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EFFECT OF IRON ON THE GROWTH AND YIELD CONTRIBUTING PARAMETERS OF WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

Field experiments were conducted at Government Adaptive Research Farm Karor Lal Eason, district- Layyah, to study the impact of trace elements on uptake of nitrogen, phosphorus, potassium and yield of wheat. The experiments were laid out in RCBD having three replications. Soil samples were collected before sowing of crop from 0-15 cm depth and analyzed for physical and chemical properties (texture, pH, EC_e, soluble, anions cations, soil organic matter, NPK, Zn, Fe and Mn). Wheat variety Bhakkar-2002 was sown during Rabi season 2005-2006 and 2006-2007. The recommended doses of N, P and K were applied @ 150:100:60 kg $N:P_2O_5:K_2O$ ha^{-1}, through broadcast at the time of sowing while N was applied in two equal doses after 25 days and 40 of sowing at the time of irrigation. Micronutrient, i.e. Fe was applied @ 0, 4, 8, 12 and 16 kg ha^{-1} alone as well as combined in a same trial, in the form of Iron sulphate at the time of sowing. Results showed that application of recommended NPK fertilizer significantly increased all parameters of wheat, i.e. Plant height, spike length (cm), number of spikelets $spike^{-1}$, number of fertile tillers m^{-2} straw yield, grain yield and 1000-grain weight, significantly over control (no NPK). Application of Fe also showed a significant response to wheat at lower rates. High rates of Fe reduced/ did not effect the growth and yield contributing parameters of crop. The best results were obtained when applied Fe @ 12 Kg ha^{-1} with recommended NPK. Increasing rates of Fe dose up to 12 kg ha^{-1} increased grain yield while higher rate did not have any significant effect.

Key words: Trace element (Fe), NPK fertilizer, wheat (*Triticum aestivum* L.), Pakistan.

INTRODUCTION

Evidence of greater nutritional value in crops is currently a subject of intense debate (Murphy *et al.*, 2008). Micronutrients are as important as macronutrients for adequate plant nutrition and a deficiency of just one nutrient can greatly reduce yield. Adequate plant nutrition with micronutrients depends on many factors. These factors include the ability of soil to supply these nutrients, rate of absorption of nutrients to functional sites and nutrients mobility within the plants. Interaction occurs between the micronutrient and some macronutrients.

Micronutrients play a vital role in growth and development of plant and occupy an important portion by virtue of their essentiality in increasing crop yields. In fact, their essential role in plant nutrition and increasing soil productivity makes their importance ever greater. In view of intensive cropping with high yielding varieties and application of high analysis major and secondary nutrient fertilizers, incidence of micronutrient deficiencies have been more pronounced (Dewal and Pareek, 2004)

Field experiment on the effect of micronutrients, zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), boron and a commercial fritted micronutrient product called Zarzameen, on the yield and the yield components of wheat (Triticum aestivum L.), in the Peshawar valley, Pakistan showed that micronutrients increased wheat dry matter, grain yield, and straw yield significantly over an unfertilized control. (Asad and Rafique, 2002).. Similarly, Abbas *et al.* (2007) evaluated the trace elements in soil of district of Sheikhupura, Pakistan and found that the zinc ranged between deficiency (<0.5 mg kg^{-1}) and adequate limits (>1.0 mg kg^{-1}) while Copper, Mn and Fe were present in adequate amounts.

Pakistan soils are generally alkaline in reaction, calcareous in nature and rich in bases. These types of soils usually contain low amounts of available micronutrients (Hodgson *et al.*, 1966). More over the introduction of high yielding varieties coupled with increased use of macronutrient containing fertilizers have further increased the mining of micronutrients from these soils (Bhatti *et al.*, 1985).

While the trend to more intensive crop production with higher yields, heavier usage of fertilizers increases the need for greater consideration and usage of micronutrients; we are also better able to cope with this problem because of increasing knowledge through improved testing methods. As farmers strive for top yields and quality, they must give more attention to micronutrient needs.

While global cereal grain yields have increased dramatically since the green revolution (Borlaug, 1983), global food systems are not providing sufficient micronutrients to consumers (Welch, 2002). Over 40% of the world's population is currently micronutrient deficient, resulting in numerous health problems, inflated economic costs borne by society, and learning disabilities for children (Sanchez and Swaminathan, 2005). Though a diversification of diet to include micronutrient rich traditional foods is a preferred solution to these challenges, staple cereal grains are the primary dietary source of micronutrients for much of the world's population without access to varied food crops (Bouis, 2003).

In some cases, however, Fe application might cause nutritional disorder due to the antagonistic effect of Fe with other cationic micronutrients, in particular with manganese (Ghasemi-Fasaei and Ronaghi, 2008). Similarly, potassium uptake by crops was increased due to application of copper and iron (Samui *et al.*, 1981).

It is evident from the above that use of both macro and micro nutrients including Fe is an important factor for wheat crop cultivation and these essential nutrients should be used in proper doses for increasing soil fertility and to boost up crop production. The present investigation was undertaken to study the effect of added iron on different growth parameters, grain and straw yields

MATERIALS AND METHODS

This research work was carried out at Adaptive Research Farm Karor, District, Layyah, which lies between 30°-45' to 31°-24', north latitude and 70°-44' to 71°-50', east longitude, during the year 2005-2006 and 2006-2007. The experiment was laid out in randomized complete block design with three replications. The experimental soil (0-15 cm depth) was analyzed for initial soil physiochemical properties. Soil texture was loam having the following characteristics; sand 40.70%, silt 37.30%, clay 22%, pH 8.1, organic matter 0.85%, $CaCO_3$ 5.5%, EC 1.5 dSm^{-1}, available N 0.60 g Kg^{-1}, available P 10.5 mg Kg^{-1}, exchangeable K 125 mg Kg^{-1}, AB-DTPA extractable Zn 0.93 mg Kg^{-1}, AB-DTPA extractable Fe 2.95 mg Kg^{-1} and AB-DTPA extractable Mn 1.15 mg Kg^{-1}. Wheat variety Bhakkar-2002 was sown during Rabi season 2005-2006 and 2006-2007 on 15th November with hand drill using seed rate 125 Kg ha^{-1}. The recommended doses of N, P and K were applied @ 150:100:60 Kg N: P_2O_5: K_2O ha^{-1} as urea, triple super phosphate and sulphate of potash, respectively, in all treatments, through broadcast at the time of sowing while N was applied in two equal doses after 25 days and 40 days of sowing at the time of irrigation. For control (T_1) no NPK and Fe was used. Fe was applied @ 0(T_2), 4 (T_3), 8(T_4), 12(T_5) and 16(T_6) (Kg ha^{-1}) in the form of Iron sulphate, by broadcasting in powder form mixed with soil at the time of seedbed preparation. All crop management and protection measures were followed. Weed control practices were included physical method *i.e*. hoeing along with weedicides application {Buctril Super 60 EC (Bromoxynil + MCPA) @ 750 mL ha^{-1} and Puma Super (Fenoxaprop) @ 1250 mL ha^{-1})}. The crop was harvested at maturity, 150 days after sowing. The growth and yield parameters were recorded. Randomized complete block design (RCBD) was used to analyze the data (Steel *et al*., 1997). Duncan's multiple range test (Duncan 1955) was used to see the significance of treatments means at 5% probability level.

RESULTS AND DISCUSSION

Plant height (cm): Results from two-year study revealed that, plant height was significantly affected by the recommended NPK application, but application of Fe along with recommended NPK showed non-significant difference compared with recommended NPK (table 1).

In year-1, in general, statistically similar effect (18.88, 20.60, 20.60, 18.88 and 17.59 % respectively more than control) was observed in case of T_6 (recommended NPK + 16 kg Fe ha^{-1}), T_5 (recommended NPK + 12 kg Fe ha^{-1}), T_4 (recommended NPK + 8 kg Fe ha^{-1}), T_3 (recommended NPK + 4 kg Fe ha^{-1}) and T_2 (recommended NPK). These treatments (T_6, T_5, T_4 and T_3) showed 7.33, 17.09, 17.0 and 7.33 % increase over T_2 (recommended NPK), respectively In year-11, all treatments receiving recommended NPK and Fe showed their significance over T_1 (no NPK). An increase of 17.65, 19.33, 18.07, 17.23 and 15.55 % was observed in case of T_6 (recommended NPK + 16 kg Fe ha^{-1}), T_5 (recommended NPK + 12 kg Fe ha^{-1}), T4 (recommended NPK + 8 kg Fe ha^{-1}), T_3 (recommended NPK + 4 kg Fe ha^{-1}) and T_2 (recommended NPK), respectively over T_1 (no NPK).

Number of tillers m^{-2}: The effectiveness of all the treatments on number of tillers m^{-2} is clearly evident from data given in table-1. In year-1, T_5 (recommended NPK along with Fe @ 12 kg ha^{-1}) gave maximum number of tillers m^{-2} (287.33), which were 48.62 and 4.48 % more than T_1 (control) and (T_2) recommended NPK, respectively. All treatments receiving Fe application were statistically at par with each other. In year-11, statistically similar effect (52.82, 53.18, 51.23, 49.47 and 49.29 % respectively more than control) was observed in case of T_6, T_4, T_3 and T_2. These treatments (T_6, T_5, T_4 and T_3) showed 2.37, 2.60, 1.30 and 0.12 % increase over T_2 (recommended NPK), respectively.

Spike length (cm): The effect of Zn application on spike length was statistically significant during both the years.

In year-1, T_2 (recommended NPK) increase spike length by 48.91 % over T_1 (control). Treatments receiving Fe along with recommended NPK (T_6, T_5, T_4 and T_3), were statistically similar with each other and showed 57.12, 59.07, 57.31 and 55.21 % increase over T_1 (control) and 5.51, 6.82, 5.64 and 4.23 % increase over T_2 (recommended NPK), respectively. In year-11, all treatments receiving Fe doses were statistically significant from T_2 (recommended NPK) and T_1 (control) but statistically similar with each other. Maximum spike length (13.89 cm) was noted with T_6 while minimum was recorded in T_1 (no NPK).

Number of spikelets spike^{-1}: As regard number of spikelets spike^{-1} recommended NPK and Fe rates both increased the spikelets spike^{-1} significantly (table 1). In year-1, statistically similar effect (15.37, 15.53, 15.47, 15.20 and 15.10 %, respectively, more than control) was observed in case T_6, T_5, T_4, T_3 and T_2, respectively. In year-11, application of NPK and Fe both had a significant response. T_5 (recommended chemical fertilizers + 12 kg Fe ha^{-1}) gave maximum spikelets spike^{-1} (15.60) followed by 16.63 in case of T_6.

1000-grain weight (g): Data pertaining to 1000-grain weight of wheat as affected by recommended NPK and Fe application rates is presented in table 11. As far as recommended NPK is concerned, 52.68 and 65.83 % increase in 1000-grain weight was observed during 1st and 2nd year, respectively, over control (no NPK). As regard Fe application rates applied during 1st year, maximum mean 1000-grain weight (34.77 g) was recorded in those plots where Fe was applied @ 12 kg ha^{-1} along with recommended NPK. T_6 was second best treatment (34.57g). Treatments T_4 and T_3 where Fe was applied @ 8 and 4 kg ha^{-1}, respectively, along with NPK, were at par with T_2 where only recommended NPK was applied. Similar trend was observed during 2nd year.

Straw yield (Mg ha^{-1}): The data pertaining to straw yield (table-II) of wheat as affected by different Fe rates and recommended NPK indicate the significant effect of Fe rates and recommended NPK on straw yield. In year-1, maximum straw yield (5.93 Mg ha^{-1}) was observed in T_3 (recommended NPK + Fe @ 4 kg ha^{-1}) and it showed 78.40 and 5.95 % increase over and T_1 (no NPK) and T_2, respectively. It was followed by T_5, T_4, T_6 and T_2. These treatments were statistically at par with each other and statistically significant from T_1 (no NPK).

In year-II, treatment T_5 (recommended NPK along with Fe @ 12 kg ha^{-1}) gave maximum straw yield (6.64 Mg ha^{-1}) showing 7.24 and 86.43 % increase over T_1 and T_2 respectively. It was followed in descending order by T_4, T_3, T_6 and T_2, respectively.

Grain yield (Mg ha^{-1}): The data regarding grain yield of wheat is affected by different Fe rates and recommended NPK are presented in table 11, which exhibit that Fe rates and recommended NPK significantly affected grain yield. In year-1, application of NPK increased the grain yield 128.43% over control. T_5 (recommended chemical fertilizers along with Fe @ 12 kg ha^{-1}) gave maximum grain yield (4.22 Mg ha^{-1}) showing 8.68 and 148.04 % increase over recommended NPK and control, respectively. It was followed in descending order by T_4, T_6 and T_3 and T_2 that showed 144.31, 144.12 and 138.63 % increase over T_1 (control) and 7.04, 6.96 and 4.55 % increase over T_2. In year-II, in general, statistically similar effect (156.09, 155.49, 155.09 and 148.50 % respectively, more than control) was observed in case T_5, T_6, T_4 and T_3, while these treatments showed 9.66, 9.40, 9.23 and 6.41 % increase in grain yield over T_2 (recommended NPK), respectively. Effect of lower rates of Fe application was more pronounced than higher rate.

Applications of iron affected all the growth and yield parameters of wheat at all the rates. As regard growth and yield parameters, application of Fe significantly increased the number of tillers m^{-2}, spike length, 1000-grain weight, straw yield and grain yield of wheat in year-1, while in year-2 it also increased the number of tillers m^{-2}, spike length, 1000-grain weight, straw yield and grain yield, over recommended NPK. But all growth and yield parameters of wheat obtained by applying different doses of Fe were statistically non significant or at par with each other. Best results were obtained by applying Fe @ 12 kg ha^{-1}. Similar results were obtained by Ziaeian and Malakouti (2001) who conducted 25 field experiments in order to study the effects of micronutrients on wheat production in calcareous soils. The results showed that Fe fertilization caused significant increase in grain yield, straw yield, 1000-grain weight, and the number of seeds per spikelet. With the application of Fe, their concentration and total uptake in grain and flag leaves and the grain protein content increased significantly.

Singh and Ram (2005) initiated a 25-year-long fertilizer experiment in 1971 to evaluate the nutrient and micronutrient uptake of the rice and Wheat. They described that Fe uptake by the entire rice-wheat-cowpea cropping sequence varied from 2274 to 6169 g ha^{-1} .The highest removal of Fe was observed with 100% NPK+FYM. The removal of micronutrients by the annual cropping cycle depleted the availability of Fe in the range of 0.1-1.8, respectively, under different treatments.

Table-I Effect of different Fe doses on growth parameters of wheat (*Triticum aestivum* L.); the data are average of three replications

Treatments	Plant height (cm)		Number of tillers m^{-2}		Spike length (cm)		Number of spikelets $spike^{-1}$	
	Year-1	Year-2	Year-1	Year-2	Year-1	Year-2	Year-1	Year-2
T1= Control	77.67b	79.33b	193.33c	188.67b	8.73c	8.93c	9.94b	10.27c
T2= [a]NPK	91.33a	91.67a	275.00b	281.67a	13.00b	13.20b	15.10a	15.30ab
T3 =NPK+ [b]4 Kg Fe ha^{-1}	92.33a	93.00a	278.67ab	282.00a	13.55a	13.87a	15.20a	15.03b
T4=NPK+ 8 Kg Fe ha^{-1}	93.67a	93.67a	282.67ab	285.33a	13.73a	13.93a	15.47a	15.43ab
T5=NPK+ 12 Kg Fe ha^{-1}	93.67a	94.67a	287.33a	289.00a	13.89a	13.87a	15.53a	15.83a
T6=NPK+ 16 Kg Fe ha^{-1}	92.33a	93.33a	286.00a	288.33a	13.72a	14.11a	15.37a	15.60ab

[a]The N, P and K fertilizers were applied @ 150:100: 60 Kg N: P_2O_5:K_2O ha^{-1}, respectively in all the treatments
[b]The Fe was applied in the form of Iron sulphate by broadcasting in powder form and mixed with soil at the time of seedbed preparation
†Means sharing similar letter(s) in a column do not differ significantly at p=0.05

Table-II Effect of different Fe doses on yield and yield contributing parameters of wheat (*Triticum aestivum* L.); the data are average of three replications

Treatments	Treatments description	1000-grain weight G		Straw yield Mg ha^{-1}		Grain yield Mg ha^{-1}	
		Year-1	Year-2	Year-1	Year-2	Year-1	Year-2
T1	Control	21.33 c	20.00 c	3.32 c	3.25 b	1.70 c	1.67 c
T2	[a]NPK	32.57 b	33.17 b	5.59 b	5.65 a	3.88 b	3.90 b
T3	NPK+ [b]4 Kg Fe ha^{-1}	33.67 ab	34.00 ab	5.92 a	5.86 a	4.06 ab	4.15 ab
T4	NPK+ 8 Kg Fe ha^{-1}	33.90 ab	34.20 ab	5.77 ab	5.92 a	4.15 a	4.26 a
T5	NPK+ 12 Kg Fe ha^{-1}	34.77 a	35.23 a	5.81 ab	6.06 a	4.22 a	4.28 a
T6	NPK+ 16 Kg Fe ha^{-1}	34.57 a	35.10 a	5.64 ab	5.74 a	4.15 a	4.27 a

The N, P and K fertilizers were applied @ 150:100: 60 Kg N: P_2O_5:K_2O ha^{-1}, respectively in all the treatments
[b]The Fe was applied in the form of Iron sulphate by broadcasting in powder form and mixed with soil at the time of seedbed preparation
†Means sharing similar letter(s) in a column do not differ significantly at p=0.05

Table- 111 Effect of Iron on the economics of wheat.

Fe application (Kg ha^{-1})	Expenditure			†Income from wheat			Increased income over control	Net Return	*Value/cost (VCR) ratio
	Fe treatment	"Sowing + 'NPK	Total	Grain	Straw	Total			
NPK	0.00	351.51	351.51	704.21	145.33	849.54	0.00	498.03	0.00
[b]4	6.80	351.51	358.31	743.13	152.32	895.44	45.90	537.13	78.97
8	13.60	351.51	365.11	761.23	151.15	912.38	62.84	547.27	40.23
12	20.40	351.51	371.91	769.38	153.48	922.86	73.32	550.94	27.00
16	27.21	351.51	378.72	762.14	147.14	909.28	59.74	530.56	19.50

'Expenditures on NPK sources were as follows: N, 0.276 US$ kg^{-1}; P_2O_5, 0.464US$ kg^{-1}; K_2O, 0.585US$ kg^{-1} (NFDC, 2006).
'Expenditures on Fe source was 1.70 S$ kg^{-1}
"Sowing expenditures were as follows: ploughing and seed bed preparation, 25.86 US$; seed, 28.87 US$; weedicide, 28.88 US$; irrigation, 34.47 US$; harvesting and threshing, 63.79 US$
†Price of the wheat produce was as follows: wheat grain, 181.03 US$ Mg^{-1}; wheat straw = 25.86 US$ Mg^{-1}.
*Value/cost (VCR) ratio = Net return/ expenditure due to Fe treatment
[a]The N, P and K fertilizers were applied @ 150:100: 60 Kg N: P_2O_5:K_2O ha^{-1}, respectively in all the treatments
[b]The Fe was applied in the form of ferrous sulphate (19 %) by broadcasting in powder form and mixed with soil at the time of seedbed preparation
†Means sharing similar letter(s) in a column do not differ significantly at p=0.05

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