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Effect of foliar application of different nutrients on growth and yield of wheat (*Triticum aestivum* L.) under sodic soil

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Abstract
The present investigation entitled "Effect of foliar application of different nutrients on growth and yield of wheat (*Triticum aestivum* L.) under sodic soil" was carried out at main experiment station (MES) of Acharaya Narendra Dev University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.). During *rabi* season - 2017-18. The experiment was laid in field condition with randomized block design and three replications. Seven treatments comprised of five different nutrients as zinc sulphate (0.5%) and (0.7%), boric acid (0.2%) and (0.4%) and potassium nitrate (0.1%) and (0.3%) applied as foliar application at 35 DAS of crop growth. A controlled set was also maintained. The observations were recorded as growth parameters at, 40, 60 and 90 DAS, yield and yield attributing traits were recorded at harvest. All the foliar application of nutrients increased the growth characters *viz.*, plant height (cm), number of tillers per m^2, dry weight plant was found significantly superior with foliar application of 0.7% zinc sulphate at all the stages of crop over control. Yield characters *viz.*, length of spike (10.5cm), No. of grains per spike (45.10), no. of grains per plant (40.20), Grain yield/m^2 (285), grain yield qha^1 (28.50), test weight (38.26g) and harvest index (29.80%) were recorded significantly higher with foliar application of 0.7% zinc sulphate followed by foliar application of 0.3% of potassium nitrate over control.

Keywords: wheat, zinc sulphate, sodicity, boric acid, potassium nitrate

Introduction
Wheat (*Triticum aestivum* L.) is a staple food of the world and belongs to family Poaceae (Gramineae). It is most important staple food of about two billion people (36% of the World population). About 55% of the world population depends on wheat for intake of about 20% of food calories. Wheat is self-pollinated crop and it has been described as the 'King of cereals'. It is the world's most widely cultivated food crop and is primarily grown in temperate regions and also at higher altitude under tropical climatic areas in winter season. Wheat is the single most important cereal crop that has been considered as integral component of the food security system of the several nations. It is grown in the world with an area of 221.60 million hectare, production of 728.3 million tonnes with productivity of 3.3 tonnes per hectare (Anonymous 2015) [3]. In India, it is grown in an area of 30.47 million hectare, production 95.85 million tone's with a productivity of 3.15 tonnes per hectare. Uttar Pradesh having first rank in respect of both area (9.95 million hectare) and production (30.24 million tone's) with a productivity of 3.10 tone's per hectare in 2015 (Anonymous 2015) [3]. Plants need large quantities of potassium, the uptake of which frequently exceeds the uptake of nitrogen. Not only the plant tissues had higher K^+ content than the other cations but K^+ regulates effectively many physiological and biochemical processes (Bajwa, 1994) [4]. Potassium utilization by plants through foliar application is well recognised and is being practiced in agricultural advanced countries (Fernandez and Eichert, 2009) [7]. Foliar applied fertilizers often show a better efficacy which may help to reduce the required dose. Therefore, this study was planned to compare different concentrations of K_2SO_4 and KNO_3 for foliar application to obtain optimum wheat yield under different wheat planting techniques. Sodic soils are characterized by a disproportionately high concentration of sodium (Na) in their cation exchange complex. They are usually defined as containing an exchangeable sodium percentage greater than 15%. These soils tend to occur within arid to semiarid regions and are innately unstable, exhibiting poor physical and chemical properties, which impede water infiltration, water availability and

ultimately plant growth. The yield of a crop depends upon the interaction between its genetic potential and the environment in which it grows. Foliar fertilization in recent times is receiving considerable attention for increasing crop yields. The beneficial effect of zinc on several ornamental plants were studied, Farahat *et al.* (2007) [6]. Sodic soil are widespread in the world and in India. It occurs mainly in Indo-Gangetic alluvial plains, where it is estimated to cover about 2.8mha. In India, salt affected soils are spread 7.0mha, of which, 1*29 mha exists in U.P. alone (Abrol and Bhurnbla 1971) [2]. Zinc is the last element in the first transition series to be required by plants. The normal concentration of zinc in plants ranges from 25-100ppm on dry matter basis. The available zinc in Indian soil ranges between 0.08-20.5ppm. Application of zinc has been found to boost the growth and yield of crops to a great extent (Zaid *et al*., 1997) [1]. In zinc stressed plants, protein synthesis is inhibited and amino acids are accumulated up to inhibitory level (Cakmak & Marschner, 1990) [5]. Potassium nitrate an ionic salt of potassium ions K^+ and nitrate ions NO_3^-, and is therefore an alkali metal nitrate. It occurs as a mineral nutrient and is a natural solid source of nitrogen. Potassium nitrate is one of several nitrogen-containing compounds collectively referred to as saltpeter or saltpetre. Major uses of potassium nitrate are in fertilizers, tree stump removal, rocket propellants and fireworks. Foliar application of Boron single or shared with other micronutrients had positive effect on growth, yield and yield parameters of wheat crop. In optimizing fertilization strategies, addition of foliar application develops fertilizer use efficiency and reduces soil pollution. Foliar application of Boron single or shared with other micronutrients at different growth stages have been shown to be effective in efficient consumption of Boron by wheat and thus increase grain sitting and increase the grain yield, number of grains per spike, number of spikelet per spike and thousand grain weight.

Materials and Methods

The present experiment was conducted during *Rabi* season of 2017-18 at the Main Experimental Station (MES), of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). Experimental site is situated 42 km away from Ayodhya on Ayodhya-Raibarreilly road between latitude of 24.47 ^{0}north and longitude of 82.12^0 and 83.98 ^{0}east on an elevation of 113 meters in the gangetic alluvium of eastern Uttar Pradesh. Seven treatments comprised of five different nutrients as zinc sulphate (0.5%) and (0.7%), boric acid (0.2%) and (0.4%) and potassium nitrate (0.1%) and (0.3%) applied as foliar application at 35 DAS of crop growth. The observations were recorded as growth parameters at 40, 60 and 90 DAS, yield and yield attributing traits were recorded at harvest. All the foliar application of nutrients increased the growth characters *viz*., plant height (cm), number of tillers per m^2, dry weight plant. Yield and yield attributing traits as length of spike, No. of grains per spike, No. of grains per plant, Grain yield/m^2, grain yield qha^{-1}, test weight and harvest index.

The analysis of variance for the design of experiment was carried out according to the procedure outlined by Panse and Sukhatme (1961).

Results and Discussion

Plant height

Overall, the results indicated that sodicity decreased the plant height in all treatment which was taken in the investigation. The maximum plant height was observed with the foliar application of 0.7% $ZnSO_4$ ha^{-1} followed by 0.3% KNO_3 and 0.2% boric acid foliar application at all the stages(40, 60, 90 DAS and At harvest) of crop growth (Table-1). Application of 0.7% $ZnSO_4$ and other treatments have significantly been improved the plant height under sodic soil condition. Generally poor plant height under sodic soil condition particularly in zinc deficient soil might be because of zinc is co-factor of enzyme carbonic anhydrase and aldolase. Therefore, zinc deficient soil may adversely affect the enzyme activity and carries corresponding metabolic reaction which ultimately affect the plant growth particularly plant height. Similar findings are in agreement with Patel *et al.* (2005) [10] and Singh *et al.* (2006) [14] in which they reported that application of zinc sulphate has improved plant height significantly. It was generally observed that plant height increased upto the stage of at harvest which might be because of physiology of the plant (gradual growth from germination to at harvest).

Table 1: Effect of foliar application of different nutrients on plant height (cm) at various growth stages on wheat under sodic soil

Treatment	Plant height (cm)			
	40 DAS	60 DAS	90 DAS	At harvest
T1 - Control	25.80	36.20	55.30	72.10
T2 -0.2% Boric acid	27.20	39.30	58.20	78.00
T3 -0.4% Boric acid	27.60	41.50	62.40	81.20
T4 -0.5% $ZnSO_4$	27.30	40.20	59.70	84.20
T5 -0.7% $ZnSO_4$	28.20	44.40	65.60	94.50
T6 -0.1% KNO_3	27.40	39.80	60.40	78.30
T7 -0.3% KNO_3	27.80	42.60	63.40	91.30
SEm ±	0.99	1.47	2.20	2.92
CD at 5%	3.06	4.53	6.78	7.99

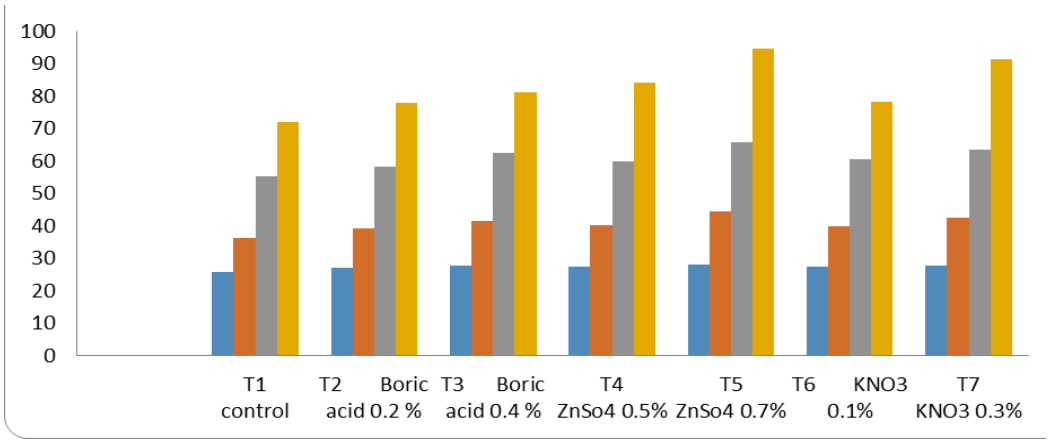

Fig 1: Effect of foliar application of different nutrients on plant height (cm) at various growth stages on wheat under sodic soil

Number of tillers

Significantly higher number of tillers was found with foliar application of 0.7% Zinc sulphate (Table-2). Treatment of foliar application of 07% zinc sulphate gave significantly profuse tillering as compared to other foliar application at tillering and booting stages and non-significant variation was observed at later stages. Significant influence of tillers by the varieties might be due to its genetical characters coupled with positive role of 0.7% zinc sulphate towards profuse tillering. These results are in accordance with that of Singh *et al.* (2006) [14].

Table 2: Effect of foliar application on number of tillers sq. m.$^{-1}$ at various growth stages of wheat under sodic soil

Treatment	Numbers of tillers (sq.m^{-1})			
	40 DAS	60 DAS	90 DAS	At harvest
T1 - Control	140.40	193.80	260.20	250.40
T2 -0.2% Boric acid	144.60	250.20	270.60	260.40
T3 -0.4% Boric acid	148.30	260.40	295.30	280.50
T4 -0.5% $ZnSO_4$	156.50	275.80	300.20	280.20
T5 -0.7% $ZnSO_4$	160.40	280.30	335.60	310.30
T6 -0.1% KNO_3	145.80	260.40	288.80	278.60
T7 -0.3% KNO_3	160.20	278.90	308.20	285.80
SEm ±	5.54	9.42	10.51	10.22
CD at 5%	17.06	29.03	32.37	31.50

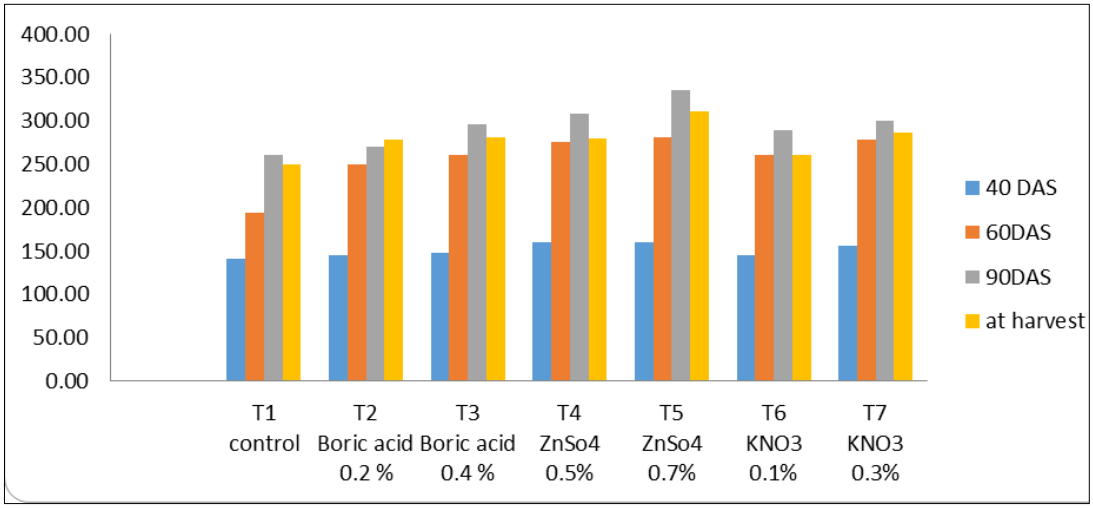

Fig 2: Effect of foliar application on number of tillers sq. m.$^{-1}$ at various growth stages of wheat under sodic soil

Total dry matter per plant

The results indicated that the maximum total dry weight was recorded with the foliar application of 0.7% $ZnSO_4$ at all stage (40, 60, 90 DAS and at harvest). The total dry weight was significantly increased 0.7% $ZnSO_4$ over at stages of plant growth (Table -3). These findings are enclose conformity with Singh and Shukla (1995), Gupta and Mali *et al.* (2003) who obtained similar improvement in dry matter production by leaves and stem by the use of zinc sulphate application through foliar application.

Table 3: Effect of foliar application on total dry matter plant^{-1} (g) at various growth stages in wheat varieties under sodic soil:

Treatment	Dry weight plant^{-1} (g)			
	40 DAS	60 DAS	90 DAS	At harvest
T1 - Control	1.10	2.60	4.27	11.10
T2 -0.2% Boric acid	1.30	3.25	5.30	12.22
T3 -0.4% Boric acid	1.43	3.65	5.76	12.50
T4 -0.5% $ZnSO_4$	1.34	3.42	5.50	12.34
T5 -0.7% $ZnSO_4$	1.69	3.85	6.12	13.10
T6 -0.1% KNO_3	1.52	3.34	5.70	12.42
T7 -0.3% KNO_3	1.53	3.78	6.02	12.71
SEm ±	0.05	0.12	0.20	0.44
CD at 5%	0.16	0.38	0.62	1.35

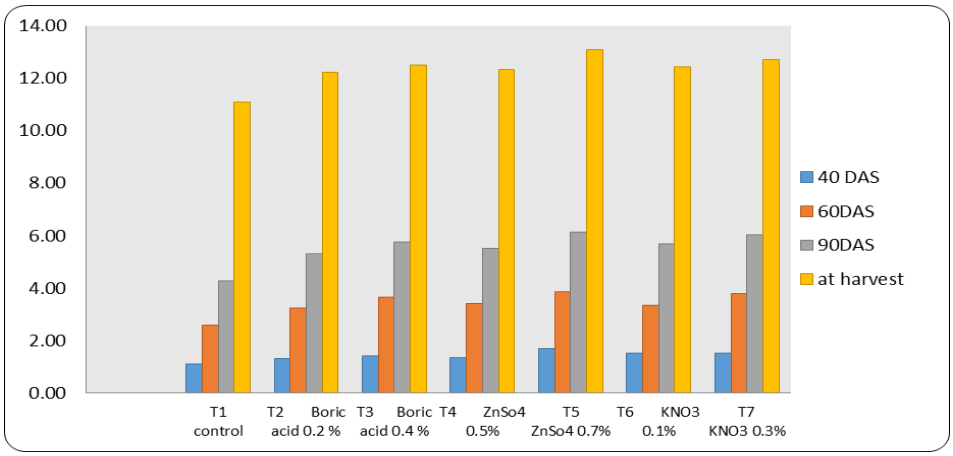

Fig 3: Effect of foliar application on dry weight plant-1 (g)on wheat under sodic soil

Yield and Yield Attributes Traits

The result of this research indicates that there existed significant impact of zinc foliar application on the various yield attributes of wheat crop. The yield is final product of all physiological, metabolic process as influenced by many yield components like spike length (cm), number of grains spike^{-1}, number of grains plant^{-1}, Grain yield(g), grain yield qha^{-1}, test weight and harvest index were significantly increased with increasing level of $ZnSO_4$ treatment as compared to control (Table -4,5,6). The maximum length of spike (10.50 cm), number of grains per Spike (45.10) number of grains per plant (210.20) of 0.7% zinc sulphate followed by KNO_3 the length of spike (10.10 cm), number of grains per Spike (42.50), number of grains per plant (197.60). Minimum the length of spike (9.10 cm), number of grains per Spike (38.70), number of grains per plant (180.10) were by 0.2% boric acid foliar application. The maximum increment in yield and yield components were recorded with foliar application of 0.7% zinc sulphate (28.50 q/hq) followed by 0.3% KNO_3 (28.10 q/ha) and 0.2% boric acid (27.01 q/ha) at all the growth stages over control. 0.7 % zinc sulphate showed maximum yield components than 0.3% potassium nitrate and 0.4% boric acid. This was due to 0.7 % zinc sulphate had higher amount of carbohydrate content, chlorophyll content, as well as maintained greater number of grain yield (285.00 g), test weight (38.26 g). In might be due to application of zinc sulphate increased total chlorophyll content in leaf which is major components for photosynthesis, leading to greater dry matter production. Application of $ZnSO_4$ also increased the synthesis & translocation of carbohydrate to the site of grain formation (Prasad *et al.* 2003) [11]. Similar findings were also reported by several other workers Alla *et al.* (1996), Verma (2003) [15]. Keeping in this view, zinc sulphate are also increased the leaf area, leaf number, number of tillers per plant which were directly influenced the crop yield of wheat. These findings are with reported by (Khattak *et al.* 2015, Rawashdeh and Sala 2014) [8, 12]

Table 4: Effect of foliar application on Length of spike (cm), No. of grains spike and No. of grains plant[1], of wheat varieties under sodic soil.

Treatment	Length of spike (cm)	No. of grains spike^{-1}	No. of grains plant^{-1}
T1 - Control	7.90	36.30	154.50
T2 -0.2% Boric acid	9.10	38.70	180.10
T3 -0.4% Boric acid	9.80	42.30	195.30
T4 -0.5% $ZnSO_4$	9.50	40.20	190.80
T5 -0.7% $ZnSO_4$	10.50	45.10	210.20
T6 -0.1% KNO_3	9.80	39.10	185.50
T7 -0.3% KNO_3	10.10	42.50	197.60
SEm ±	0.34	1.51	6.81
CD at 5%	1.04	4.65	20.98

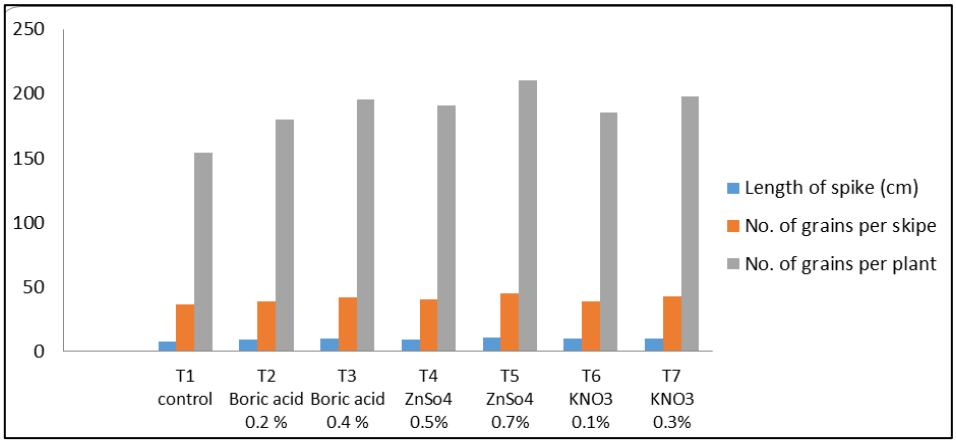

Fig 4: Effect of foliar application on length of spike (cm), number of grains spike^{-1} and number of grains plant^{-1} on wheat under sodic soil

Table 5: Effect of foliar application on grain yield (g) sq. m.$^{-1}$ (g), grain yield (q ha^{-1}) and test weight (g) of wheat varieties under sodic soil.

Treatment	Grain yield (g) sq. m.$^{-1}$	Grain yield q. ha^{-1}	Test weight (g)
T1 - Control	266.00	26.60	33.52
T2 -0.2% Boric acid	270.00	27.01	35.10
T3 -0.4% Boric acid	275.00	27.50	37.82
T4 -0.5% $ZnSO_4$	273.00	27.30	36.31
T5 -0.7% $ZnSO_4$	285.00	28.50	38.26
T6 -0.1% KNO_3	272.00	27.20	35.45
T7 -0.3% KNO_3	281.00	28.10	37.83
SEm ±	12.84	1.27	1.31
CD at 5%	11.57	3.91	4.02

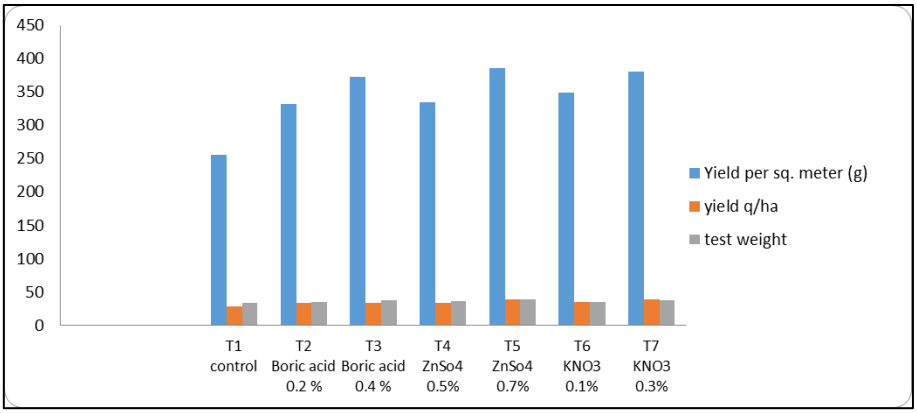

Fig 5: Effect of foliar application of different nutrients on grain yield sq. m^{-1} (g), grain yield (q.ha^{-1}) and test weight (g) of wheat under sodic soil

Table 6: Effect of foliar application harvest index (%) of wheat varieties under sodic soil.

Treatment	Harvest index (%)
T1 - Control	26.00
T2 -0.2% Boric acid	27.13
T3 -0.4% Boric acid	28.43
T4 -0.5% $ZnSO_4$	27.80
T5 -0.7% $ZnSO_4$	29.80
T6 -0.1% KNO_3	28.11
T7 -0.3% KNO_3	29.60
SEm ±	1.16
CD at 5%	2.58

Conclusion

Soil sodicity decreased growth parameters in all the varieties. Application of $ZnSO_4$ significantly improved the growth parameters. Response of zinc sulphate as foliar application 0.7% improved the plant height, number of tillers, number of leaves, leaf area and dry weight plant^{-1} in all stage (40, 60, 90 DAS and At harvest) of wheat at all the growth stages. The 0.7% zinc sulphate showed maximum plant height, number of tillers and total dry matter, as compared to 0.3% potassium nitrate and 0.2% boric acid at all the crop growth stages. Soil sodicity had adverse effect on yield attributes. Foliar application of 0.7% zinc sulphate significantly enhanced the Spike length(cm), Number of grains per Spike, number of grain plant^{-1}, Grain yield (q ha^{-1}), Test weight (g) and harvest index (%), respectively over other treatments (0.3% potassium nitrate and 0.2% boric acid). 0.7% zinc sulphate found better in respect to yield attributing parameters and yield than other foliar application.

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