSO_4$ @ 12.5 kg / ha as basal + Foliar spray of $ZnSO_4$ @ 1.0%. However, it was at par with the application of 100% RDF + GLM @ 6.25 t / ha + $ZnSO_4$ @ 12.5 kg / ha as basal + Foliar spray of $ZnSO_4$ @ 0.5%. (Table 1)

Increased in plant height might be attributed to accelerate the enzymatic activity and auxin metabolism in plants, which promote growth of the rice. Similar results were reported by Maqsood *et al*. (1999) and Alloway (2008). And also adequate availability of zinc and its role on growth hormone production which is particularly important for internode elongation might have contributed for better growth attributing characters. These findings are confirmity with earlier results observed by Cheema *et al.* (2006) and Calvin *et al.* (2001) in rice. Adequate soil application of zinc sulphate and green leaf manuring increased the availability of zinc at early stages of the crop followed by foliar application of zinc maintains the availability of nutrients at later stages found greater production of tillers (Fig. 1). This is in line findings with Slaton *et al*. (2005) and Naik and Das. (2007). The higher dry matter production in the above said treatment might be due to application of zinc sulphate as basal with green leaf manuring causes good growth at earlier stages as well as the entire growth period which in turn increased leaf area, tiller numbers and in turn in higher DMP (Fig. 2). These findings confirmation with the results of Bisht *et al*. (2006) and Pooniya and Shivay, 2012.

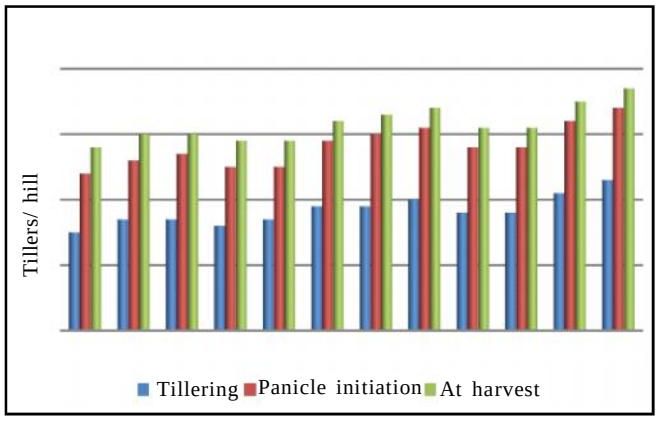

Fig. 1 : Methods of zinc nutrition with green leaf manuring on tiller production of rice

Table 1 : Methods of zinc nutrition with green leaf manuring on growth attributes of rice

Treatments	Plant height (cm)			Number of tillers hill^{-1}			Dry matter production (kg ha^{-1})		
	T	PI	HA	T	PI	HA	T	PI	HA
T_1	30	81	96	15	24	28	1426	8483	12659
T_2	34	85	102	17	26	30	1587	9144	13408
T_3	35	85	102	17	27	30	1669	9317	13737
T_4	31	82	99	16	25	29	1470	8739	12947
T_5	32	84	102	17	25	29	1508	8995	13124
T_6	37	89	107	19	29	32	1788	9783	14234
T_7	38	90	108	19	30	33	1812	9987	14659
T_8	41	91	110	20	31	34	1851	10002	14864
T_9	35	89	108	18	28	31	1684	9444	13854
T_{10}	36	91	109	18	28	31	1717	9510	13933
T_{11}	43	92	112	21	32	35	1869	10097	15218
T_{12}	45	93	115	23	34	37	1952	10242	15806
S.E.±	2	3	5	1	1	2	92	247	329
C.D.(P=0.05)	5	6	10	2	3	4	100	514	682

Tillering (T), Panicle initiation (PI), Harvest stage (HA)

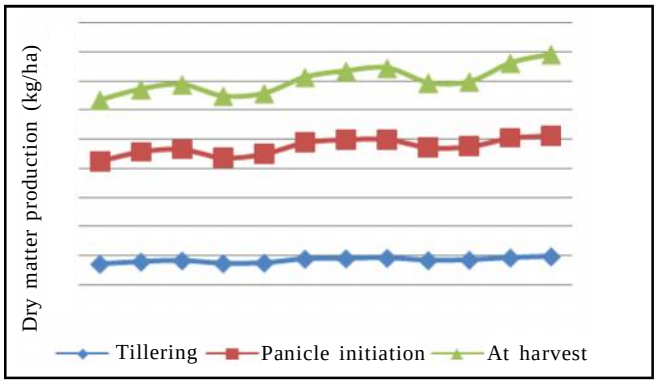

Fig. 2 : Methods of zinc nutrition with green leaf manuring on dry matter production of rice

Growth analysis of rice:

Growth analysis based on the responses to various factors of environment, provides a means to improve yield of crops by modifying the controllable factors of the environment. The higher value of growth analysis *viz*., leaf area index and crop growth rate were recorded with the application of 100% RDF + Green leaf manure @ 6.25 t/ha + $ZnSO_4$ @ 12.5 kg/ha as basal + Foliar spray of $ZnSO_4$ @ 1.0% (Table 2).

In general, LAI has a close correlation with grain yield. LAI was found to increase in all along the vegetative phase and attained its maximum at panicle initiation stage. The higher LAI might be due to greater availability of nutrients, vigorous root activity, greater expansion of the leaf blades and better soil fertility by application of zinc + green leaf manuring leads to more number of tillers which in turn increased the LAI. This finding was conformity with the results of Singh and Shivay (2014) and Yaseen *et al*. (1999).

CGR makes the assessment of crop productivity unit land^{-1} and it is the derivative of dry matter production and was significantly influenced by zinc nutrition as basal + foliar spray coupled with green leaf manure. There was a progressive increase in CGR, which reached its peak at panicle initiation stage and then decreased gradually. This might be due to rate of photosynthesis, respiration and canopy area interaction. The decreasing trend might be due to leaf abscission at the later stages. A similar result was closely related to the findings of Saha *et al*. (2007) and Ghasal *et al*. (2015).

Grain and straw yield :

Grain and straw yield were favorably influenced by different method of application of zinc with green leaf manuring. The treatment receives RDF + green leaf manure + $ZnSO_4$ 12.5 kg / ha as basal + 1% foliar spray had recorded maximum rice grain and straw yield. It was followed 100% RDF + GLM @ 6.25 t / ha + $ZnSO_4$ @ 12.5 kg / ha as basal + 0.5 % foliar spray (Table 3). The yield increased of these two treatments was not significantly different from many other treatments. The yield increase was due to increased crop growth and thus, influenced the yield attributes by application of

Table 2 : Methods of zinc nutrition with green leaf manuring on growth analysis of rice

Treatments	Leaf area index		Crop growth rate (kg ha^{-1} day^{-1})	
	T	PI	T-PI	PI-HA
T_1	2.19	4.21	235	139
T_2	2.49	4.30	252	142
T_3	2.54	4.32	255	147
T_4	2.25	4.25	242	140
T_5	2.34	4.27	250	138
T_6	2.70	4.54	267	148
T_7	2.72	4.62	272	156
T_8	2.88	4.62	272	162
T_9	2.60	4.45	259	147
T_{10}	2.65	4.50	260	147
T_{11}	2.90	4.77	274	171
T_{12}	2.96	4.89	276	185
S.E.±	0.15	0.19	9	13
C.D. (P=0.05)	0.31	0.40	20	27

Tillering (T), Panicle initiation (PI), Harvest stage (HA)

organic sources (GLM), recommended inorganic fertilizers such as NPK and zinc applied at entire crop growth stages (Fig. 3).

Table 3: Methods of zinc nutrition with green leaf manuring on grain and straw yield (kg ha^{-1}) of rice

Treatments	Grain yield	Straw yield
T_1	5776	6739
T_2	6166	7127
T_3	6322	7257
T_4	5888	6773
T_5	6009	6850
T_6	6569	7460
T_7	6751	7625
T_8	6850	7757
T_9	6384	7296
T_{10}	6410	7339
T_{11}	6991	7886
T_{12}	7105	8072
S.E.±	217	247
C.D.(P=0.05)	452	514

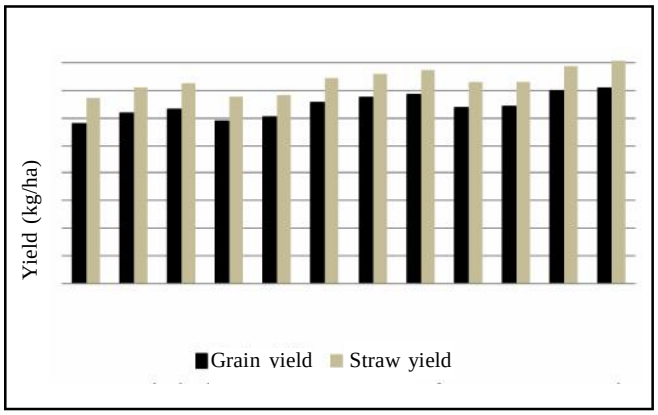

Fig. 3 : Methods of zinc nutrition with green leaf manuring on grain and straw yield (kg ha^{-1}) of rice

As well as it was due to the zinc nutrition, 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) might have boosted the crop growth for the better production of biological as well as economical yield of rice. The current studies corroborated with earlier findings of Khan *et al.* (2007) and Singh and Shivay (2016).

Conclusion:

Combined application of zinc through basal + foliar with green leaf manuring significantly influenced the growth and yield of rice. Application of zinc with basal and two foliar spray of zinc sulphate at tillering and panicle initiation stage with incorporation of green leaf manuring which reduces the pH towards the acidity and enhances the availability of zinc to the plants resulting higher growth and growth analysis of rice. From the experimental results, it could be concluded that application of 100% RDF + GLM @ 6.25 t / ha + $ZnSO_4$ @ 12.5 kg / ha as basal + Foliar spray of $ZnSO_4$@1.0% could be considered as a better option for achieving higher productivity of rice.

Authors' affiliations :

M. HEMALATHA AND A. VELAYUTHAM, Agricultural College and Research Institute (T.N.A.U.), KILLIKULAM (T.N.) INDIA

R. AMUTHA, Agricultural College and Research Institute (T.N.A.U.), MADURAI (T.N.) INDIA

M. JOSEPH, Agricultural Research Station (T.N.A.U.), KOVILPATTI (T.N.) INDIA

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