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EFFECT OF ZINC ON BLACKGRAM IN RICE- BLACKGRAM CROPPING SYSTEM OF COASTAL SALINE SOILS

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ABSTRACT

A field experiment was conducted during *kharif* and *rabi* seasons of 2002-2003 and 2003-2004 on a saline soils, to study the effect of various levels, methods of application and residual effect of Zn on yield, nutrient concentration and uptake of blackgram (*Vigna mungo*). Twelve treatments comprising of four $ZnSO_4$ levels (0, 12.5, 25 and 50 kg ha^{-1}) were distributed to the two crops of rice-blackgram in a cropping system. The maximum grain and haulm yields of blackgram were recorded with treatment that received 25 kg $ZnSO_4$ ha^{-1} to blackgram. The effect of all foliar treatments applied at different stages of crop proved to be at par with each other. The performance of the treatments was in the order: soil application > foliar treatments > residual fertility. The nutrient status of soil at the end of rice-blackgram cropping sequence indicated that the available N and Zn status of soil increased and that of K to decrease when compared with the initial soil status.

INTRODUCTION

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, offers the most practical means of eradicating malnutrition. Blackgram is cultivated in an area of 5.55 lakh hactares 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 hactares with productivity of 2 to 2.5 quintals ha^{-1} (Andhra Pradesh Agricultural Statistics at a Glance, 2002). The crop is grown as a relay crop after *kharif* paddy purely on residual fertility. No supplementary irrigations are given to the crop. The Guntur district in A.P alone has 1.74 lakh hactares area under this legume crop. The average productivity of the crop in this area however is less than two quintals. Besides, the inland salinity problem prevalent in deltaic soils seems to increase year by year. In salt affected soils although the solubility of zincate ions increases with raise in pH (NaOH) but the interaction with calcium ion in between pH 6 to 8 results in minimum zinc solubility product and thereby Zn deficiency (Somani and Totawat,1993., Bandyopadhyay, 1997).As a consequence of salinity hazard in rice-pulse cropping system the deficiency of some essential nutrients especially zinc is inevitable. Zinc deficiency symptoms are also exhibited in blackgram crop. Despite these facts farmers are growing the blackgram crop owing to its lucrative market value.

An experiment conducted at saline fields, Bapatla, indicated that zinc applied blackgram crop performed well in terms of yield than that of crop that received no zinc. So far zinc is not recommended to blackgram but only to *kharif* paddy. It is recommended to apply $ZnSO_4$ @ 50 kg ha $^{-1}$ after every two crops of paddy when a single crop of paddy is taken (*rabi* fallow), while in two crop-crop sequences it is recommended to apply @ 50 kg ha^{-1} to every crop of paddy. Hence this experiment was conducted to find an ideal level of zinc to blackgram in rice-blackgram cropping system.

MATERIAL AND METHODS

The soil (sandy clay loam) at experimental site had almost neutral pHs and saline ECe prior to raising of *kharif* paddy in both the fields selected for study during the two years of study. The soil was low, medium and high with respect

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to available N, P_2O_5, and K_2O during both the years of study (Table 1). Twleve treatments were distributed to the two crops i.e., *kharif* paddy and *rabi* blackgram, in a randomized block design.

- T_1 : Control (no zinc)
- T_2 : 12.5 kg $ZnSO_4$ ha^{-1} to paddy crop
- T_3 : 25 kg $ZnSO_4$ ha^{-1} to paddy crop
- T_4 : 50 kg $ZnSO_4$ ha^{-1} to paddy crop
- T_5 : 12.5 kg $ZnSO_4$ ha^{-1} to blackgram
- T_6 : 25 kg $ZnSO_4$ ha^{-1} to blackgram
- T_7 : 50 kg $ZnSO_4$ ha^{-1} to blackgram
- T_8 : 0.2% spraying of $ZnSO_4$ at 25 days after sowing
- T_9 : 0.2% spraying of $ZnSO_4$ at flowering of blackgram
- T_{10} : 0.2% spraying of $ZnSO_4$ at pod formation of blackgram
- T_{11} : $T_8 + T_9$
- T_{12} : absolute control (no N,P,K and Zinc to either crops)

During both the years of study (2002-03 and 2003-04), paddy was planted during second week of August and blackgram during first week of December. Treatments T_2-T_4 constituted residual zinc fertility to *rabi* blackgram. Blackgram variety LBG-645 was grown as relay crop succeeding *kharif* paddy. Blackgram seed was broadcasted three days before harvest of rice crop in rice-blackgram cropping system. The seed rate of 16 kg per acre was adopted. Rice (*cv*.BPT5204) as the first crop in cropping system received a state recommended dose of N, P_2O_5 and K_2O fertilizers (120:60:40 kg ha^{-1}). The *rabi* blackgram received no fertlizer and was grown purely on residual fertility. Zinc in the form of zinc sulphate was applied one day before broadcasting of blackgram seed in the field i.e., four days before harvest of rice crop. 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 blackgram and compared with initial status.

RESULTS AND DISCUSSION

Effect on yields : The results presented in Table 2 show that, the application of zinc at all levels significantly increased the seed and haulm yields of blackgram over control. Seed yields of treatments receiving $ZnSO_4$ directly was greater than those of foliar treatments, while these in turn proved better than treatments that received $ZnSO_4$ during preceding paddy (residual fertility). The maximum seed yield during both the years was recorded in treatment T_6, and T_7 which received $ZnSO_4$ @ 25 kg and 50 kg ha^{-1} through soil application to blackgram crop. The increment in T_6 treatment was 105 and 258 per cent over no zinc control (T_1) and absolute control (T_{12}, that neither received N, P, K nor zinc), respectively. It was interesting to observe that all the treatments receiving zinc sulphate during preceding paddy recorded yields on par with each other. This indicates that direct application of zinc sulphate to blackgram is more effective than

Table 1. Initial status of soil pH, E.Ce and available N, P, K and Zinc 2002-04.

Depth	Sand	Silt	Clay	Textural	pH	ECe	N	P_2O_5	K_2O	Zn	CEC
Cm	(per cent)			class		(dSm^{-1})	(kg/ha)			ppm	cmol (p^+)/kg
2002-03											
0-15	65.1	10.0	24.9	Sandy clay loam	8.25	4.84	239.11	34.4	420.21	0.46	27.17
15-30	60.1	25.0	14.9	Sandy loam	8.32	4.26	218.2	23.2	407.30	0.42	20.83
2003-04											
0-15	66.1	11.4	22.5	Sandy clay loam	7.62	4.2	282.0	38.28	622.0	0.44	25.86
15-30	64.4	16.8	18.8	Sandy loam	7.41	3.4	253.0	32.65	685.0	0.40	19.28

Table 2. Effect of Zn application on yields of blackgram during two years of study.

Treatments	Blackgram					
	Seed (kg ha^{-1})			Haulm (kg ha^{-1})		
	2002-03	2003-04	Mean	2002-03	2003-04	Mean
T_1	164.00	109.33	136.67	918.00	633.3	775.67
T_2	202.67	122.00	162.33	1293.33	832.7	1063.00
T_3	246.00	132.67	189.33	1293.33	858.0	1075.67
T_4	269.33	134.67	202.00	1373.33	861.3	1117.33
T_5	376.00	129.33	252.67	1600.00	838.7	1219.33
T_6	412.67	147.33	280.00	1666.67	856.0	1261.33
T_7	395.33	134.00	264.67	1652.00	841.3	1246.67
T_8	296.67	126.67	211.67	1309.67	832.3	1071.00
T_9	312.00	113.33	212.67	1442.67	820.7	1131.67
T_{10}	361.33	112.00	236.67	1536.00	814.0	1175.00
T_{11}	360.00	120.67	240.33	1581.33	809.3	1195.33
T_{12}	102.67	54.00	78.33	700.00	501.0	600.50
Mean	291.56	119.67	205.61	1363.86	791.6	794.38
		Sem $\pm$	CD(0.05)		Sem $\pm$	CD(0.05)
Year (Y)		3.14	6.36		23.66	48.03
Treatments (T)		15.26	37.39		43.39	106.31
YxT		21.58	68.63		61.37	195.14
CV(%)		12.86			6.97	

that of residual fertility. Though the foliar treatments performed better than residual fertility, soil application resulted in better yields. All the treatments receiving foliar application at any stage or in combination exhibited on par performance. The increase in seed yield in foliar treatments was 41% over that of residual treatments (means of respective treatments). Similarly the yields of treatments that received $ZnSO_4$ directly were 17.7 per cent higher than those of foliar application (mean of all respective treatments).

These results are in agreement with the findings of Krishna *et al.* (1997) and Revathy *et al.* (1997). However, the yields were low during second year owing to cyclone during December 2003 due to which the blackgram crop was late sown i.e, during January 2004. Puste and Jana (1995) reported similar trend of results to soil application of zinc in pigeon pea crop. Gupta and Vyas (1994) and Singh and Singh (1995) reported favourable effect of zinc application on seed yield of soybean.

The haulm yield too followed similar trends. The highest yield increments were observed in direct application rather than residual fertility. Among direct treatments, that receiving 25 and 50 kg $ZnSO_4$ ha^{-1} recorded higher, yet on par yields. These results are in concurrence with the findings of Sharma *et al.* (1990) and Vasavirani (1999).

The increase in seed and haulm yield of blackgram due to zinc might be attributed 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 yield in blackgram crop in rice-rice-pulse cropping sequence.

Table 3. Effect of Zn application on seed N, P and K uptake of blackgram during two years of study.

Treatments	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)			Zn uptake (mg/kg)		
	2002-03	2003-04	Mean	2002-03	2003-04	Mean	2002-03	2003-04	Mean	2002-03	2003-04	Mean
T_1	5.15	3.86	4.51	0.71	0.48	0.60	1.81	1.36	1.59	2.86	2.48	2.67
T_2	6.81	4.41	5.61	0.91	0.57	0.74	2.22	1.44	1.83	4.27	3.15	3.71
T_3	8.43	4.84	6.64	1.13	0.57	0.85	2.63	1.55	2.09	6.25	3.96	5.11
T_4	9.27	4.94	7.11	1.30	0.59	0.95	2.9	1.57	2.24	6.72	4.64	5.68
T_5	12.36	4.43	8.40	1.70	0.60	1.15	3.6	1.5	2.55	8.82	3.65	6.24
T_6	14.47	4.93	9.70	1.94	0.66	1.30	4.19	1.6	2.9	9.91	4.80	7.36
T_7	14.73	4.67	9.70	1.95	0.61	1.28	3.97	1.55	2.76	11.08	5.09	8.09
T_8	9.81	4.60	7.20	1.37	0.54	0.96	2.98	1.46	2.22	6.15	3.18	4.67
T_9	10.25	3.98	7.12	1.44	0.49	0.96	3.06	1.38	2.22	6.57	3.14	4.86
T_{10}	11.93	3.78	7.86	1.71	0.49	1.10	3.52	1.3	2.41	7.56	2.92	5.24
T_{11}	11.61	4.22	7.92	1.67	0.55	1.11	3.47	1.38	2.43	6.60	2.95	4.78
T_{12}	3.02	1.83	2.43	0.39	0.25	0.32	1.26	0.92	1.09	1.62	1.51	1.57
Mean	9.82	4.21	7.01	1.35	0.53	0.94	2.97	1.42	2.2	5.20	3.46	4.33
		Sem±	CD (0.05)		Sem±	CD (0.05)		Sem±	CD (0.05)		Sem±	CD (0.05)
Year (Y)		0.08	0.17		0.02	0.04		0.04	0.09		0.12	0.24
Treatments (T)		0.52	1.27		0.08	0.19		0.14	0.35		0.42	1.02
Y × T		0.73	2.34		0.11	0.35		0.2	0.64		0.59	1.87
CV (%)		12.83			14.11			14.62			14.93	

Table 4. Effect of Zn application on haulm N, P and K uptake of blackgram during two years of study

Treatments	N (kg/ha)			P (kg/ha)			K(kg/ha)			Zn (mg/kg)		
	2002-03	2003-04	Mean	2002-03	2003-04	Mean	2002-03	2003-04	Mean	2002-03	2003-04	Mean
T_1	13.38	9.86	11.62	2.17	0.47	1.32	14.34	8.97	11.66	11.60	9.86	10.73
T_2	21.30	16.25	18.78	3.46	0.39	1.93	24.3	8.87	16.59	30.89	12.35	21.62
T_3	22.88	18.57	20.73	3.54	0.44	1.99	26.99	9.32	18.16	38.83	14.93	26.88
T_4	26.24	20.18	23.21	3.80	0.43	2.12	30.7	9.7	20.2	50.40	16.32	33.36
T_5	27.70	14.55	21.13	4.16	0.47	2.31	32.48	8.97	20.73	47.27	13.94	30.61
T_6	32.16	17.20	24.68	4.45	0.50	2.48	35.06	9.34	22.2	62.03	16.61	39.32
T_7	35.35	16.98	26.17	4.79	0.49	2.64	36.16	9.1	22.63	72.11	17.43	44.77
T_8	21.16	15.68	18.42	3.64	0.52	2.08	24.01	8.74	16.38	30.49	12.09	21.29
T_9	21.88	18.08	19.98	3.90	0.45	2.18	28.92	8.53	18.73	35.30	12.18	23.74
T_{10}	24.61	14.21	19.41	4.21	0.38	2.29	31.55	8.36	19.96	38.80	12.54	25.67
T_{11}	25.50	13.96	19.73	4.15	0.43	2.29	33.5	8.17	20.84	40.81	12.44	26.63
T_{12}	8.47	5.68	7.08	1.34	0.14	0.74	7.26	5.53	6.4	8.97	8.21	8.59
Mean	23.39	15.10	19.24	3.63	0.43	2.03	27.11	8.63	17.87	38.96	13.24	26.10
		Sem±	CD (0.05)		Sem±	CD (0.05)		Sem±	CD (0.05)		Sem±	CD (0.05)
Year (Y)		0.42	0.85		0.14	0.28		0.84	1.71		1.2	2.44
Treat. (T)		0.94	2.31		0.18	0.45		1.23	3.01		1.31	2.3
YxT		1.33	4.24		0.26	0.83		1.74	5.52		1.85	5.88
CV (%)		12.17			15.71			10.7			10.02	

Table 5. Effect of Zinc on status of soil available N, P, K and Zn at harvest of blackgram

Treatments	N (kg/ha)			P (kg/ha)			K(kg/ha)			Zn (mg/kg)		
	2002-03	2003-04	Mean	2002-03	2003-04	Mean	2002-03	2003-04	Mean	2002-03	2003-04	Mean
T_1	268.07	311.33	289.70	28.73	34.37	31.55	363.40	536.30	449.85	0.40	0.37	0.39
T_2	285.87	305.07	295.47	25.93	31.97	28.95	347.33	528.10	437.72	0.71	0.85	0.78
T_3	287.60	300.20	293.90	24.07	31.13	27.60	345.40	548.53	446.97	0.89	0.85	0.87
T_4	274.87	310.63	292.75	24.80	32.33	28.57	349.73	511.83	430.78	0.61	1.02	0.82
T_5	260.33	328.77	294.55	25.53	36.77	31.15	356.33	544.47	450.40	1.00	0.81	0.91
T_6	271.93	305.80	288.87	30.47	33.50	31.99	344.40	511.83	428.12	0.64	0.86	0.75
T_7	286.00	300.87	293.44	29.53	37.43	33.48	349.87	532.20	441.04	1.06	0.82	0.94
T_8	290.33	325.30	307.82	26.40	33.87	30.14	349.27	499.57	424.42	0.59	0.51	0.55
T_9	295.87	298.10	296.99	27.07	30.80	28.94	350.87	632.90	491.89	0.45	0.55	0.50
T_{10}	278.67	328.73	303.70	26.53	32.50	29.52	345.20	507.73	426.47	0.50	0.39	0.45
T_{11}	288.73	318.30	303.52	24.27	31.97	28.12	357.80	503.63	430.72	0.66	0.55	0.61
T_{12}	183.20	277.33	230.27	12.87	27.37	20.12	313.33	434.27	373.80	0.13	0.02	0.08
Mean	272.62	309.20	290.91	25.52	32.83	29.18	347.74	524.28	436.01	0.64	0.63	0.64
		Sem±	CD (0.05)		Sem±	CD (0.05)		Sem±	CD (0.05)		Sem±	CD (0.05)
Year (Y)		4.23	8.59		2.52	NS		12.04	24.45		0.03	0.06
Treat. (T)		11.68	28.62		3.14	7.7		28.27	NS		0.05	0.11
YxT		15.52	52.54		4.44	NS		39.98	NS		0.06	0.2
CV (%)		6.62			15.92			11.47			6.28	

Effect on crop nutrition : The results on the uptake of nutrients (Zn, N, P and K) in seed and haulms are presented in Tables 3 and 4.

The highest zinc uptake in blackgram seed (8.09 mg kg^{-1}) was observed in treatment that received 50 kg $ZnSO_4$ ha^{-1} to blackgram crop. However, in the treatment that received 25 kg $ZnSO_4$ ha^{-1} to blackgram highest uptake of N (9.7 kg ha^{-1}), P (1.3 kg ha^{-1}) and K (2.9 kg ha^{-1}) was observed. The zinc uptake in haulm increased with increasing levels of $ZnSO_4$ applied 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. In haulms the highest uptake of N, P and K was observed in either treatment that received 25 or 50 kg $ZnSO_4$ per hactare; however, these two treatments were on par with each other. The highest uptake of zinc (44.70 mg kg^{-1}), nitrogen (26.17 kg ha^{-1}), phosphorus (2.64 kg ha^{-1}) and potassium (22.63 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 by blackgram (23.21 kg ha^{-1}) was recorded in T_4, which 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 haulm of chickpea progressively increased with increasing zinc levels.

Variations in soil status of available N, P, K and Zn at harvest of blackgram crop : The initial N status of soil (before crop sequence) was low during both the years. However the magnitude of N increased at harvest of blackgram as compared to initial soil status despite crop removal by *kharif* rice (mean of twelve treatments). This increase was due to the reason that blackgram being a legume crop, fixes the atmospheric 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 decrease of N at harvest of blackgram (Table 5). The initial phosphorus status of soil was medium during both the years. In no zinc control the soil P has slightly increased as comp[ared to initial soil, 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 blackgram crop when compared to initial soil. Similar trends were also observed in no zinc control and in absolute control. The zinc status of soil after harvest of blackgram (mean of twelve treatments) was higher than that of the initial. This increase brings the soil status of zinc to slightly above critical value. 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 from zinc fertilization. This clearly indicates the removal of Zn in absence of N, P and K nutrients in the crops. Tomar *et al*. (1996) reported similar increases in residual soil available zinc after harvest of groundnut.

CONCLUSION

Increasing levels of $ZnSO_4$ increased the seed and haulm yield of blackgram crop. Highest yields of seed and haulms were recorded when $ZnSO_4$ @ 25 kg ha^{-1} was applied through soil application directly to blackgram. Residual fertility of zinc proved poorer to direct application as indicated through low seed/haulm yields of blackgram. All the foliar treatments of $ZnSO_4$ to blackgram crop performed equally but only next to direct Zn application. It is a practice that every year farmers apply 50 kg $ZnSO_4$ ha^{-1} to first crop of rice in sequence. From the reasons discussed under above heads, it is evident that the application of $ZnSO_4$ @ 25 kg ha^{-1} each crop of rice and blackgram every year could be beneficial to both the crops in cropping sequence in coastal saline soils.

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