International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664, Print ISSN: 2664-7656
Received: 07-10-2022, Accepted: 22-10-2022, Published: 10-11-2022
Volume 4, Issue 2, 2022, Page No. 72-75

Effect of iron and phosphorous on yield and uptake of oat in alluvial soil of western Uttar Pradesh

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Abstract

A pot experiment was carried out to investigate the effects of iron and phosphorous on oat yield and uptake. Four treatments of iron ($F_0 = 0$, $F_1 = 3$, $F_2 = 6$, and $F_3 = 9$ mg kg^{-1}) and phosphorous ($P_0 = 0$, $P_1 = 20$, $P_2 = 40$, and $P_3 = 60$ mg kg^{-1}) were used. The maximum grain and straw yields (37.4 and 51.68 mg pot^{-1}) were recorded under Fe_2 treatment of iron. However, the highest dose (Fe_3) of iron significantly decreased the grain and straw yield of oat as compared to Fe_0, Fe_1 and Fe_2 treatments. The grain and straw yields of oats increased with increasing levels of phosphorous. The highest grain and straw yields of oats were observed at P_3 treatment of phosphorous. The maximum uptake of phosphorous by oat grain and straw was noticed under P_3 treatment. The application of iron also increased the utilisation of phosphorous by oat grain and straw significantly over control. The maximum value of phosphorous uptake was recorded under Fe_2 treatment of iron. The Fe_3 treatment of iron showed an antagonistic effect on the uptake of phosphorous by oat grain under all the treatments of phosphorous. The maximum yield of oat grain and straw was observed under $Fe_2 + P_3$ treatment. The highest phosphorous uptake by oat grain and straw was noticed under $P_3 + Fe_2$ treatment. while the highest iron uptake by oat grain was observed under $P_2 + Fe_2$ treatment.

Keywords: iron, phosphorous, yield, uptake, oat

Introduction

Plant nutrient management is mainly governed by the level of nutrients in the soil. Plants need micronutrients (mineral elements) in small quantities to perform a range of physiological functions (White *et al*. 2012) [20]. By virtue of their functions in the building and repair of protoplasm and regulation of metabolic processes, micronutrients play an important role in the maintenance of the physical organisation and activities in living cells. These are generally deficient in saline, sodic, highly leached, sandy, and highly calcareous soils, and an application of these micronutrient cations on such soils has favoured the growth and yield of crops. In addition to these, several factors, including weathering of minerals, liming, degree of leaching, mineralization of organic matter, and moisture content, are said to control the status of micronutrient cations of soils. The relative abundance of different chemical forms of these micronutrient cations varies from soil to soil, depending upon these factors.

Among various important micronutrients, iron (Fe) is especially important on account of its vital and indispensable role in plant growth. Iron is the most important micronutrient, as it is the main component of haemoglobin, myoglobin, and cytochromes. It is involved in several metabolic reactions, such as energy production, immune defence, and thyroid function (Frossard *et al*. 2000) [6]. It is the main component of various hemi and nonheme Fe enzymes and carriers, such as cytochromes and ferredoxins. Cytochromes are respiratory electron carriers, whereas ferredoxins are involved in nitrogen fixation, photosynthesis, and electron transfer (Frossard *et. al*. 2000; Fageria; Stone, 2012) [6, 5]. In alkaline soils, it is likely to occur in short supply, which may be inadequate to meet the requirements of cultivated crops. Several factors, including mineralization of organic matter, redoes potential, degree of leaching, calcareousness, and moisture level, are said to control the iron status of soils. Determination of most deficiencies has been based primarily on visual symptoms, field experiments, pot experiments, and plant analysis.

In recent years, the continued use of higher amounts of fertilizers, intensive cropping and the use of high-yielding varieties has tended to the deficiencies of micro nutrients in soil and a number of crops have been found to respond favourably to the application of iron. The use of chemical fertilizers, which are commonly used at present for supplying major plant nutrients, is likely to encourage or depress the availability of other nutrients as well.

Phosphorus (P) is an essential element required for plant growth and root development. It is one of the most limiting nutrients in agricultural cropping systems (Guignard *et al*., 2017; Khan *et al*., 2018) [7, 10]. It is found in every living cell of plants and animals. It is known to be associated with several vital functions in the plant body, such as utilisation of sugar and starch, photosynthesis, nucleus formation and cell division, fat and albumen formation, cell organization, and transfer of the heredity characters. An antagonistic relationship between iron and phosphorous has been reported in soils and plants (Brown *et al*. 1959) [2], and likewise, they influence yields of crops differently. High phosphorus concentration inhibits the movement of iron in the plant.

The growth of a plant depends on many factors, among which nutrient supply, rate of absorption, distribution of nutrients to functional sites and the degree of mobility within the plants are important. Mutual antagonistic interaction between the micronutrients as well as with certain macronutrient either in soils or at the absorption sites or within the plant are well documented (Tiwari et.al 1976; Takkar et.al 1976) [18, 17]. The application of macro and micronutrients is recommended to ameliorate their deficiencies. Nutrient interactions in soils and plants are to be expected unless available nutrient contents are monitored through regular soil and plant analysis programs. Keeping in mind the facts stated above, the current study was conducted to investigate the effect of iron and phosphorous on oat crop yield and uptake in alluvial soil of western Uttar Pradesh.

Materials and Methods

The effect of iron (Fe) and phosphorous (P) on oat yield and uptake was studied in a pot experiment using four levels of Fe (F_0 = 0, F_1 = 3, F_2 = 6, and F_3 =9 mg kg^{-1}) and P (P_0 = 0, P_1 =20, P_2 =40, and P_3 =60 mg kg^{-1}). The experiment was conducted in a factorial randomised block design with three replications. The soil for this experiment was collected from the surface (0.15 cm) of a field of C.C.R. (P.G.) College farm, Muzaffarnagar. The collected soil was crushed with a wooden hammer and sieved through a 2 mm sieve before use. The required earthen pots of similar size and shape were selected, cleaned, and lined with polythene sheets. After mixing the soil thoroughly, 10 kg of soil was filled in each pot. Iron and phosphorous were applied through iron chelate and single superphosphate, respectively. The basal doses of nitrogen and potassium (60 mg kg^{-1} N and 30 mg kg^{-1}K_2O) were applied through urea and potassium sulphate at the time of sowing. At an appropriate moisture level, the soil of each pot was pulverised and seeded with 10 seeds of oat on November 20. The plants were thinned to five when they attained a height of 5–10 cm. The plants in pots were irrigated with deionized water as and when required. The plants were grown up to maturity. At harvest, the yield of grain and straw was recorded separately.

The pH, electrical conductivity (EC), organic carbon (OC) content, and calcium carbonate ($CaCO_3$) content of the soil were determined using standard procedures given by Jackson (1967) [8]. Available Fe was determined using the method described by Lindsay and Norvell (1978) [11]. Calcium carbonate was determined by Piper's (1950) [14] rapid titration method. Organic carbon was determined by the Walkley and Black (1934) [19] chromic acid digestion rapid titration method. The $NaHCO_3$ solution was used to extract available P (Olsen *et al*. 1954) [13], and the concentration of P in the extract was determined using the Murphy and Riley (1962) [12] method.

The straw and grain samples were analysed for P and Fe. The samples were wet digested with a nitric and perchloric acid mixture as outlined by Johnson and Ulrich (1959) [9]. The P and Fe in acid extract were determined by adopting standard methods. The uptake of nutrients by plants was calculated by multiplying their content values with the corresponding dry matter yield. The physico-chemical properties of the soil used for the experiment are given in table 1.

Table 1: Physico-chemical properties of the soil.

pH	EC (dSm^{-1})	$CaCO_3$ (%)	Organic carbon (%)	Available P (kg ha^{-1})	Available Fe (mg kg^{-1})	Sand (%)	Silt (%)	Clay (%)	Soiltexture
7.6	0.08	0.25	0.50	22.2	3.2	60.0	19.7	19.9	Sandy loam

Results and Discussion

Yield

The grain and straw yield of the oat crop increased significantly with the Fe application up to Fe_2 level over control (table 2). Both the levels of Fe_1 and Fe_2 of Fe proved significantly superior over control in respect of oat yield. The maximum grain and straw yields (37.40 and 51.68 g pot^{-1}) were recorded under Fe_2 treatment of Fe. The percent increase in grain and straw yield due to Fe_1 and Fe_2 over control was 3.3 and 11.1 and 4.8 and 11.1, respectively. The highest dose (Fe_3) of Fe significantly decreased the grain and straw yield of oat as compared to Fe_0, Fe_1, and Fe_2 treatments. These results are similar to the findings of Singh and Singh (1996) [16] and Singh *et al*. (1997) [15]. All the levels of Fe differed significantly from each other in respect of grain and straw yield.

The application of P also increased the grain and straw yield of oat significantly over control (table 2). The grain and straw yields of oats increased with increasing levels of P. The highest grain and straw yields of oats were observed at P_3 treatment. Phosphorus levels P_1, P_2, and P_3 increased oat grain yield by 4.05, 13.67, and 17.43 percent, respectively, when compared to the control. Straw yield increased by 5.41 percent, 14.56 percent, and 20.50 percent, respectively. These results are in conformity of the results of Deshmukh *et al*. (1993) [4] and Chaudhary and Das (1996) [3].

Table 2: Effect of Fe and P levels on yield (g pot^{-1}) and uptake (mg kg^{-1}) of oat crop.

Treatment	Yield		Uptake			
	Grain	Straw	Phosphorous		Iron	
			Grain	straw	Grain	Straw
Fe levels						
Fe_0	33.65	47.08	87.82	44.32	2.86	9.98
Fe_1	34.78	49.33	87.91	42.64	3.55	12.29
Fe_2	37.40	51.68	92.76	48.84	4.24	12.50
Fe_3	32.20	43.15	80.48	39.97	3.94	12.30
SE±	0.26	0.051	1.32	2.01	0.047	0.029
CD (P=0.05)	0.64	0.093	2.76	4.24	0.096	0.059
P levels						
P_0	30.35	43.43	74.26	31.85	3.67	10.82
P_1	31.58	45.78	81.19	39.35	3.62	11.07
P_2	34.48	49.70	91.91	48.44	3.70	11.55
P_3	35.65	52.33	101.60	55.44	3.60	11.72
SE±	0.26	0.051	1.32	2.01	0.47	0.029
CD (P=0.05)	0.64	0.093	2.76	4.24	NS	0.059

Uptake

The uptake of P by oat grain and straw increased significantly with an increase in P application (table 2). The maximum uptake of P by oat grain and straw was observed under P_3 treatment of P. Bahl *et al.* (1997) [1] and Singh *et al.* (1997) [15] also reported that P application increased its uptake by the crop. The increase in P uptake by oat grain due to P_1, P_2 and P_3 over control was 9.34, 23.8 and 36.85 percent, respectively. The respective increases in P uptake by oat straw were 23.6, 52.1, and 75.0 percent.

The application of Fe also increased the utilisation of P by oat grain and straw significantly over control (table 2). The maximum value of P uptake was noticed with Fe_2 treatment of Fe. The application of Fe_3 treatment caused a significant reduction in P uptake over Fe_2 treatment. The Fe_3 treatment of Fe showed an antagonistic effect on the uptake of P by oat grain under all the levels of P.

Interaction effect

The interaction of Fe and P had a significant effect on the grain and straw yield of oat (table 3). The grain and straw yields of oats were increased when these two elements were applied in combination. The maximum yield of oat grain and straw was recorded under Fe_2 + P_3 treatment. The higher level of Fe (Fe_3) showed an antagonistic effect on the grain and straw yield of oat.

The interaction effect of Fe and P was significant on P uptake by oat grain (table 4). The maximum value of P uptake was noticed with the application of P_3 along with F_2 treatment. The Fe_3 treatment of Fe showed an antagonistic effect on the utilisation of P by oat grain under all the levels of P. The adverse effect of Fe_3 treatment on the utilization of P by oat grain was much more pronounced in the absence of P.

The utilisation of Fe by oat grain increased up to P_2 treatment over control and then markedly reduced with P_3 treatment of P. The maximum value of Fe uptake by oat grain was observed under the P_2 + Fe_2 (5.24 mg pot^{-1}) combination of treatments (table 4). At the Fe_3 treatment of Fe, a reduction in its uptake by oat was noticed.

Table 3: Interaction effect of Fe and P on oat grain and straw (mg pot^{-1}) yield.

Fe levels (mg kg^{-1})	Grain				Straw			
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3
Fe_0	30.4	31.8	35.4	37.0	41.6	44.9	49.5	52.3
Fe_1	31.4	33.1	36.6	38.0	44.1	46.7	51.7	53.8
Fe_2	33.3	34.7	38.4	39.2	47.0	49.6	53.6	56.5
Fe_3	30.3	30.7	31.5	32.4	41.0	41.9	44.0	44.7
SE±	0.73				0.082			
CD (P=0.05)	1.48				0.167			

Table 4: Interaction effect of Fe and P on the uptake of P and Fe by oat grain (mg pot^{-1})

P levels (mg kg^{-1})	P Uptake				Fe uptake			
	Fe_0	Fe_1	Fe_2	Fe_3	Fe_0	Fe_1	Fe_2	Fe_3
P_0	71.2	73.5	81.3	71.0	3.65	4.43	5.10	5.06
P_1	81.0	80.8	84.7	78.3	3.69	4.39	5.07	4.87
P_2	93.6	93.0	97.5	83.5	3.89	4.47	5.24	4.77
P_3	105.4	104.3	107.5	89.5	3.77	4.45	5.12	4.63
SE±	2.734				0.0877			
CD (P=0.05)	5.542				0.1896			

Conclusion

From the above study, it may be concluded that the application of Fe is beneficial only up to Fe_2 (6 mg kg^{-1}) for yield and uptake of oat. While the yield and uptake of oat increased significantly with increasing levels of P up to P_3 treatment. The maximum P uptake by oat grain was observed under P_3 + Fe_2 treatment. The treatment Fe_2+P_3 gave the maximum yield (grain and straw) of oat, and the treatment P_2+Fe_2 gave the maximum uptake by oat grain.

References

1. Bahl GS, Pasricha NS, Ahuja KL. Effect of fertilizer N and P on the grain yield, nutrient uptake and oil quality of sunflower. J. Indian Soc. Soil Sci.,1997:45:290-296.
2. Brown JCV, Tiffin LL, Holmes RS, Specht AW, Resnicky JW. Internal inactivation of iron in soyabean as affected by root growth medium. Soil Sci.,1959:87:89-94.
3. Chaudhary HP, Das SK. Effect of P, S and Mo application on yield of rainfed black gram and their residual effect on safflower and soil and water conservation in an eroded soil. J. Indian Soc. Soil Sci.,1996:44:741-745.
4. Deshmukh VN, Atre AK, Rangacharya RP, Puwatkar SS. Effect of phosphorous and potassium application on growth yield, quality and nutrient uptake by groundnut. J. Pot. Res.,1993:9(1):72-75.
5. Fageria NK, Stone LF. Micronutrient deficiency problems in South America. In: Alloway, B.J., editor, Micronutrient deficiencies in global crop production. Springer, Dordrecht, Netherlands, 2012, 245-266. Doi: 10.1007/978-1-4020-6860-7-10
6. Frossard E, Bucher M, Machler F, Mozafar A, Hurrel R. Potential for increasing the contents and bioavailability of Fe, Zn and Ca in plants for human nutrition. J. Sci. Food and Agriculture,2000:80(7):861-879.
7. Guignard MS, Leitch AR, Acquisti C, Eizaguirre C, Elser JJ, Hessen DO *et at*. Impacts of nitrogen and phosphorous from genomes to natural ecosystems and agriculture. Front. Ecol. Evol.,2017:5:70. Doi: 10.3389/fevo.2017.00070
8. Jackson ML. Soil chemical analysis, Prentice Hall of India Pvt. Ltd., New Delhi, 1967.
9. Johnson CM, Ulrich A. Analytical methods for use in plant analysis. Calif. Agric. Stat. Bull., 1959, 766.
10. Khan A, Li G, Ayaz M, Zhang H, Wang R, Lv F *et al*. Phosphorous efficiency, soil phosphorous dynamics and critical phosphorous level under long term fertilization for single and double cropping systems. Agric. Ecosyst. Environ.,2018:256:1-11. Doi. 10.1016/j.agee.2008.01.006
11. Lindsay WL, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J.,1978:42:421-428.
12. Murphy J, Riley JP. A modified single method for the determination of phosphates in natural waters. Anal. Chim. Acta.,1962:27:31-36.
13. Olsen SR, Cole CV, Watanabe PS, Dean LA. Estimation of available phosphorous in extraction with 0.5 M Na_2HCO_3. USDA Ciru., 1954, 939.
14. Piper CS. Soil and plant analysis. The University of Adelaide, Australia, 1950.
15. Singh R, Sharma RK, Singh M. Studies on soil phosphorous and response of sunflower to applied phosphorous on some soils of Haryana. J. Indian Soc. Soil Sci.,1997:45:301-305.
16. Singh Vinay, Singh Sandeep. Relation of available micronutrients in soils and plants. J. Indian Soc. Soil Sci.,1996:44:800-802.
17. Takkar PN, Bansal RL, Mann MS, Randhawa NS. Micronutrient status of soils and wheat crop of Punjab. Fertilizers News,1976:21(8):47-51.
18. Tiwari KN, Pathak AN, Upadhyay RL. Studies on Fe and Zn nutrition of rice at varying moisture regimes in a black clay soil of Uttar Pradesh. J. Indian Soc. Soil Sci.,1976:24(3):303-307.
19. Walkley A, Black TA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science,1934:37:29-38.
20. White PJ, Broadley MR, Gregory PJ. Managing the Nutrition of Plants and People. Applied and Environmental Soil Science, 2012. doi.org/10.1155/2012/104826.