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ORIGINAL ARTICLE

Studies on the effect of Zinc levels , and methods of boron application on growth, yield and protein content of Wheat (*Triticum aestivum* L.)

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ABSTRACT
A field experiment was carried out to evaluate the effect of zinc levels and methods of application of boron on the growth, yield and protein content of wheat (Triticum aestivum L.) during the winter (Rabi) season in two consecutive years, i.e. 2003-04 and 2004-05 at the Allahabad agricultural Institute – Deemed University, Allahabad. Texture of the soil was sandy loam, slightly alkaline in nature, nitrogen (61.70, 68.62 kg/ha), phosphorus (10.48, 15.45 kg/ha) and potash (188.23, 220.03 kg/ha). The treatments comprised three levels of zinc (0, 3.5 and 7 kg ha^{-1}*) through zinc sulphate and four methods of application of boron (0, soil application @ 0.5 kg* ha^{-1}*, foliar spray @ 0.5kg* ha^{-1} *at 45 and 60 days after sowing and soil application @ 0.25 kg* ha^{-1} *+ foliar spray @ 0.25 kg* ha^{-1} *at 45, 60 DAS) as borax, making 12 treatment combinations, each replicated three times. On the basis of the findings of the experiment, zinc @ 7 kg* ha^{-1}*, soil application of boron @ 0.25 kg* ha^{-1} *+ foliar application of boron @ 0.25 kg* ha^{-1} *and their combination (i.e., 7 kg* ha^{-1} *zinc + soil application of boron @ 0.25 kg* ha^{-1} *+ foliar application of boron @ 0.25 kg* ha^{-1}*) was found superior over all other treatments in relation to plant height, dry weight, effective tillers yield and yield attributes and protein content in grains, of wheat crop.*
Key words: *Wheat, zinc, boron, zinc sulphate, borax, foliar spray.*

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INTRODUCTION

Wheat is cultivated in most of parts of the world. It is staple diet for majority of the population in both developed and developing countries. Wheat compares well with other important cereals in the nutritive value. It contains more protein than other cereals. The nutritive values of wheat are starch (60-68%), protein (8-15%), fat, sugar, cellulose, minerals, vitamins, etc [1].

Wheat is known to respond to the application of several macro and micronutrients during its growing stages and results in enhanced output in terms of yield. Micronutrients comprising zinc, copper, iron, manganese, boron, molybdenum and chlorine are though required by plants in much smaller amounts, yet are as essential as the major nutrients such as nitrogen, phosphorus, potassium etc.

According to recent, deficiency of zinc is widespread and covers about 48% area in the country [2]. Zinc was one of the first micronutrients, essentiality of which for plant growth has been confirmed. Zinc also plays a role in nucleic acid and protein synthesis and helps in the utilization of phosphorus and nitrogen, as well as in seed formation. Zinc is an important element for terrestrial life since it is required as either a structural component or reaction site in numerous proteins. Zinc deficiency in wheat resulted in sever reduction in growth, grain yield and seedling vigour, and enhances sensitivity of plants to pathogens. Decrease in grain quality is another typical consequence of zinc deficiency in wheat [3].

Boron is also one of the seven essential micronutrients required for the normal growth of most of the cereal, fruit and vegetable crops. It is the only non-metal among the seven plant micronutrients. Since its discovery as an essential trace element, the importance of boron as an agricultural chemical has grown very rapidly. The requirement of boron varies greatly between crops and cultivars and between soil and climatic conditions. Boron is unique among the essential mineral micronutrients because it is the only element that is normally present in soil solution as non-ionized molecule over the pH range suitable for plant growth. Boron is involved in the transport of sugars across cell membranes and in synthesis of cell wall material. It influences transportation through the control of sugar and starch formation. It also influences cell development and elongation [4]. Boron affects carbohydrates metabolism and plays a role in amino acid formation and synthesis of proteins [5]. Deficiency of boron can also cause reduction in crop yield and inferior crop quality. Boron is an essential plant food element, having a specific role in growth and development of plants. Intensive agriculture involving exhaustive high yielding varieties of rice and wheat has led to heavy withdrawal of nutrients from the soil. Imbalanced use of chemical fertilizers by the farmers has deteriorated soil health. The widely practiced rice-wheat system in northern India is one such instance, where sustainability is under threat. However, it is the most productive and profitable system. To curb this trend of declining yield, there is a need to adopt the concept of INM [6]. Micronutrients such as zinc, boron manganese, Molybdenum, copper, iron and chlorine are important components of INM and may help to recover the soil health in the cropping system.

MATERIAL AND METHODS

The experiment was laid out in randomized block design (3x4 factorial), having 3 levels of zinc (0,3.5 and 7 kg ha^{-1}) through zinc sulphate and four methods of application of boron (0,soil application @ 0.5 kg ha^{-1}, foliar spray @ 0.5 kg ha^{-1} at 45 and 60 days after sowing, and soil application @ 0.25 kg ha^{-1}+foliar spray @ 0.25 kg ha^{-1} at 45, 60 day after sowing) through borax; making 12 treatment combinations, each replicated 3 times.

Soil of the experimental field was sandy loam in texture, alkaline in nature, nitrogen (61.70, 68.62 kg/ha), phosphorus (10.48, 15.45 kg/ha) and potash (188.23, 220.03 kg/ha). pH of the soil was 7.3 and 7.2, organic carbon 0.72% and 0.76%; available zinc 1.185 and 1.189 ppm; available boron 0.015 and 0.019 ppm, during first and second year of experimentation, respectively. Soil samples were collected from plot of each treatment of research field at initial as well as final stage of the experimentation to the 15cm. the dried soil samples were subjected to various analysis. Soil pH and electrical conductivity were estimated respectively [7]. The available nitrogen phosphorus, potassium and organic carbon content were estimated with the methods as described by Subbaiah and Asija [8] by alkaline potassium permanganate estimation of available phosphorus,; Jackson,[7] using Olsen's method ,potassium was determined by Flame photometer method Jackson [10] and organic carbon by rapid titration [9],respectively.

RESULTS AND DISCUSSION

Yield and yield attributes such as plant height, number of effective tillers/m^2, plant dry weight, grain yield, straw yield and protein content in grains were significantly affected by the treatment as well as their interaction.

The data pertaining to plant height was recorded at 70 and 90 DAS. The effect of levels of zinc and methods of boron application on plant height was found to be significant at 90 DAS, during both the years of experimentation. Treatment combination Z_2 B_3 (i.e @ zinc 7 kg ha^{-1} + application of boron @ 0.25 kg ha^{-1} in soil + foliar spray @ 0.25 kg ha^{-1}) recorded the maximum pant height (88.09 cm in 1st year 90.47 cm in 2nd year), which was followed by and significantly higher than the treatment combination Z_2 B_2 (i.e., zinc @ 7 kg ha^{-1} and foliar spray of boron @ 0.5 kg ha^{-1}) with values of 86.88 and 87.89 cm in 1st Year and in 2nd Year, respectively, and the minimum (82.13 cm in 2003-04 and 82.88 cm in 2nd year was recorded with control plot (Z_0 B_0).

With the increase in levels of zinc and change in methods of application of boron from soil application to foliar application and then to soil application + foliar application, the plant height gradually increased, which might be attributable to greater photosynthetic activity and chlorophyll synthesis due to zinc and boron fertilization resulting into better vegetative growth. Salet *et al.* [11] and Shaaban *et al.* [12] also reported similar results.

Number of leaves per plant recorded at 70 and 90 DAS. The effect levels of zinc and methods of application of boron significantly affected the number of leaves per plant at 70 and 90 DAS during both the years of experimentation. In these intervals treatment combination Z_2 B_3 (i.e, zinc @ 7 kg ha^{-1} and application of boron @ 0.25 kg ha^{-1} in soil + foliar spray @ 0.25 kg ha^{-1}) recorded the maximum number of leaves per plant (19.11, 19.11 at 70 DAS and 22.44, 22.44 at 90 DAS and 1st Year and in 2nd Year, respectively), which was significantly higher than the treatment combination Z_2 B_2 (i.e., zinc @ 7 kg ha^{-1} and foliar spray of boron @ 0.5 kg ha^{-1}), (18.22, 18.44 at 70 DAS and 21.22 21.89 at 90 DAS 1st Year and in 2nd Year, respectively) in both the years. The treatment combinations Z_2 B_2 was statistically at par with Z_2 B_3 at 90 DAS in 2nd year the minimum was recorded with control plot (Z_0B_0).

At successive stages of growth, the number of leaves per plant gradually increase with the increase in levels of zinc and change in methods of application of boron from soil application to foliar application and then to soil application + foliar application, which might be attributable to greater photosynthetic activity and chlorophyll synthesis due to zinc and boron fertilization resulting into better vegetative growth. These results are in conformity with the findings of Magomendaliev *et al* [13].

Table 1. Effect of Different levels of Zinc and methods of Boron Application on Plant Height, Number of leaves and Plant Dry weight of wheat (*Triticum aestivum* L)

Treatment Combinations		Plant Height (cm)				Number of leaves / Plant				Plant Dry Weight (g)			
		1st Year		2nd Year		1st Year		2nd Year		1st Year		2nd Year	
		70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS
T_0	Control Z_n 0 kg ha-1+ B0 kg ha-1	59.28	82.13	60.64	82.88	15.33	15.11	15.63	15.83	6.33	15.11	6.33	14.93
T_1	Z_n 0 kg ha-1+ soil app. of B0.5kg ha-1	59.67	83.64	60.67	82.90	15.44	18.54	15.66	18.96	6.42	18.54	6.50	18.83
T_2	Z_n 0 kg ha-1 + foliar app .of B 0.5kg ha-1	59.94	83.83	60.91	83.39	15.66	18.98	15.86	19.51	6.50	18.72	6.50	18.90
T_3	Z_n 0 kg ha-1+ soil app of B0.25kg ha-1 +foliar app .of B 0.25kg ha-1	60.28	84.44	60.94	84.33	16.00	19.03	16.21	19.77	6.75	19.03	6.77	19.42
T_4	Z_n 3.5kg ha-1+B0 kg ha-1	61.13	84.65	61.79	85.03	16.55	19.11	16.65	20.11	6.75	19.20	6.92	19.60
T_5	Z_n 3.5kg ha-1+ soil app .of B0.5kg ha-1	61.22	85.37	61.79	85.03	16.77	19.33	16.99	20.22	6.83	19.43	7.00	19.72
T_6	Z_n 3.5kg ha-1+ foliar app .of B0.5kg ha-1	61.43	85.44	62.06	85.48	17.33	19.43	17.44	20.88	6.92	19.44	7.00	19.89
T_7	Z_n 3.5kg ha-1+ soil app .of B0.25kg ha-1 + foliar app .of B 0.25kg ha-1	61.61	85.67	62.64	86.15	17.33	19.44	17.44	20.89	7.00	19.48	7.17	20.05
T_8	Z_n 7.0kg ha-1+ B0 kg ha-1	61.77	85.69	62.64	86.17	17.44	19.89	17.44	21.00	7.00	19.72	7.17	20.42
T_9	Z_n 7.0kg ha-1+ soil app .of B0.5kg ha-1	62.05	85.88	63.18	86.73	17.44	20.20	17.54	21.18	7.17	20.20	7.33	20.53
T_{10}	Z_n 7.0kg ha-1 + foliar app .of B 0.5kg ha-1	62.16	86.88	63.26	87.89	18.22	21.22	18.44	21.89	7.50	20.22	7.67	20.98
T_{11}	Z_n 7.0kg ha-1+ soil app .of B0.25kg ha-1 + foliar app .of B 0.25kg ha-1	62.55	88.09	64.15	90.47	19.11	22.44	19.11	22.44	8.33	21.85	8.58	21.80
	C.D. (5%)	-	0.87	-	1.39	0.55	0.79	0.56	1.30	0.44	1.62	0.49	1.82

The effect of zinc levels and different methods of boron application had a significant effect on plan dry weight at 70 and 90 DAS during both the years. Maximum dry weight per plant (8.33 g, 8.58 g at 70 DAS and 21.85 g, 21.80 g at 90 DAS in 1st Year and in 2nd Year, respectively) was obtained with treatment combination Z_2 B_3 (i.e., zinc @ 7 kg ha^{-1} and application of boron @ 0.25 kg ha^{-1} in soil + foliar spray @ 0.25 kg ha^{-1}) during both the years. Treatment combination Z_2 B_3 was significantly higher than Z_2 B_2 was statistically at par with Z_2 B_3 in first year. The minimum dry weight per plant (6.33 g, 6.33 g at 70 DAS and 15.11 g, 14.93 g at 90 DAS in1st Year and in 2nd Year, respectively) was recorded with control plot (Z_0 B_0).
There was increased dry weight at successive stages of growth, with the increase in levels of zinc and boron application. The increased tillering due to boron supplementation might have resulted in significant increase in plant dry weight. These results are in conformity with the findings reported by Mitra and Jana [14] and Wongmo *et al*. [15].
Crop growth rate worked out at 70 and 90 DAS under different treatments at successive stage of growth the effect of Zinc levels and different methods of boron application was significant only at 90 DAS during both the years of experimentation. At 90 DAS in 2003-04, treatment combination Z_2 B_3 (i.e., zinc @ 7 kg ha^{-1} and application of boron @ 0.25 kg ha^{-1} in soil + foliar spray @ 0.25 kg ha^{-1}) recorded significantly maximum crop growth rate (41.91) followed by Z_2 B_1 (i.e., zinc @7 kg ha^{-1} and soil application of boron 0.5 kg ha^{-1} (39.42) and the minimum remained with control plot (Z_0 B_0). Z_2 B_2 was statistically at par with Z_2 B_3. In the second year of experimentation 2nd year treatment combination Z_2 B_2 (i.e, zinc @7 kg ha^{-1} and foliar spray of boron @ 0.5 kg ha^{-1}) recorded the significantly maximum crop growth rate (41.28) followed by Z_2 B_3 (i.e., zinc @ 7 kg ha^{-1} and application of boron @ 0.25 kg ha^{-1} in soil + foliar spray @ 0.25 kg ha^{-1}) 40.97 at 90 DAS. The minimum crop growth rate was with control plot (Z_0 B_0). Rerkasem *et al*. [16] observed that response to external boron supply has resulted in to higher crop growth.

Table 2. Effect of Different levels of Zinc and methods of Boron Application on Crop Growth Rate, Relative Growth Rate and Number of Effective Tillers in wheat (*Triticum aestivum* L)

Treatment Combinations		**Crop Growth Rate g m^2 day^{-1}**				**Relative Growth Rate gg^{-1} day^{-1}**				**Number of Effective Tillers/m^2**	
		1st Year		2nd Year		1st Year		2nd Year		1st Year	2nd Year
		70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS		
T_0	Control Z_n 0 kg ha^{-1}+ B0 kg ha^{-1}	11.11	27.21	11.11	26.66	0.019	0.019	0.019	0.019	293.84	295.20
T_1	Z_n 0 kg ha^{-1}+ soil app. of B0.5kg ha^{-1}	10.80	37.59	11.11	38.23	0.018	0.023	0.018	0.023	304.00	311.60
T_2	Z_n 0 kg ha^{-1} + foliar app .of B 0.5kg ha^{-1}	10.85	37.87	10.85	38.44	0.017	0.023	0.018	0.023	316.80	325.20
T_3	Z_n 0 kg ha^{-1}+ soil app of B0.25kg ha^{-1} +foliar app .of B 0.25kg ha^{-1}	11.57	38.08	11.52	39.23	0.018	0.023	0.018	0.023	326.80	328.80
T_4	Z_n 3.5kg ha^{-1}+B0 kg ha^{-1}	11.47	38.60	11.88	39.32	0.018	0.023	0.018	0.023	341.20	333.20
T_5	Z_n 3.5kg ha^{-1}+ soil app .of B0.5kg ha^{-1}	11.63	39.06	11.99	39.42	0.017	0.023	0.018	0.023	342.40	339.60
T_6	Z_n 3.5kg ha^{-1}+ foliar app .of B0.5kg ha^{-1}	11.73	38.52	11.42	39.95	0.017	0.022	0.016	0.023	342.40	345.20
T_7	Z_n 3.5kg ha^{-1}+ soil app .of B0.25kg ha^{-1} + foliar app .of B 0.25kg ha^{-1}	11.52	38.70	11.68	39.94	0.017	0.022	0.016	0.022	342.40	348.40
T_8	Z_n 7.0kg ha^{-1}+ B0 kg ha^{-1}	11.42	39.42	11.52	41.09	0.016	0.022	0.016	0.023	350.00	354.00
T_9	Z_n 7.0kg ha^{-1}+ soil app .of B0.5kg ha^{-1}	11.52	40.39	12.04	40.92	0.016	0.022	0.016	0.022	352.40	354.80
T_{10}	Z_n 7.0kg ha^{-1} + foliar app .of B 0.5kg ha^{-1}	12.40	39.42	12.40	41.28	0.017	0.022	0.016	0.022	354.40	357.60
T_{11}	Z_n 7.0kg ha^{-1}+ soil app .of B0.25kg ha^{-1} + foliar app .of B 0.25kg ha^{-1}	14.31	41.91	14.57	40.97	0.018	0.028	0.017	0.020	364.40	362.80
	C.D. (5%)	-	5.12	-	5.69	-	0.002	-	1.002	10.98	10.56

Relative growth rate worked out at 70 and 90 DAS at successive stage of growth. The significant affect only 90 DAS in both the year of experimentation. At 90 DAS in 1st Year, treatment combinations Z_0 B_1, Z_0 B_2, Z_0, B_3, Z_1, B_0 and Z_1 B_1 recorded the maximum relative growth rate followed by Z_1 B_2, Z_1 B_3, Z_2 B_0, Z_2 B_1 and Z_2 B_2. However, most of the treatment combinations were significantly higher than control (Z_0 B_0). Response to external boron supply might have resulted into higher crop growth rate and relative growth rate. Rerkasem *et al*. [16] also observed similar results.

Plants treated with combination, Z_2B_3 (i.e., 7 kg ha^{-1} zinc + soil application of boron @ 0.25 kg ha^{-1} + foliar application of boron @ 0.25 kg ha^{-1}) produced the maximum number of effective tiller/m^2 (364.40 and 362.80 in 1st Year and in 2nd Year, respectively) during both the years of experimentation. The minimum remained with Z_0 B_0 (control plot). However, Z_2 B_2 was statistically at par with Z_2 B_3 in both the years.

Increase of zinc levels and application of boron, half in the soil and half through foliar spray, resulted into higher number of effective tillers per m^2. This trend might be due to the fact that zinc and boron are active ingredients of energy metabolism pathway of plants. It plays a major role in photosynthesis and is a structural constituent of many intermediaries in the process of photosynthesis and carbohydrate metabolism. Thus, the increase in levels of zinc and boron application method (Soil + foliar application) led to greater availability of zinc and boron to the plants, which increased their metabolic efficiency and ultimately led to increased vegetative growth and number of effective tillers. Mitra and Jana [14] reported similar results.

The effect of zinc and boron as seen in treatment combination Z_2 B_3 (zinc@ 7 kg ha^{-1} and application of boron @ 0.25 kg ha^{-1} in soil + foliar spray @ 0.25 kg ha^{-1}) registered maximum grain yield (50.83 and 51.00 q ha^{-1} in 1st Year and 2nd Year respectively), and was significantly higher than Z_2 B_2 (i.e., zinc @7 kg ha^{-1} and foliar spray of boron @ 0.5 kg ha^{-1}) (49.17 and 49.33 q ha^{-1} in 1st Year and 2nd year respectively). The minimum (38.67 and 38.83 q ha^{-1} in 1st Year and in 2nd Year, respectively) was recorded with control plot (Z_0 B_0). The grain yield with Z_2 B_3 was 19.66% and 19.55% higher than the control plot in 1st Year and in 2nd Year, respectively. All the treatment combinations showed better results than the control plot (Z_0 B_0).

The highest grain yield obtained with boron through soil + foliar application, as compared to other methods of boron application, was due to the fact that split application including foliar feeding resulted in higher boron uptake. Boron enhances the uptake and translocation of sugars and is implicated in carbohydrate metabolism resulting in increased number of grains $spike^{-1}$ and weight of 1000 seeds, ultimately giving higher grain yield. Chatterjee *et al.* [7], Mishra *et al.* [18], Roy and Pradhan [19] also reported similar results.

The increase in grain yield with increasing dose of zinc and boron application (soil +foliar) might be due to synergistic action of zinc and boron. These results are in conformity with the findings reported by EL-fouly *et la*. [20], Mitra and jana [14], Sahay *et al.* [21] and Torun *et al.* [22].

Treatment combination Z_2 B_3 (i.e., zinc @ 7 kg ha^{-1} and application of boron @ 0.25 kg ha^{-1} in soil + foliar spray @ 0.25 kg ha^{-1}) gave significantly maximum straw yield (75.00 and 75.50 in 1st Year and in 2nd

Year, respectively) followed by Z_2 B_2 (i.e., zinc @ 7 kg ha^{-1} and foliar spray of boron @ 0.5 kg ha^{-1}) in 1st Year and in 2nd Year, However, Z_2 B_2 was statistically at par with Z_2 B_3. The minimum was recorded with control plot (Z_0 B_0). The straw yield with Z_2 B_3 was 36.25% and 36.52% higher than the control in 1st Year and in 2nd Year, respectively.

The increase in straw yield with increasing dose of zinc and boron application (soil + foliar) might be due to increased photosynthetic efficiency and carbohydrate metabolism resulting in superior vegetative growth and yield attributes. Similar results were also reported by Sahay *et al*. [21], Yaduvanshi [23], Roy and Pradhan [19] and Islam *et al. [*24].

Table 3. Effect of Different levels of Zinc and methods of Boron Application on Grain yield, Straw Yields and Protein in Grains of wheat (*Triticum aestivum* L)

Treatment combination		Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Protein content %	
		1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
T_0	Control Z_n 0 kg ha^{-1}+ B0 kg ha^{-1}	38.67	38.83	48.33	48.37	11.41	11.30
T_1	Z_n 0 kg ha^{-1}+ soil app. of B0.5kg ha^{-1}	40.00	40.17	49.67	50.00	11.55	11.49
T_2	Z_n 0 kg ha^{-1} + foliar app .of B 0.5kg ha^{-1}	43.33	43.50	55.83	56.00	11.66	11.60
T_3	Z_n 0 kg ha^{-1}+ soil app of B0.25kg ha^{-1} +foliar app .of B 0.25kg ha^{-1}	44.17	44.33	56.67	57.33	11.61	11.54
T_4	Z_n 3.5kg ha^{-1}+B0 kg ha^{-1}	45.00	44.83	58.33	58.50	12.16	12.15
T_5	Z_n 3.5kg ha^{-1}+ soil app .of B0.5kg ha^{-1}	45.00	45.17	60.00	63.83	12.41	12.40
T_6	Z_n 3.5kg ha^{-1}+ foliar app .of B0.5kg ha^{-1}	45.00	45.17	63.50	63.82	12.37	12.37
T_7	Z_n 3.5kg ha^{-1}+ soil app .of B0.25kg ha^{-1} + foliar app .of B 0.25kg ha^{-1}	45.67	46.00	65.00	65.53	12.40	12.42
T_8	Z_n 7.0kg ha^{-1}+ B0 kg ha^{-1}	45.83	46.02	66.67	67.17	12.94	12.98
T_9	Z_n 7.0kg ha^{-1}+ soil app .of B0.5kg ha^{-1}	46.67	47.00	70.83	71.17	12.97	12.98
T_{10}	Z_n 7.0kg ha^{-1} + foliar app .of B 0.5kg ha^{-1}	49.17	49.33	74.00	74.50	13.08	13.02
T_{11}	Z_n 7.0kg ha^{-1}+ soil app .of B0.25kg ha^{-1} + foliar app .of B 0.25kg ha^{-1}	50.83	51.00	75.00	75.50	13.24	13.15
	C.D. at 5%	1.26	0.93	1.64	1.43	0.12	0.16

Best quality of grains with maximum protein content (13.24 and 13.15% in 1st Year and in 2nd Year, respectively) was produced by treatment combination of zinc 7 kg ha^{-1} + soil application of boron @ 0.25 kg ha^{-1}+ foliar application of boron @ 0.252 kg ha^{-1} (Z_2 B_3). The minimum remained with Z_0 B_0 (control plot) in both the years of study.

Increase in zinc dose led to concomitant increase in protein content in wheat during both the years of cultivation. The vital role played by zinc in synthesis of protein and indole acetic acid, chlorophyll formation and in auxin metabolism may be assigned for increased protein content in wheat grains. Hossain *et al* [25], Paliwal *et al*. [26], Firouzabadi *et al*. [27] and Khorub and Gupta [28] also reported similar results.

Increase in grain yield and yield attributes due to increase in the doses of zinc and different methods of application of boron (soil, foliar application) was seen during both the years, which might be due to the reason that zinc is actively involved in the physiological process in plants. It plays a major role in increasing the rate of photosynthesis by increasing the enzymatic activity of carbonic anhydrase enzyme, which is important in governing the rate of photosynthesis and enhanced carbohydrate metabolism with increase in doses of zinc application could be reason for increase in the yield of wheat. The results are will supported by the findings of Vyas and Chaudhary [29], Kaya *et al*. [30] and Shrivastava.

CONCLUSION

Based on the results of the experiments carried out during two consecutive years, it may be concluded that treatment combination of zinc @ 7.0 kg ha^{-1} and soil application of boron @ 0.25 kg ha^{-1} + foliar application of boron @ 0.25 kg ha^{-1} was superior over all other treatments in relation to plant growth, effective tillers, plant dry weight, yield and quality of wheat crop.

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