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Effect of Zinc on Blackgram in Rice- Blackgram Cropping System in Coastal Saline Soils

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ABSTRACT

A field experiment was conducted during kharif and rabi 2002-2003 on a saline soil, that is low in available Zn and N, medium and high in available P and K, respectively, to study the effect of various levels of Zn, method of application and residual effect of Zn on yield, nutrient concentration and nutrient uptake in balckgram. The maximum grain and hulm yields of blackgram were recorded with treatment T6 (25 kg $ZnSO_4$ ha^{-1} to blackgram). Foliar treaments at different stages of blackgram were also compared. The treatments T2, T3 and T4 that received $ZnSO_4$ through soil applications in previous crop of rice recorded low yield compared to direct application. The nutrient status of soil at the end of rice-blackgram cropping sequence indicated that the available N, P and Zn status of soil increased and that of K was found to decrease when compared with the initial soil status.

key words: Rice-blackgram cropping system, Saline soils, Zinc .

Pulses play a significant role in Indian Agriculture as they provide protein-rich components in average human diet. They contain 20-24 per cent *i.e.,* about 2.5 times more amount of protein than in cereal grains and hence, offer the most practical means of eradicating malnutrition. Blackgram is cultivated in an area of 5.55 lakh ha, in Andhra Pradesh with an output of 3.90 lakh tonnes. In Krishna-Godavari zone of Andhra Pradesh, blackgram is grown in about 3,13,648 ha with a productivity of 2 to 2.5 quintals ha^{-1}. The Guntur district alone has 1.74 lakh ha. area under this legume crop. The extent of blackgram cultivation is increasing year by year in Krishna-Godavari zone of Andhra Pradesh. Gradually, the inland salinity problem seems to increase in these deltaic soils. As a consequence of this salinity hazard in rice-pulse cropping system the germination of pulse seed is very poor, even if germination is unhindered, the seeding death is observed at 20-25 days of age. Besides this, zinc deficiency symptoms are exhibited in blackgram crop.

MATERIAL AND METHODS

Twelve treatments comprising of four $ZnSO_4$ levels (0, 12.5, 25 and 50 kg ha^{-1}) were imposed on the two crops of kharif rice and rabi blackgram. Treatments were replicated thrice in RBD concept. The experimental soil (sandy clay loam) had pH and EC values of 8.25, 8.32 and 4.84, 4.26 (dS m^{-1}) in surface (0-15 cm) and sub-surface (15-30 cm), respectively. Prior to raising of kharif paddy, the soil was low, medium and high with respect to available N (239.11 kg ha^{-1}), P_2O_5 (34.4 kg ha^{-1}), and K_2O (420.21 kg ha^{-1}), respectively. Blackgram variety LBG-645 was grown as relay crop succeeding kharif paddy during 2002-03. Blackgram seed was broadcasted at a seed rate of 16 kg ac^{-1}, three days before harvest of rice crop in rice-blackgram cropping system. Zinc in the form of zinc sulphate was applied one day before broadcasing of blackgram seed in the field *i.e.*, four days before harvest of rice crop. Zinc sulphate was applied @ 12.5, 25, 50 kg ha^{-1} as $ZnSO_4$ to T_5, T_6 and T_7 treatments respectively. Treatments T2, T3 and T4 received $ZnSO_4$ @ 12.5, 25, and 50 kg ha^{-1} during the preceding rice. treatment T1 constituted no Zn control. Foliar spraying of 0.2 per cent $ZnSO_4$ at 25 days after sowing (T_8) at flowering (T_9) and at pod formation of crop (T_{10}) were treated, while treatment T_{11} involves the combination of T_8 + T_9. Treatment T_{12} received nither zinc nor NPK (absolute control). Plant samples were collected at harvest stage of blackgram crop. Standard procedures were adopted for the estimation of N,P,K and Zn in these samples. Soil samples were collected at harvest of both the crops of rice and blackgram and compared with initial status.

RESULTS AND DISCUSSION

Effect on yield

The results presented in Table 1 and 2 with respect to seed and haulm yield showed that, the application of zinc at all levels significantly increased

Table 1. Effect of zinc application on seed yield, nutrient concentration and uptake of nutrients in blackgram crop

Treatments	Yield (kg ha^{-1})	Concentration N	P	K	Zn	Uptake N	P	K	Zn
		(per cent)			(ppm)	(kg ha^{-1})			(mg kg^{-1})
T_1	164.0	3.14	0.43	0.80	17.50	5.15	0.71	1.31	2.86
T_2	202.7	3.37	0.45	0.85	21.17	6.81	0.91	1.73	4.27
T_3	246.0	3.43	0.46	0.86	25.50	8.43	1.13	2.13	6.25
T_4	269.3	3.45	0.48	0.89	29.83	9.27	1.30	2.40	8.05
T_5	376.0	3.29	0.45	0.82	23.50	12.36	1.70	3.10	8.82
T_6	412.7	3.51	0.47	0.89	28.83	14.47	1.94	3.69	11.91
T_7	395.3	3.73	0.49	0.88	33.00	14.73	1.95	3.47	13.08
T_8	297.3	3.29	0.46	0.83	20.67	9.81	1.37	2.48	6.15
T_9	312.0	3.29	0.46	0.82	21.17	10.25	1.44	2.56	6.57
T_{10}	361.3	3.30	0.47	0.84	20.83	11.93	1.71	3.02	7.56
T_{11}	360.0	3.22	0.47	0.82	18.50	11.61	1.67	2.97	6.60
T_{12}	102.7	2.96	0.38	0.74	15.67	3.02	0.39	0.76	1.62
SEm$\pm$	28.7	0.07	0.02	0.03	0.91	0.97	0.15	0.27	0.85
CD (0.05)	58.6	0.15	0.03	0.05	1.86	1.99	0.30	0.56	1.73
C.V %	12.05	2.72	3.89	3.90	4.83	12.15	13.27	13.60	14.86

the seed and haulm yield over control. The maximum seed yield (412.7 kg ha^{-1}) was recorded in treatment T_6, which received $ZnSO_4$ @ 25 kg ha^{-1} to blackgram increase was 151.6 and 301.9 over no zinc cotrol (T_1) and absolute control (T_{12}, that received neither N,P,K nor zinc). The increase in seed yield per kg $ZnSO_4$ applied was maximum in T_5 (16.95 kg per kg $ZnSO_4$), followed by T_6 (9.95 kg per kg $ZnSO_4$). Favourable effect of zinc application on seed yield of soybean was reported by Gupta and Vyas (1994) and Singh and Singh (1995).

The highest haulm yield (1666.6 kg ha^{-1}) was recorded in T_6, that received 25 kg $ZnSO_4$ ha^{-1} to blackgram and this treatment recorded 81.5, 138.1 per cent more haulm yield over no zinc control (T_1) and absolute control (T_{12}), respectively. These results are in concurrence with the findings of Sharma *et al.,* (1990) and Vasavirani (1999).

Among foliar treaments, treament T_{10} (0.2% $ZnSO_4$ as foliar spray at pod formation) recorded highest grain yield (361.3 kg ha^{-1}) compared to T_8 (0.2% $ZnSO_4$ foliar spray at 25 DAS), T_9 (0.2% $ZnSO_4$ foliar spray at flowering) and T_{11} (T_8 +T_9). Treatment T_{10} had put up 120.3 and 251.9 per cent more yield over no zinc control (T_1) and absolute control (T_{12}) respectively. These results are in line with the findings of Krishna *et al.* (1997) and Revathy *et al.* (1997).

The treatments T_2, T_3 and T_4 received $ZnSO_4$ @ 12.5, 25 and 50 kg ha^{-1} to the preceding kharif-rice so as to study the residual effect of $ZnSO_4$ applied to previous rice crop on present crop of blackgram. Among these, the treatment T_4, recorded significantly higher seed yield (269.3 kg ha^{-1}) over no zinc control (T_1, 164.0 kg ha^{-1}) and absolute control (T_{12}, 102.7 kg ha^{-1}) which correspond to 64.2 and 162.3 per cent increase over no zinc control and absolute control, respectively. The haulm yield of treaments (T_2, T_3 and T_4) which received $ZnSO_4$ @12.5, 25.0 and 50.0 kg ha^{-1} to previous rice crop were on par with each other and recorded 40.8, 39.8 and 49.6 per cent more haulm yield over no zinc control.

The increase in seed and haulm yield of blackgram due to zinc might be attributed basically to the reason that, zinc shows beneficial effects on chlorophyll content and so it indirectly influences the photosynthesis and reproduction. The channelization of photosynthates during reproductive stage might have been influenced by zinc, by way of its involvement in electron transport (Baker *et al.,* 1982) Sudharsan and Ramaswami (1993) found that residual effect of $ZnSO_4$ gave good seed and haulm yield in blackgram crop in a groundnut-blackgram cropping system. Selvi and Ramaswami (1995) also reported similar results with respect to seed and haulm yiled in blackgram crop in rice-rice-pulse cropping sequence.

Effect on Crop nutrition

The results on the concentration and uptake of nutrients (Zn, N, P and K) are presented in Tables 1 and 2. In grain the highest concentration of Zn (33 ppm), N (3.73%) and P (0.49%) were recorded in T_7 (treament that received 50 kg $ZnSO_4$ ha^{-1}). The treatments T_8, T_9, T_{10} and T_{11} that received 0.2 per cent $ZnSO_4$ through foliar spray were at par with each other with respect to zinc and N concetration in seed. The highest K concentration (0.89%) was recorded in T_6, which received 25 kg $ZnSO_4$ ha^{-1}. The reason for this response may be low zinc status of the initial experimental soil.

The nutrient concentration of haulm too was effected by zinc application. the treatment T_7 (which received $ZnSO_4$ @ 50 kg ha^{-1} to blackgram) recorded the highest concentration of Zn (43.67 ppm), N (2.14%) and P (0.29%), whereas, the highest K concentration was recorded in treatment T_4 (2.75%) which received $ZnSO_4$ @ 50 kg ha^{-1} during previous rice crop. The increase in uptake was due to the increased concentration of this element in plant together with an increase in biomass yield with application of zinc. Yadav *et al.* (1991) in groundnut reported the similar type of findings.

The highest zinc uptake in seed was observed in T_7 (13.08 kg^{-1}) that received 50 kg $ZnSO_4$ ha^{-1} to blackgram crop. The highest uptake of N (14.73 kg ha^{-1}) and P (1.95 kg ha^{-1}) was observed in T_7 (50 kg $ZnSO_4$ ha^{-1} to blackgram). However, the treatment T_6 (25 kg $ZnSO_4$ ha^{-1} to blackgram) recorded highest uptake of K (3.69 kg ha^{-1}). The zinc uptake in haulm increased with increasing levels of $ZnSO_4$ during kharif-rice (T_2, T_3 and T_4) and rabi-blackgram (T_5, T_6 and T_7) and all these treatments were significantly different from each other. The highest uptake of nutrients such as zinc (72.12 mg kg^{-1}), nitrogen (35.35 kg ha^{-1}), phosphorus (4.79 kg ha^{-1}) and potassium (43.16 kg ha^{-1}) were recorded in T_7, that received 50 kg $ZnSO_4$ ha^{-1} to *rabi*-blackgram .

Among the treatments receiving zinc during preceding kharif-rice, the highest N uptake (26.24 kg ha^{-1}) was recorded inT_4, that received 50 kg $ZnSO_4$ ha^{-1} to *kharif*-rice.

Sakal *et al.* (1998) reported similar type of results that the zinc uptake by seed and halum of chick pea progressively increased with increasing zinc levels.

Table 2. Effect of zinc application on haulm yield, nutrient concentration and uptake of nutrients in blackgram crop

Treatments	Yield	Concentration				Uptake			
		N	P	K	Zn	N	P	K	Zn
	(kg ha^{-1})	(per cent)			(ppm)		(kg ha^{-1})		(mg kg^{-1})
T_1	918.0	1.46	0.24	2.33	12.67	13.38	2.16	21.34	11.60
T_2	1293.3	1.64	0.27	2.42	23.83	21.30	3.46	31.30	30.89
T_3	1283.3	1.77	0.27	2.63	30.00	22.88	3.54	33.99	38.83
T_4	1373.3	1.91	0.28	2.75	36.80	26.24	3.80	37.70	50.40
T_5	1600.0	1.73	0.26	2.47	29.53	27.70	4.16	39.48	47.27
T_6	1666.7	1.93	0.27	2.52	37.17	32.16	4.45	42.06	62.03
T_7	1652.0	2.14	0.29	2.61	43.67	35.35	4.79	43.16	72.12
T_8	1309.7	1.61	0.28	2.36	23.33	21.16	3.64	31.01	30.49
T_9	1442.7	1.52	0.27	2.49	24.50	21.88	3.90	35.91	35.30
T_{10}	1536.0	1.60	0.27	2.51	25.10	24.61	4.21	38.55	38.80
T_{11}	1581.3	1.59	0.26	2.56	25.87	25.17	4.15	40.50	40.81
T_{12}	700.0	1.21	0.19	2.05	12.83	8.47	1.34	14.26	8.98
SEm$\pm$	85.2	0.06	0.02	0.07	1.12	1.79	0.36	2.42	2.59
CD (0.05)	174.0	0.13	0.04	0.15	2.28	3.65	0.73	4.94	5.28
C.V %	7.66	4.44	8.47	3.68	5.04	9.36	12.02	8.68	8.13

Table 3. Effect of zinc application on soil pH, EC(dS m^{-1}), soil available N, P and K (kg ha^{-1}) and Zinc (ppm) at harvest of crops in rice-blackgram cropping system

Treatments	pH		EC		N		P		K		Zn (ppm)	
	After paddy	After blackgram	After paddy	After blackgram	After paddy	After blackgram	After paddy	After blackgram	After paddy	After blackgram	After paddy	After blackgram
T_1	8.11	8.16	4.13	4.00	340.1	288.8	38.7	39.1	363.4	355.4	0.40	0.44
T_2	8.19	7.99	3.97	4.00	357.9	314.7	35.9	39.0	347.3	342.0	1.21	1.53
T_3	8.11	8.12	4.00	3.93	359.6	308.5	34.1	36.6	345.4	348.9	1.39	1.97
T_4	8.19	8.15	3.97	4.03	346.9	309.3	34.8	38.7	349.7	338.1	2.11	2.41
T_5	8.14	8.14	3.93	3.80	332.3	304.1	35.5	36.5	356.3	347.9	1.50	0.57
T_6	8.19	8.10	4.00	3.93	343.9	297.4	40.5	39.9	344.4	337.9	2.14	0.60
T_7	8.12	8.09	3.93	4.07	358.0	311.2	39.5	38.4	349.9	344.0	2.56	0.54
T_8	8.21	8.05	3.90	3.77	362.3	318.4	36.4	38.2	349.3	348.1	0.79	0.50
T_9	8.07	8.19	3.97	3.77	367.9	312.4	37.1	37.1	351.0	342.2	0.85	0.57
T_{10}	8.16	8.08	4.00	3.93	350.7	304.9	36.5	37.4	345.2	343.3	0.69	0.58
T_{11}	8.17	8.03	3.93	3.83	360.7	304.3	34.3	38.0	357.8	353.3	0.86	0.53
T_{12}	8.03	8.04	3.83	3.73	255.2	202.6	22.9	26.1	313.3	335.8	0.33	0.43
Mean	8.14	8.10	3.96	3.90	344.63	298.05	35.52	37.08	347.75	344.74	1.24	0.89
SEm±	0.05	0.052	0.13	0.13	11.3	11.7	1.70	1.96	12.75	16.35	0.06	0.058
CD (0.05)	0.11	0.105	NS	0.27	23.03	23.8	3.48	3.99	26.03	NS	0.23	0.118
C.V %	0.78	0.78	3.88	4.23	4.01	4.80	5.87	6.46	4.49	5.81	6.31	8.09

Variations in status of available N, P, K and Zn at harvest of blackgram crop

The initial N status of soil was low (239.11 kg ha^{-1}). However the magnitude of N increased at harvest of blackgram (+15.63) despite crop removal by kharif rice (mean of twelve treat ments). This increase was due to the reason that blackgram being a legume crop, fixes the atmos pheric nitrogen in the soil. These results corroborate the findings of the Tomar *et al.*(1996) in groundnut. Almost similar trend was observed in case of no zinc control. In absolute control there was slight increase of N at harvest of blackgram (Table 3). The initial phosphorus status of soil was 34.4 kg ha^{-1}. At harvest of blackgram grown succeeding *kharif* rice, it increased to 35.52 kg ha^{-1}. In no zinc control the soil P slightly increased, whereas, in absolute control it decreased. Similar results were also reported by Tomar *et al*. (1996) in groundnut crop.

The soil K decreased at harvest of black gram crop when compa red to initial soil. Similar trend were also observed in no zinc control and in absolute control. The zinc status of soil increased after harvest of blackgram due to the crop, which was understood as excess even after crop removal. Whereas, in case of no zinc control and absolute control the zinc status of soil decreased due to crop removal and these were completely excluded form zinc fertilization. This clearly indicates that the removal of Zn in absence of N, P and K nutrients in the crops. Similar increases in residual soil avialable zinc after harvest of groundnut was reported by Tomar *et al.*(1996).

Conclusion

Increasing levels of $ZnSO_4$ increased the seed and haulm yield of blackgram crop. However, treatment T_6 (25 kg $ZnSO_4$ ha^{-1} to blackgram) was found to be more beneficial than that of treatment T_7 (that received 50kg $ZnSO_4$ ha^{-1} to blackgram) with respect to seed and haulm yields.

1.The treatments T_2, T_3 and T_4 that received $ZnSO_4$ through soil application in previous crop of rice recorded low seed haulm yield of blackgram crop compared to direct application. Among those treatments T_4 (that received 50 kg $ZnSO_4$ ha^{-1} to previous kharif rice)recorded the highest seed and haulm yield of blackgram crop.

2. Among the foliar treatments of $ZnSO_4$ to blackgram crop, T_{11}(0.2% $ZnSO_4$ spraying at 25 DAS and at flowering) recorded the highest seed and haulm yield.

3. From the findings of the experiment and from the reasons discussed in above heads it is covincingly evident that the the application of $ZnSO_4$ @ 25 kg ha^{-1} could be ideally recommended for blackgram crop in saline soils of coastal Andhra Pradesh for optimum yields.

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