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Fortification of Zinc in Rice-Greengram Cropping System

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ABSTRACT

A field experiment was conducted during *kharif* and *rabi*, 2015-16 on clay loam soils of Regional Agricultural Research Station, Anakapalle to study the effect of fortification of zinc in rice-greengram cropping system. The results revealed soil application of 50 kg $ZnSO_4$ ha^{-1} along with foliar application of 0.2% $ZnSO_4$ at panicle emergence to *kharif* rice significantly enhanced the growth parameters, yield attributes and yield by 11.6 to 15.9 per cent as compared to no application of zinc. Similarly, foliar application of 0.2% $ZnSO_4$ to rice fallow greengram at flowering significantly improved the yield and quality of rice fallow greengram besides realizing higher net returns and hence application of Zinc to rice-greengram system the improved the productivity and quality of this cropping system.

Key words: *Net returns, Rice-fallow greengram, Yield, Zinc content.*

Rice-rice fallow greengram is the major cropping system in North Coastal Zone of Andhra Pradesh. The productivity of pulse crops in this zone is very low (5-7q/ha). Cropping system has attained great significance in intensified agriculture in India and experiments on crop-ping systems are the ultimate solution to overcome the drawbacks of mono cropping system to exploit the soil intensively for enhanced food production. Sustaining the supply of deficient micronutrients along with macronutrients in appropriate amount and right proportion is a key to maximize productivity and quality of grains from micronutrients. The area under the rice and greengram in Andhra Pradesh is 1.484 million hectares and 0.123 million hectares, respectively. Of these 31,007 hectares is under the rice-greengram system in the north coastal zone of A.P. Agronomic biofortification is of great importance in enriching seeds with Zn. It is a complementary approach to breeding strategy and is likely to be required for ensuring success of breeding efforts. In case of greater bioavailability of the grain Zn derived from foliar application than from soil, agronomic biofortification would be a very attractive and useful strategy in solving Zn deficiency-related health problems globally (Cakmak, 2008). Hence, a trial was undertaken to study the effect of Zinc on growth, yield and the content of Zn in grains/seeds of rice- greengram system.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* and *rabi*, 2015-16 at Regional Agricultural Research Station, Anakapalli. The soil was clay loam in texture with a neutral pH of 7.42 and EC of 0.22 dSm^{-1}, medium in organic carbon (0.64%), low in available nitrogen (200.7 kg ha^{-1}), medium in available phosphorus (22.1 kg ha^{-1}), high in available potassium (358.4 kg ha^{-1}) and low in available zinc (0.37 ppm). The experiment was laid out in a randomized block design with six treatments in four replications for rice crop during *kharif* and in *rabi* each of these six treatments were further subdivided into three subtreatments each in split plot design and replicated four times for the rice fallow greengram (Table 1 and 2). A total rainfall of 837.4 mm was received in 34 rainy days during the growth period of rice, while no rain was received during the growth period of rice fallow greengram. During *kharif* , rice variety MTU-1001 was transplanted by adopting a spacing of 20 x 10 cm. A recommended dose of 120 kg N, 60 kg P_2O_5 and 50 kg K_2O ha^{-1} was applied through urea, single superphosphate and muriate of potash, respectively. During *rabi*, greengram was sown immediately after harvesting the rice crop. Data on growth and yield parameters of rice and greengram along with grain/seed content of Zinc was recorded. Statistical analysis of all the data collected are carried out following the analysis of variance technique for randomized block design (RBD) and split plot design as outlined by Gomez and Gomez, 1984. Zinc content in the plants was estimated by using Atomic Absorption Spectrophotometer method, Lindsay and Norvell, 1978.

RESULTS AND DISCUSSION

The results indicated that the growth parameters (Table 1) *viz.,* plant height and drymatter production at harvest were significantly influenced by the zinc treatments applied to rice. Taller plants and highest drymatter were recorded with soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence (M_5) which was on a par with that of soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at flowering (M_6) and both of them were on a par with soil application of 62.5 kg $ZnSO_4$ ha^{-1} (M_4) and soil application of 50 Kg $ZnSO_4$ ha^{-1} (M_3) but were significantly superior to all the other treatments taken for study. The increase in plant height and dry matter might be due to zinc application and it's inter-relationship with auxin production, an important growth promoter regulating the stem elongation and cell enlargement Khanda *et al*. (1997) and Sreenivasa Rao, (2003).

Various zinc treatments have significantly influenced the yield attributing characters *viz*., productive tillers m^{-2} and filled grains $panicle^{-1}$. Among the different treatments, soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence (M_5) resulted in highest values of these yield attributes which were on a par with soil application of 62.5 kg $ZnSO_4$ ha^{-1} (M_4) and these two treatments were comparable with soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at flowering (M_6) and soil application of 50 Kg $ZnSO_4$ ha^{-1} (M_3) while they were significantly superior to rest of the treatments M_2 (soil application of 37.5 Kg $ZnSO_4$ ha^{-1}) and M_1 (Control-No zinc). This increase in productive tillers due to soil and 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. Similar findings were also reported Ravikiran and Reddy (2004).

The highest grain yield were recorded (Table 1) with soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence (M_5) which was on a par with that of soil application of 62.5 kg $ZnSO_4$ ha^{-1} (M_4) and both of them were comparable with application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at flowering (M_6) and soil application of 50 Kg $ZnSO_4$ ha^{-1} (M_3). With respect

Table 1. Growth, yield parameters and Zinc content (ppm) in grain of rice as influenced by different zinc treatments.

Treatment	Plant height (cm) at harvest	Drymatter production (kg ha^{-1}) at harvest	Productive tillers m^{-2} at harvest	No.of filled grains $panicle^{-1}$	Grain yield (kg ha^{-1})	Zinc content in grain (ppm)
M_1 :Control	112.4	10100	259	120	5070	20.0
M_2 : 37.5 kg $ZnSO_4$ ha^{-1}	114.4	10800	276	129	5205	22.0
M_3 : 50 kg $ZnSO_4$ ha^{-1}	119.0	11400	290	141	5614	25.0
M_4 : 62.5 kg $ZnSO_4$ ha^{-1}	121.0	12100	312	152	5709	27.0
M_5 : 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence	123.9	12250	318	158	5878	29.5
M_6 : 50 kg $ZnSO_4$ ha^{-1}+ 0.2% spray of $ZnSO_4$ at flowering	122.4	12025	305	150	5661	29.5
SEm±	2.42	410.47	9.36	5.99	158.4	0.92
CD (P= 0.05)	7.3	1237	28	18	477	2.7
CV (%)	4.07	7.17	6.38	8.46	5.73	7.23

to quality characters of rice, highest zinc content in rice grain was recorded with soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence (M_5) statistically similar with application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at flowering (M_6) which were on a par with that of soil application of 62.5 kg $ZnSO_4$ ha^{-1} (M_4) while M_4 was on a par with M_3 (soil application of 50 Kg $ZnSO_4$ ha^{-1}). The increased grain yield with zinc foliar spray might be attributed to enhanced yield components viz., number of productive tillers, number of filled grains $panicle^{-1}$, faster grain filling and also due to biochemical utilization of zinc in the shoot. These results are in complete agreement with the findings of Ravikiran and Reddy (2004). The increased zinc content in 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. Similar findings were also reported by Khan *et al*. (2003); Stalin *et al*. (2011);

Among the growth parameters of rice fallow greengram (Table 2), highest drymatter production was recorded with soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence (M_5) followed by soil application of 62.5 kg $ZnSO_4$ ha^{-1} (M_4) and both of them were on par with application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at flowering (M_6) and soil 50 Kg $ZnSO_4$ ha^{-1} (M_3). Increase in drymatter production may be due to optimum dose of zinc sulphate which significantly enhanced vegetative and reproductive growth. With respect to the yield attributes *viz.,* number of pods per plant were found to differ significantly only among the subplots. The maximum number of pods per plant were recorded in S_3 (foliar application of 0.2% spray of $ZnSO_4$ at 25 DAS + 0.2% spray of $ZnSO_4$ at flowering) which was on a par with foliar application 0.2% spray of $ZnSO_4$ at flowering (S_2).The influence of zinc on seed yield of rice fallow greengram applied in rice crop was found to be non significant in the main plots, where as in the subplots, highest seed yield was recorded with foliar application of 0.2% spray of $ZnSO_4$ at 25 DAS + 0.2% spray of $ZnSO_4$ at flowering (S_3) which was on a par with foliar application of 0.2% spray of $ZnSO_4$ at flowering (S_2). The increase in seed yield due to foliar application of zinc might be due to the concomitant increase in number of pods per plant, and drymatter accumulation. These results are in conformity to those of Rizk and Abdo (2001) and Mali *et al.*(2001). The highest net returns for rice were obtained with soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence (M_5) and with foliar application of 0.2% spray of $ZnSO_4$ at 25 DAS + 0.2% spray of $ZnSO_4$ at flowering (S_3) for rice fallow greengram. The interactions between the treatments of main and subplots for the quantitative and qualitative characters as mentioned above at all the growth stages of rice fallow greengram were found to be non significant.

CONCLUSION

Hence, it can be concluded that soil application of 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence to rice and foliar application of 0.2% of $ZnSO_4$ at flowering to rice fallow greengram was found to improve the growth and yield besides being remunerative and fortifying the zinc content in grain/seed of rice- greengram system.

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Table 2. Growth, yield parameters, Zinc content (ppm) of seed and economics of rice fallow greengram as influenced by different zinc treatments.

Treatment	Drymatter production (kg ha^{-1}) at 60 DAS	Number of pods per plant	Seed yield (kg ha^{-1})	Zinc content in seed (ppm)	Net returns of cropping system (₹ ha^{-1})
Main plots : Rice					
M_1 : Control	2739	6.8	61	29.6	68280
M_2 : 37.5 kg $ZnSO_4$ ha^{-1}	2750	6.8	609	30.8	69823
M_3 : 50 kg $ZnSO_4$ ha^{-1}	2773	7.0	625	31.2	76838
M_4 : 62.5 kg $ZnSO_4$ ha^{-1}	2891	7.5	669	34.6	81285
M_5 : 50 kg $ZnSO_4$ ha^{-1} + 0.2% spray of $ZnSO_4$ at panicle emergence	2864	7.1	657	32.8	82874
M_6 : 50 kg $ZnSO_4$ ha^{-1}+ 0.2% spray of $ZnSO_4$ at flowering	2950	7.3	674	33.6	79195
SEm±	94.95	0.29	25.41	1.44	2592.78
CD (P= 0.05)	NS	NS	NS	NS	8124
CV (%)	9.86	14.60	13.77	15.63	12.22
Sub plots : Rice fallow Green gram					
S_1 : 0.2% spray of $ZnSO_4$ at 25 DAS	2628	5.8	587	27.9	72539
S_2 : 0.2% spray of $ZnSO_4$ at flowering	2845	7.5	647	33.0	77412
S_3 : S_1 + S_2	2972	8.0	685	35.4	79196
SEm±	62.62	0.19	20.09	0.98	1457.23
CD (P= 0.05)	186	0.5	58	2.8	4345
CV (%)	9.20	13.91	15.40	15	9.72
MxS	NS	NS	NS	NS	NS

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