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# Evaluation of suitability of soil test methods for available phosphorus and potassium under hybrid maize cultivation

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**Abstract**
An experiment was conducted to obtain simple, cost effective, efficient, and plant uptake correlated soil test methods for determination of phosphorus (P) and potassium (K) in Mollisols of Uttarakhand. Soil samples were collected before sowing of hybrid maize to evaluate the soil test methods for available P and K. Methods used were Olsen's-P and AB-DTPA for available P; and $NH_4OAc$-K and AB-DTPA for available K. Suitability of these methods for given soil nutrients was evaluated by comparing the $R^2$ values (coefficient of determination) obtained from regression analysis. Results concluded that the $R^2$ values of obtained equations by using different combinations of soil test methods for the determination of available P and K in soil were highly significant. Superior $R^2$ value for hybrid maize (0.684**) was observed with Olsen's P in comparison to AB-DTPA method ($R^2$ value 0.6805 **) for available P determination. Also, for available K determination, Superior $R^2$ value for hybrid maize (0.6849) was observed with Neutral ammonium acetate in comparison to AB-DTPA method ($R^2$ value 0.6830 **). It showed that Olsen's method for P and ammonium acetate method for K are more promising and superior over other methods.

**Keywords:** Available soil phosphorus, available soil potassium, hybrid maize, Mollisols, soil test method

## Introduction

*Zea mays* (maize) is one of the most important cereal crops of the world. In India, it is emerging as a third most important crop after rice and wheat covering an area of 9.4 Mha with the annual production of 23 MT. Its importance lies in the fact that it is not only used for human food & animal feed but also widely used for corn starch industry, corn oil production, baby corn etc. It has become an important raw material in food processing, poultry, dairy, meat and ethanol industry. In India, maize is grown traditionally during Kharif i.e. June-October with high temperature i.e. >35 ˚C. Maize is having tremendous yield potential under irrigated conditions. It is a quick growing and high yielding crop. It is also one of the most efficient field crops as far as producing higher dry matter per unit quantity of water is concerned. The production potential of maize is largely dependent on its nutrient management. In context of nutrient management, soil testing is gaining importance with the increasing awareness of precision agriculture. In the current and future scenario, soil testing is and will be proving to have a holistic role not just limited to fertilizer recommendation for a crop based on soil test but a measure to sustain soil quality. The purpose of soil testing has to be changed from just fertilizer recommendation to soil test for soil quality assessment and resource management for production systems and variable soil uses (Goswami, 2006). Soil fertility levels are maintained considering the need of the crop. For sustaining the production system, it is pre-requisite that the nutrient demand of a crop to produce a target yield and the amount extracted from the soil should be perfectly matched. For this, soil testing is a pre-requisite to recognize the nutrient imbalance in the soils so as to apply the required amounts of nutrients in order to bridge the gap, optimize the crop nutrition for higher yields and maintain the soil health. A number of soil test methods have been used to extract the nutrients from the soil, but the calibration between the extractable nutrient level and the plant growth may not be available for all the extractants. Most of these are specific for one plant nutrient and involve separate procedures of determination which make them time consuming, laborious, cumbersome and costly. An ideal soil test method is one that is simple, rapid, reliable, less expensive and easily adaptable to the situations. Improvements in instrumentation and analytical techniques have drastically favoured the use of universal extractant which allows measuring a number of elements with a single extraction (Gartley *et al.*, 2002, Bibiso *et al.*, 2015) [1]. However, the suitability and accuracy of such extractants for determination of available nutrients must be verified on the basis of their relationships with soil, existing analytical methods, and finally the crop responses. Various methods have been advocated by several workers to determine available nutrients in soils (Velayutham *et al.*, 1985), but none of these has been found to be universally applicable as the availability of nutrients depends on its amount in the soil, soil characteristics, soil mineralogical composition, soil temperature and soil organic matter content etc. However, when there is variation in more than one nutrient for both soil and applied nutrients in field conditions, the simple correlation coefficients between soil test value for single nutrient and crop yield may not give correct results due to the interaction effects of soil and applied nutrients. Therefore, multiple regression analyses including all the primary nutrients (N, P and K) at a time can be employed as an alternative approach for evaluating the suitability of different soil test methods using $R^2$ values. Such a screening method is useful to select the most appropriate soil test method (Mosi and Lakshminarayanan, 1985) [7]. Therefore, this present study was undertaken to evaluate the suitability of soil test methods for determination of P and K in soil under field conditions taking hybrid maize as a test crop.

## Materials and Methods

### Experimental site

The field experiment was conducted at Norman E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (29°N latitude, 79°29' E longitude and 243.84 meters above MSL) during 2017-18 in two phases *viz.*, soil fertility gradient experiment and test crop experiment as per the technical programme of All India Coordinated Research Project (AICRP) on Soil Test Crop Response (STCR).

### Experimental details

In the first phase, the experimental field was divided into three equal strips, and graded doses of 0:0:0, 100:100:100 and -1200:200:200 ($N:P_2O_5:K_2O$ kg $ha^{-1}$) were applied in strip I, II and III, respectively and wheat was grown as an exhausting crop. To minimize the interference of soil and other management factors affecting crop yield for the successful conduct of soil test crop response study, appreciable variation in soil fertility was created artificially as per the fertility gradient approach plan of AICRPon STCR. In the second phase, each fertility gradient strip was divided into 24 plots (21 treatments + 3 controls) resulting in seventy-two (24×3) plots of 9 $m^2$ (3 m × 3 m) size in all three strips. Treatments comprising various selected combinations of N, P, K and farm yard manure (FYM) were randomly allocated in each of these three strips. Test crop experiment was laid out as per AICRP on STCR plan and design with treatments comprised of various selected combinations of four levels of N (0, 60, 120 and 180 kg $ha^{-1}$), P (0, 30, 60 and 90 kg $ha^{-1}$), K (0, 20, 40 and 60 kg $ha^{-1}$), and three levels of FYM (0, 5 and 10 t $ha^{-1}$) for hybrid maize. Fertilizer treatments and controls were randomly distributed in each strip.

Soil sampling and chemical analysis before application of basal dose of fertilizers to hybrid maize, representative soil samples (0-15 cm depth) were collected from 72 plots and analyzed for available N, P and K. Methods used were Olsen's (Olsen *et al*., 1954) [8] and AB-DTPA (Soltanpour and Schwab, 1977) [14] for available P; neutral normal ammonium acetate ($NH_4OAc$) (Hanway and Hiedal, 1952) [4] and AB-DTPA (Soltanpour and Schwab, 1977) [14] for available K. After the application of FYM and fertilizers in plots, hybrid maize cultivar P3377 was grown following standard agronomic practices. The crop was harvested at maturity from net plots, and grain yield was recorded and expressed as quintals per hectare (q $ha^{-1}$).

### Statistical analysis

Availability indices of P and K were determined by multiple regression equations using grain yield as dependent variable (Y), and soil test values and fertilizer doses as independent variables. The coefficient of determination ($R^2$) values was calculated by different combinations of soil test methods with grain yield in presence of NPK doses and their interactions. Data were analyzed to find out multiple regression equations for different functions with selected soil test methods used for determining Olsen's and AB-DTPA method (for P) and neutral normal $NH_4Oac$ and AB-DTPA (for K). Correlation analysis was also carried out between grain yield, and different soil test methods and applied fertilizer N, P and K in hybrid maize.

## Results and Discussion

### Available N, P and K in soil

The amounts of soil available P and K by different extraction methods in the same soil type showed great differences between different methods. Available P by Olsen's method ranged from 23.95 to 49.62 kg $P_2O_5$ $ha^{-1}$ with mean value of 36.18 kg $P_2O_5$ $ha^{-1}$ while with ABDTPA method, available P ranged from 17.44 to 41.87 kg $P_2O_5$ $ha^{-1}$ with mean value of 28.90 kg $P_2O_5$ $ha^{-1}$. Available K by $NH_4OAc$ method ranged from 115.58 to 237.88 kg $ha^{-1}$ with mean value of 179.70 kg $ha^{-1}$, while with ABDTPA method it ranged from 111.55 to 233.85 kg $ha^{-1}$ with mean value of 175.46 kg $ha^{-1}$. For P, both AB-DTPA method and Olsen's tests remove soil P with $HCO_3^-$ ions and mainly from Ca- phosphates (Elrashidi *et al*., 2001) [2]. For available K, ammonium acetate extracted the highest amounts of K followed by AB-DTPA, which was due to the presence of higher concentration of $NH_4^{+1}$ ions in $NH_4OAc$. Ammonium ions are known to efficiently replace exchangeable potassium as well as potassium from specific sites (Sharma *et al*., 2018) [11]. In case of P and K, the extractability was maximum with Olsen's and neutral normal $NH_4OAc$, respectively in these soil and climatic conditions. Similar types of results were also observed by Gangola (2016) [3], Kumar (2016) [6] and Singh *et al.* (2020) [12] for different crops in same type of soils.

### Suitability of different methods to estimate available nutrients in soil

Various soil test methods evaluated by working out a correlation between soil test values and grain yield of Hybrid maize under field conditions. The relative suitability of different soil test method for a given nutrient was judged from comparison of the magnitude of $R^2$ values of the regression equations obtained by including alternatively one method each time keeping the methods of other nutrients constant. Generally, the $R^2$ values above 0.66 are taken as indication of good fit, 0.45 to 0.65 as moderate fit, and below 0.45 as poor fit of the equation (ICAR, 1974). Data were analyzed to find out multiple regression equation for different functions with selected soil test methods i.e. Olsen's or AB-DTPA method and neutral normal $NH_4OA_C$or AB-DTPA method to determine, available phosphorus and potassium in soil, respectively.

**Available phosphorus**

Evaluation of P fertility status of soil is necessary to make a sound P fertilizer recommendation for optimizing crop yield. Therefore following multiple regression equations have been developed for the evaluation of available phosphorus.

**I) Olsen's P**

Yield = - 88.1997 + 0.2200 * SN + 1.3809 * SP + 0.1913 * SK + 0.0914 * FN + 2.4697 * FP + 0.1666 * FK + 0.0009 * FN2 - 0.0143 * FP2 - 0.0071 * FK2 - 0.0002 * FNSN - 0.0498 * FPSP + 0.0030 * FKSK……………………………..

$R^2$ = 0.684**

**II) AB-DTPA P**

Yield = - 75.6132 + 0.2221 * SN + 1.2233 * SP + 0.2019 * SK + 0.0873 * FN + 2.1771 * FP + 0.2601 * FK + 0.0010 * FN2 - 0.0151 * FP2 - 0.0075 * FK2 - 0.0003 * FNSN - 0.0408 * FPSP + 0.0023 * FKSK……………………………..

$R^2$= 0.6805**

**Available Potassium**

Numerous methods have been advocated by several workers to measure the available K status of the soils but none of these has been found to be universally applicable. Therefore following multiple regression equations have been developed for the evaluation of available potassium.

**I) Neutral Ammonium Acetate**

Yield = - 88.1997 + 0.2200 * SN + 1.3809 * SP + 0.1913 * SK + 0.0914 * FN + 2.4697 * FP + 0.1666 * FK + 0.0009 * FN2 - 0.0143 * FP2 - 0.0071 * FK2 - 0.0002 * FNSN - 0.0498 * FPSP + 0.0030 * FKSK…………………………. (I)

$R^2$ = 0.6849**

**II) AB-DTPA K**

Yield = - 81.4268 + 0.2218 * SN + 1.3818 * SP + 0.1556 * SK + 0.0960 * FN + 2.4364 * FP + 0.0017 * FK + 0.0009 * FN2 - 0.0141 * FP2 - 0.0075 * FK2 - 0.0003 * FNSN - 0.0493 * FPSP + 0.0042 * FKSK…………………………. (I)

$R^2$= 0.6830**

** Significant at the 0.01 level.

* Significant at the 0.05 level.

Where, SN, SP and SK = Soil test value (kg $ha^{-1}$) of nitrogen phosphorus and potassium respectively.

OC= Soil test value as organic carbon (%).

FN, FP and FK = Applied fertilizer dose (kg $ha^{-1}$)of nitrogen phosphorus and potassium respectively.

Y = Grain yield (q $ha^{-1}$) of Hybrid maize.

In the present investigation, on the basis of the $R^2$ value derived from regression equations, Olsen's method ($R^2$=0.684**) was found superior to AB-DTPA method ($R^2$= 0.6805**). Pandey (2010) also reported similar type of results with cabbage crop in Mollisol. Neutral normal $NH_4OA_{C}$- K method ($R^2$ = 0.6849**) was found superior to AB-DTPA K method ($R^2$ = 0.6830**) in case of determination of available potassium as indicated by higher $R^2$ values. Similar findings were also reported by (Singh *et al.* 1969 and Sachan *et al.* 1972) [10, 13] in Mollisol.

**Conclusion**

Therefore from the above observations, it can be suggested that Olsen's method and neutral ammonium $NH_4OA_C$ method can be taken as indices for determining soil available phosphorus and soil available potassium respectively in Mollisol of Uttarakhand.

**References**


1. Bibiso M, Taddesse AM, Gebrekidan H, Melese A. Evaluation of universal extractants for determination of selected micronutrients from soil. Bulletin of the Chemical Society of Ethiopia. 2015;29(2):199-213.
2. Elrashidi MA, Alva AK, Huand YF, Calvert DV, Obreza TA, He ZL. Accumulation and downward transport of phosphorus in Florida soils and relationship to water quality. Communications in Soil Science and Plant Analysis. 2001;32:3099-3119. DOI: 10.1081/CSS-120001110.
3. Gangola P. Soil test crop response studies in French bean (*Phaseolus vulgaris* L.) and Maize (*Zea mays* L.) cropping sequence. Thesis, Ph.D. G.B. Pant University of Agriculture and Technology, Pantnagar, 2016, 203.
4. Hanway JJ, Heidel H. Soil analysis methods as used in Iowa state college soil testing laboratory. Iowa Agriculture. 1952;57:1-31.
5. I.C.A.R. Fifth coordinator's Progress report (1971-72). All India Scheme for Investigation on Soil Test Crop Response Correlation. Presented at fifth Workshop of All India Coordinated Scheme on Soil Test Crop Response Correlation Studies, I.C.A.R., held at Ranchi, 1972.
6. Kumar S. Soil test crop response studies for balanced fertilization of turmeric (*Curcuma longa* L.) in a Mollisols of Uttarakhand. Thesis, Ph.D. G.B. Pant University of Agriculture and Technology, Pantnagar, 2016, 183.
7. Mosi AD, Lakshminarayanan S. Development of soil test based recommendations for potassium- Tamil Nadu experience. Proceedings of Group Discussion on Soil Testing Plant Analysis and Fertilizer Evaluation, 1985, 22-23.
8. Olsen SR. Estimation of available phosphorus in soils by extraction with sodium bicarbonate (No. 939). US Dept. of Agriculture, 1954.
9. Pande J. Soil test crop response based balanced fertilization of Cabbage (*Brassica oleracea* var. *capitata*) grown in Mollisol of Uttarakhand. Ph.D., thesis submitted to G. B. Pant University of Agriculture and Technology, Pantnagar, 2010, 94.
10. Sachan RS, Ram N, Gupta RA, Ram B, Singh K. Soil test crop response correlation. Annual report. G.B. Pant Univ. of Ag. & Tech., Pantnagar, Nainital, 1972, 420-426.
11. Sharma SK, Sharma A, Rana S, Kumar N. Evaluation of multi-nutrient extractants for determination of available P, K, and micronutrient cations in soil. Journal of Plant Nutrition, 2018, 1-11.
12. Singh VK, Gautam P, Singh K, Sen S, Kumar V, Meena SS, Singh DN. Evaluation of soil test methods for available nitrogen, phosphorus and potassium in direct-seeded rice–wheat cropping sequence. Journal of Agri. Search. 2020;7(2):74-81
13. Singh TA, Singh M, Ghosh D. Development of soil tests for phosphorus and potassium. Annual report. G.B. Pant Univ. of Ag. & Tech., Pantnagar, Nainital, 1969.
14. Soltanpour PA, Schwab AP. A new soil test for

simultaneous extraction of macro-and micro-nutrients in alkaline soils. Communications in Soil Science and Plant Analysis. 1977;8(3):195-207.

15. Velayuthan M, Sankar MGR, Reddy KCK. Soil test-crop response research work in India for fertilizer recommendation. In International Symposium on Soil Test Crop Response Correlation Studies, Dhaka (Bangladesh) SSSB, 1984-1985.