yield by predominance of dominance X dominance ($\hat{l}$) interaction effects. Moreover, it is evident from the results on gene effects that positive and significant additive X additive interactions prevailing in crosses 2 X 1 and 3 X 1 for all the traits indicated that selection would be advantageous in further generations. While the presence of negatively significant dominance X dominance gene effects in most of the crosses for ear bearing tillers per plant, ear length, grain number per ear and grain yield showed that a diminishing effect due to this type of gene action could occur. Similar observations were reported by Singh and Rai(1987) in bread wheat. On the basis of unlike signs of ($\hat{h}$) and ($\hat{l}$) components, all the crosses for ear bearing tillers per plant, ear length and grain yield and majority of crosses for plant height, grain number per ear and 100-grain weight showed the operation of complementary type of epistasis for all the traits studied, thus, indicating fixable nature of the characters under selection in advanced generations. Kaushik and Sharma (1988) had also observed similar predominant role of complementary gene action. The additive X additive interaction coupled with duplicate type of epistasis in cross 3x1 for all the traits indicated the possibility of improvement for higher grain yield through yield components.

Of the twelve crosses studied, two viz., Co 41 X ADT 37 and IR 50 X ADT 37 could be used successfully in rice breeding programmes in view of the presence of dominance ($\hat{h}$) component and sizeable amount of additive ($\hat{d}$) component of genetic variance. These two crosses could also be used for the exploitation of both additive and additive X additive components through biparental mating in F_2 generation as suggested by Gill *et al.* (1973).

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RESPONSE OF SORGHUM-WHEAT ROTATION TO DIFFERENT SOURCES OF ZINC IN VERTISOL

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ABSTRACT

A field experiment was conducted to study the efficiency of different sources of zinc in sorghum-wheat crop rotation on calcareous vertisol of Parbhani. Zinc application 4kg Zn/ha through zincated superphosphate proved its superiority over other zinc sources in producing grain and fodder yield of sorghum. Among the zinc sources, the residual effect of zincated superphosphate was significantly higher in producing grain and straw yield of wheat followed by farm yard manure and zinc sulphate. Zinc application @ 4kg Zn/ha through different Zinc sources significantly increased uptake of Zn,N and P by wheat crop. Highest uptake of nutrients was recorded with zincated superphosphate in both the crop.

Takkar (1986) recorded large areas of zinc deficiency in the country followed by iron and manganese. To preserve soil Zn status, it is necessary to develop suitable strategy of Zn management particularly under intensive cropping pattern. Very little information is available on zinc management using different zinc sources in different cropping sequences and their residual values. Zinc containing fertilizers are available for use under the different trade marks and therefore it

Table 1. Grain and fodder yield (q/ha) of sorghum and wheat as influenced by different sources of zinc.

Treatments	Grain	Dry matter
	Sorghum	
Control	26.16	74.05
Zincated urea	35.47	100.00
Zincated suphala	34.38	89.67
Zincated superphosphate	37.08	106.89
Zinc sulphate	33.99	94.97
FYM	29.36	83.96
S.E. ±	00.85	06.84
C.D. at 5%	02.53	19.36
	Wheat	
Control	16.82	30.40
Zincated urea	18.11	33.51
Zincated suphala	19.15	34.87
Zincated superphosphate	23.45	41.82
Zinc sulphate	22.32	38.28
FYM	22.34	41.43
S.E. ±	01.09	01.86
C.D. at 5%	03.08	05.47

is necessary to evaluate their relative efficiency. Keeping in view these facts the present investigation was undertaken.

MATERIALS AND METHODS

The field experiment was conducted at M.A.U. farm, Parbhani with sorghum CSH-9 using different sources of zinc in calcareous vertisol. The experimental soil was typic Chromustert and had pH8.10EC$_e$ 0.32 dsm^{-1} at 25°C, CEC 46 me/100 g soil, Organic carbon 0.68 per cent and DTPA extractable Zn 0.68 ppm. The standard methods of soil analysis were used (Jackson, 1967). The DTPA extractable Zn was estimated as per the method given by Lindsay and Norvell (1969).

The sources of Zn used were zincated urea (2% Zn and 46% N), zincated suphala (2% Zn and 20% N, 20% P_2O_5), zinc sulphate (22.7% Zn), farm yard manure (10 T/ha) alongwith control. There were six treatments replicated nine times in randomised block design during the 1987-88 using sorghum wheat crop rotation. The recommended dose of 120 kg N and 50 kg P_2O_5 and 50 kg K_2O per ha was applied to sorghum crop CSH-9. The 4 kg Zn/ha was applied through each zinc source. The data was subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1961). The nitrogen and phosphorus content in this plant and grain were estimated by following the standard procedure outlined Piper (1966). Zinc was analysed by using Atomic Absorption Spectro photometer.

RESULTS AND DISCUSSION

The data on direct effect of various zinc sources on sorghum (Table 1) indicated differential of Zn carriers. Application of Zn significantly increased the grain and fodder yield of sorghum over control; Highest grain yield of sorghum (37.08 q/ha was obtained due to the application of zincated superphosphate. The relative efficiency of zinc sources in grain and fodder production was in order; ZnSSP > Znu > ZnS > $ZnSO_4$ > FYM. Application of zinc through zincated urea, zincated suphala and zinz sulphate did not differ significantly in increasing the grain and fodder yield of sorghum. The grain and straw yield of wheat varied between 16.82 to 23.45 q/ha and 30.40 to 41.82 q/ha respectively due to the residual effect of different treatments. Maximum increases was recorded with the application of zincated superphosphate. The relative efficiency of different sources on wheat yield followed the order ZnSSP > FYM > $ZnSO_4$ > Zns > Znu.

The effect of different zinc sources found to be significant in increasing the zinc uptake to sorghum (Table 2). Zn uptake varied from 76.5 to 139.0 g/ha in grain and 126.7 to 356.5 g/ha in straw. The total uptake ranged from 203.2 to 495.7 g/ha Zincated superphosphate showed significantly higher zinc uptake (485.7 g/ha) in sorghum. Application of zinc through different zinc sources showed significantly more residual effect on uptake of zinc over control. The increase zinc uptake with different sources ranged from 53.6 to 120.6, 35.0 to 66.8 and 88.6 to 187.4 g/ha in grain, straw and total uptake of wheat, respectively. Zincated superphos. phate proved to be a good residual source of zinc to succeding wheat.

Effect of different zinc sources found to be significant in increasing nitrogen uptake by sorghum grain and fodder (Table 2) The N uptake varied between 41.63 and 65.60, 29.8 and 58.81 and 70.71 and 124.41 kg/ha grain, fodder and total, respectively. Highest N uptake was observed in

Table 2. Direct and residual effect of different zinc sources on Zn, N, and P uptake by sorghum-wheat.

	Zn Uptake g/ha			N Uptake kg/ha			P Uptake kg/ha		
	Grain	Fodder	Total	Grain	Fodder	Total	Grain	Fodder	Total
				Sorghum					
Control	76.5	126.7	203.2	41.63	29.08	70.71	5.78	7.51	13.29
Zincated urea	125.3	313.9	439.2	59.50	54.32	113.82	8.74	11.71	20.45
Zincated suphala	119.3	265.3	384.6	59.87	56.07	115.94	8.32	9.85	18.17
Zincated superphosphate	139.0	356.6	495.7	65.60	58.81	124.41	9.43	12.51	21.94
Zinc sulphate	111.8	253.4	365.2	56.69	46.94	103.63	8.00	10.78	18.78
Farm Yard Manure	95.0	192.0	287.0	48.85	38.25	87.10	6.82	8.99	15.81
S.E. ±	7.35	2.14	4.63	3.92	1.41	3.01	0.52	0.83	1.30
C.D. at 5%	21.03	6.13	13.24	11.12	4.04	8.62	1.48	2.38	3.73
				Wheat					
Control	56.6	35.0	88.69	28.19	16.65	44.84	4.51	2.83	7.34
Zincated urea	86.9	48.1	135.0	32.28	19.57	51.85	5.21	3.34	8.55
Zincated suphala	81.6	51.2	132.8	34.25	19.18	53.43	5.36	3.63	8.99
Zincated superphosphate	120.6	66.8	187.4	44.14	26.67	70.81	6.82	4.66	11.48
Zinc sulphate	102.1	52.1	154.2	40.45	21.47	61.92	5.90	4.02	9.92
Farm Yard Manure	107.9	49.8	157.7	41.57	22.02	63.59	6.25	4.52	10.77
S.E. ±	5.74	3.76	8.34	2.38	1.44	3.42	0.34	0.25	0.56
C.D. at 5%	16.42	10.75	23.85	6.81	4.14	9.78	0.97	0.71	1.61

grain and straw due to application of zincated superphosphate followed by zincated suphala which were on par with each other. Zinc application to previous crop exerted significant influence on the succedding wheat crop indicating highest N uptake by grain and straw over control. The nitrogen uptake ranged from 28.19 to 44.14, 16.65 to 26.67 and 44.84 to 70.81 kg/ha in grain, straw and total by wheat, respectively. Highest uptake of N was recorded with residual effect of zincated superphosphate followed by FYM and they were on par.

The effect of different zinc sources were found to be significant in increasing P uptake by sorghum (Table 2). Phosphorus uptake was in range of 5.78 to 9.43, 7.51 to 12.51 and 13.29 to 21.94 kg/ha in grain, fodder and total of sorghum respectively. Among the different sources of zinc, zincated superphosphate showed highest value of P uptake by grain, fodder and total by sorghum. Application of different zinc sources to previous crop exerted significant increased uptake of P in grain, fodder and grain + fodder by wheat. The P uptake ranged 4.51 to 6.82, 2.83 to 4.66 and 7.34 to 11.48 kg/ha in grain, straw and grain + straw of wheat, respectively. Among different zinc sources, zincated superphosphate recorded highest value of P uptake in grain, straw and total by wheat.

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