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Effect of FYM and Zinc Nutrition on Growth, Yield and Grain Fortification of Different Rice Varieties

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ABSTRACT

A field experiment was conducted at the Agricultural College Farm, Bapatla on a clay loam soil during *kharif* season of 2012 to study the effect of different treatments on improving the zinc content in the grain of different rice varieties. The findings of the experiment revealed that the higher grain yield, straw yield, harvest index and zinc content in rice grain were recorded with the variety, Akshaya (BPT 2231). Significant improvement in productivity and zinc content of rice grain in rice were noticed with soil application of FYM @10 t ha^{-1} along with zinc through foliar spraying twice at panicle initiation and heading stages.

Key words : Foliar spray, Rice varieties, Soil application, Yield and Zn content.

Rice is the staple food crop for more than half of the world's population which supplies adequate energy in the form of calories and is a good source of thiamine, riboflavin and niacin (Stalin *et al*., 2011). But, it is a poor source of many essential mineral nutrients, especially Zn and Fe which are specially required for human nutrition. Undoubtedly, with the introduction of high yielding varieties of cereals expecially rice and their continuous cultivation caused the deficiency of secondary and micronutrients in time and space which resulted in yield stagnation (Gill and Singh, 2009).

In this context, zinc (Zn) deficiency is a well-documented problem in food crops causing decreased crop yields and nutritional quality. In rural India, rice and wheat contribute to nearly 75 % of the daily calorie intake. Among cereal crops especially rice provides 50-80 % of energy intake of the people in developing countries, however, it is a poor source of many essential nutritional substances especially micronutrient *viz,* zinc . The major reason for zinc deficiency is the reliance on cereal-based diets may induce Zn deficiency-related health problems in human beings. For better zinc nutrition of human beings, cereal grains should contain around 40-60 mg Zn kg^{-1}, but in the present situation, the polished rice grain contains an average of 12 mg Zn kg^{-1} only. Zn plays an important role in the production of proteins in the body and thus, helps in wound healing, blood formation and growth and maintenance of all tissues. Zn also supports immune function and storage release and function of insulin and it is important in host defence mechanism against cancer (Rajendra Prasad, 2010). Zn deficiency is responsible for many severe health complications, including impairments of physical growth, immune system and learning ability, combined with increased risk of infections, DNA damage and cancer.

It is, therefore, essential to have a short-term approach to improve Zn concentration in cereal grains. Application of Zn fertilizers or Zn-enriched NPK fertilizers (e.g. agronomic biofortification) offers a rapid solution to the problem. Agronomic biofortification would be a very attractive and useful strategy in solving Zn deficiency related problems globally and effectively.

MATERIAL AND METHODS

A field experiment was conducted during *kharif*, 2012 at the Agricultural College Farm, Bapatla. The soil was clay loam (sand 28 %, silt 24 %, clay 48 %) with pH 8.0, organic carbon 0.4% and 210, 20, 362 kg ha^{-1} and 0.6 ppm available N, P_2O_5, K_2O and Zn, respectively. The soil was deficient in available zinc. The experiment was laid out in Randomized Block Design with Factorial Concept and replicated thrice. The experiment consisted of three varieties (BPT 2231, MTU 1061, NLR 145) and six treatments viz., Recommended NPK only (T_1), T_1 + 10 t ha^{-1} FYM (T_2), T_1 + 50 kg $ZnSO_4$ ha^{-1} as soil application (T_3), T_1 +10 t ha^{-1} FYM+ 50 kg $ZnSO_4$ ha^{-1} as soil application (T_4), T_1 + 10 t ha^{-1} FYM + 0.5 % $ZnSO_4$ foliar spray at panicle initiation (PI) and heading stages (T_5), T_1 + 0.5% $ZnSO_4$ foliar spray at PI and heading stages (T_6). Twenty eight day old seedlings were transplanted with a spacing of 20 cm ×15 cm. A well decomposed farmyard manure as per the treatments was used as organic source for NPK applied at the time of final land preparation just 3 days prior to zinc application. A common dose of 160 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} was applied through urea, single superphosphate and muriate of potash respectively. Entire quantity of phosphorus and half of potassium and one third of the N was applied at the time of final land preparation just before transplanting. The remaining nitrogen was applied in two equal splits at active tillering (30 DAT) and panicle initiation (60 DAT) stages. The remaining half of K was applied at PI stage. Zinc sulphate @ 50 kg ha^{-1} was applied to soil 3 days after N, P and K application as per the treatments. For foliar application of Zn, sprays of $ZnSO_4$ (0.5 %) were given (500 L ha^{-1}) with hand sprayer during morning hours. However, no measurable foliar burning or precipitation was recorded within 24 hours of foliar treatments imposed.

Plant samples at harvesting stage from different treatments were utilized for chemical analysis after grinding into fine powder. Zinc content in the grain samples and its uptake by plant was determined by Atomic absorption Spectro-photometer method (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Effect on growth

Foliar spraying of zinc along with FYM application influenced growth parameters such as plant height, number of tillers m^{-2}, drymatter production which, in turn, increased the yield of crop (Table 1). All the growth parameters were significantly influenced by varieties and treatments. However, interaction between varieties and treatments was not significant. Taller plants were observed with the variety MTU 1061, whereas higher number of tillers m^{-2}, drymatter production was observed with the variety BPT 2231. Among all the treatments, treatment T_5 (10 t ha^{-1} FYM + 0.5 % $ZnSO_4$ foliar spray at PI and heading stages) recorded highest plant height, number of tillers m^{-2}, drymatter production. This might be due to quicker and better utilization of zinc through foliar feeding at different growth stages of rice which might have increased the plant height. These results are in agreement with the findings of various scientists like Kumar *et al*. (1999) and Chaudhary and Sinha (2007).

Days to 50 % flowering and days to maturity were more for BPT 2231. Among the various treatments, T_5 (10 t of FYM + Zn 0.5% foliar spray twice at PI and heading stages) took lesser number of days (105.7) to attain 50 % flowering, which was on a par with T_6 (Zn 0.5% foliar spray twice at PI and heading stages).

Effect on yield

Foliar spraying of zinc along with FYM application influenced yield components which, in turn, increased the yield of crop (Table 2). Among the varieties, more productive tillers, total grains panicle^{-1} and filled grains panicle^{-1} were observed with BPT 2231 (202.9, 173.4 and 152.2 respectively) and found significantly superior to NLR 145 (181.4, 170.1 and 148.4 respectively) and MTU 1061 (171.5, 165.7 and 143.8 respectively) whereas, higher test weight (21.4g) was recorded with the variety, MTU 1061. Among the various treatments tested, higher number of productive tillers m^{-2}, total grains panicle^{-1}, filled grains panicle^{-1} and test weight (190, 175.4, 152.3 and 20.9 g respectively) were observed with T_5 (10 t of FYM ha^{-1} along with Zn 0.5% foliar spray twice at PI and heading stages) which was on a par with T_6 (Zn 0.5% foliar spray twice at PI and heading stages) and T_4 (10 t of FYM along with soil application @ 50 kg $ZnSO_4$ ha^{-1}) and found significantly superior to rest of the treatments. This increase in yield attributes due to foliar application of zinc might be due to increased photosynthetic rate, excessive accumulation of sucrose, glucose and fructose in leaves, which might have increased the physiological parameters of the plant. The present findings are in accordance with the results obtained by Kumar *et al*. (1999) and Chaudhary and Sinha (2007).

Table 1.Growth of rice as affected by different nutrient combinations and varieties.

Particulars	Plant height (cm)	Tillers (No m^{-2})	Dry matter production (kg ha^{-1})	Days to flowering	Days to maturity
Varieties (V)					
V_1: BPT-2231 (Akshaya)	108.1	365.2	13231	110.5	140.5
V_2: MTU-1061 (Indra)	112.1	266.4	12168	107.5	137.6
V_3 : NLR-145 (Swarnamukhi)	96.0	291.0	12186	102.5	132.8
SEm$\pm$	0.43	3.92	64.1	0.09	0.17
CD (p=0.05)	1.4	12.3	208	0.4	0.5
Treatments (T)					
T_1: Recommended NPK	100.9	272.2	11847	108.0	138.8
T_2: T_1 + 10 t ha^{-1} of FYM	102.8	289.4	12229	107.7	137.7
T_3: T_1 + soil application of ZnSO4 @ 50 kg/ha.	105.3	304.4	12528	107.0	137.0
T_4: T_1 + 10 t ha^{-1} of FYM + soil application of ZnSO4 @ 50 kg/ha.	106.5	322.0	12622	106.7	136.7
T_5: T_1 + 10 t ha^{-1} of FYM+ ZnSO4 0.5% foliar spray twice at PI and heading stages	109.2	333.0	13099	105.7	135.7
T6: T_1 + ZnSO4 0.5% foliar spray twice at PI and heading stages	107.8	324.1	12844	106.0	136.0
SEm$\pm$	0.45	4.0	78.3	0.12	0.19
CD (p=0.05)	1.6	14.7	248	0.4	0.6
Interaction (V X T)	NS	NS	NS	NS	NS
CV (%)	7.8	11.8	10.2	1.0	1.1

Among the three varieties, BPT 2231 recorded higher grain and straw yields of 5765 and 6966 kg ha^{-1}respectively followed by NLR 145 with 5220 and 6466 kg ha^{-1} and MTU 1061 with 5021 and 6646 kg ha^{-1} respectively . The highest grain and straw yields of 5632 and 6967 kg ha^{-1} was recorded with T_5 (T_1 +10 t of FYM + ZnSO4 0.5% foliar spray twice at PI and heading stages) which was significantly superior to T_6 (T_1 + ZnSO4 0.5% foliar spray twice at PI and heading stages) which, in turn, was on a par with T_4 (T_1 +10 t of FYM along with soil application @ 50 kg $ZnSO_4$ ha^{-1}) and found significantly superior to rest of the treatments. The increased yield with Zn foliar spray might be attributed to enhanced yield components viz., number of productive tillers, number of filled grains $panicle^{-1}$, and faster grain filling and also due to biochemical utilization of zinc in the shoot. The present results corroborate with the findings of Chaudhary and Sinha, 2007 and Malla Reddy *et al*., 2011. Further, Stalin *et al.* (2011) also observed that the supply of micronutrient zinc through foliar spraying resulted in better absorption of this nutrient, thereby helping in photosynthetic activity and effective translocation to storage organs, thus, contributing to the increased yield. Harvest index (45.7) was higher with BPT 2231, which might have more efficiency in converting drymatter into grain. The highest harvest index (46.8) was recorded with T_5 (T_1 +10 t of FYM + Zn 0.5% foliar spray twice at PI and heading stages) which was significantly superior to T_6 (T_1 +Zn 0.5% foliar spray twice at PI and heading stages) and rest of the treatments which might be due to increased efficiency in converting drymatter into grain due to the application of zinc.

Effect on Zn content (ppm) in grain and straw

The variety, BPT 2231 recorded more amount of zinc content in grain (35.8 ppm) and

Table 2.Yield attributes, yield and zinc content of rice varieties as affected by different nutrient combinations.

Particulars	Productive tillers (No m^{-2})	Total grains $panicle^{-1}$	Number of filled grains $panicle^{-1}$	Test weight (g/1000 grains)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Zinc content (ppm)	
								Grain	Straw
Varieties (V)									
V_1: BPT-2231 (Akshaya)	202.9	173.4	152.2	19.7	5765	6966	45.8	35.8	117.3
V_2: MTU-1061 (Indra)	171.5	165.7	143.8	21.4	5021	6646	44.3	30.8	103.0
V_3: NLR-145 (Swarnamukhi)	181.4	170.1	148.4	21.0	5220	6466	44.5	33.2	110.7
SEm±	0.88	0.63	0.58	0.06	40.5	29.9	0.17	0.08	0.30
CD (p=0.05)	3.5	2.0	1.7	0.2	147	91	0.5	0.3	1.1
Treatments (T)									
T_1: Recommended NPK	180.3	163.0	143.0	20.2	5063	6285	43.4	23.1	78.5
T_2: T_1 + 10 t ha^{-1} of FYM	182.3	165.8	145.8	20.7	5212	6517	44.0	24.3	82.6
T_3: T_1 + soil application of ZnSO4 @ 50 kg/ha.	185.4	167.3	147.3	20.8	5283	6744	44.4	32.7	107.1
T_4: T_1 + 10 t ha^{-1} of FYM + soil application of ZnSO4 @ 50 kg/ha.	186.4	173.2	149.7	20.8	5359	6763	44.9	37.1	123.9
T_5: T_1 + 10 t ha^{-1} of FYM+ Zn 0.5% foliar spray twice at PI and heading stages	190.0	175.4	152.3	20.9	5632	6967	46.8	41.3	137.1
T6: T_1 + Zn 0.5% foliar spray twice at PI and heading stages	187.1	173.8	150.7	20.8	5464	6880	45.6	41.0	133.0
SEm±	1.26	0.76	0.67	0.07	40.2	29.9	0.02	0.11	0.35
CD (p=0.05)	4.2	2.4	2.0	NS	123	109	0.6	0.4	1.3
Interaction (V X T)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.7	8.5	7.9	3.2	8.8	10.1	6.2	4.0	5.8

straw (117.3 ppm) compared to other varieties. The maximum Zn content in grain and straw (41.30 ppm and 137 ppm respectively) were recorded with T_5 (T_1 +10 t of FYM + ZnSO4 0.5% foliar spray twice at PI and heading stages) which was on a par with T_6 (T_1 +ZnSO4 0.5% foliar spray twice at PI and heading stages) and these two treatments proved to be significantly superior to rest of the treatments. The increased zinc content in whole grain might be due to direct application of zinc at critical growth stages, which might have helped in increased absorption in the grain during ripening and also due to its direct absorption in plant tissue resulted in increased grain content of zinc. These results are in conformity with findings of Dhaliwal *et al*., 2010 and Stalin *et al*. (2011).

From the foregoing discussion, it can be concluded that application of FYM@10 t ha^{-1} along with zinc through foliar spraying twice at PI and flowering stages was found to be effective in increasing yield parameters leading to higher productivity and also found to be better as this treatment has resulted in higher zinc content in grain and its uptake by plant. The variety, BPT 2231 seems to be the most promising variety in realization of higher grain yield and zinc content in grain.

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