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Response of zinc fertilization on production and profitability of Pearl millet (*Pannisetum glaucum*) under rainfed condition of Rajasthan

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ABSTRACT

Three years field experiment conducted at Agricultural Research Station, Bikaner (Rajasthan) to study the effect of zinc application on production potential and profitability of rainfed pearl millet. On the basis of pooled data, results revealed that application of zinc through $ZnSO_4$ @ 20 kg/ha recorded significantly higher plant height (119.19 cm), number of leaves/plant (5.37), dry matter/plant (52.85 g), total tillers/plant (4.89), effective tillers/plant (3.62), length of ear (22.19 cm), test weight (7.17 g), seed yield (1608 kg/ha), stover yield (3147 kg/ha), protein content (11.60%), net return (Rs.10,868) and B:C ratio (2.96) $ZnSO_4$ @ 20 kg/ha and over the control plot. Further, data showed that significantly higher growth parameters, yield attributes, seed yield (1412 kg/ha), stover yield (3098 kg/ha), protein content (11.10%), net return (Rs. 10,842) and B:C ratio (3.10) were obtained under 0.5% foliar spray of $ZnSO_4$ at tillering stage which was statistically at par with 0.5% foliar spray of $ZnSO_4$ at pre-flowering stage. Thus, the findings of present investigation indicated that application of Zn @ 20 kg/ha as well as a foliar spray of 0.5% at pre-flowering stage booted the yields of pearl millet and obtained maximum net returns under the rainfed conditions of Rajasthan.

Keywords: Economics, grain yield, pearl millet, protein content, $ZnSO_4$

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the world's hardiest warm season crop among the cereals and well adapted to drought-prone areas, low soil fertility, and high-temperature situations (Rinku *et al.*, 2014). It is the fourth most important cereal in India in terms of area cultivated after rice, wheat and sorghum (Singh *et al.*, 2017 and Shekhawat *et al.*, 2015). Pearl millet is a principal source of energy, protein, vitamin and minerals for millions of poorest peoples in the regions, where it is cultivated. It is a rich source of Ca, K, Mg, Fe, Zn, Mn, riboflavin, thiamine, niacin, lysine and tryptophan. Major pearl millet growing states are Rajasthan, Uttar Pradesh, Maharashtra, Haryana and Gujarat and accounted 92.6% of total area under pearl millet and contributed to 92.27% of total production. In India, it is cultivated in about 7.8 mha with the production of 9.25 MT with an average productivity of 1270 kg/ha (Anonymous, 2016).

Micronutrient plays many important roles in plant nutrition and crop production (Singh and Kumar, 2009). Zinc is important for plant growth, as plants require a proper balance of all the essential nutrients for normal growth and optimum yield It is required as a structural component of a large number of proteins, such as transcription factors and metallo enzymes (Singh and Kumar, 2009). It also helps in the formation of chlorophyll and auxins. Zinc is the most common deficient micronutrient element in the soil in the world and more than 50 per cent soils of India are deficient in Zn (Kumar *et al.*, 2016). Micronutrients have not only cured nutritional disorder in plants but are also known to improve the yield and quality (Jakhar *et al.*, 2006). Its deficiency in soils may reduce crop yield and quality because zinc plays a vital role in protein metabolism, zinc fertilization can improve protein content in many crops. Keeping all the facts in view, the present investigation was, therefore, undertaken with an objective to study the zinc fertilization on production and profitability of pearl millet.

MATERIALS AND METHODS

Field experiments were conducted during three consecutive *kharif* (rainy) seasons of 2004-2007, at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner to study the effect of zinc fertilization on production and profitability of pearl millet under the rainfed conditions. Experimental soil was loamy sand, alkaline in reaction (pH 8.3), low in organic carbon (0.07%), available N (101.2 kg/ha), medium in available P (9.8 kg/ha), high in available K (216.5 kg/ha) and low in available zinc (0.46 ppm). The climatic of the area is warm, and rainfall during crop period was 112.6 mm, 118.5 mm and 166.6 mm in 2004-05, 2005-06 and 2006-07, respectively. The experiment comprised of nine treatment combinations of 3 levels of zinc soil application (0, 10 and 20 kg $ZnSO_4$/ha) and 3 levels 0.5% foliar spray of $ZnSO_4$ (control, at tillering and pre-flowering stage) and laid out in factorial randomized block design and replicated thrice.

Uniform recommended a dose of fertilizer (80-60-40 kg NPK/ha) was applied through zinc sulphate as per treatment.

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For this study, the pearl millet hybrid (HHB-67) was raised in a row spaced at 45 cm. The crop was supplemented with life-saving irrigation when it felt necessary. Recommended local crop management practices, weed control measures and plant protection measures were done in the crops. Various growth and yield attributes were observed at harvest following the standard procedure. The net plot grain yield was converted to grain yield in terms of kg/ha. Protein content in grain was worked out by multiplying the nitrogen content in grain with the factor by (AOAC, 1970).

The prevailing market price of inputs as per treatments of each crop was considered for working out the cost of cultivation. Net returns (Rs. /ha) was calculated by deducting the cost of cultivation (Rs. /ha) from gross returns, while B: C ratio were worked out as a ratio of gross return (`/ha) to cost of cultivation (Rs. /ha). Statistical analysis of the data was done as per the standard analysis of variance technique suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of $ZnSO_4$ on soil application

Growth attributes significantly influenced by different levels of $ZnSO_4$ during three consecutive years and pooled (Table 1). Application of increasing levels of $ZnSO_4$ showed significant improvement in plant height, number of leaves/plant, dry matter/plant, total tillers/plant and effective tillers/plant under 20 kg $ZnSO_4$/ha was higher 9.8, 12.5, 38.9, 38.1, 37.6% and 5.5, 17.2, 23.6, 25.7, 21.6% over control and 10 kg $ZnSO_4$/ha, respectively. Prasad *et al.* (2014) result revealed that application of 10 kg Zn/ha produced higher plant height, number of tillers/plant and dry matter production (g/plant). Further, application of $ZnSO_4$ @ 20 kg/ha significantly enhanced ear length and test weight over control and 10 kg $ZnSO_4$/ha.

Increase in length of the ear and test weight under 20 kg $ZnSO_4$/ha was observed to be 12.8, 31.1% and 9.5, 21.57% over control and 10 kg $ZnSO_4$/ha, respectively. The response of Zn may be attributed to the low available zinc in soil and also its role in various enzymatic reactions and it acts as a catalyst in various growth processes and in hormone production and protein synthesis which results in increasing the growth and yield attributes of pearl millet.

Graded levels of applied $ZnSO_4$ showed substantial improvement in seed and stover yield of pearl millet up to 20 kg $ZnSO_4$/ha (Table 2). On the pooled basis, increase in seed and stover yield under 20 kg $ZnSO_4$/ha was 40.5, 24.8% and 26.4, 17% over control and 10 kg $ZnSO_4$/ha, respectively. Significant improvement in growth of pearl millet led to the greater accumulation of biomass resulting in increased grain and stover yield. Increased translocation of photosynthates towards reproductive system improved source and sink relationship. Seed biological yield and HI increased up to the residual effect of 7.5 kg zinc/ha.

There was a significant improvement in protein content of grain with increase the levels of applied $ZnSO_4$ up to 20 kg/ha and that 20 kg was 24.7 and 13.2% higher over control and 10 kg $ZnSO_4$/ha, respectively. Keram *et al.* (2014) results showed that application of zinc @ 10 and 20 kg/ha significantly increased crude protein content in grains by 21.89 and 23.03 per cent over control.

The net returns and B: C ratio of pearl millet crop also increased significantly with increase in levels of $ZnSO_4$ up to 20 kg/ha (Table 3). Application of 20 kg $ZnSO_4$/ha recorded significantly higher net return (Rs. 10,868) and B: C ratio (2.96) that was 43.74, 11.27% and 30.86, 10.53% higher over control and 10 kg $ZnSO_4$/ha, respectively. However, B: C ratio was statistically at par with 10 kg $ZnSO_4$/ha. This may be attributed to higher grain and stover yield of pearl millet under 20 kg $ZnSO_4$/ha that ultimately contributed to net return and B: C ratio.

Effect of zinc as foliar spray

Foliar spray of $ZnSO_4$ had a significant effect on growth parameters over control during three consecutive years and

Table 1: Effect of different methods of zinc application on growth parameters of pearl millet at harvest stage

Treatment	Plant height (cm)				No. of green leaves/ plant				Dry matter/plant (g)				Total tillers/ plant			
	2004	2005	2006	Pooled	2004	2005	2006	Pooled	2004	2005	2006	Pooled	2004	2005	2006	Pooled
Soil application																
Control	104.09	109.44	112.00	108.51	3.08	4.14	4.77	4.00	36.49	39.72	39.89	38.70	3.92	3.26	3.43	3.54
10 kg $ZnSO_4$	110.80	115.33	116.00	114.04	3.57	5.02	5.48	4.69	45.70	46.83	49.33	47.29	5.07	4.13	4.14	4.45
20 kg $ZnSO_4$	114.69	121.11	121.78	119.19	3.86	6.00	6.27	5.37	49.49	53.61	55.44	52.85	5.54	4.57	4.54	4.89
SEm±	0.79	0.85	0.89	0.48	0.09	0.13	0.14	0.09	0.60	0.63	0.68	0.72	0.08	0.09	0.11	0.10
CD (P=0.05)	2.35	2.55	2.68	1.45	0.56	0.38	0.42	0.56	1.78	1.90	2.03	2.15	0.55	0.58	0.34	0.30
Foliar application																
Control	104.69	107.89	112.11	108.23	3.19	4.44	4.88	4.17	37.06	38.17	39.11	38.11	4.04	3.36	3.71	3.70
0.5% $ZnSO_4$ spray at tillering	113.91	119.44	120.11	117.82	3.74	5.44	5.92	5.04	48.76	51.94	53.78	51.49	5.43	4.34	4.29	4.69
0.5% $ZnSO_4$ Spray at pre-flowering	110.98	118.56	117.56	115.70	3.57	5.28	5.71	4.85	45.87	50.06	51.78	49.23	5.06	4.26	4.12	4.48
SEm±	1.28	1.39	1.46	0.79	0.14	0.51	0.53	0.13	0.91	1.04	1.11	1.17	0.14	0.15	0.19	0.15
CD (P=0.05)	3.84	4.16	4.37	2.36	0.42	0.63	0.66	0.39	2.74	3.11	3.32	3.51	0.41	0.46	0.56	0.44

Table 2: Effect of different methods of zinc application on yield attributes and protein content of pearl millet at harvest stage

Treatment	Effective tillers/ plant				Length of ear (cm)				Test weight (g)				Protein content (%)			
	2004	2005	2006	Pooled	2004	2005	2006	Pooled	2004	2005	2006	Pooled	2004	2005	2006	Pooled
Soil application																
Control	2.67	2.63	2.59	2.63	19.59	19.69	19.73	19.67	5.40	5.47	5.55	5.47	9.21	9.28	9.41	9.30
10 kg $ZnSO_4$	3.02	3.29	3.29	3.20	21.07	21.27	21.40	21.24	6.57	6.63	6.76	6.65	10.40	10.50	10.69	10.53
20 kg $ZnSO_4$	3.40	3.70	3.77	3.62	21.93	22.26	22.38	22.19	7.08	7.16	7.28	7.17	11.39	11.59	11.83	11.60
SEm±	0.08	0.08	0.09	0.07	0.54	0.56	0.57	0.58	0.11	0.12	0.13	0.11	0.15	0.17	0.50	0.16
CD (P=0.05)	0.53	0.54	0.57	0.51	0.73	0.79	0.81	0.85	0.33	0.35	0.38	0.34	0.45	0.50	0.59	0.48
Foliar application																
Control	2.62	2.80	2.77	2.73	19.71	19.83	19.86	19.80	5.52	5.59	5.70	5.60	9.55	9.63	9.75	9.64
0.5% $ZnSO_4$ spray at tillering	3.31	3.53	3.46	3.43	21.82	21.94	22.08	21.95	6.97	7.04	6.75	7.05	11.00	11.10	11.19	11.10
0.5% $ZnSO_4$ spray at pre-flowering	3.16	3.29	3.42	3.29	21.06	21.43	21.57	21.35	6.56	6.62	7.15	6.64	10.45	10.64	10.99	10.69
SEm±	0.12	0.13	0.14	0.10	0.40	0.43	0.45	0.47	0.18	0.19	0.50	0.19	0.57	0.57	0.59	0.56
(P=0.05)	0.37	0.39	0.41	0.30	1.20	1.32	1.36	1.30	0.54	0.57	0.58	0.56	0.82	0.81	0.86	0.78

pooled data (Table 1). Due to foliar spray of $ZnSO_4$ @ 0.5% at tillering stage significantly increased plant height, number of leaves/plant, dry matter/plant, total number of tillers/plant and effective tillers/plant which was statistically at par with 0.5% foliar spray of $ZnSO_4$ at pre-flowering stage and in term of percentage was 7.1, 20.9, 37.5, 26.8 and 25.6% higher over control, respectively.

Yield attributes *viz*. length of ear and test weight was significantly influenced by foliar spray of $ZnSO_4$. Application of 0.5% $ZnSO_4$ as a foliar spray at tillering stage was at par with 0.5% foliar spray at the pre-flowering stage, significantly enhanced ear length and test weight 10.8 and 25.9% higher over control.

On the pooled basis, application of 0.5% $ZnSO_4$ at tillering stage significantly increased grain and stover yield of pearl millet which was at par with 0.5% foliar spray at pre-flowering (Table 3). The magnitude of increase in grain and stover yield was 30.3, 19.9% and 21.4 and 13.8% due to a foliar spray of 0.5% $ZnSO_4$ at tillering stage over control and pre-flowering stage, respectively. On the pooled basis, application of 0.5% foliar spray of $ZnSO_4$ at tillering stage showing perceptible improvement in protein content of pearl millet grain. The 0.5% foliar spray at tillering stage increase the protein content by 15.15 and 10.89% higher over control and 0.5% foliar spray at tillering stage but it remains at par with 0.5% foliar spray of $ZnSO_4$ at pre-flowering stage. Higher net return (Rs. 10,842) and B:C ratio (3.10) were recorded under 0.5% foliar spray of $ZnSO_4$ at tillering which was comparable

Table 3: Effect of different methods of zinc application on yields and economics of pearl millet

Treatment	Grain yield (kg/ha)				Straw yield (kg/ha)				Net return (x 10^{3}`/ha)				B:C ratio			
	2004	2005	2006	Pooled	2004	2005	2006	Pooled	2004	2005	2006	Pooled	2004	2005	2006	Pooled
Soil application																
Control	964	1043	1111	1039	2167	2567	2827	2520	6.43	7.66	8.60	7.56	2.41	2.69	2.89	2.66
10 kg $ZnSO_4$ kg/ha	1127	1338	1475	1313	2574	3037	3235	2949	7.84	10.23	11.62	9.89	2.55	3.02	3.30	2.94
20 kg $ZnSO_4$	1272	1500	1608	1460	2772	3257	3413	3147	8.80	11.35	12.45	10.87	2.59	3.05	3.25	2.96
SEm±	22	32	34	24	46	52	57	55	0.13	0.27	0.31	0.15	0.03	0.05	0.06	0.05
CD (P=0.05)	65	96	104	71	139	155	170	163	0.40	0.81	0.92	0.46	0.08	0.16	0.18	0.15
Foliar application																
Control	931	1090	1232	1084	2222	2720	2803	2582	5.88	7.90	9.16	7.65	2.19	2.61	2.84	2.55
0.5% $ZnSO_4$ spray at tillering	1235	1455	1545	1412	2704	3101	3488	3098	8.84	11.20	12.49	10.84	2.73	3.18	3.44	3.10
0.5% $ZnSO_4$ spray at pre-flowering	1196	1336	1417	1316	2586	3040	3185	2937	8.35	10.15	11.01	9.84	2.63	2.97	3.16	2.92
SEm±	36	52	57	39	47	76	99	93	0.22	0.44	0.50	0.25	0.05	0.09	0.10	0.08
CD (P=0.05)	107	157	170	116	140	228	297	278	0.66	1.32	1.50	0.75	0.15	0.26	0.30	0.24

to 0.5% foliar spray at pre-flowering stage and significantly superior to control. The percent increase in net return and B: C ratio was 41.8, 21.6% and 28.7, 14.5% over control and 0.5% foliar spray of $ZnSO_4$ at pre-flowering stage, respectively.

CONCLUSION

From the present experimental results indicated that application $ZnSO_4$ @ 20 kg/ha as soil application and foliar spray 0.5% at tillering stage increase the growth characters, yield attributes and yields. Similarly, maximum net return and B:C was also observed under $ZnSO_4$ @ 20 kg/ha as soil application and foliar spray 0.5% at tillering stage of pearl millet under rainfed condition.

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