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Influence of zinc on yield attributes and yield of aromatic rice

S PRANEETH KUMAR, S NARENDER REDDY and A SIVA SANKAR

Department of Crop Physiology, College of Agriculture
Professor Jayashankar Telangana State Agricultural University
Rajendranagar, Hyderabad 500030 Telangana, India
Email for correspondence: suvarnapraneeth@gmail.com

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ABSTRACT

The investigations were made to study the effect of Zn on yield attributes and yield of aromatic rice with three treatments of zinc viz 0, 25 and 50 kg $ZnSO_4$/ha and 4 aromatic rice genotypes viz Chittimutyalu, Sumathi, Sugandha Samba and RNR-2354. The experiment was laid out in randomized block design with factorial concept and replicated thrice. The results of the experiment showed that basal application of Zn at 50 kg $ZnSO_4$/ha and among the genotypes Sugandha Samba and RNR-2354 recorded highest grain yield.

Keywords: Aromatic rice; genotypes; zinc; yield

INTORDUCTION

Rice (*Oryza sativa* L) is the most important staple food for a large part of the world's human population especially in east and south Asia. India is the world's second largest producer of white rice accounting for about 20 per cent of world's rice production. The aromatic rice varieties occupy a prime position in national and international markets due to their excellent quality characters namely aroma, fineness and kernel length for cooking. The aroma and taste are due to the presence of chemical compound 2-acetyl-1-pyrolline. Varieties of aromatic rice include Basmathi, Jasmine, Texmati, Wehani and Wild Pecan.

Zinc is an essential micronutrient for crop plants. In India 50 per cent of the soils are Zn-deficient. Zn-deficient soils lead to severe losses in yield and nutritional value. Zn application in rice increases crop productivity and nutritional value. Zn not only improves the quality of plants but also improves the energy value, crude protein and carbohydrate content. It increases grain yield between 20 and 50 per cent (Jat et al 2008). Over the years traditional rice varieties were replaced by modern high yielding varieties. Removal of large quantities of Zn by these varieties continuously without rotation and excessive phosphatic fertilizer use have resulted in depletion of available Zn in the soil. Moreover it is difficult for the farmer to identify Zn deficiency symptoms which are described as Khaira in India (Nagarajan 1983). Many sources of Zn can be applied by different methods. Well tested application methods for Zn include broadcast application, foliar spray, soaking or dusting the seed in Zn solution/dust and dipping the seedling roots in Zn suspension/slurry. Zn deficiency is effectively controlled by field application of $ZnSO_4$. Trials concluded in different agro-ecological zones of India showed that soil application of 25–50 kg/ha of $ZnsO_4$ is optimum for rice

MATERIAL and METHODS

The field experiment was laid out in a factorial randomized black design with four aromatic rice genotypes viz Chittimuthyalu (V_1), Sumathi (V_2), Sugandha Samba (V_3) and RNR-2354 (V_4) and three treatments viz $ZnSO_4$ 0 kg (Zn_0), $ZnSO_4$ 25 kg/ha (Zn_{25}) and $ZnSO_4$ 50 kg/ha (Zn_{50}) replicated thrice. Panicle length was measured from the base primary rachis to the topmost spikelet and the mean was expressed as panicle length in cm. The total number of grains from 10 panicles was counted and mean values were worked out. After counting filled and unfilled grains present on the panicle the filled grain percentage was calculated with the help of following formula:

$$\text{Filled grain (\%)} = \frac{\text{Number of filled grains}}{\text{Total number of grains}} \times 100$$

After counting filled and unfilled grains present on panicles the spikelet sterility percentage was calculated with the help of following formula:

$$\text{Spikelet sterility (\%)} = \frac{\text{Number of unfilled grains}}{\text{Total number of grains}} \times 100$$

Thousand filled grains were counted from each plot and their weight was expressed in grams. Grains from net plot area were thoroughly sun-dried and weighed and yield per hectare was determined based on net plot area. After separation of grains from plants of each plot the straw was sun-dried till a constant weight was obtained and expressed as kg/ha. Harvest index is the ratio of grain yield to the total biological yield (grain + straw) and was calculated for each variety and calculated as:

$$\text{Harvest index} = \frac{\text{Grain yield (kg/ha)}}{\text{Total biological yield (kg/ha)}}$$

RESULTS and DISCUSSION

Data on the effect of Zn on various yield attributes and yield of rice genotypes are presented in Table 1.

There was significant increase in panicle length due to graded levels of Zn application. Highest panicle length of 23.15 cm was recorded with 50 kg $ZnSO_4$/ha which was at par with 25 kg $ZnSO_4$/ha (22.48 cm) in comparison to control (20.71cm). Among the genotypes highest panicle length of 23.19 cm was recorded in Sugandha Samba (V_3) followed by RNR-2354 (V_4) (23.04 cm) and lowest of 19.21 cm in Chittimuthyalu (V_1). Interaction between aromatic rice genotypes and Zn levels was significant. Highest panicle length of 24.60 cm was recorded with 50 kg $ZnSO_4$/ha in variety Sugandha Samba (V_3) whereas lowest of 18.27 cm was recorded in control in case of Chittimuthyalu (V_1). Pooniya et al (2009) observed that Zn fertilization treatments showed significant effect on all the yield attributing characters. Similar results were also reported by Metwally (2011) and Shivay et al (2008).

The number of spikelets/panicle was significantly influenced by Zn levels. Highest number of spikelets/panicle of 127.64 with 50 kg $ZnSO_4$/ha followed by 121.85 with 25 kg $ZnSO_4$/ha was recorded whereas lowest number of spikelets/panicle of 115.19 was recorded in control. Genotype Sugandha Samba (V_3) recorded maximum number of spikelets/panicle (145.67) followed by RNR-2354 (V_4) (129.01) while the lowest (101.53) was recorded in Chittimuthyalu (V_1). In case of interaction genotype Sugandha Samba (V_3) with 50 kg $ZnSO_4$/ha treatment recorded highest number of spikelets/panicle (155.48) whereas lowest was recorded in Chittimuthyalu (V_1) (98.11). Similar results were also reported by Rahman et al (2008) and Khan et al (2007) who reported that the increase in number of spikelets/panicle was due to the effect of Zn in enhancing the physiological functions of the crop like photosynthesis and translocation of plant nutrients which ultimately increased the number of spikelets/panicle.

Highest number of filled grains per hill was recorded with 50 kg $ZnSO_4$/ha (1075.08) followed by 25 kg $ZnSO_4$/ha (971.36) as compared to 872.31 in control. Among the aromatic rice genotypes maximum filled grains 1311.19 per hill were recorded in Sugandha Samba (V_3) followed by RNR-2354 (V_4) (908.19) and minimum (795.61) in Chittimuthyalu (V_1). Under interactions highest number of filled grains per hill (1483.43) was recorded with 50 kg $ZnSO_4$/ha in Sugandha Samba (V_3) and lowest (720.39) with control in Chittimuthyalu (V_1).

Maximum filled grain percentage was recorded with 50 kg $ZnSO_4$/ha (80.71) followed by 25 kg (74.47) as compared to control (69.31%). Among the aromatic rice genotypes maximum filled grain percentage (84.30) was recorded in Sugandha Samba (V3) followed by RNR-2354 (V4) (76.48) and minimum of 68.12 was recorded in Chittimuthyalu (V_1). Under interaction effect Sugandha Samba (V_3) at 50 kg $ZnSO_4$/ha recorded highest filled grain percentage of 88.93 whereas Chittimuthyalu (V_1) reorded lowest percentage of 61.87 with control. Similar increase in filled grain percentage with Zn application was also reported by Metwally (2011) who observed that it is due to role of Zn in pollination and fertilization of the

Table 1. Influence of Zn supply on yield attributes and yield of aromatic rice genotypes

Treatment	Panicle length (cm)	Number of spikelets /panicle	Number of filled grains/hill	Number of unfilled grains/hill	Filled grains (%)	Spikelet sterility (%)	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	HI
V_1Zn_0	18.27	98.11	720.39	443.67	61.87	38.13	18.43	4255.56	10355.56	0.29
V_1Zn_{25}	19.37	101.6	790.38	407.33	66.00	34.00	19.43	4611.11	11260.00	0.29
V_1Zn_{50}	20.01	104.89	876.08	269.33	76.48	23.52	20.40	5833.33	12266.67	0.32
V_2Zn_0	21.20	103.16	806.67	420.00	65.75	34.25	19.10	4947.78	10688.89	0.32
V_2Zn_{25}	23.61	111.23	876.93	367.67	70.46	29.54	20.40	5322.22	11333.33	0.32
V_2Zn_{50}	24.22	115.69	946.38	315.00	75.03	24.97	20.93	6144.44	12644.44	0.33
V_3Zn_0	21.33	135.76	1142.67	290.00	79.71	20.29	19.59	5133.33	11377.78	0.31
V_3Zn_{25}	23.65	145.76	1307.46	243.33	84.28	15.72	22.66	5700.19	12455.56	0.31
V_3Zn_{50}	24.60	155.48	1483.43	185.00	88.93	11.07	24.87	6311.11	13522.22	0.32
V_4Zn_0	22.04	123.72	819.50	352.33	69.90	30.10	19.00	4911.25	11155.56	0.31
V_4Zn_{25}	23.30	128.82	910.67	269.67	77.14	22.86	21.27	5522.22	11633.33	0.32
V_4Zn_{50}	23.78	134.48	994.41	212.33	82.41	17.59	21.43	6195.56	12266.67	0.34
Mean of varieties										
V_1	19.21	101.53	795.61	373.44	68.12	31.88	19.42	4900.00	11294.10	0.3
V_2	23.01	110.03	876.66	367.56	70.41	29.59	20.14	5471.48	11555.60	0.32
V_3	23.19	145.67	1311.19	239.44	84.3	15.7	22.37	5714.88	12451.90	0.31
V_4	23.04	129.01	908.19	278.11	76.48	23.52	20.57	5543.01	11685.20	0.32
Mean of Zn levels										
Zn_0	20.71	115.19	872.31	376.5	69.31	30.69	19.03	4811.98	10894.40	0.31
Zn_{25}	22.48	121.85	971.36	322	74.47	25.53	20.94	5288.94	11670.60	0.31
Zn_{50}	23.15	127.64	1075.08	245.42	80.71	19.29	21.91	6121.11	12675.00	0.33
Variety (V)										
SEm±	0.11	0.72	14.23	7.81	0.59	0.59	0.18	41.07	103.94	0.0029
$CD_{0.05}$	0.31	2.12	41.74	22.89	1.74	1.74	0.52	120.45	304.87	0.0085
Zinc (Zn)										
SEm±	0.09	0.62	12.33	6.76	0.51	0.51	0.15	35.56	90.02	0.0025
$CD_{0.05}$	0.27	1.83	36.15	19.83	1.51	1.51	0.45	104.31	264.02	0.0073
Interaction (V x Zn)										
SEm±	0.19	1.25	24.65	13.52	1.03	1.03	0.31	71.13	180.03	0.005
$CD_{0.05}$	0.54	12.05	72.3	39.65	3.02	3.02	0.91	208.62	NS	0.0147

V_1: Chittimuthyalu, V_2: Sumathi, V_3: Sugandha Samba, V_4: RNR-2354, Zn_0: $ZnSO_4$ 0 kg, Zn_{25}: $ZnSO_4$ 25 kg/ha, Zn_{50}: $ZnSO_4$ 50 kg/ha, HI: Harvest index rice florets and positive role of it in increasing the photosynthetic metabolites which translocate and fill the spikelets.

Zn application at 50 kg $ZnSO_4$/ha resulted in mean spikelet sterility of 19.29 per cent as compared to 30.69 per cent in control. Genotype Sumathi (V_2) (29.59%) recorded maximum spikelet sterility followed by RNR-2354 (V_4) (23.52%) while the lowest was recorded in Sugandha Samba (V_3) (15.70%). Under interaction effect genotype Sumathi (V_2) at control recorded highest spikelet sterility (24.97%) whereas Sugandha Samba (V_3) reorded lowest spikelet sterility of 11.07 per cent with control. Similar reduction in the spikelet sterility with increasing levels of Zn application was also reported by Metwally (2011).

The 1000-grain weight was significantly influenced by Zn levels. With the increase in the Zn levels there was an increase in the test weight. Highest 1000-grain weight of 21.91 g was recorded with 50 kg $ZnSO_4$/ha followed by 20.94 g with 25 kg as against lowest (19.03 g) in control. Suganda Samba (V_3) recorded maximum 1000-grain weight (22.37 g) followed by RNR-2354 (V_4) (20.57g) while the lowest (19.42 g) was recorded in Chittimuthyalu (V_1). In case of interaction effect Sugandha Samba (V_3) at 50 kg $ZnSO_4$/ha recorded highest test weight of 24.87 g and Chittimuthyalu (V_1) recorded lowest test weight of 18.43 g with control. Similar increase in the test weight with increased Zn application was also reported by Metwally (2011), Naik and Das (2007) and Cheema et al (2006).

Highest grain yield of 6121.11 kg/ha was recorded with 50 kg $ZnSO_4$/ha followed by 5288.94 kg/ha with 25 kg while lowest of 4811.98 kg/ha was recorded in control. Among the genotypes Sugandha Samba (V_3) recorded maximum grain yield of 5714.88 kg/ha followed by RNR-2354 (V_4) with 5543.01 kg/ha while the lowest grain yield of 4900.00 kg/ha was recorded in Chittimuthyalu (V_1). Highest grain yield of 6311.11 kg/ha was recorded with 50 kg $ZnSO_4$/ha in Suganda samba (V_3) and lowest of 4255.56 kg/ha was in Chittimuthyalu (V_1) without Zn application (control). Among the Zn levels 50 kg $ZnSO_4$/ha resulted in highest grain yield which can be attributed to highest leaf area index, leaf area duration, fluorescence, photosynthetic rate, panicle length, number of spikelets/ panicle, number of filled grains and test weight. Among the aromatic genotypes Sugandha Samba recorded highest grain yield which can be attributed to more number of effective tillers, leaf area index, panicle length, number of spikelets, filled grains and test weight. Similar increase in the yield with Zn application was attributed to increased synthesis of indole acetic acid which in turn might have helped in initiation of primordial reproductive parts and partitioning of photosynthates towards the grain (Rahman et al 2008).

Highest straw yield of 12675.00 kg/ha was recorded with 50 kg $ZnSO_4$/ha followed by 11670.56 kg/ha with 25 kg while lowest of 10894.44 kg/ha was recorded in control. Among the genotypes Suganda Samba (V_3) recorded maximum straw yield of 12451.85 kg/ha followed by RNR-2354 (V_4) of 11685.19 kg/ha while the lowest of 11294.07 kg/ha was recorded in Chittimuthyalu (V_1). Similar results were also reported by Metwally (2011) who attributed the increase in straw yield to the favorable effect of Zn on the proliferation of roots and thereby increasing the uptake of plant nutrients for the luxurious vegetative growth of plants. Rahman et al (2008) and Pooniya et al (2009) have also reported similar increase in straw yield with Zn application.

Highest harvest index of 0.33 was recorded with 50 kg $ZnSO_4$/ha whereas the lowest of 0.31 was recorded with 25 kg and control treatment. Genotype Sumathi (V_2) and RNR-2354 (V_4) recorded maximum harvest index (0.32) while the lowest (0.30) was recorded in Chittimuthyalu (V_1). Under interaction effect highest harvest index of 0.34 was recorded with 50 kg $ZnSO_4$/ha application in Sumathi (V_2) and lowest of 0.29 in Chittimuthyalu (V_1) without Zn application (control). The harvest index is mainly controlled by partition of photosynthates between grain and straw during the crop growth period. The variation in partitioning of photosynthates in grain and vegetative organs of different treatments might have caused a significant variation in harvest index. Similar results were also observed in their experiment by Maqsood et al (1999).

CONCLUSION

From the present study it can be concluded that increased Zn supply in aromatic rice had positive effect on yield and yield attributes. Among the treatments Zn at 50 kg $ZnSO_4$/ha and genotypes Sugandha Samba (V_3) and RNR-2354 (Vv) resulted in highest yield attributes and grain yield.

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