Phosphorus Adsorption Capacity of Four Soil Series for P Requirement of Wheat (*Triticum aestivum L*)

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Abstract: A pot experiment was conducted in order to know the phosphorus requirement of wheat as affected by different levels of phosphorus (P) for obtaining 95% relative yield grown in four soil series i.e. Gishkori, Buzdar, Sultanpur and Tikken of Dera Ismail Khan Khyber Pakhtunkhwa, Pakistan. The various treatment levels were consisted of 0, 5.5, 11.0, 16.5 and 22.0 mg P/kg of soil. Wheat dry matter yield remained at highest (1.1g) where P was supplemented at 22.0 mg P/kg in Gishkori and lowest (0.95g) in Tikken soil with the same P applied level. An increase in phosphorus concentration was recorded in wheat shoot with an increase in applied P level. Maximum phosphorus percentages recorded in wheat were 0.28 and 0.26 grown in Gishkori and Buzdar soil series followed by Sultanpur and Tikken with values of 0.11 and 0.10 respectively against P applied level of 22.0 mg P/kg soil. Minimum P concentration was noted in control. The phosphorus content of wheat and P levels were highly correlated with r values of 0.99. 0.99. 0.98 and 0.74 for Gishkori, Buzdar, Sultanpur and Tikken soil series respectively.

Keywords: Phosphorus, Adsorption Capacity, Soil Series, Wheat.

INTRODUCTION

Phosphorus is the second required nutrient needed after nitrogen by the plants for their better growth. Plants obtain this nutrient from soil solution that is mostly in available form to absorb. While, the remaining portion of phosphorus is either adsorbed or precipitated [1]. The availability of phosphorus to plants fluctuates due to some important factors related to soil. These factors include present phosphorus (P) status in soil, organic matter content, soil texture and chemistry of soil minerals etc. These are the minerals that immobilize the added phosphorus in soil and plants are not able to utilize it for their various physiological functions [2].

Each soil has its own capacity to supply adequate amount of P to growing plants for their proper growth. It has been experienced that 0.2 mgL^{-1} is the standard P concentration that provides sufficient amount of P to many crops [3]. Chaudhry *et al.* [4] concluded that to maintain standard P concentration i.e. 0.2 mgL^{-1}in soil solution, it was necessary to apply 22-67 $mgKg^{-1}$ of P in soil for maize crop. Memon *et al.* [5] concluded that in calcareous soils of Pakistan P requirement of wheat for 95% yield was 0.032 mgL^{-1}. While, several workers [6-8] used P sorption approach to determine P requirement of various crops.

In Pakistan, where soils are strongly calcareous and alkaline in nature have low P sorption capacity [9]. A total of 50 to 100 kg P_2O_5 is essentially required to supply the sufficient quantity of P to growing plants. For obtaining maximum yield soil samples are taken and tested in laboratories for P status. These tests do not provide sufficient information regarding quantities of fertilizers needed by the crops. There is need of calibration of soil for P requirement of crop [10]. To find out the correct amount of P fertilizers for any particular crop P sorption isotherms are used to get information about the relationship between P concentrations present in soil solution and the quantities of P sorbed by the soil [11].

It has been observed that use of P sorption isotherms is limited for alkaline soils. Keeping in view the phenomenon an attempt was initiated in order to aware about the P requirement of wheat grown on various available soil series of Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan.

MATERIAL AND METHODS

Soils were attributed to soil series using the Maps and Memories of Reconnaissance Soil Survey of Dera Ismail Khan [12] of the Directorate of Soil Survey, West Pakistan.

Tikkin

The location is seven kilometers along D.I Khan and Bannu road. The soils of the series are deep and very

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deep, moderately well drained, calcareous, medium textured. It has a brown/ dark brown, friable moderately calcareous, massive loam top soil.

Gishkori

The location of the soil sample is forty-four kilometers south of D. I. Khan along the D. G. Khan road. The soils are very deep, well drained, calcareous and moderately fine textured. The top soil is brown, firm, massive, calcareous and of silty clay texture.

Buzdar

The location of this soil series is Milepost 31 along the D. I. Khan D. G. Khan road. This consists of very deep, moderately well drained calcareous, saline alkali, fine textured soils.

Sultanpur

The site is situated at RD.56 along Kot Hafiz distributory. The soils of the series are deep, well drained, calcareous, medium textured. It has dark grayish brown, friable, calcareous, massive, silty loam top soil.

The soil samples were taken at a depth of 0-30 cm with the help of soil auger. These samples were brought in a laboratory where were air dried, ground, then passed from 2 mm sieve and kept in refrigerator for further analyzes for different physical and chemical properties of soil. The soil texture was determined by using hydrometer method, soil reaction (pH) on the saturated soil paste, electrical conductivity (EC_e dS/m) on its saturation extract and total calcium carbonate ($CaCO_3$) by the titration method as described in USDA Hand Book 60 [13]. While, organic matter (%) was analyzed by Walkely and Black method [14].

A pot experiment with complete randomized block design (RCBD) having five different levels of P and replicated three times was conducted using soils of Gishkori, Buzdar, Sultanpur and Tikken series collected from Dera Ismail Khan Khyber Pakhtunkhwa, Pakistan. Each pot was filled with 2.5 kg of 2 mm sieved and dried soil. Five different treatment levels consisted of 0, 5.5, 11.0, 16.5 and 22.0 mg P/kg of soil, were used and applied in the form of triple super phosphate. Five seeds of wheat were sown in each pot. All pots received 0.6g of nitrogen in the form of urea. The half quantity of urea was used after seed germination while, the remaining quantity was applied after 10 days of first application and distilled water was used for irrigation. Any weed emerged during the experimental period was removed by hand. The crop was harvested after six weeks of seed sowing. The harvested material was washed with distilled water, roots were separated and dry weight was recorded [15]. Total P in dried plant material was determined by wet double digestion using ascorbic acid method of Watanabe and Olsen [16]. Correlation studies between soil solution P and dry matter yield were also made. After harvesting, soil samples from all treatments were taken, ground, sieved through 2 mm mesh sieve and P was extracted with 0.1 N $NaHCO_3$ by using the method of Olsen extraction. The estimated phosphorus in the extractant was correlated to plant P. The critical level of P in the soil was calculated at 95% of maximum yield.

RESULTS AND DISCUSSION

The data regarding some physical and chemical characteristics of all four soil series presented in Table

Table 1: Physico-Chemical Characteristics of Four Soil Series

S. No	Soil Series	Location	pH	ECe 10^{-3}	$CaCO_3$ %	Organic matter %
1	Gishkori	44 Km south of D. I. Khan along the D. G. Khan Road.	7.9	3.20	15.25	0.22
2	Buzdar	Milepost 31 along the D. I. Khan-D. G. Khan Road.	8.2	2.00	17.00	0.26
3	Sultanpur	R.D.56 along the Kot Hafiz Distributory.	7.7	3.80	10.50	0.42
4	Tikken	7 Km north of D. I. Khan along the Bannu Road.	8.1	1.45	14.00	0.35
Textural separate percentage (%) and textural classes of four soil series						
S. No	**Soil Series**	**Clay**	**Silt**	**Sand**	**Textural Class**	
1	Gishkori	52	36	12	Clay	
2	Buzdar	48	45	7	Silty clay	
3	Sultanpur	21	32	47	Loam	
4	Tikken	20	19	61	Sandy clay loam	

1 reveals that texture of soil varied from clay, loam to sandy clay loam. The samples were moderately alkaline in reaction with pH values ranged from 7.7 to 8.2, non-saline and highly calcareous in nature (>10 %). The organic matter content of all the soil samples was less than one percent (< 1%) and low in available phosphorus. These results are in line with the findings of Uddin *et al*. [17] who analyzed the soil samples from different series of Dera Ismail Khan and concluded that were sandy loam to clay in texture, moderately to strongly alkaline in reaction, highly calcareous and low to medium in organic matter content.

The phosphorus contents of wheat as affected by various levels of P in different soil series grown in pot culture are given in Figure **1**. The highest phosphorus percentage of 0.28% was recorded in Gishkori followed by Buzdar with value of 0.26%, whereas the lowest of 0.10% was recorded in the Tikken soil when the same quantity of 22.0 $mgKg^{-1}$ of Pwas applied. At P applied level of 5.5 $mgKg^{-1}$ of P maximum P content (0.16 %) was noted in wheat grown in Gishkori soil while, minimum value of P (0.04 %) was obtained from wheat planted in Tikken soil. It is evident from the data obtained that an increase of phosphorus content was recorded in wheat with an increase in applied P level in all the soils. However, soils with greater buffering capacity could successfully replenish P in solution; hence wheat grown in soil with greater clay contents absorbed more phosphate. While, due to low P content wheat plants were not able to absorb sufficient P from soil solution for their normal growth. These findings are in line with that of Hue *et al.* [18] who reported that the rate of uptake of P by plant is approximately proportional to the concentration of the nutrient in solution.

The effect of different levels of P on dry matter yield of wheat grown in pots contained soils of four series (Gishkori, Buzdar, Sultanpur and Tikken) is mentioned in Figure **2**. Maximum dry matter yield (1.1g) was noted in Gishkori followed by Buzdar with value of 1.01 g, whereas minimum of 0.95g was noted in Tikken soil series that received same amount of 22.0 $mgKg^{-1}$of soil during the experimental period. At P applied level of 5.5 $mgKg^{-1}$ soil highest dry matter yield (0.74g) of wheat was obtained when grown in Gishkori soil while, lowest value (0.54g) of the same parameter was noted in wheat planted in Tikken soil. It is evident from the data available that dry matter yield of wheat plants increased with an increase in the P concentration in wheat. Dry matter yields are analyzed to investigate the availability of soil phosphorus levels and to get informed about the differences in dry matter production of crops due to different inherent capacities of different soils. These results are in line with the findings of Alam [19]. Phosphorus application associated with 95% of maximum yield for Gishkori, Buzdar, Sultanpur and Tikken soil series found were 19.75, 20.00, 20.80 and 20.75 mg/kg of soil respectively. Dry matter yield and P

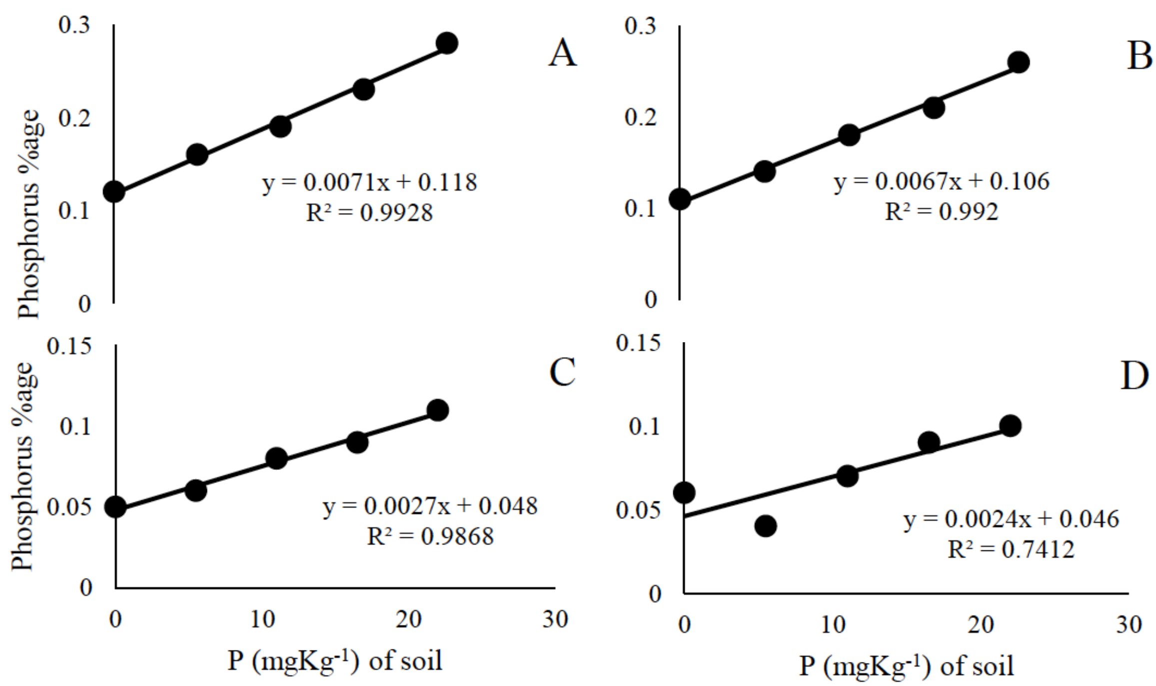

Figure 1: Phosphorus percentage in wheat as affected by various levels of P in four soil series of Dera Ismail Khan, (**A**) Gishkori (**B**) Buzdar (**C**) Sultanpur and (**D**) Tikken.

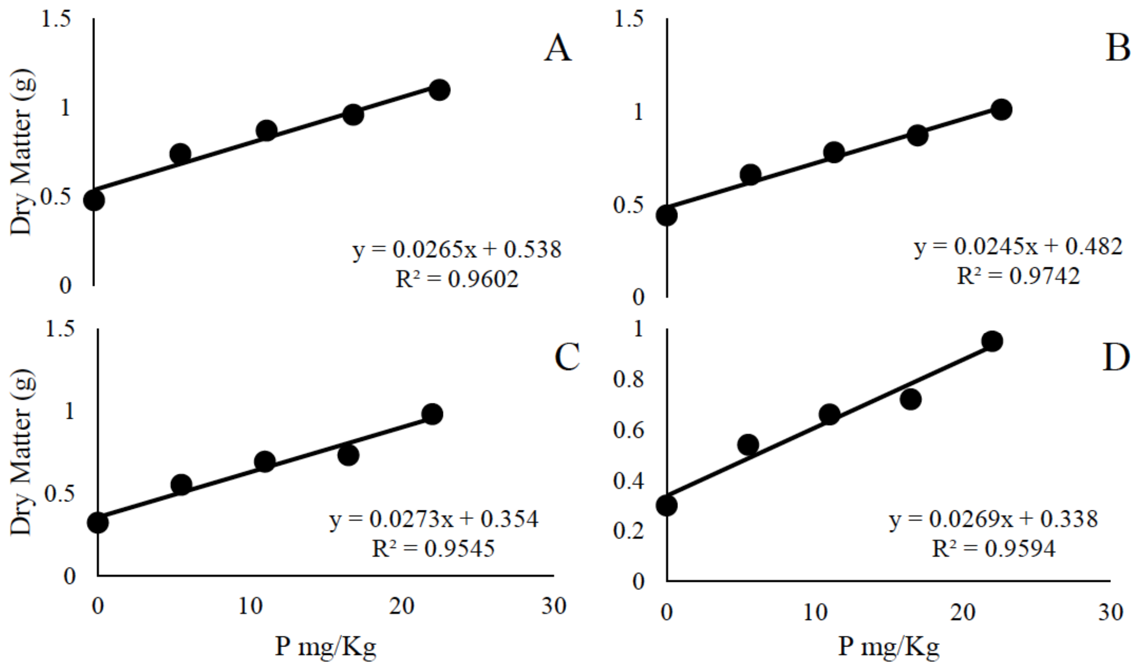

Figure 2: Dry matter yield of wheat grown in different soils with various levels of applied phosphorus (**A**) Gishkori (**B**) Buzdar (**C**) Sultanpur and (**D**) Tikken.

application levels were correlated with r values of 0.96, 0.97, 0.95 and 0.95 for Gishkori, Buzdar, Sultanpur and Tikken respectively.

As evident these values vary with the soil texture. Coarse textured soils require greater quantities of phosphate in soil solution, as they have the low buffering capacity and further the cross section for diffusion in such type of soil is small because of low moisture content and the path for diffusion is crooked [20, 21]. The most important factor which influences the flux of phosphorus to the root surface is the concentration of P in the soil. This in turn determines the diffusion gradient of P in the soil. Since the amount of P in the soil solution at any time is small as compared with the P requirement of a crop, it seems essential to describe the ability of the soil system (buffering capacity) to replenish the P in solution (quantity factor) as crop uptake depletes the supply. Fox and Kamprath [22] established a procedure for plotting P sorption curves integrating the P intensity and quantity aspects of soils which play a critical role in P flux to roots of growing plants. The slope of P sorption curves is directly proportional to the buffering capacity of the soil and the intercept at zero P sorption gives an estimate of P in the soil solution.

CONCLUSIONS

The availability of phosphorus in soil depends upon the physical and chemical characteristics of each soil. An increase in phosphorus content and dry matter yield of wheat largely depends on increase in applied P level in soil. As per available data, four soil series of Dera Ismail Khan, could be arranged on the basis their ability to supply P as Tikken > Sultanpur > Buzdar and Gishkori.

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