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Studies on The Calibration Method For Phosphorus Application on Wheat

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Abstract

Yield response of wheat to applied P was studied in Pirsabak soil series (Pakistan). Dry matter yield, plant height and number of tillers per plant showed positive response to adjusted available P at low levels, while negative response was observed for these parameters at higher levels. Phosphorus content of soil and P content of leaf showed corresponding increase to the adjusted available P. The derived non linear equations can be used to calculate the optimum requirement of phosphorus for wheat crop.

Introduction

This is a well known fact that fertilizers play a pivotal role in increasing yield and improving the quality of crops. Though fertilizers play an important role in increasing the yield, yet there is no scientific basis for making fertilizer recommendations in this part of the country for wheat crop. Fertilizer recommendations are just based on the results from field research trials (Bhatti *et al*., 1995; Bakhsh *et al*., 1994; Gandapur and Bhatti, 1983; Rehman *et al*., 1982). Responses to phosphorus applications, keeping N and K_20 at constant levels were given little attention. However some research work was initiated on the calibration of yield response of crops to applied phosphorus (Akram *et al*., 1994; Ali *et al*., 1992; Bhatti *et al*., 1986, 1995). Moreover, the calibration of Soil test for phosphorus with the field crops also did not receive importance. No research work has been done in the past in this part of the country to estimate the yield potential and phosphorus fertilizer requirements of wheat for irrigated and dry land areas. The main objective of this project was to develop a regression model for the estimation of wheat yield and formulating phosphorus fertilizer requirements on the basis of predicted wheat yield.

Materials and Methods

A pot experiment was conducted in the glasshouse of NWFP Agricultural University, Peshawar to calibrate the yield response of wheat to initial soil phosphorus. Test soil was collected in bulk from Pirsabak soil series in Mardan district (Pakistan) from a depth of 0 to 20 cm. After preparation, it was pre-treated with 0, 10, 20 and 30 mg kg^{-1} P to maintain four different adjusted soil phosphorus levels of 4.7, 14.7, 24.7 and 34.7 mg kg^{-1} P, respectively. Here, these soil levels are defined as soil A, B, C and soil D. The experiment was laid out in a completely randomized design with three replications, placing four kilograms of the prepared soil into each plastic pot lined with polyethylene bag. Phosphorus fertilizer (SSP) was used which supplied 0, 40, 80,120, 160 and 200 kg P_20_5 ha^{-1} along with basal dose of 120 kg N and 90 kg K_20 ha^{-1} in the form of urea and potassium sulfate, respectively. Adjusted available P was calculated for each soil as shown in Table 2.

Data on dry matter yield, plant height, number of tillers per plant, soil P and plant phosphorus were recorded. Physico-chemical properties of the soil were determined Table 1. Texture was determined as described by Moodie *et al*. (1959). Electrical conductivity of the saturated extract was determined by the method of USDA Hand book 60 (Richards, 1954). pH of the saturated paste was determined using pH meter (Black, 1965). Organic matter was determined by the method prescribed by Black (1965). Available phosphorus was determined by Olsen *et al*. (1954) method using 0.5 N $NaHCO_3$. Plant phosphorus was determined by wet digestion method (Richards, 1954), The data were analyzed according to the methods given by Leclerg *et al*. (1962). The treatment means were compared with New Duncan's Multiple Range Test of significance.

Table 1: Physico-chemical properties of the soil used in the experiment

Properties	Soil depth (0-20 cm)
Clay	16.4%
Salt	67.8%
Sand	15.8%
Textural Class	Silt Loam
Organic matter	1.44%
Lime ($CaCO_3$)	2.5%
pH	7.7
E Ce	1.33 mmhos/cm
Extractable phosphorus	4.73 ppm

Results and Discussion

Dry matter yield: The response of dry matter yield to the adjusted available P is shown in Fig. 1. The general trend of the curve shows that dry matter yield gave positive response to the adjusted available P. The dry matter yield increased until 58 ppm of adjusted available P and the following equation was derived.

$$Y = 3.19 + 0.263\, x - 0.002\, x^2 \quad (r = 0.86) \tag{1}$$

Where:
Y = Plant height (cm)
X = Adjusted available P (ppm)

Table 2: Initial available p levels of different soils

Phosphorus applied P (ppm)	Soil adjusted P (ppm)			
	A	B	C	D
0	4.70	14.70	24.70	34.70
8.74	13.44	23.44	33.44	43.44
17.48	22.18	32.18	42.18	52.18
26.22	30.92	40.92	50.92	60.92
34.96	39.66	49.66	59.66	69.66
43.70	48.40	58.40	68.40	78.40

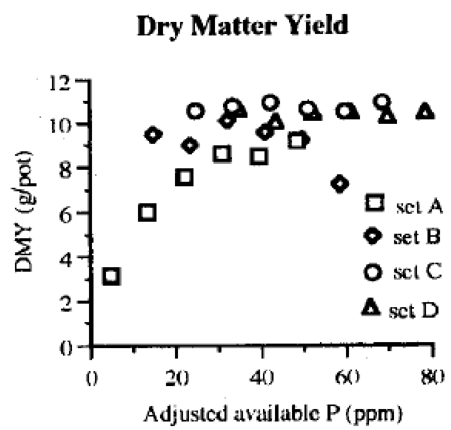

Fig. 1: Effect of phosphorus application on dry matter yield of wheat

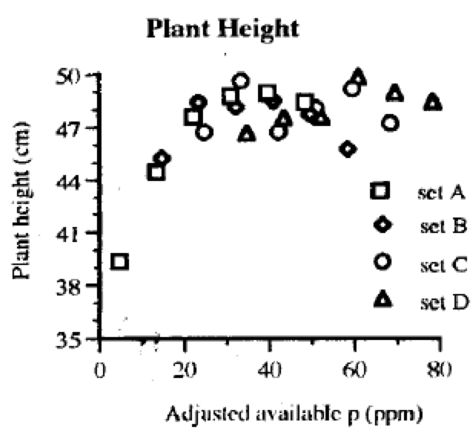

Fig. 2: Effect of phosphorus application on plant height

For a profitable yield of wheat, the soils with different adjusted available P levels such as, 4.70~48.40, 14.70~58.40, 24.70~68.40 and 34.70~78.40 ppm P should be fertilized with 45, 30, 0 and 0 ppm of available P.

Effect of phosphorus application on plant height: The response of plant height to the adjusted available P is shown in Fig. 2. The plant height increased until 58 ppm P and then showed decreasing trend. To calibrate the response of plant height to the adjusted available P, the following non linear equation was derived.

$$Y = 40.69 + 0.299x - 0.003x^2 \quad (r = 0.83) \qquad (2)$$

Where:
Y = Plant height (cm)
X = Adjusted available P (ppm)

Effect of phosphorus application on wheat tillering: The response of tillers per plant to the adjusted available p is shown in Fig. 3. The general trend of the curve shows that all the levels of adjusted available P were found with significantly higher tiller number, showing the pronounced effect of phosphorus application on tillering capacity of wheat. The tiller number increased until 60 ppm P and then decreased. To calibrate the tillering response of wheat to adjusted available P, the following non linear equation was derived.

$$Y = 3.399 + 0.080x^2 \quad (r = 0.91) \qquad (3)$$

Y = Number of tiller per plant
X = Adjusted available P (ppm)

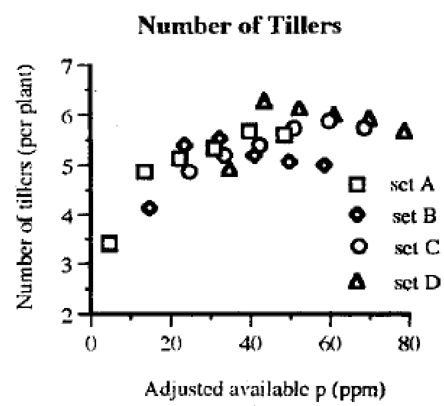

Fig. 3: Effect of phosphorus application on wheat tillering

Effect of phosphorus application on P content of soil after harvest: The response of P content of the soil to the adjusted available P is shown in Fig. 4. The graph shows that there was a corresponding increase in the P content of the soil with the increase in the adjusted available P. To calibrate the P content response of soils after harvest to the adjusted available P, the following non linear equation was derived.

$$Y = 5.788 + 0.285x + 0.000x^2 \ (r = 0.80) \qquad (4)$$

Where:
Y = P content of soil after harvest
X = Adjusted available P (ppm)

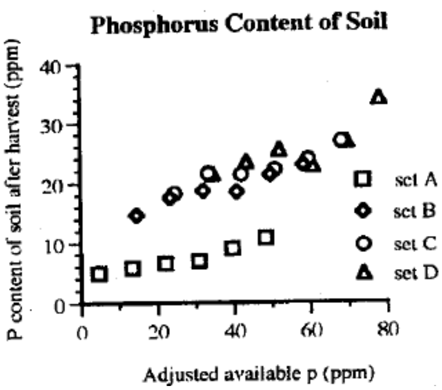

Fig 4: Effect of phosphorus application on P content of soil after harvest

Effect of phosphorus application on P concentration in leaf
The response of P content of leaf to the adjusted available P is shown in Fig. 5. The graph shows corresponding increase in P content of leaf due to the increase in the adjusted available P. To calibrate the response of P content of leaf to the available P, the following non linear equation was derived.

$$Y = 0.090 + 0.003x + 0.000x^2 \ (r = 0.95) \qquad (5)$$

Where:
Y = P content of leaf
X = Adjusted available P (ppm)

Phosphorus uptake efficiency: Phosphorus uptake efficiency was calculated for all the soils with different adjusted p levels as follow:

$$(\text{P uptake by plants/adjusted P level}) \times 100. \qquad (6)$$

In case of soil A with 4.70-48.40 ppm of adjusted available P, the phosphorus uptake efficiency was relatively higher as compared to the P uptake efficiency in other three soil. This may be due to the reason that in soil A the initial available P level is relatively low as compared to the others. So, soil A showed more efficient use of phosphorus application as compared to the other soils (Fig. 6).

Dry matter yield efficiency as affected by P uptake: The efficiency of dry matter yield as affected by P uptake is

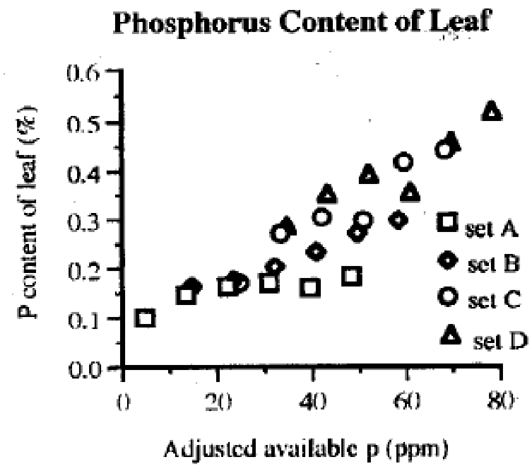

Fig. 5: Effect of phosphorus application on P content of leaf

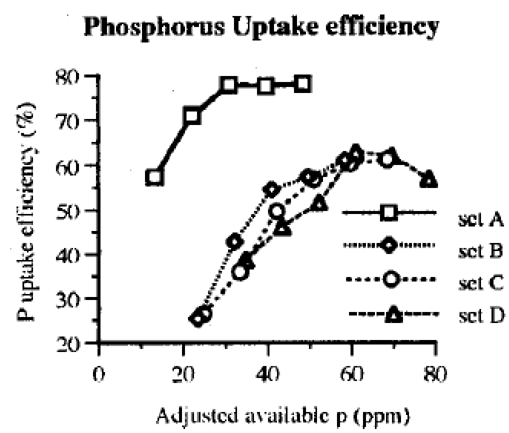

Fig. 6: Phosphorus uptake efficiency

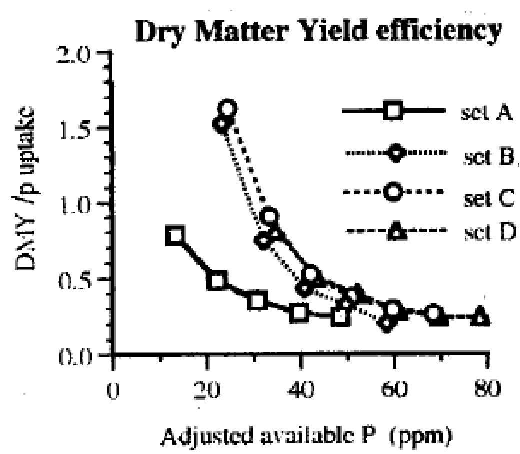

Fig. 7: Dry matter yield efficiency per P uptake

shown in Fig. 7. In all of the soils the (dry matter yield/P uptake) ratio decreased with the increase in the adjusted available P. The decrease in the (dry matter yield/P uptake) ratio is sharp until 40 ppm of adjusted available P, and after this the decreasing trend is not remarkable. As compared to soil D, soil A shows more efficient use of P application. This may be due to the relatively low level of initial available P in soil A, and shows more efficient use of phosphorus application. Reduction in the dry matter yield at higher levels of phosphorus may be due to interaction/imbalance of phosphorus with other nutrients.

Further research work is recommended for the calibration of soil test for phosphorus with the yield of field crops and critical levels of phosphorus in soils and wheat plant should be determined. It is needed to develop a model for fertilizer recommendations on the basis of calibration of soil test against plant concentration and yield response to applied nutrients, in pots and field experiments.

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