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Assessing the Impact of Zinc and Boron Supplementation on Oats Grown under Red and Lateritic Soil of West Bengal

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ABSTRACT

Background: *Avena sativa* L. (common oat) is the most important among the cultivated oat belongs to the Poaceae family and is known as Jai or Javi in Indian subcontinent. It is important winter forage in many parts of the world and is grown as multipurpose crop for grain, pasture, forage or as a rotation crop.

Methods: A field experiment was conducted to study the effect of Zinc Sulphate and Borax on growth, yield components, yield and economics of oats seed production in red and lateritic soil of West Bengal during *rabi* seasons of 2015-16 and 2016-17 at agricultural farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal. The experiment was laid out in factorial randomized block design having two factors each with four levels (Zinc Sulphate with 0, 15, 20 and 25 kg/ha as well as Borax with 0, 5, 10 and 15 kg/ha).

Result: Pooled data over two years of experiments showed that soil application with Zinc Sulphate and Borax at various levels significantly influenced growth attributes (dry matter accumulation, leaf area index and crop growth rate), yield components (no. of panicles/m^2, no. of filled grains/panicle and test weight), yield (seed yield, straw yield and biological yield) and economics of oats seed production. With increasing levels of $ZnSO_4$ application, highest number of panicles/m^2 (196.27), seed yield (3.00 t/ha), straw yield (6.94 t/ha) and biological yield (9.85 t/ha) were obtained at 25 kg/ha though these were at par with 20 kg $ZnSO_4$/ha. Higher number of filled grains/panicle (76.47), test weight (29.93 g), seed yield (2.95 t/ha), straw yield (6.70 t/ha) and biological yield (9.63 t/ha) were found with application of borax @ 10 kg/ha. The highest gross return, net return and return per rupee investment was achieved with application of $ZnSO_4$ @ 20 kg/ha (₹ 1,17,257/ha, ₹ 68,997/ha and 2.65, respectively) which was significantly higher than both of 25 kg $ZnSO_4$/ha (₹ 1,15,051/ha, ₹ 64,489/ha and 2.52, respectively) and 15 kg $ZnSO_4$ /ha (₹ 1,05,198/ha, ₹ 59,240/ha and 2.44, respectively). Similarly, highest gross return, net return and return per rupee investment was obtained with application of borax @ 10 kg/ha (₹ 1,15,537/ha, ₹ 69,070/ha and 2.67, respectively). A significant interaction between Zinc Sulphate and borax was found towards seed yield, biological yield, gross return, net return and return per rupee investment in oats seed production. Use of $ZnSO_4$ at 20 kg/ha and borax at 10 kg/ha conjunctively achieved highest seed yield (3.28 t/ha), biological yield (10.81 t/ha), gross return (₹ 1, 27, 530/ha), net return (₹ 78,760/ha) and return per rupee investment (₹ 3.78) in oats seed production.

Key words: Borax, Economics, Growth attributes, Sulphate, Yield Components, Yield, Zinc.

INTRODUCTION

Oats is the most important cereal fodder crop grown in winter in north western, central India and are now extending to the eastern region. Oat ranks sixth in world cereal production following wheat, maize, rice, barley and sorghum. *Avena sativa* L. (common oat) is the most important among the cultivated oat belongs to the Poaceae family and is known as Jai or Javi in Indian subcontinents. Before being used as a food, it was used for medicinal purposes. With the development in field of nutrition, oat was recognized as a healthy food in the mid 1980's signifying that a substance in it helped to prevent heart disease and therefore, it became more popular for human nutrition. The dietary fibre complex with its antioxidants and other phytochemicals is effective against cardiovascular disease and some types of cancer (Jacobs *et al*., 1998a, 1998b; Slavin *et al*., 2000; Thompson, 1994). It is also rich in dietary fiber, β-glucan, minerals and antioxidants which has been reported to benefit the relief of various disorders (Madhujith and Shahidi, 2007; Brindzova *et al*., 2008) such as cardiovascular disease (Berg *et al*., 2003), serum cholesterol (Chen *et al*., 2006), diabetes (Tapola *et al*., 2005) and obesity (Zdunczyk *et al*., 2006).

Oats have been viewed as a low input crop and has commonly cultivated in soil low in fertility. The progress of advanced agronomic practices with high market demand compelled the researchers for better nutrient management when growing oats. The sowing of oats is generally practised

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without addition of fertilizers and its nutrition is dependent on the residual fertilizer from previous crops. This may result to a decrease in fodder production and its nutritional value that causes nutritional deficiencies in animals fed exclusively with such forage. Moreover, the inadequate availability of zinc (Zn) and boron (B) in the soil may limit the development of crops and also affect forage plants. These minerals are required for the basic processes of plant life. Zinc helps in the synthesis of tryptophan and is required for plant growth, nitrogen metabolism, starch and chlorophyll synthesis and ATPase activity (Malta *et al*., 2002). Boron is essential for maintaining the integrity of cell membrane, cell wall synthesis and lignification (Goldbach *et al*., 2001). Thus, disproportion of these minerals can cause nutritional imbalances and that of subsequent effect on dry matter production. Very limited findings are known about the effect of applying these micronutrients on production and nutritional value of oats. Thus present experiment was attempted to study the effect of zinc sulphate and borax on growth, yield components, seed yield and economics of oats.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal in red and lateritic soil during *rabi* season of 2015-16 and 2016-17. The fodder crop, var. JHO-822, a multi-cut fodder variety was grown following recommended package of practices having a net plot size of 4 m × 3 m. Seeds were sown on 7th December, 2015 and 27th November, 2016 and harvested on 10th April, 2016 and 1st April, 2017, respectively. The experimental site was situated at 23°39′N latitude and 87°42′E longitude with an average altitude of 58.90 m above mean sea level in sub-humid, semi-arid, subtropical lateritic belt of West Bengal with hot summer and moderately cold and short winter. The total rainfall received during the crop season was 54.3 mm, which was sporadic. The soil of the experimental site was slightly acidic (pH 5.98), sandy loam texture with low level organic carbon content (0.39%), medium in nitrogen (189.26 kg/ha), low in phosphorus (32.64 kg/ha) and medium in potassium (151.25 kg/ha) contents. The experiment, consisting of two factors such as soil application of zinc sulphate at 04 levels (0, 15, 20 and 25 kg/ha) and borax at 04 levels (0, 5, 10 and 15 kg/ha) having 16 treatment combinations, was laid out in factorial randomized block design (FRBD) with each treatment replicated thrice. Observations on different growth parameters were recorded at regular interval. The experimental data of two years of observations were pooled over and statistically analyzed by using software SAS version 3.0.

RESULTS AND DISCUSSION

Growth attributes

Soil application of $ZnSO_4$ and borax had significant influence on growth attributes of oats (*viz*. plant height, number of tillers/plant, dry matter accumulation, leaf area index and crop growth rate) at different growth stages under study as evidenced from pooled data over two years of field experiments (Table 1, 2). Application of $ZnSO_4$ @ 25 kg/ha showed highest plant height (150.27 cm) and dry matter accumulation (744.35 g/m^2) at 90 DAS, number of tillers/plant (8.88) and leaf area index (4.0) at 60 DAS and crop growth rate (19.17 g/m^2/day) during 45-60 DAS. However, these were statistically at par with 20 kg zinc sulphate/ha. These findings were in accordance with the results reported by Tiwari *et al*. (1990), Arora and Singh (2004) and Joshi *et al*. (2007).

Similarly, application of Borax at 15 kg/ha produced highest plant height (151.24 cm) and dry matter accumulation (748.88 g/m^2) at 90 DAS, number of tillers/plant (8.83) and leaf area index (4.10) at 60 DAS and crop growth rate (19.04 g/ m^2/day) at 45-60 DAS though these were at par with borax @ 10 kg/ha. Conjunctive use of $ZnSO_4$ and borax had no significant interaction on various growth attributes of oats except dry matter accumulation at 45 DAS, leaf area index at 30 DAS and crop growth rate during 30-45 DAS. These results were in agreement with the findings of Wrobel *et al* (2006), Josji *et al*. (2007) and Khanday *et al.* (2009).

Yield components and yield

A significant response was found among various levels of $ZnSO_4$ and borax application towards yield components, yield and harvest index of oats (Table 3). With increasing levels of $ZnSO_4$ application, highest number of panicles/m^2 (196.27), seed yield (3.00 t/ha), straw yield (6.94 t/ha) and biological yield (9.85 t/ha) were obtained at 25 kg/ha though these were at par with 20 kg $ZnSO_4$/ha. However, higher number of filled grains/panicles (77.07) and test weight (30.06 g) were found at 20 kg/ha of $ZnSO_4$ application. Highest number of panicles/m^2 (198.30) was observed with application of borax @15 kg/ha though this was similar with 10 kg borax/ha. Higher number of filled grains/panicle (76.47), test weight (29.93 g), seed yield (2.95 t/ha), straw yield (6.70 t/ha) and biological yield (9.63 t/ha) were obtained with application of borax @ 10 kg/ha. The findings were in accordance with the study reported by Hazra and Sinha (1996) and Khanday *et al.* (2009). No significant interaction was found between $ZnSO_4$ and borax on yield components of oats.

A significant interaction between $ZnSO_4$ and borax was found on seed yield and biological yield of oats (Table 4). Combined application of $ZnSO_4$ @ 20 kg/ha and borax @ 10 kg/ha produced highest seed yield (3.28 t/ha) and biological yield (10.81 t/ha) of oats. Significant response of micronutrients like zinc and boron to yield components, seed yield and straw yield of oats was also mentioned by Tiwari *et al.* (1990); Ziaeian and Malakouti (2001); Wrobel *et al* (2006) and Khanday *et al.* (2009).

Economics

In oats seed production, application of various levels of $ZnSO_4$ and borax had significant effect on gross return, net

Table 1: Effect of zinc sulphate and borax application on different growth parameters of oats (pooled data of two years).

Treatment	Plant height (cm)					Number of tillers/plant				Dry matter accumulation (g/m^2)				
$ZnSO_4$ (kg/ha)	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
0	35.88	72.30	98.55	130.32	137.10	3.42	5.18	8.04	6.19	29.40	102.75	367.54	582.87	686.45
15	38.86	76.14	102.63	135.93	143.36	3.80	5.33	8.27	6.49	33.79	129.99	396.25	609.82	726.31
20	41.12	79.49	107.69	140.89	146.58	3.96	5.73	8.62	6.83	38.44	139.29	412.19	621.89	740.91
25	41.89	79.94	111.24	144.74	150.27	4.11	6.12	8.88	6.98	42.52	147.64	422.13	632.74	744.35
SEm(±)	0.65	1.38	1.60	1.36	1.38	0.15	0.15	0.17	0.13	0.66	2.26	4.64	5.89	9.65
CD ($p=_{0.05}$)	1.89	3.97	4.62	3.93	3.98	0.43	0.44	0.50	0.38	1.92	6.51	13.40	17.00	27.86
Borax (kg/ha)														
0	34.88	72.75	94.45	128.76	135.82	3.34	5.07	7.91	6.24	29.29	103.04	367.41	582.11	688.05
5	38.72	76.01	99.09	137.28	141.31	3.70	5.50	8.36	6.56	33.65	131.21	399.47	608.39	728.59
10	41.52	79.23	111.35	140.75	148.95	4.08	5.92	8.76	6.83	38.87	141.39	412.54	625.50	732.55
15	42.67	79.88	115.22	145.09	151.24	4.16	5.87	8.83	6.86	42.26	144.02	418.69	631.26	748.88
SEm(±)	0.65	1.38	1.60	1.36	1.38	0.16	0.13	0.18	0.13	0.66	2.26	4.64	5.89	9.65
CD ($p=_{0.05}$)	1.89	3.97	4.62	3.93	3.98	0.43	0.44	0.50	0.38	1.92	6.51	13.40	17.00	27.86
Zn × B Interaction														
SEm (±)	1.31	2.74	3.20	2.67	2.75	0.29	0.31	0.34	0.38	1.32	4.51	9.28	11.76	19.29
CD ($p=_{0.05}$)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	13.01	NS	NS	NS

return and return per rupee investment (Table 3). The highest gross return, net return and return per rupee investment was achieved with application of $ZnSO_4$ @ 20 kg/ha (₹1,17,257/ha, ₹68,997/ha and 2.65, respectively) which was significantly higher than both of 25 kg $ZnSO_4$/ha (₹1,15,051/ha, ₹64,489/ha and 2.52, respectively) and 15 kg $ZnSO_4$/ha (₹1,05,198/ha ₹59,240/ha and 2.44, respectively). Similarly, highest gross return, net return and return per rupees investment was obtained with application of borax @ 10 kg/ha (₹1,15,537/ha, ₹69,070/ha and 2.67, respectively). However, this was statistically at par with borax @ 15 kg/ha (₹1, 14,576/ha, ₹67,089/ha and 2.63, respectively). A significant interaction was found between zinc sulphate and borax on economics of oats seed production (Table 5). Conjunctive use of $ZnSO_4$ @ 20 kg/ha along with borax @ 10 kg/ha in oats showed highest gross

Table 2: Effect of zinc sulphate and borax application on leaf area index and crop growth rate of oats (pooled data of two years).

Treatment	Leaf area index					Crop growth rate (g/m²/day)			
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30-45 DAS	45 -60 DAS	60-75 DAS	75-90 DAS
$ZnSO_4$ (Kg/ha)									
0	1.40	2.09	3.36	3.31	2.81	4.94	17.64	14.47	7.47
15	1.67	2.47	3.59	3.40	3.14	6.48	18.20	14.97	8.29
20	1.95	2.66	3.82	3.64	3.21	6.93	18.54	15.08	8.97
25	2.00	2.70	4.00	3.76	3.53	7.35	19.17	15.28	8.97
SEm(±)	0.06	0.10	0.18	0.17	0.15	0.15	0.31	0.29	0.37
CD ($p=_{0.05}$)	0.15	0.15	0.31	0.30	0.25	0.41	1.09	1.01	0.45
Borax (kg/ha)									
0	1.44	2.19	3.21	3.24	2.90	4.91	17.72	14.32	7.86
5	1.74	2.22	3.67	3.28	3.03	6.58	18.04	14.69	8.52
10	1.87	2.69	3.81	3.58	3.24	7.04	18.70	15.28	8.33
15	1.97	2.80	4.10	4.01	3.42	7.17	19.04	15.46	9.09
SEm (±)	0.06	0.10	0.18	0.17	0.15	0.15	0.31	0.29	0.37
CD($p=_{0.05}$)	0.15	0.28	0.31	0.30	0.25	0.41	1.09	1.01	0.45
Zn × B interaction									
SEm (±)	0.11	0.19	0.34	0.34	0.30	0.28	0.61	0.58	0.79
$CD_{0.05}$	0.31	NS	NS	NS	NS	0.81	NS	NS	NS

Table 3: Effect of Zinc sulphate and borax on yield components, yield and economics of oats seed production (pooled data of two years).

Treatment	Number of panicles/m²	Number of filled grains/ panicle	Test weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Gross return (₹/ha)	Net return (₹/ha)	Return per rupee investment (₹)
$ZnSO_4$ (kg/ha)										
0	175.12	65.93	28.65	2.23	5.21	7.44	29.63	88107	49057	2.30
15	183.81	71.60	29.13	2.69	6.08	8.77	30.75	105198	59240	2.44
20	194.52	77.07	30.06	2.91	6.74	9.74	30.81	117257	68997	2.65
25	196.27	72.02	29.22	3.00	6.94	9.85	29.50	115052	64489	2.52
SEm(±)	1.87	1.82	0.50	0.06	0.12	0.13	0.64	1707	1707	0.04
$CD_{0.05}$	5.40	5.26	1.44	0.17	0.35	0.36	1.86	4930	5019	0.11
Borax (kg/ha)										
0	172.20	65.51	28.52	2.30	5.56	7.85	28.92	91225	46798	2.18
5	181.47	69.92	29.07	2.67	6.04	8.70	30.73	104273	58826	2.45
10	197.75	76.47	29.93	2.95	6.70	9.63	30.65	115538	69070	2.67
15	198.30	74.72	29.60	2.92	6.68	9.61	30.39	114577	67089	2.63
SEm(±)	1.87	1.82	0.50	0.06	0.12	0.13	0.64	1707	1707	0.04
$CD_{0.05}$	5.40	5.26	1.44	0.17	0.35	0.36	1.86	4930	5019	0.11
(Zn × B) interaction										
SEm (±)	3.74	3.63	1.00	0.11	0.24	0.25	1.29	3414	3414	0.04
$CD_{0.05}$	NS	NS	NS	0.32	NS	0.82	3.75	9860	9858	0.23

Table 4: Interaction effect between $ZnSO_4$ and Borax on Seed yield and Biological yield of oats (pooled data of two years).

Borax (kg/ha)	Seed yield (t/ha)				Biological yield (t/ha)			
	$ZnSO_4$ (kg/ha)				$ZnSO_4$ (kg/ha)			
	0	15	20	25	0	15	20	25
0	1.45	2.39	2.63	2.71	5.96	8.20	9.42	9.46
5	2.26	2.70	2.92	2.78	8.21	8.54	9.73	9.51
10	2.53	2.83	3.28	3.17	9.30	9.60	10.81	10.36
15	2.67	2.85	3.17	2.97	9.43	9.88	10.75	10.65
SEm(±)		0.09				0.14		
$CD_{0.05}$		0.26				0.41		

Table 5: Effect of interaction between $ZnSO_4$ and Borax on economics of oats seed production (pooled data of two years).

Borax (kg/ha)	Gross return (₹/ha)				Net return (₹/ha)				Return per rupee investment (₹)			
	$ZnSO_4$ (kg/ha)				$ZnSO_4$ (kg/ha)				$ZnSO_4$ (kg/ha)			
	0	15	20	25	0	15	20	25	0	15	20	25
0	59775	94045	103900	107180	22255	49617.5	57170	58148	2.05	2.85	3.34	3.31
5	88695	103960	114070	110365	50155	58512.5	66320	60313	2.90	3.04	3.40	3.27
10	99735	110790	127530	124095	60175	64322.5	78760	73023	3.29	3.41	3.78	3.46
15	104220	111995	123525	118565	63640	64507.5	73735	66473	3.33	3.40	3.68	3.55
SEm(±)		3413.58				3413.58				0.08		
$CD_{0.05}$		9859.90				9857.90				0.23		

return, net return and return per rupee investment (₹1, 27,530/ha, ₹78,760/ha and 3.78, respectively).

CONCLUSION

Combined application of $ZnSO_4$ @ 20 kg/ha and borax @ 10 kg/ha achieved significantly higher yield components and seed yield as well as higher gross return, net return and return per rupee investment in oats seed production.

Conflict of interest

All authors declare that they have no conflict of interest.

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