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Response of bread wheat and nutrient removal with new micronutrient molecules fertilization

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ABSTRACT

A field experiment entitled effect of newly formulated micronutrient fertilizers on crop performance, economic and nutrients uptake of wheat (*Triticum aestivum* L.) was conducted during *rabi* 2017-18 and 2018-19 at Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India. The recommended doses of N, P and K were applied @ 120 N: 60 P_2O_5: 40 K_2O kg/ha in combination with different micronutrients fertilizers of Zn, Mn and B. The pooled data of experiment revealed that the growth and yield attributes including yield were maximum in T_{11} (RDF+ soil application of Zn HEDP + $MnSO_4$+ Colemanite) while the cost of cultivation was minimum in T_{12}. The study consisting of different combination of micronutrients sources indicated that highest values of growth parameters, yield attributes, grain yield (4.25 t/ha), straw yield (5.89 t/ha), net returns (54870 ₹/ha) and B:C ratio (2.12) were recorded with T_{11} (T_1 +soil application of Zn HEDP + $MnSO_4$+ Colemanite) followed by treatment T_{12} (T_1 + foliar application of Zn HEDP + EDTA Mn + DOT). The uptake of zinc, manganese and boron was increased due to their application in combination with NPK either soil or foliar application. All the parameters including economics were minimum under T_1. Appropriate combination of zinc, manganese and boron with recommended dose of primary nutrients for wheat crop was beneficial in every parameters including output.

Keywords: Colemanite, EDTA, HEDP, Micronutrients, Wheat

Wheat (*Triticum aestivum* L.) the most important staple food is grown on more land than any other commercial crops in the world. In India wheat was grown with an area of about 30.6 million ha with production of 98.38 million tons and with the productivity of 3098 kg/ha (Anonymous 2018). Apart from the other factors the micronutrients (zinc, boron and manganese are common) deficiency emerging as limiting factor in wheat. These essential micronutrients are part of the photosynthesis, chlorophyll formation, nucleic acid, protein synthesis, N-fixation and other biochemical pathways. The right source and mode of application is much important for the corrections of deficiencies. The foliar applications of nutrients in addition to soil application resulted in improved productivity and quality of crops (Rehman *et al*. 2014 and Kumar *et al*. 2015). A new form of zinc source Zn-HEDP (Hydroxyethylidene diphosphonic acid) can chelate with Zn ion to form stable chelating compounds and it can be used as both soil and foliar applications. Manganese plays an important role in oxidation and reduction processes and electron transport in photosynthesis and thereby increases efficiency of photosynthesis and carbohydrates assimilation by enhancing nitrate-reducing enzyme. It differ in cropping systems varies from soil to soil as well as system to system (Narender *et al.* 2017). Manganese sulphate is generally applied in soil to correct its deficiency but now a day EDTA Mn ($C_{10}H_{14}MnN_2O_8$), a stable water soluble metal chelate, mainly used as manganese source.

Boron is second most deficient micronutrient in Indian soils and its deficiency cause improper development of inflorescence very short awns and reduction in yield and quality (Wang 2003). Colemanite ($Ca_2B_6.O_{11}.5H_2O$), containing 35-40% B_2O_3, is a natural mineral that is applied as boron fertilizer. Its moderate water solubility makes it a controlled-release material and makes sure the availability of boron for a longer time period (Gandahi *et al.* 2016) while disodium octaborate tetrahydrate ($Na_2B_8O_{13}.4H_2O$), salt is preferred for foliar spray. The present study was carried out to study the new source of micronutrients on the performance of wheat.

MATERIALS AND METHODS

The field experiment was conducted during *Rabi* 2017–18 and 2018–19 at the CRC, Sardar Vallabhbhai

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Patel University of Agriculture & Technology, Meerut, Uttar Pradesh. Geographically the site of experiment lies at 29° 08', N latitude and 77° 41' E longitude at an altitude of 237 m amsl. The soil sample was taken with the help of tube auger and analyzed for various soil properties following standard procedures. The sandy loam texture soil of experimental field was slightly alkaline in reaction (*p*H 7.78), EC (0.30 dS/m at 25C°) and organic carbon (4.55 g/kg). The soil was low in available nitrogen (215.30 kg/ha), medium in phosphorus (12.50 kg/ha), medium in available potassium (230.15 kg/ha), sulphur (13.20 kg/ha), in DTPA extractable Zn (0.80 mg/kg), available manganese (1.50 mg/kg) and hot water extracted boron (0.60 mg/kg). The 12 treatments were laid out in randomized block design with three replications. Treatments consisted T_1 Control (N:P:K 120:60:40 kg/ha), T_2 (T_1 +soil application of $ZnSO_4$ @ 25 kg/ha), T_3 (T_1 + soil application of Zn HEDP @ 5 kg/ha), T_4 (T_1 + foliar application of Zn HEDP @0.5 %), T_5 (T_1 +soil application of $MnSO_4$@ 12.5 kg/ha), T_6 (T_1 + foliar application of EDTA Mn @ 0.5%), T_7 (T_1 + soil application of Colemanite @ 7.5 kg/ha),T_8 (T_1 +soil application of Borax @ 10 kg/ha),T_9 (T_1 + foliar application of Disodium octaborate tetrahydrate (DOT) @ 0.3 %), T_{10} (T_1 + soil application of $ZnSO_4$+ $MnSO_4$+ Borax), T_{11} (T_1 +soil application of Zn HEDP + $MnSO_4$+ Colemanite), T_{12} (T_1 + foliar application of Zn HEDP + EDTA Mn + DOT). The wheat cultivar (PBW-590) was sown on 12th and 09th December during first and second year, respectively, by using 120 kg/ha seed rate with row to row spacing of 20 cm. The recommended dose of N, P_2O_5 and K_2O 120, 60 and 40 kg/ha, respectively was applied. Half dose of N, full dose of P, K and along with Zn, Mn and boron as per treatments were applied at the time of sowing. Remaining half dose of N was applied in two equal split at the time of first and third irrigation. The foliar application of different micronutrients (Zn HEDP @0.5 %, EDTA Mn @ 0.5%, DOT @ 0.3 %) as per treatment in wheat was made at three different growth stages, tillering, jointing and booting stage. Five plants were tagged randomly in each net plot and their individual height was recorded in centimeters with the help of meter scale from the base to the tip of fully expanded leaves and number of tillers was recorded by using a quadrate of one square meter from three places in each plot. The yield attributes were recorded from five randomly selected plants from each plot. All the micronutrient fertilizers were purchased from Dayal Fertilizers Groups @ Zn HEDP ₹ 500/kg, EDTA Mn ₹ 500/kg, Colemanite ₹ 100/kg, DOT ₹ 350/kg. Gross return was calculated on the basis of grain and straw yield and their prevailing market prices, i.e. ₹ 1735 and 1840 (grain), ₹ 450 and 500 per q (straw) during 2017-18 and 2018-19, respectively. The net return was computed by deducting the cost of cultivation from the gross returns and benefit: cost ratio was calculated by dividing the net returns with the cost of cultivation.

$$\text{B:C} = \frac{\text{Net return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

RESULTS AND DISCUSSION

Growth attributes: Although growth attributes like plant height and number of tillers/m^2 are not directly related to the yield of crop but a better growth of plant is necessary for higher yield of crop. Results (Table 1) revealed that the maximum plant height 97.12 cm was recorded with T_{11} (T_1 + soil application of Zn HEDP + $MnSO_4$ + Colemanite) followed by T_{12} (NPK + Foliar application of Zn HEDP + EDTA Mn + DOT) and T_3 (NPK + Soil application of Zn HEDP @ 5 kg/ha) while minimum 80.56 cm with T_1 (N:P:K 120:60:40 kg/ha). The significant increment in plant height with application of T_{11} as compared to T_1, T_9, T_8, T_6, T_4 and T_5 was 20.55, 17.29, 12.87, 12.62, 10.67 and 8.53%, respectively. Among the treatments consisting only

Table 1 Effect of different micronutrients on growth, yield attributes and yield (t/ha) of wheat on pooled basis (2017–18 and 2018–19)

Treatment	Plant height (cm)	Tillers/ m^2	Spike length (cm)	Spikelets/ spike	No. of grains/spike	Test weight (g)	Grain yield	Straw yield
T_1	80.56	204.68	8.35	15.60	31.60	34.36	3.19	4.69
T_2	92.16	258.13	9.78	19.87	38.33	39.20	3.83	5.34
T_3	93.65	271.75	10.18	21.65	40.35	41.15	4.07	5.57
T_4	87.75	232.27	8.84	18.55	35.50	37.30	3.51	5.12
T_5	89.48	243.61	9.03	19.05	36.10	37.95	3.63	5.18
T_6	86.23	229.75	8.67	17.40	34.25	37.13	3.46	4.91
T_7	90.66	251.40	9.40	19.15	37.00	38.80	3.75	5.24
T_8	86.04	224.98	8.57	16.75	33.68	36.25	3.38	4.83
T_9	82.80	218.00	8.49	16.40	32.85	35.70	3.28	4.73
T_{10}	92.77	267.54	9.90	20.85	39.50	40.40	3.96	5.47
T_{11}	97.12	297.55	10.65	23.75	42.50	43.35	4.25	5.89
T_{12}	95.87	281.23	10.33	22.29	41.33	42.85	4.12	5.68
SEm±	2.47	9.81	0.33	0.75	1.36	1.22	0.13	0.18
CD at 5%	7.23	28.77	0.98	2.20	3.99	3.58	0.39	0.53

zinc application with RDF the highest value of plant height 93.65 cm was obtained with T_3 (NPK + Soil application of Zn HEDP @ 5 kg/ha).

The number of tillers/m^2 another growth attribute was recorded during crop growth period. On the basis of two year pooled data the maximum number of tillers/m^2 297.55 at harvesting with the application of RDF + soil application of Zn HEDP + $MnSO_4$ + Colemanite were statistically at par to the T_{12} (281.23), T_3 (271.75) and significantly higher than rest of the treatments. The percent increase in tillers/m^2 with T_{11} over T_{12} and T_3 was 5.80 and 9.49%, respectively. The minimum number of tillers/m^2 204.68 was found with T_1. The T_{11} recorded an increase of 45.37, 36.49, 32.25, 29.51, 28.10, 22.14, 18.35, 15.27 and 11.21% over T_1, T_9, T_8, T_6, T_4, T_5, T_7, T_2 and T_{10}, respectively. The number of tillers/m^2 were more with foliar application of boron through DOT as in T_9 as compared to T_1 but less than the other two sources of boron, i.e. borax and colemanite. The combination of all three micronutrients (Zn, Mn and B) with NPK either as soil or foliar application is found better than any of the combinations. The result found are in close proximity of the findings of Mukherjee (2012) and Jat *et al*. (2013).

Yield attributes: The pooled data regarding the yield attributing characters were found maximum with application of RDF + soil application Zn HEDP + $MnSO_4$+ Colemanite with spike length 10.65 cm, spikelet/spike 23.75, no. of grains/spike 42.50 and test weight 43.35 g followed by NPK + foliar application of Zn HEDP + EDTA Mn + DOT. The treatment T_1 acquired the minimum value for all the characters, *i.e.* spike length 8.35 cm, spikelets/spike 15.60, grains/spike 31.60 and test weight 34.36. With the critical evaluation of pooled data it was found that in comparison to control T_1 an increase of 27.54% in spike length, 52.24% in spikelets/spike, 34.49% in no. of grains/spike and 26.16% in test weight was found in T_{11}. By comparing T_1 and T_{12} there was an increase of 23.71% in spike length, 42.88% in spikelets/spike, 30.79% in no. of grains/spike and 24.70% in test weight with the application of micronutrients. Table 1 revealed that the combination of all three micronutrients (Zn, Mn and B) either as soil or foliar application is best practice than non application of micronutrients or their sole application. The above mentioned points show the clear importance of micronutrients in wheat crop cultivation. The increase of yield attributes with micronutrients application might be attributed to the fact that micronutrients are known to have an important role as a metal component of enzymes or as a functional, structural or regulatory co-factor of a wide number of enzymes (Dahshouri *et al.* 2017). The results found in conformity with the findings of Nadim *et al.* (2013) and Barma *et al.* (2019).

Grain and straw: The grain and straw yield of wheat is a composite and interactive result of earlier discussed yield attributes. It is quite evident from the data (Table 1) that grain and straw yield increased with the application of micronutrients. Application of RDF along with soil application of Zn HEDP + $MnSO_4$+ Colemanite (T_{11}) proved superiority over all other treatments with maximum grain and straw yield 4.25 t/ha and 5.89 t/ha, respectively. The minimum grain and straw yield 3.19 and 4.69 t/ha, respectively was recorded with T_1. Percent increase of grain yield in T_{11} as compared to all other treatments ranged from 3.15 to 33.22% maximum found over T_1 and minimum with T_{12}. Among three micronutrients used the importance of zinc was foremost followed by manganese and boron. The yield of grain and straw in T_3 was increased by 6.26 and 4.30% over T_2 while by 15.95 and 8.78% over T_4. Grain yield on pooled basis was increased by 27.58, 13.79 and 17.55% due to sole application of zinc, manganese and boron over RDF, respectively. Same trend was also found in straw yield but with different magnitude. The data of yield presented in Table 1 revealed that the grain yield in soil application of chelated zinc is significantly better than foliar application of chelated zinc. The application of boron and zinc fertilizers either as soil or foliar application improve the grain and straw yield because these nutrients accelerate the translocation of sugar and starch, synthesis of amino acids and proteins (Goswami 2007). The results are in consonance with findings of Singh *et al*. (2012) and Narender and Malik (2015) who reported that increasing levels of zinc increased wheat yield.

Uptake of zinc, Mn and B: The zinc uptake by grain was more as compared to wheat straw in all the treatments (Table 2). The zinc uptake by wheat grain and straw ranged from 57.93 to 120.79 and 51.30 to 95.78 g/ha, respectively under different treatments. The maximum zinc uptake by grain and straw 120.79 and 95.78 g/ha, respectively under T_{11} due to highest yield and content was statistically *at par* to T_3 in case of grain and T_3, T_{10} and T_{12} in case of straw and significantly higher than rest of the treatments. Maximum manganese uptake by grain and straw 148.19 and 127.19 g/ha, respectively was recorded with T_{11} while minimum 68.22 and 62.51 g/ha, respectively under T_1. From the data it is clear that manganese uptake by grain and straw with the application of T_{11} as compared to RDF was 117.22 and 103.47 %, respectively higher. The foliar application of EDTA Mn @ 0.5% showed an improvement in uptake by both grain and straw over T_1. Manganese uptake by grain and straw was 136.93 and 119.89 g/ha, respectively under T_{12}. The uptake of boron was more in straw than grain and ranged from 14.55 to 30.63 and 34.73 to 72.86 g/ha, respectively due to application of different treatment. The maximum uptake of boron by grain and straw 30.63 and 72.86 g/ha, respectively with the application of T_{11} followed by T_{12}, T_{10} and T_7. The application of boron sources like colemanite, borax and DOT improved the boron uptake in both grain and straw in comparison to all other treatments where no boron source was applied. The grain and straw boron uptake increased by 79.03, 69.65 (T_1), 49.62, 45.55 (T_2), 29.40, 37.76 (T_3), 69.81, 55.54 (T_4), 28.51, 58.02 (T_5), 52.42, 65.18% (T_6) over T_7. Pallavi and Sudha (2017) reported that the application of zinc fertilizers increases the uptake of this nutrient by wheat grain. The content and uptake of nutrients increase with a combined

Table 2 Effect of different micronutrients on uptake (g/ha) of Zn, Mn and B by grain and straw and on economics of wheat on pooled basis (2017–18 and 2018–19)

Treatment	Zinc uptake		Manganese uptake		Boron uptake		Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B : C ratio
	Grain	Straw	Grain	Straw	Grain	Straw				
T_1	57.93	51.30	68.22	62.51	14.55	34.73	44546	79234	34689	1.78
T_2	100.66	80.98	84.91	72.49	17.41	40.48	45796	93820	48025	2.05
T_3	111.42	88.66	91.90	79.04	20.13	42.77	47046	99294	52249	2.11
T_4	87.68	74.51	77.81	70.68	15.34	37.88	45708	87113	41405	1.91
T_5	74.70	67.69	120.50	89.74	20.27	37.05	45671	89556	43886	1.96
T_6	68.65	62.83	116.84	88.43	17.09	35.67	45708	85107	39400	1.86
T_7	78.42	69.00	83.10	75.03	26.05	58.92	45296	91979	46684	2.03
T_8	67.48	60.43	75.36	72.04	23.32	57.04	45346	83381	38036	1.84
T_9	63.50	56.70	73.69	69.56	22.35	54.56	45383	81147	35765	1.79
T_{10}	104.19	84.75	135.06	107.45	28.23	66.47	47721	96855	49135	2.03
T_{11}	120.79	95.78	148.19	127.19	30.63	72.86	48946	103991	55045	2.12
T_{12}	103.31	86.11	136.93	119.89	28.71	68.60	46507	100749	54242	2.17
SEm±	5.52	4.05	5.16	8.50	1.65	3.86	-	-	-	-
CD at 5%	16.17	11.87	15.13	24.92	4.85	11.33	-	-	-	-

foliar application of Zn, Fe and Mn (Gomaa *et al.* 2015 and Narwal *et al.* 2010).

Economics: The economics of wheat production of above study was calculated and presented in Table 2. The maximum cost of cultivation ₹ 48946 was found with RDF + soil application of Zn HEDP + $MnSO_4$+ Colemanite followed by ₹ 47721 and ₹ 47046 under T_{10} and T_3, respectively. Economic analysis revealed that higher gross return and net return ₹ 103991 and ₹ 55045, respectively was found in T_{11} with benefit cost ratio of (2.12). It is obvious because of higher grain and straw yield in the treatment T_{11} as compared to other treatments which consequently resulted in higher net return. The minimum net return was recorded with application of T_1, *i.e.* ₹ 34489 with B:C ratio 1.77. The economics of trial also justify the importance of micronutrients application over primary nutrients alone. The foliar application of zinc as in T_3 obtained more net return (₹ 41405) and B:C ratio (1.91) as compared to T_1. The application of micronutrients in combination of NPK enhanced the yield and thereby increases the net income from wheat cultivation (Meena *et al.* 2017). These results are in line with the findings of Singh *et al*. (2019).

Based on two year wheat trial data it is concluded that only the application of macronutrients in wheat is not so beneficial in terms of yield and economics. The higher plant height, number of tillers/m^2, yield attributes, grain and straw yield, gross returns, net returns and B:C ratio were recorded with the RDF + soil application of Zn HEDP + $MnSO_4$+ Colemanite.

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