Evaluation of Soil Test Phosphorus Fertilizer Use in Maize-Wheat Cropping Sequence in a Typic Ustochrept

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INTRODUCTION

- Phosphorus (P) is one of the key nutrient elements for achieving higher yields of crops like maize and wheat.
- Recovery efficiency of added P in northwestern (NW) India soils ranges from 10 to 40%.
- Continuous P fertilization for attaining higher yields has thus led to high P build-up.
- A considerable part of cultivated land of this region qualifies for 'high P' (9-20 mg kg^{-1}) and 'Very high P' (> 20 mg kg^{-1}) status as per regional soil test P based classification.
- Very high P soils are recommended to receive no P fertilizer application, despite this farmers continues to using P fertilizer.
- Depletion of P sources and environmental consequences of excessive P call for its economization.

AIMS

- To study the temporal changes in soil P in soils with different initial soil test P levels with varying P fertilizer rates in maize and wheat crops.
- To find out critical soil test P levels above which maize and wheat crop yields will be sustained without adding P fertilizer.
- Comparisons of critical concentrations calculated by different statistical methods.

MATERIALS & METHODS

- Soil test P and grain yields data were collected for 11 years (1999-2000) from a long-term fertilizer experiment site (referred as PAU-1) on maize-wheat cropping system running since 1971 at research farm of Punjab Agricultural University Ludhiana, India.
- Out of ten different fertilizer combinations, 100%NPK treatment with a built up P status of 28 kg P ha^{-1} was selected and splitted in three subplots that received three P rates of 0, 13, and 26 kg P ha^{-1}.
- To verify the results obtained at site PAU-1, two field experiments were conducted. The first site at Punjab Agricultural University Ludhiana research farm (PAU-2) had three simulated soil test P gradient strips referred as ISP_1, ISP_2 and ISP_3.
- The second field represented a farmer's field (FF) under a long-term maize-wheat sequence.
- The soil at both the sites was loamy sand and was classified as Typic Ustochrept .
- Five rates of fertilizer P (0, 13, 26, 40 and 52 kg P ha^{-1} for both the crops) were randomized over each strip at both the sites.
- Composite soil samples of plow layer (0 - 15 cm) and plant samples were collected from all plots after harvest and analyzed for P status.
- Critical soil P concentrations were calculated by developing a relationship between soil test phosphorus concentration and relative grain yield using different statistical models viz. Linear, quadratic and exponential besides, Graphical approach of Cate and Nelson.

STATISTICAL ANALYSIS

- Nonlinear regression analyses for Critical Concentration determination were performed using the PROCREG procedure in SAS™ Statistical Software Version 9.3.

RESULTS & DISCUSSION

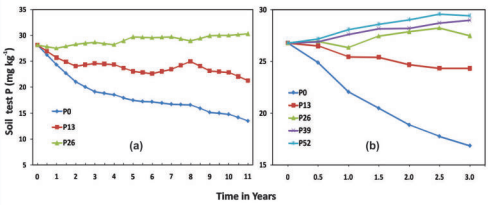

Fig. 1. a) Long term temporal changes in soil test phosphorus over time at PAU-1 site and (b) Short term temporal changes at FF

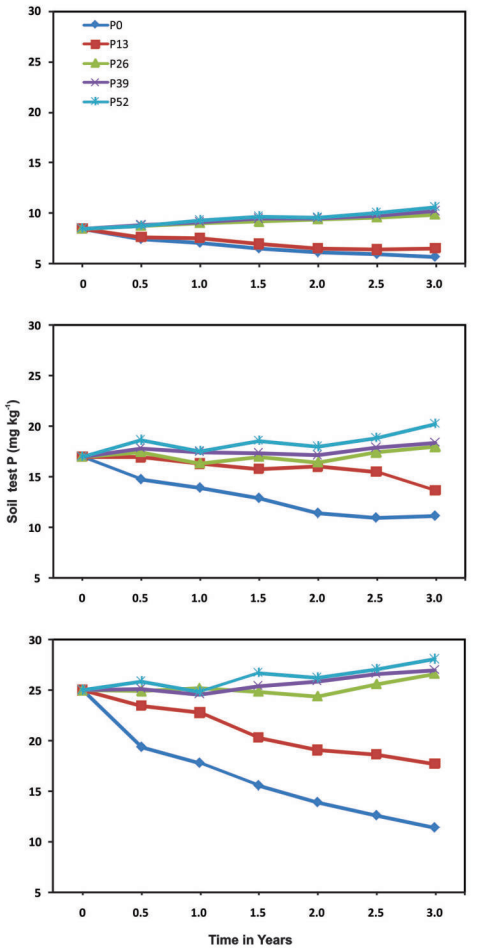

Fig. 2. Short term changes in soil test phosphorus over time at PAU-2

Statistical models usedto determine critical concentrations of soiltest P from relative grain yield and soil test P across all sites for maize and wheat

Crop	Model[T]	Equation	R^2	CC[$]
Maize				
	LP	67.9 +1.33X	0.48	20.0
	QP	$58.6 + 2.7X - 0.045X^2$	0.52	20.5
	EXP	$109.5 - 52.8e^{-0.0636X}$	0.47	20.3
Wheat				
	LP	60.1+1.64X	0.53	21.0
	QP	$61.1 + 1.48X - 0.0059X^2$	0.53	25.5
	EXP	$102.7 - 53.8e^{-0.076X}$	0.51	25.5

[T] All Statistical models (LN-linear plateau; QD- quadratic plateau; and EXP- exponential plateau) were significant at $P < 0.001$

[$] CC was calculated at 95% of Relative yield

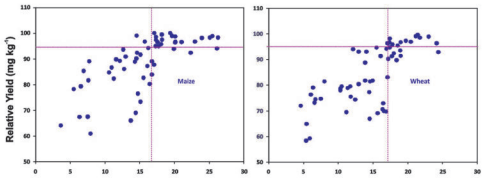

Fig 3. Relationship between Relative grain yield of maize and wheat and Soil test P across all sites of experiments by using Graphical Cate Nelson.

- At PAU-1 site, plots receiving no P application exhibited a gradual, linear and a less steep decline in soil test- P of 2.4 kg P $ha^{-1}yr^{-1}$ for first 11 years.
- At farmer's field similar P trends for without P fertilizer plots were recorded, an average P decline rate of 4.0 kg P ha^{-1} at FF coincides with 4.3 kg P ha^{-1} at PAU-1 for first three years.
- Under no P applied plots at PAU-2 a sharp P decline during first two years of study was observed and an average P decline to the tune of 2.8 mg P kg^{-1} yr^{-1} in ISP_2 and 5.0 mg P kg^{-1} yr^{-1} in ISP_3 was estimated.
- P rates of 26 kg P ha^{-1} or higher increased soil P buildup and maximum buildup was noticed at 52 kg P ha^{-1} at all sites.
- The critical limit of STP calculated by various statistical models varies from 20.0 to 20.5 mg P kg^{-1} for maize and 21.0 to 25.5 mg P kg^{-1} for wheat.
- Critical concentrations of 17.0 mg P kg^{-1} for both maize and wheat was predicted by graphical Cate Nelson, which virtually synchronizes with the results obtained from different P status soils on 18 short-term field trials.

CONLUSIONS

- For attaining yield sustainability of maize and wheat crops under 'high P' soils, 13 kg P ha^{-1} can be applied and for 'very high P' soils, no P application is required until the soil test level recede below the threshold level of 17 mg P kg^{-1}.
- Graphical Cate Nelson model was found to be the best fitted model in assessing critical concentrations of Soil test P in loamy sand soils.

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