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Effects of Iron on the Wheat Crop (*Triticum aestivum* L.) by Uptake of Nitrogen, Phosphorus and Potassium

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Abstract: Field experiments were carried out at Adaptive Research Farms, with the aim to study the influence of trace element on take up of phosphorus, potassium and nitrogen on wheat yield. RCBD design was used having three replications. Samples of soil were collected prior the sowing of wheat crop at a depth of 0-15 cm and were examined for chemical and physical properties (pH, soluble anion and cations, EC_e, soil organic matter and texture, NPK and Fe). (Wheat variety) was planted during Rabi season 2005-2006 and 2006-2007. The recommended doses of N, P and K were applied @ 150:100:60 kg/ha, respectively, through broadcast at the time of sowing while N was applied in two equal doses after 25 and 40 days of sowing at the time of irrigation. Micronutrient, i.e., Fe was applied @ 0, 4, 8, 12 and 16 kg/ha unaided in the form of Iron sulphate at sowing time. All crop management and protection measures were followed. Results of the different studies conducted showed that application of Fe increased NPK uptake and their concentration in soil significantly over control. Application of recommended NPK improved micronutrient (Fe) uptake appreciably and this resulted in a slight decreased micronutrient (Fe) contents in soil as compared to control. Micronutrients application enhanced the yield and growth parameters of wheat, their total take up also effect in the build-up of micronutrients in the upper 15 cm soil layer, to be available for next crop. Application of Fe also showed a noteworthy response to wheat at lower rates, when applied alone. Severe decrement of Fe didn't effect the growth and yield contributing parameters of crop. The results of our study reveal that the application of Fe has no significant effect on the NPK uptake by wheat crop.

Key words: NPK fertilizers, NPK uptake, Pakistan, trace element (Fe), wheat (*Triticum aestivum* L)

INTRODUCTION

Being a staple food of Pakistani people wheat is grown in every part of the country. It contributes 12.7% to the value added in agriculture and 2.6% to GDP. In the year 2007-2008 the area under cultivation were 8578 thousand hectares which shows the increment of 1.9% over the last year i.e., 8414 thousand, with a production of 24 million tons, respectively. The general estimated wheat crop was 21.75 million tons, 6.6% less than last year and 9.4% less than the target for this year. There are several reasons for the decline in wheat production.

Better nutritional value in crops is a major theme of concentrated debate (Murphy *et al.*, 2008). Micronutrients are as essential as macronutrients for adequate plant nutrition because the deficiency of only one nutrient can greatly reduce yield. Better plant nutrition in addition to micronutrients depends on many factors in soil. These factors individual the potentiality to provide these nutrients charges of concentration of nutrients to operable sites and nutrients mobility within the plants. Interaction occurs between the micronutrient and some macronutrients. Interaction is an influence of one element upon other in alliance to plant growth (Olsen, 1972). Also the differential response to one element in combination with varying levels of a second elements applied simultaneously i.e., both the elements together produce an enhanced effect and this effect is not because of one of them alone (Olsen, 1972). Such interaction may take place in the soil and within the plants. So these interactions should be taken into account when supplying sufficient micronutrients to plants.

Micronutrients having a very important role in development and growth of plants and occupy a major essentiality in enhancing crop yields. In real, their important role in plants nutrition and enhancing soil

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productivity makes their ever greater. In observation of intensive cropping with high yielding varieties and application of high analysis, major and secondary nutrient fertilizers, incidence of micronutrient shortage have been more marked (Dewal and Pareek, 2004)

The inclination for more crop production having greater yields, greater usage of fertilizer increases the want for greater consideration and usage of micronutrients; we are able to manage with this problem because of increasing knowledge due to improved testing methods. As a matter of fact that the farmers who struggle for top quality and yields, they have to provide more attention to micronutrient needs. The significance of the use of Mn, Cu and Zn on crop production of these soils was discussed in 1930 at the Second International Congress of Soil Science by Allison (1930). Since then researchers and field testers through field-testing have demonstrated the minor need of micronutrients on vegetables, crops and orchids.

Since the green revolution the cereal grains yield has been increased drastically (Borlaug, 1983), though the global food systems are not providing adequate 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 comprise micronutrient rich traditional foods is a favoured solution to such challenges, staple cereal grains are the prime dietary source of micronutrients for much of the world's population without access to varied food crops (Bouis, 2003).

Metal uptake by plants is characterized by selectivity; accumulation and nature of genotypes, Moreover the introduction of high yielding varieties coupled with increased the consumption of micronutrients from those soils (Bhatti *et al*., 1986). It is a fact that all the micronutrients take part in complex metabolic processes in plants and influence the growth of plants. They may become either component of enzyme, vitamins and hormones.

Iron is momentous for photosynthesis and chlorophyll formation. Chlorophyll is the minute "sun-panels" which the plants use to take energy from the sun and also able to give plants their green color). Photosynthesis is the procedure in which the real sunrays are harvested. Enzymes to regulate transpiration in plants also use iron. Transpiration is the process in which the plants pull water up from the ground and let it through minute openings on the lower side of the leaves which is called stomata. Thus the available nutrients dissolve in the water to reach all parts of the plant.

Although in few cases, Fe application might cause nutritional disorder due to the aggressive effect of Fe with other cationic micronutrients, in specific with manganese (Mn) (Ghasemi-Fasaei and Ronaghi, 2008). Likewise, Dewal and Pareek (2004) reported that nitrogen uptake by crop enhanced due to zinc application. Similarly, potassium uptake by crops was enhanced due to application of copper and iron (Samui *et al.*, 1981).

Keeping in view the important role of iron in crop production the present, study was designed to evaluate its effect on the wheat crop production.

MATERIALS AND METHODS

This research job was conducted during the year 2005-2006 and 2006-2007 at Adaptive Research Farms which is sandwiched between 30º-45′ to 31º-24′, north latitude and 70º-44′ to 71º-50′, east longitude. Having three replications with a randomized consummate block designing RCBD was used in this inquiry. The experimental soil (0-15 cm depth) was analyzed for initial soil physicochemical 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 dS/m, available N 0.60 g/kg, exchangeable K 125 mg/kg, AB-DTPA extractable Zn 0.93 mg/kg, available P 10.5 mg/kg, AB-DTPA extractable Fe 2.95 mg/kg and AB-DTPA extractable Mn 1.15 mg/kg. (Wheat cultivar) was introduce in Rabi season 2005-2006 and 2006-2007 on 15th November using hand drill with a seed rate 125 kg/ha. In all treatments the practical N P K magnitude relation was 150 100 60 triple superintendent phosphate N P2O5 K2O ha 1 as carbamide and sulfate of caustic potash, respectively at the clip of sowing through program whilst N was practical at the time of irrigation in two peer doses aft 25 years and 40 days of sowing. At the clip of bed readying Fe was practical in the word form of Fe sulfate pulverization word form assorted with dirt 0 4 8 12 and 16 kg/ha by broadcast medium. All crop management and protection measures were followed. Weed control practices were included physical method i.e., hoeing along with application of Puma Super (Fenoxaprop) @ 1250 mL/ha) and Buctril Super 60 EC (Bromoxynil+MCPA) @ 750 mL/ha) which are weedicites. The crop was harvested at maturity, 150 days after sowing. The fresh weight was determined in the field; an aliquot was randomly taken for the determination of dry matter, NPK and micronutrients analysis. The samples of grains and straw were kept at 65ºC for 48 h and then their dry weights were obtained to access grain and straw yield on dry weight basis. The grains and straw samples were ground with a grinding mill. Soil samples were taken, dried out in air and examined for determination of soil organic carbon, micronutrients and NPK after harvesting of crop. Hydrometer method (Bouyoucos, 1962) was followed for particle size analysis. Nitrogen in soil was determined using macro Kjehldhal's apparatus by Gunning and Hibbard's method of sulphuric acid digestion and distillation of ammonium into 4% boric acid. Phosphorous was calculated by taking 10 mL, 0.5 N $NaHCO_3$ solutions and 5 g soil. Solution pH was adjusted at 8.5. Five mL of aliquot of clear filtrate was taken in 25 mL volumetric flask and potassium tartrate and sulphuric acid were added. Filtrate color intensity was calculated on spectrophotometer at 880 nm (Watanabe and Olsen, 1965). Soil was extracted with ammonium acetate solution (1.0 N of pH 7.0) and potassium was calculated by Jenway PFP-7 flame photometer in the extract (Hand Book 60, Method 18). Using the modified method of Walkly and Black (1934) soil organic carbon was determined (Nelson and Sommers, 1982). By dissolving 1.97 g of DTPA and 79.06 g NH_4HCO_3 in a liter solution the AB-DTPA extracting solution was prepared. With the help of HCL the pH of the solution was adjusted to 7.60. Ten gram me of dirt was located in a 250 mL Erlenmeyer flask full with the add-on of 20 mL of recently put un-neurotic extracting answer barrel for 15 min, proceedings by guardianship flasks clear on mover and shaker at 180 cycles per min (Soltanpour, 1985). The mixture was filtered and metals were found out with atom like absorption spectrophotometer (Model Thermo Electron S-Series). According to Wolf (1982) method, the dried and ground shoot material (0.1 g) was digested with hydrogen peroxide and sulphuric acid. Nitrogen was determined using micro Kjeldhal's apparatus by Gunning and Hibbard's method. Total phosphorus was ascertained by spectrophotometer using 400 nm wavelengths and contrasting the sample concentration against standard curve (Hand Book 60, Method 61). Potassium in the digested material was ascertained by Jenway PFP-7 flame photometer (Hand Book 60, Method 5). For the micronutrients analysis, plant samples were constrained to digestion and then Mn, Fe and Zinc were asertained with atomic absorption spectrophotometer (Model Thermo Electron S-Series). For every bath of samples there were kept one reagent vacant (no plant material). Randomized Complete Block Design (RCBD) was used to analyze the data (Steel and Torrie, 1980). Duncan's multiple range test (Duncan, 1955) was used to see the significance of treatments means at 5% probability level.

RESULTS

Effect of different Fe doses on total nitrogen uptake (kg/ha): During both years, application of recommended NPK along with different rates of Fe increased the N-uptake significantly over control (no NPK) as Table 1. During 1st year, T2 (recommended chemical fertilizers) showed maximum uptake (106.07 kg/ha) showing 95.26% increase over control. It was followed in descending order by T4 (recommended NPK+Fe @ 8 kg/ha), T5 (recommended NPK+Fe @ 12 kg/ha), T6 (recommended NPK+Fe @ 16 kg/ha) and T3 (recommended NPK+Fe @ 4 kg/ha) that showed 94.85, 93.19, 91.85 and 90.11% increase over T1 (control), respectively. These all treatments were statistically similar with each other and significant from control. Data trend shows that increasing Fe doze decreased the total N uptake (grain+straw).

Next year (2006-7), similar trend in data were observed. Application of NPK increased the N uptake 97.2%, over control. All treatments receiving Fe doses along with recommended NPK, were statistically non significant compared with T2 (recommended NPK).

Effect of different Fe doses on total P uptake (kg/ha): During both the years (2005-6 & 2006-7), application of NPK increased the P uptake over control while application of Fe along with recommended NPK decreased the P uptake compared with treatments receiving recommended NPK as Table 1.

In 2005-6, maximum P uptake (140.59) was observed in case of T2 (recommended NPK). It was followed by T3 (recommended NPK+Fe @ 4 kg/ha), T4 (recommended NPK+Fe @ 8 kg/ha), T5 (recommended NPK+Fe @ 12 kg/ha) and T6 (recommended chemical fertilizers along with Fe @ 16 kg/ha) showing 136.85, 135.81, 127.28 and 125.83% increase over T1 (no NPK) and 1.56, 2.0, 5.54 and 6.14% decrease over recommended NPK, respectively. During year 2006-07, similar data trend was observed but increase in P uptake was more as compared to year-1.

Effect of different Fe doses on total K uptake (kg/ha): Data pertaining to total K uptake of wheat as affected by recommended NPK and Fe application rates is presented

Table 1 : Effect of different Fe doses on total N, P and K up ta by wheat (*Triticum aestivum* L.); the data are average of three replications

Treatments	Total N uptake (Kg/ha)		Total P uptake (Kg/ha)		Total K uptake (Kg/ha)	
	Year-1	Year-2	Year-1	Year-2	Year-1	Year-2
T_1 = NPK (control)	55.29 b	54.10 b	16.03 b	14.60 c	54.33 b	56.33 b
T_2 = [a]NPK	107.96 a	106.67 a	38.57 a	38.53 a	129.67 a	137.00 a
T_3 = NPK+[b]4 Kg Fe/ha	105.11 a	107.50 a	37.97 a	38.10 ab	133.00 a	139.00 a
T_4 = NPK+8 Kg Fe/ha	107.73 a	108.38 a	37.80 a	37.60 ab	136.00 a	138.00 a
T_5 = NPK+12 Kg Fe/ha	106.81 a	107.59 a	36.43 a	37.53 ab	135.67 a	138.67 a
T_6 = NPK+16 Kg Fe/ha	106.08 a	106.03 a	36.20 a	35.80 a	133.67 a	136.67 a

a: The N, P and K fertilizers were utilized @ 150: 100: 60 Kg N: P_2O_5: K_2O/ha, in all the treatments; [b]: The Fe was utilized as a Iron sulphate through broadcasting in dust form and mixed with soil sharp at seedbed preparation; †: Means sharing similar letter (s) in a column do not vary considerably at p = 0.05

Table 2: Effect of different Fe doses on total, Fe uptake and content in soil, by wheat (*Triticum aestivum* L.); the data are average of three replications

	Total Fe uptake (g/ha)		Fe contents in soil (mg/Kg)	
Treatments	Year-1	Year-2	Year-1	Year-2
T_1 = NPK (control)	1636.67 e	1540.00 e	2.93 e	3.03 e
T_2 = [a]NPK	3575.00 d	3613.00 d	2.5 e	2.4 e
T_3 = NPK+[b]4 Kg Fe/ha	4308. 00 c	4547.00 c	3.5 d	3.7 d
T_4 = NPK+8 Kg Fe/ha	4793.00 b	4926.00 b	4.7 c	4.6 c
T_5 = NPK+12 Kg Fe/ha	5150.00 a	5218.00 a	5.7 b	6.0 b
T_6 = NPK+16 Kg Fe/ha	4950.00 ab	5027.00 ab	7.2 a	7.8 a

[a]: The N, P and K fertilizers were utilized @ 150: 100: 60 Kg N: P_2O_5: K_2O/ha, in all the treatments; [b]: The Fe was utilized as a Iron sulphate through broadcasting in dust form and mixed with soil sharp at seedbed preparation; †: Means sharing similar letter (s) in a column do not vary considerably at p = 0.05

Table 3: Effect of different Fe doses on soil organic matter and NPK contents in soil; the data are on average of three replications

	Soil organic matter (%)		N content in soil (g/Kg)		P content in soil (mg/Kg)		K content in soi (mg/Kg)	
Treatments	Year-1	Year-2	Year-1	Year-2	Year-1	Year-2	Year-1	Year-2
T_1 = NPK (control)	0.59 b	0.58 e	0.47 b	0.49 b	8.76 d	8.27 c	115.33 c	111.00 c
T_2 = [a]NPK	0.66 a	0.69 a	0.61 a	0.63 a	12.0 c	12.23 b	159.7 b	162.7 b
T_3 = NPK+[b]4 Kg Fe/ha	0.66 a	0.68 a	0.63 a	0.65 a	13.4 ab	13.30 ab	161.0 b	161.3 b
T_4= NPK+8 Kg Fe/ha	0.65 a	0.69 a	0.64 a	0.66 a	13.1 bc	13.50 ab	165.7 ab	165.0 ab
T_5= NPK+12 Kg Fe/ha	0.67 a	0.69 a	0.64 a	0.66 a	13.67 ab	13.50 ab	165.0 ab	164.0 ab
T_6 = NPK+16 Kg Fe/ha	0.67 a	0.69 a	0.66 a	0.67 a	14.30 a	14.20 a	168.7 a	171.7 a

[a]: The N, P and K fertilizers were utilized @ 150: 100: 60 Kg N: P_2O_5: K_2O/ha, in all the treatments; [b]: The Fe was utilized as a Iron sulphate by broadcasting in dust form and mixed with soil sharp at seedbed preparation; †: Means sharing similar letter (s) in a column do not vary considerably at p = 0.05

in Table 1. As far as recommended NPK is concerned, 138.66 and 143.21% increase in total K uptake was observed during 1st and 2nd year, respectively, over control (no NPK).

As regard Fe application rates during the year 2005-06, all treatments receiving Fe doses were statistically non-significant compared to each other. Maximum mean K uptake (136 kg/ha) was recorded in those plots where Fe was applied @ 8 kg/ha along with recommended NPK, while minimum (54.33) in case of control (no NPK). Increasing Fe doses upto 8 kg/ha increased the K uptake while higher doses of Fe i.e., 12, 16 kg/ha decreased K uptake showing antagonistic effect between Fe and K.

In 2006-07, maximum K uptake (139 kg/ha) was observed in case of T3 (recommended chemical fertilizers+4 Fe kg/ha). It was followed in descending order by T5 (recommended NPK+Fe @ 12 kg/ha), T4 (recommended NPK+Fe @ 8 kg/ha), T2 (recommended NPK), T6 (recommended NPK+Fe @ 16 kg/ha) and T1 (no NPK).

Treatment combinations T6, T5, T4, T3 and T2 increased the k uptake by 146.76, 146.17, 144.98, 143.21 and 142.62% over T1, respectively.

Effect of different Fe doses on total Fe uptake (g/ha): Data pertaining to total Fe uptake by wheat crop as affected by recommended NPK and Fe application rates is presented in Table 2. As far as recommended NPK is concerned, 118.43 and 134.61% increase in total Fe uptake was observed during 1st and 2nd year, respectively, over control (no NPK).

As regard Fe application rates during the year 2005-06, all treatments receiving Fe doses were statistically significant from treatments receiving no Fe dose (T1, T2). In 2005-06, maximum mean Fe uptake (5150 g) was recorded in those plots where Fe was applied @ 12 kg/ha along with recommended NPK, showing 44.06% increase over T2 (recommended NPK), while minimum (1636.67 g) in case of control (no NPK). Second best treatment (4950 g) was T6 (recommended chemical fertilizers along with Fe @ 16 kg/ha) and it showed 202.44 and 38.46% increase over T1 (no NPK) and T2 (recommended chemical fertilizers). Statistically these two treatments were equivalent. It was followed in descending order by T4 and T3 showing 192.87 and 163.24% increase over control and 34.08 and 20.51% increase over recommended NPK.

In 2006-07, similar data trend was observed, i.e., increasing the Fe application rates up to 12 kg/ha increased its uptake. Maximum Fe-uptake (5218.33 g/ha) was detected in T5 (suggested chemical substance fertilizers along with Fe 12 kg/ha)

Next best treatment (5026.67 g/ha) was T6 (recommended chemical fertilizers along with Fe @ 16 kg/ha). It was followed in descending order by T4, T3 and T2 showing 219.87, 195.24 and 134.61% increase over control, respectively. Treatments T4 and T3 showed 36.34 and 25.84 5 increase over control, respectively.

Effect of different iron doses on soil chemical analysis:
Effect of different Fe doses on soil organic matter (%): Data pertaining to total Soil Organic Matter (SOM) as affected by recommended NPK and Fe application rates is presented in Table 3. As far as recommended NPK is concerned, 0.66 and 0.67% SOM was observed, during 1st and 2nd year, showing 12.99 and 19.54% increase, respectively, over control (no NPK).

As regard Fe application rates during the year 2005-06, all treatments receiving Fe doses along with recommended NPK were statistically non-significant compared to the treatment receiving recommended NPK only. In 2006-07, maximum SOM was observed in case of T6 (recommended NPK+16 kg Fe/ha) while minimum in case of control (no NPK).

Effect of different Fe doses on Nitrogen (N) content in soil (g/kg): The results obtained from statistical interpretation of N concentration in soil (Table 3) showed that N concentration was significantly increased with the application of recommended NPK along with Fe over control. In 2005-06, T6 (recommended chemical fertilizers+4 kg Fe/ha) gave maximum N contents (0.66) in soil showing 8.20 and 40.43% increase over recommended NPK and control, respectively. Treatment T6 was statistically non significant compared to T5, T4, T3 and T2.

During year 2006-07, in general, statistically similar effect (38.10, 36.05, 34.69, 32.65 and 28.57%, respectively, more than control) was observed in case T6 (recommended NPK+Fe @ 16 kg/ha), T5 (recommended NPK+Fe @ 12 kg/ha), T4 (recommended NPK+Fe @ 8 kg/ha), T3 (recommended NPK+Fe @ 4 kg/ha) and T2 (recommended NPK), respectively. These treatments (T6, T5, T4 and T3) showed 7.71, 5.82, 4.76 and 3.17% increase over T2 (recommended NPK), respectively.

Effect of different Fe doses on Phosphorus (P) content in soil (mg/kg): The results obtained from statistical interpretation of P concentration in soil (Table 3) showed that P content in soil was significantly increased with the application of recommended NPK along with Fe over control, in 2005-06. Maximum soil P contents (14.6 mg/kg) were observed in case of (T6 (recommended NPK+Fe @ 16 kg/ha) and it showed 63.24% increase over control. It was followed in descending order by T5 (recommended NPK+Fe @ 12 kg/ha), T4 (recommended NPK+Fe @ 8 kg/ha), T3 (recommended NPK+Fe @ 4 kg/ha), T2 (recommended NPK) and T1 (no NPK).

During year 2006-07, in general, similar trend was observed. Increment in Fe application also increased the soil P contents presenting their decreased uptake, though all treatments getting Fe doses were statistically at par compared to each other.

Effect of different Fe doses on potash (K) content in soil (mg/kg): The data regarding potash (K) content in soil (mg/kg) as affected by different Fe rates and recommended NPK are presented in Table 3, which exhibit that Fe rates and recommended NPK significantly affected K content in soil.

During first year (2005-6), application of NPK increased the K content in soil 38.44% over control. T6 (recommended chemical fertilizers+Fe @ 16 kg/ha) gave maximum k content in soil (168.67 mg/kg). It was followed in descending order by T4 (recommended NPK+Fe @ 8 kg/ha), T5 (recommended NPK/+Fe @ 12 kg/ha), T3 (recommended NPK+Fe @ 4 kg/ha) and T2 (recommended NPK) that showed 43.65, 43.07, 39.60 and 38.44% increase over T1 (control). These treatments (T5, T4, T3 and T2) showed 3.76, 3.34 and 0.83% increase over T1 (no NPK), respectively. All treatments receiving Fe doses were statistically non-significant compared to each other.

During next year (2006-07), in general, same trend was observed as in year-1. Maximum K contents in soil (171.67 mg/kg) were observed in case of T6 (recommended chemical fertilizers+Fe @ 16 kg/ha) while minimum in control.

Effect of different Fe doses on iron (Fe) content in soil (mg/kg): The data regarding Iron (Fe) content in soil (mg/kg) as affected by different Fe rates and recommended NPK are presented in Table 2, which exhibit that Fe rates and recommended NPK significantly affected Fe content in soil.

During first year (2005-6), application of NPK showed statistically similar Fe contents as in control (no NPK). Increasing the application rates of Fe increased the Fe built up in soil. Maximum mean Fe concentration was observed in case of T6 (recommended NPK+Fe @ 16 kg/ha) showing 145.73 and 180.16% increase over T1 (no NPK) and T2 (recommended NPK), respectively. It was followed in descending order by T5 (recommended NPK+Fe @ 12 kg/ha), T4 (recommended NPK+Fe @ 8 kg/ha) and T3 (recommended NPK+Fe @ 4 kg/ha) that showed 123.61, 83.92 and 38.52% increase over T2 (recommended NPK), respectively.

During next year (2006-07), in general, statistically similar trend was observed but there was more soil Fe built up as compared to first year. Maximum mean concentration of Fe was observed in case of T6 (recommended NPK+Fe @ 16 kg/ha) showing 159.73 and 217.20% increase over T1 (no NPK) and T2 (recommended NPK), respectively. It was followed in descending order by T5 (recommended NPK+Fe @ 12 kg/ha), T4 (recommended NPK+Fe @ 8 kg/ha) and T3 (recommended NPK+Fe @ 4 kg/ha that showed 141.94, 88.17 and 53.09% increase over T2 (recommended NPK), respectively.

DISCUSSION

Applications of iron affected the yield and growth parameter of wheat and NPK uptake at all the rates. As observed that on yield and growth parameters, application of Fe significantly improved the number of tillers m^{-2}, straw yield, spike length, 1000-grain weight and grain yield of wheat in first year, whilst in second year it increased the spikelets $spike^{-1}$, spike length, 1000-grain weight and grain yield on suggested NPK. But the obtained yield and growth parameters of wheat, through the application of distinct doses of Fe were statistically non significant or at par with each other. Most excellent results were obtained through applying Fe @ 12 kg/ha.

Table 4: Economics of using distinct Fe doses along with suggested NPK, for wheat production in the field; the data are average of two years

Treatments	Expenditure			†Income from wheat			Increased income over control	Net return	*Value/Cost (VCR) Ratio
	'Nutrient sources"	Sowing expenses	Total	Grain	Straw	Total			
[a]NPK	169.63	181.88	351.51	710.56	142.24	852.80	0.000	501.29	0.00
NPK+[b]4 Kg Fe/ha	194.01	181.88	375.90	762.16	156.47	918.62	65.819	542.73	2.70
NPK+8 Kg Fe/ha	218.39	181.88	400.28	780.26	159.83	940.09	87.284	539.81	1.79
NPK+12 Kg Fe/ha	242.77	181.88	424.66	812.84	157.89	970.73	117.931	546.08	1.61
NPK+16 Kg Fe/ha	267.15	181.88	449.04	816.47	155.69	972.15	119.353	523.12	1.22

'Expenditures on different nutrient sources were as follows: N, 0.276 US$/kg; P_2O_5, 0.464US$/kg; K_2O, 0.585US$/kg; Fe, 4.42S$/kg (NFDC, 2006); "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$; †: Price of the wheat produce is as follows: wheat grain, 181.03 US$/Mg; wheat straw, 25.86 US$/Mg; *Value/Cost (VCR) Ratio: Net return/expenditure due to Fe treatment; [a]: The N, P and K fertilizers were utilized @ 150: 100: 60 Kg N: P_2O_5: K_2O/ha, in all the treatments; [b]: The Fe was utilized as a Iron sulphate by broadcasting in dust form and mixed with soil particle sharp at seedbed preparation; †: Means sharing similar letter (s) in a column do not vary considerably at p = 0.05

Likewise results were obtained by Ziaeian and Malakouti (2001) who carry out 25 field experiments in order to study the effects of micronutrients on wheat production in calcareous soils. Results showed that Fe fertilization caused noteworthy increase in the number of seeds per spikelet, straw yield, 1000 grains weight and grain yield. Through the use of Fe, the concentration and total uptake in grain and flag leaves and the grain protein content improved prominently.

Our results are contradictory with Shukla and Warsi (2000) who investigated the effect of Fe with medium fertilizer levels (1% Fe solution at 25, 37 and 49 days after sowing) on the growth and nutrient content of wheat. The application of Fe had no noteworthy effect on the yield and growth of wheat and found Fe was higher in content in the straw.

The outcomes of our research revealed that the application of Fe by wheat crop had no significant effect on the NPK uptake. Significant decrement in P uptake in second year was observed. Similar to our findings, Park *et al.* (2004) conducted experiment and found that P fixation was highest with iron (Fe) as compared to Aluminum (Al) and Calcium (Ca).

However economics of using distinct Fe doses along with suggested NPK, for wheat production in the field, total data is also analysed by average of 2 years mentioned in the Table 4.

Increasing rates of Fe doses up to 12 kg Fe/ha increased its uptake while higher rated did not have any significant effect. It also increased Fe built up in soil. Application of Fe did not affect the uptake of Zn but there was a significant decrease in Mn uptake showing an antagonistic effect between them.

Our findings are in line with Singh and Ram (2005) who initiated a 25-year-long fertilizer experiment in 1971 to evaluate the nutrient and micronutrient uptake of the rice and wheat. He elucidated that Fe uptake by the entire rice-wheat-cowpea cropping sequence varied from 2274 to 6169 g/ha. The highest removal of Fe was observed with 100% NPK+FYM. The deletion of micronutrients by the annual cropping cycle depleted the accessibility of Fe in the range of 0.1-1.8, respectively, under different treatments. Similarly, greater amounts of phytosideophores were exuded by roots grown under Fe than Zn deficiency. Genotypes responsive to Zn shortage had the Fe transport rate increased by Zn deficiency.

CONCLUSION

Application of Fe also showed a noteworthy response to wheat at lower rates, when applied alone. Severe decrement of Fe didn’t effect the growth and yield contributing parameters of crop. The results of our study reveal that the application of Fe has no significant effect on the NPK uptake by wheat crop.

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