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SOIL IRON STATUS AND RESPONSE OF WHEAT TO IRON IN RELATION TO PHOSPHORUS

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ABSTRACT

One hundred twenty nine samples collected from alluvial soils in semi arid region of Agra (U.P) were analysed for total and available iron. Total and available Fe ranged from 1.0 to 4.0% and 1.50 to 17.50 mg kg^{-1}, respectively. About 27% soil samples were deficient in available iron. Available iron was significantly and positively correlated with organic carbon and negatively with pH and $CaCO_3$. The results of a field experiment showed that wheat responded significantly to iron and phosphorus up to 20 kg Fe and 60 kg P_2O_5 ha^{-1}. The average increase in grain and straw yield over control was 24.8 and 22.0 % with P while it was 16.0 and 13.3 % with Fe. The uptake of Fe and P by wheat grain and straw increased significantly with increase in the level of Fe and P up to 40 kg Fe and 90 kg P_2O_5 ha^{-1}, respectively. The uptake of N and K increased significantly up to 20 kg Fe and 60 kg P_2O_5 ha^{-1}.

Keywords: Iron status. Response, wheat, iron, phosphorus

INTRODUCTION

Wheat (*Triticum aestivum* L.) occupies a prominent place as an important crop contributing 40 percent to the total food grain production, and is next only to rice (*Oryza sativa* L.). Inspite of heavy inputs the crop yields are declining because of limitation of one or more micronutrients (Swarup et al. 1998). Among the micronutrient cations, iron has been noted to be a limiting element other than zinc in alkaline soils as its deficiency is being observed on several crops. A substantial amount of soluble iron in such soils gets converted in to unavailable forms. Iron helps in formation of chlorophyll and it is important constituent of the enzyme nitrogenase, which is essential in the nitrogen fixation. Phosphorus ia an important plant nutrient, next only to nitrogen and classed along with nitrogen and potassium as a major plant nutrient. It is involved in a wide range of plant processes from cell division to the development of good root system and to ensure timely and uniform ripening of the crop. Indian soils are generally poor in available phosphorus. Response to iron application depends not only its availability in soil but also, among other factors, on the availability of P (Chahal et al. 1979). Hence, the present study was conducted to evaluate status and the effect of Fe and P fertilization on yield and uptake of nutrients by wheat on alluvial soil.

MATERIALS AND METHODS

One hundred and twenty nine surface (0-15 cm) soil samples were collected from alluvial soils of Agra district of U.P. These samples were analysed for pH, EC, organic carbon and calcium carbonate by adopting standard procedures (Jackson 1973). Total and available Fe in these soils was extracted with perchloric acid (Jackson 1973) and DTPA (Lindsay and Norvell 1978), respectively. Iron content in the extracts was determined on atomic absorption spectrophotometer.A field experiment was conducted during rabi seasons of 2009-10 at RBS College Research farm, Bichpuri (Agra) on a sandy loam soil. The soil was low in Olson P (8.4 $kgha^{-1}$) and DTPA-Fe (4.2 mg kg^{-1}) having pH 7.9, EC 0.25 dSm^{-1}, $CaCO_3$ 5.0 g kg^{-1} and organic carbon 3.9 g kg^{-1}. Four levels of P (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and Fe (0, 10, 20 and 40 kg ha^{-1}) were applied through triple superphosphate and ferrous sulphate, respectively. These treatments were replicated thrice in randomized block design taking wheat (PBW 343) as test crop. A uniform dose of 150 kg N and 40 kg K_2O ha^{-1} was applied through urea and muriate of potash, respectively. Half of N dose and full dose of K were applied as basal dressing at sowing and rest half dose of N was top dressed at the time of first irrigation. The crop was shown on November 10, 2009 and harvested on April 10, 2010. Grain and straw yield was recorded at harvest. Grain and straw samples were digested in di-acid (HNO_3: $HClO_4$) mixture and in this extract P was determined by molybdovanadate yellow colour method (Jackson 1973), K by flame photometer and Fe by atomic absorption spectrophotometer. Nitrogen content in grain and straw was determined by Kjeldahl method.

RESULTS AND DISCUSSION

The soils are neutral to alkaline in reaction (pH 7.0-9.0). The electrical conductivity (EC) ranged from 0.06 to 0.36 dSm^{-1}. Organic carbon content varied from 2.4 to 7.5 g kg^{-1}. The $CaCO_3$ content of

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soils, which varied from 5.0 to 35.0 g kg^{-1} with mean a value of 14.9 g kg^{-1} is a useful parameter a assess the extent of nutrients availability and their release behavior. The total Fe content in the soils ranged from 1.00 to 4.00 % with a mean value of 1.99 % (Table 1).

Table 1: Soil physic-chemical properties and iron status in soils

	Range	Mean	Remark
Soil characteristics			
pH	7.0-9.0	7.8	
EC (dSm^{-1})	0.06-0.36	0.16	
Organic carbon (g kg^{-1})	2.4-7.5	4.3	
$CaCO_3$ (g kg^{-1})	5.0-35.0	14.9	
Forms of iron			
Total (%)	1.00-4.00	1.99	
Available (mg kg-1)	1.50-17.50	6.76	27% deficient

The content of Fe DTPA varied from 1.50 to 17.50 mg kg^{-1} with a mean value of 6.76 mg kg^{-1}. This form of iron, on an average, constituted 0.03 % of the total iron in soils. Based on the critical limit for Fe as 4.5 mg kg^{-1} soil suggested by Katyal and Rattan (2003), the soils of the district are well supplied with available iron and only 27% soil samples are deficient in available Fe. These results are comparable with the findings of Kumar et al. (2011). The significant and positive correlation of Fe with organic carbon content of the soils was obtained (Table 2) which indicates the importance of organic matter in promoting the availability of Fe in the soils. The availability of Fe increased with increase in organic matter because organic matter acts as chelating reagent. Similar kind of relationship between Fe and organic carbon was also reported by Sharma et al. (2003) and Kumar et al. (2011).

Table 2: Correlation coefficient between physico chemical properties and available and total iron

Soil characteristics	'r' value	
	Total Fe	Available Fe
pH	-0.59**	-0.81**
EC (dSm^{-1})	0.10	0.09
Organic carbon (g kg^{-1})	0.24**	0.47**
$CaCO_3$ (g kg^{-1})	-0.17*	-0.42**

*** Significant at 1% level*
**Significant at 5% level*

Available Fe was negatively correlated with $CaCO_3$. The soil pH was significantly and negatively correlated with available Fe. An inverse relationship of pH and $CaCO_3$ with available Fe has also been reported by Kumar et al. (2011).

There was a significant increase in grain and straw yield of wheat over control by the application of P and Fe (Table 3). The response to P in a soil low in available P was more than that of Fe. The average increase in grain and straw yield over control was 24.8 and 22.0 % with P while it was 16.0 and 13.3 % with Fe. The response of P and Fe was observed up to 60 kg P_2O_5 ha^{-1} and 20 kg Fe ha^{-1}, respectively. The increase in yield of grain and straw with Fe and P application may be due to the fact that soil under study is low in available Fe and P. The improvement in yield of wheat with P application was due to balanced supply of this nutrient. The greater availability of P and its active involvement in shoot and root growth led to better plant growth, which later translated in the higher yield of wheat. The higher doses of P and Fe did not improve the yield significantly over their lower doses. Similar results for P and Fe were reported by Singh and Rai (2003) and Yadav et al. (2007), respectively.

Application of Fe progressively increased N uptake by wheat grain and straw from 99.7 to 123.1 kg ha^{-1} and 32.4 to 39.9 kg ha^{-1} with 20 kg Fe ha^{-1}. This may be attributed to greater grain and straw production. Nitrogen uptake decreased at 40 kg Fe ha^{-1} over 20 kg Fe ha^{-1} which may be due to decreased plant growth at 40 kg Fe ha^{-1} level, which resulted in less absorption of N. Similar results were reported by Singh et al. (2002). There was a significant increase in P uptake by the crop over control at lower levels of iron (Table 3). The substantial improvement in P uptake as a result of lower levels of Fe application has been attributed to higher grain and straw production. Similar results were also reported by Chandel (2010). Potassium uptake significantly increased up to 20 kg Fe ha^{-1} and decreased with 40 kg ha^{-1} level (Table 3). The uptake of Fe increased significantly with increasing levels of Fe from 0.51 to 0.70 and 1.19 to 1.45 kg ha^{-1} with 40 kg Fe ha^{-1}. The increase in Fe uptake with added Fe is primarily due to increased availability of iron in soil. Singh et al. (2002) also reported similar results.

Application of P significantly increased the uptake of N, P, K and Fe. There was a corresponding increase in uptake of these nutrients as the dose of phosphorus increased from 0 to 60 kg P_2O_5 ha^{-1}. The uptake of N by wheat grain increased from 93.1 to 134.2 kg ha^{-1} with 60 kg P_2O_5 ha^{-1}. The corresponding increase in N uptake by straw was from 29.9 to 40.4 kg ha^{-1}. Phosphorus and potassium by grain increased from 14.6 to 21.6 kg ha^{-1} and 21.4 to 27.8 kg ha^{-1}, respectively. The uptake of P and K by straw increased from 4.7 to 8.1 kg ha^{-1} and 101.5 to 125.7 kg ha^{-1} with 60 kg P_2O_5 ha^{-1}, respectively. Since soil of the experimental field was deficient in available P, its application increased P concentration in soil solution, consequently greater phosphorus uptake by the crop, Iron uptake by grain and straw increased from 0.51 to 0.66 kg ha^{-1} and 1.23 to 1.45 kg ha^{-1} with

Table 3: Effect of iron and phosphorus on yield and nutrient uptake (kg ha^{-1}) by wheat crop

Treatment	Yield (q ha^{-1})		Nitrogen		Phosphorus		Potassium		Iron	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Iron (kg ha^{-1})										
0	42.98	55.87	99.7	32.4	16.3	5.6	22.8	107.8	0.51	1.19
10	46.46	59.47	111.5	36.3	18.6	6.5	25.1	115.9	0.59	1.31
20	49.85	63.31	123.1	39.9	21.4	8.2	27.9	124.7	0.68	1.44
40	47.90	60.83	118.3	38.9	18.7	6.7	25.4	116.8	0.70	1.45
CD (P=0.05)	2.41	3.22	4.50	1.80	1.41	0.35	1.75	3.65	0.16	0.21
Phosphorus (kg ha^{-1})										
0	40.46	52.59	93.1	29.9	14. 6	4.7	21.4	101.5	0.56	1.23
30	47.06	60.24	108.2	36.1	17.9	6.0	24.9	116.9	0.64	1.37
60	50.51	64.15	124.2	40.4	21.2	7.7	27.8	125.7	0.66	1.43
90	49.16	62.44	122.9	40.6	21.6	8.1	26.5	121.8	0.63	1.35
CD (P=0.05)	2.41	3.22	4.50	1.80	1.41	0.35	1.75	3.65	0.16	0.21

60 kg P_2O_5 ha^{-1}, respectively. This high nutrient uptake could be attributed to increased grain and straw production and partly due to increase in their concentration. Singh and Rai (2003) and Singh et al. (2010) observed an increase in uptake of the nutrients with increasing levels of P.

On the basis of results, it is concluded that 27% soil samples were found to be deficient in available Fe. Application of Fe and P produced significantly higher yield of wheat grain and straw. The response was noted up to 20 kg Fe and 60 kg P_2O_5 ha^{-1}. The uptake of nutrients by wheat crop was also influenced by Fe and P addition.

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