The Ecoscan 8(3&4): 199-202, 2014
AN INTERNATIONAL BIANNUAL JOURNAL OF ENVIRONMENTAL SCIENCES

EVALUATION OF SOME SOIL TEST METHODS FOR AVAILABLE PHOSPHORUS AND ITS CRITICAL LIMITS FOR BLACK GRAM IN ACID SOILS OF IMPHAL WEST DISTRICT, MANIPUR (INDIA)

LINTHOI WATHAM[1], HEROJIT SINGH ATHOKPAM[1]*, WANGKHEM HEROJIT MEITEI[1], NANDINI CHONGTHAM[1], K. NANDINI DEVI[1], N. BRAJENDRA SINGH[1], N. GOPIMOHAN SINGH[1] AND N. JANAKI SINGH[2]
[1]Central Agricultural University, Imphal - 795 004 (Manipur)
[2]College of Post Graduate Studies, Central Agricultural University, Umiam - 793 103, Meghalaya
e-mail: hathokpam@yahoo.in

ABSTRACT

Six soil test methods were evaluated for response of black gram to phosphorus application on 20 surface soils (0 – 15 cm) of Imphal west district of Manipur. The suitability of the extractant was in the order: Bray 1 > Bray 2 >Mehlich 3 >Troug> Olsen (pH-8.5) >Mehlich 1. Bray 1 extractant was assessed to be the best extractant on the basis of highest degree of correlation with phosphorus uptake (control), Bray's per cent yield and Bray's per cent uptake. Therefore, Bray 1 extractant may be used as an index of available phosphorus for black gram (Uttara) grown on acid soils of Imphal west district of Manipur. The critical level is being 13 kg P_2O_5 ha^{-1} in the soils on the basis of Bray 1 method. The critical limit of phosphorus concentration in plant at 40 days was 0.45 per cent. Among the inorganic fractions Red-P and Fe-P accounted for major portion and follow the trend: Red-P > Fe-P > Al-P >Occl-P >Ca-P > Sal-P.

KEY WORDS
Phosphorus
Acid soils
Black gram
Critical limit
Bray's per cent yield

Received : 17.12.2013
Revised : 12.07.2014
Accepted : 15.09.2014

*Corresponding author

INTRODUCTION

An extraction method must be selected which gives the good indication of the amount of nutrient in the soils that available to the particular crops for the soils in the region in which the test is to be used. This can be done by collecting a large number of soils representative of the region and growing crops on these soils in the green house. This eliminates the effects of climatic variation from site to site. The amount of nutrient absorbed by the crop is then correlated to the amount of nutrient extracted by various methods to determine the best extractant of the available nutrient across the range of soils. Fertilizer recommendations for P generally are based on soil testing. The increasing demand for soil testing (because of the introduction of grid sampling methods and other site-specific management practices) necessitates the use of more efficient methods for soil testing. One possibility for improving laboratory efficiency would be to use a single extractant for multiple purposes (Antonio and Mallarino 1995).

Phosphorus is the second most important plant nutrient after nitrogen for agricultural production in most regions of the world. The deficiency in plants has been reported from various parts of India. Phosphorus is used in the plant for energy storage and transfer, maintenance and transfer of genetic code, and is structural component of cells and many biochemicals. Phosphorus deficiencies results in poor root growth, stunted top growth, reduced yield and crop quality along with delayed maturity (Mishra, 2012). Pulses production is very low and become challenging problem against the requirement of increasing population of our country. The pulses availability per capita was 69.9g in 1951, by increasing in 1971, it comes to 50g and in 1982 remained only 40g and in 2005, it was 27g. The availability of pulses is very negligible at present as against required 85g day^{-1} capita^{-1} for balanced diet (Patel *et al.*, 2013).

Phosphorus also reduces the harmful effect of excess nitrogenand imparts resistant to plants against disease. Supply of phosphorus to legume increase the number and size of root nodules and nitrogen fixing potentiality of *Rhizobium*, so it essential for obtaining the higher yield of crop (Patil and Jadav,1994).The importance of phosphorus in legumes had been reported by many workers but work on different forms of phosphorus and their relationship with soil characteristics and the suitability of various test methods suitable to acid soils of Imphal west district of Manipur is lacking. Therefore, the present investigation was undertaken to find out the relative preference of various phosphorus forms by soil test methods in relation to plant parameters in acid soils of Imphal west district of Manipur. The objective of this research was to correlate amounts of P extracted by various extractants with some physico-chemical properties of the soil.

MATERIALS AND METHODS

Twenty soil samples (0-15) cm were collected from various location of Imphal West district of Manipur. The soils texture were analysed by methods described by Chopra and Kanwar (1976), soil pH, calcium, magnesium, ammonium acetate extractable K and total N (Jackson 1973), available N (Subaih and Asija 1956), and organic carbon was determined by wet oxidation method of Walkley and Black (1934).

Two and half kg of soil were filled in pots and phosphorus were applied @ 0, 40, 60 kg P_2O_5 ha^{-1} through single super phosphate. The treatments were replicated thrice in a completely randomized design. A basal dose of nitrogen and potassium @ 20:40 N: K_2O ha^{-1} in the form of urea and muriate of potash in each pot. Black gram (*Vignamungo*) variety Uttara seeds were sown and thinned to 4 plants in each pot after 7 days of sowing. The moisture level was maintained at field capacity level in all the pots by irrigating with distilled water as and when required. The crop was harvested 40 days after sowing. The plant samples were washed to remove dirt and then oven dried at 65^{0}C for 48 hours and the dry matter yield was recorded. The samples were ground and the powdered samples were analyzed for plant nitrogen using sulphuric acid and catalysed by macrokjeldhal method, plant phosphorus by tri-acid digestion using vanadomolybdophosphoric acid yellow colour method by spectrophotometry and plant potassium by flame photometry method (Jackson, 1973).

Inorganic phosphorus fractions viz. Saloid P (Sal-P), Aluminium P (Al-P), Iron P (Fe-P), Reductant soluble P (Red-P), Occluded P (Occl-P), Calcuim P (Ca-P) were determined sequentially by modified procedure of Chang and Jackson (1966). The organic fractions were determined by pre- extraction with concentrated HCl followed by two extractions with 0.5 M NaOH (Mehta *et al*. 1954). The available phosphorus was determined by using six different extractants*viz*. Mehlich 1 (0.0125 M H_2S0_4 + 0.05 M HCl), Mehlich 3 (0.M CH_3COOH, 0.25 M NH_4NO_3, 0.015 M NH_4F, 0.013 M HNO_3, 0.001 EDTA), Olsen P (0.5 M $NaHCO_3$, pH-8.5). Troug (0.002 N H_2SO_4, pH-3), Bray and Kurtz No.1 (0.03 N NH_4F + 0.025 N HCl) and Bray No. 2 (0.1 N HCl + 0.03 N NH_4F) by spectrophotometry method as described by Jackson (1973).

Table 1: Physico-chemical properties of soil

Soil characteristic	Mean	Range
pH	4.98	4.58 – 5.67
Organic carbon (g kg^{-1})	22.2	11.3 – 35.3
Total nitrogen (%)	0.13	0.06 – 0.22
Available nitrogen (Kg ha^{-1})	315.51	225.80 - 466.42
Available K_2O (Kg ha^{-1})	152.58	98.00 - 207.50
Ca[cmol(P^+)kg^{-1}]	2.81	1.25 - 4.40
Mg [cmol(P^+)kg^{-1}]	1.86	0.15 - 4.30
Clay (%)	56.95	19.79 - 83.12

RESULTS AND DISCUSSION

Extraction of available phosphorus

The mean extractable phosphorus by various methods (Table 2) followed the trend: Bray 2 >Troug> Bray 1 >Mehlich 3 > Olsen (pH-8.5) >Mehlich 1. The different behavior of different extractants could be due to their selectivity in solubilizing specific fractions of phosphorus. Bray 2 reagent extracted highest amount of available phosphorus among all extractants. The higher solubility in Bray 2 may be due to its relatively higher strength of acidity and complexing of Al^{3+} and Fe^{3+} with F^- ions and consequent release P adsorbed by these trivalent ions. Similar result was also reported by Ballard, 1974. The Olsen extractant (0.5 M $NaHCO_3$ pH 8.5) removed lesser P than Bray 2, Troug, Bray 1 and Mehlich 3 due to mild alkaline nature which displaces P from the surface of Ca, Al and Fe phosphate by decreasing Ca activity and repression of Al^{3+} and Fe^{3+} activities respectively (Jackson 1973).

Distribution of Phosphorus fractions

The total inorganic phosphorus is divided into active and inactive forms. The former consists of Al-P, Fe-P and Ca-P and the latter consists of occluded, reductant soluble and residual P (Chang and Jackson 1975). Distribution of various inorganic fractions of total phosphorus in the soils followed the order: Red-P> Fe-P> Al-P >Occl-P >Ca-P > Sal-P. The low percentages of Sal-P and Ca-P in the soils are due to the low pH of these soils. Similar results were also reported by Loganathan and Sutton (1987).

Correlation between chemical extractants

The coefficients of correlation values between various methods (Table 3) reveal that the extractants are closely interrelated, except Olsen and Mehlich 1. Such close relationship between the different extractants suggested that these extractants extracted more or less the same forms of phosphorus indicating the existence of dynamic equilibrium among different forms of phosphorus but relatively to different degrees. Olsen and Mehlich 1 extracted phosphorus did not correlate with other extractants. The Olsen extractant had alkalizing character being poor replacer of phosphorus in acidic soils, the HCO_3^- extractant extract only the free phosphorus, as a result they generally gave poor correlation with Mehlich 3, Bray 1 and Bray 2 which has ability to extract adsorbed, labile and free phosphorus as well be complexing of Al^{3+} and Fe^{3+} with F^- ions. This observation was corroborated by Ravindra and Ananthanarayana (1999).

Table 2: Amount of phosphorous of the soils extracted by various extractant

Extractant	Range(kg P-$_2O_5$ ha^{-1})	Mean(kg P-$_2O_5$ ha^{-1})	Reference
Bray 1(0.03 N NH_4F + 0.025 N HCl)	6.30-35.90	18.93	Bray & Kurtz (1945)
Bray 2(0.1 N HCl + 0.03 N NH_4F)	17.90 -41.55	28.06	Bray & Kurtz (1945)
Mehlich 1(0.0125 M H_2S0_4 + 0.05 M HCl)	6.19-19.23	10.64	Nelson *et al*. (1953)
Mehlich3 0.2MCH3COOH,0.25MNH4NO3 ,0.015M NH4F,0.013 M HNO3,0.001 EDTA	8.97-26.93	17.18	Mehlich (1984)
Troug(0.002 N H_2SO_4, pH-3)	10.77 -41.16	26.35	Troug(1930)
Olsen Olsen P (0.5 M $NaHCO_3$, pH-8.5)	4.42-20.64	11.61	Olsen *et al*. (1954)

Table 3: Simple correlation co-efficient among the different forms of phosphorus

Forms	Bray1	Bray2	Mehlich 1	Mehlich 3	Troug	Olsen	Sal-P	Fe-P	Al-P	Red-P	Occl-P	Ca-P	Org-P
Bray-2	0.797**												
Mehlich1	-0.101	-0.340											
Mehlich3	0.642**	0.587**	-0.315										
Troug	0.682**	0.728**	-0.370	0.587**									
Olsen	0.011	-0.155	0.480*	-0.151	-0.186								
Sal-P	0.133	-0.091	0.280	0.261	0.085	0.209							
Fe-P	0.594*	0.336	-0.125	0.108	0.447*	-0.182	0.092						
Al-P	0.528*	0.456*	0.225	0.427	0.315	0.257	0.530*	0.368					
Red-P	0.394	0.334	0.123	0.477*	0.490*	0.074	0.275	-0.006	0.506*				
Occl-P	0.459*	0.353	-0.090	0.494*	0.014	-0.103	0.321	0.210	0.409	0.441			
Ca-P	0.383	0.244	0.309	0.510*	0.203	0.297	0.534*	0.141	0.385	0.583**	0.536*		
Org-P	-0.174	-0.129	0.046	-0.324	-0.395	0.122	-0.536*	0.129	-0.206	0.122	-0.095	-0.444	
Tol-P	0.293	0.289	0.055	-0.054	-0.067	0.141	-0.151	0.436	0.343	0.379	0.349	-0.018	0.775**

** Correlation is significant at the 0.01 level * Correlation is significant at the 0.05 level

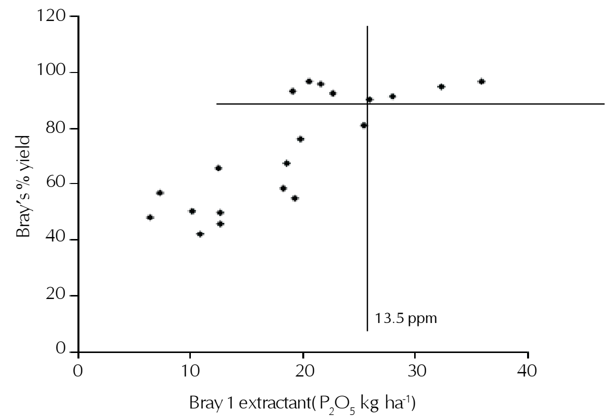

Figure 1: Relationship between Bray-1 and Bray'sPercent yield

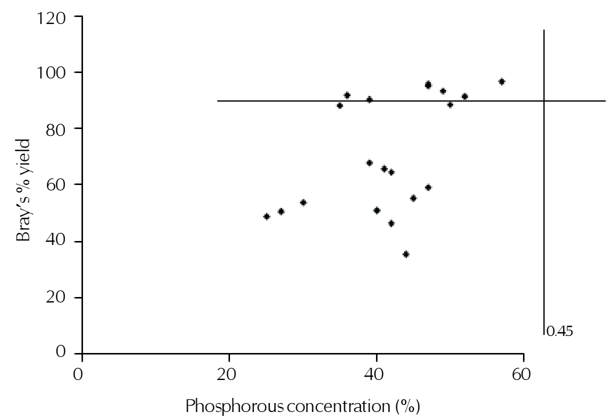

Figure 2: Relationship between phosphorus concentration and bray's per cent yield

Correlation of soil phosphorus with yield and uptake

The simple correlation coefficients between the different extractant and the yield parameters are presented in the table 4. The data revealed that all the extractants showed positive and significant correlation with Bray's per cent and uptake of Black gram except Olsen and Mehlich I. Bray's per cent yield and uptake range from 36.93 to 96.55 per cent and 28.85 to 86.18 per cent, respectively. Among the extractant used Bray 1 is most suitable extractant for determining available soil phosphorus as the degree of co-efficient of correlation between the quantities of P extracted by this extractant and yield and uptake parameters were of higher order and showed higher degree of co-efficient of correlation with Bray,s per cent yield and uptake by Black gram with 'r' values of 0.833** and 0.833**, respectively.

Critical level of phosphorus

It was observed that the critical level of phosphorus in the soils varied with methods of phosphorus extraction. According to graphical procedure of Cate and Nelson (1965), the critical level of soils ranged from 13 to 27 kgP_2O_5 ha^{-1} depending upon the methods of phosphorus extraction. A high degree of correlation between Bray 1 extractant and Bray's per cent yield indicated 13 kgP_2O_5 ha^{-1} (Fig. 1)as the critical limit of available phosphorus in these soils for demarcating the phosphorus responsive soil from the unresponsive soil ones. Similar report

Table 4: Simple correlation co-efficient between the different forms of phosphorus and yield parameters of black gram

Extractant	Dry matter yield (Control)	P content (Control)	P uptake (Control)	Bray's % Yield	Bray's % Uptake
Bray 1	0.824**	0.698**	0.887**	0.833**	0.833**
Bray 2	0.439	0.509*	0.555**	0.548*	0.631**
Mehlich 1	0.038	0.111	0.044	0.002	-0.161
Mehlich 3	0.583**	0.543*	0.691**	0.503*	0.661**
Troug	0.483*	0.506*	0.554*	0.478*	0.525*
Olsen	0.138	0.043	0.119	0.116	-0.154
Saloid-P	0.193	0.224	0.246	0.088	0.004
Iron-P	0.364	0.400	0.436	0.469*	0.433
Aluminium-P	0.395	0.422	0.448*	0.310	0.224
Reductant-soluble-P	0.285	0.450**	0.421	0.293	0.352
Occluded-P	0.415	0.286	0.428	0.431	0.468*
Calcium-P	0.509*	0.387	0.547**	0.331	0.312
Organic-P	-0.234	-0.029	-0.186	-0.190	-0.034
Total-P	0.128	0.355	0.248	0.169	0.300

** Correlation is significant at the 0.01 level*Correlation is significant at the 0.05 level

also was reported by Sanker*et al.* (2011.

The result revealed that the critical level of the phosphorus concentration in the black gram was found 0.45 per cent according to graphical procedure of Cate and Nelson (1965) using a scatter diagram (Fig.2), partitioning the two dimensional percentage yield versus phosphorus content in the 40 days old Black gram plants (control) scattered into two group. This finding was also corroborating with finding of Parmar*et al.* (2010).

ACKNOWLEDGEMENT

The authors are thankful to the Dean, College of Agriculture, Central Agricultural University, Imphal for financial help in conducting the research experiment.

REFERENCES

Antonio, P. and Mallarino 1995. Proceedings of the twenty-five north central extension industry soil fertility conference. *Potash and Phosphate Institute,* Manhattan vol. 11, University of Minnesota

Ballard, R. 1974. Extractability of reference phosphates by soil test reagents in absence and presence on soils. *Soils and Crop Science Society of Florida Proceedings*. **33**: 169-174.

Bray, R. H. and Kurtz, L. T. 1945. Determination of total, organic, and available forms of phosphorus in soils. *Soil Science*. **59**: 39-45.

Chopra, S. L. and Kanwar, J. 1976. Analytical Agricultural Chemistry, Kalayani Publisher. *Ludhiana,* New Delhi.

Jackson, M. L. 1973. *Soil Chemical Analysis. Pub. Prentice Hall of Indian Pvt.Ltd,* New Delhi.

Loganathan, P. and Sutton, P. M. 1987. Phosphorus fractions and availability in soils formed on different geological deposits in the Niger delta area of Nigeria. *Soil Sci.* **143(1):** 16-25.

Mehlich, A. 1984. Mehlich 3 soil test extractant: A modification of the Mehlich 2 extractant. *Communication in Soil Sci. and Pl. Analysis* **15:** 1409-1416.

Mehta, N. C., Legg, J. O., Goring, C. A. J. and Black, C. A. 1954. Determination of organic phosphorus in soils. *Soil Sci. Soc. Am. Proc.* **18**: 443-449.

Mishra, L. K. 2012. Effect of phosphorous and zinc fertilization on biochemical composition of wheat. *The Bioscan*. **7(3):** 445-449.

Nelson, W. L., Mehlich, A. and Winters, E. 1953. The development, evaluation and use of soil tests for phosphorus availability. *Agron*. **4:** 153-158.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, F. S. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *U.S. Dept. of Agric. Circ*. **19**: 939

Parmar, K. B., Polara, K. B., Hadiyal, T. M., Babariya, N. B. and Davaria, R. L. 2010. Response and critical limits of phosphorus for black gram grown in medium black calcarious soils. *An. Asian. J. Soil Sci*. **5(2)**: 406-410.

Patel, H. R., Patel, H. F., Maheriya V. D. and Dodia I. N. 2013. Response of Kharif green gram (*Vignaradiata* L. Wilczek) to sulphur and phosphorus fertilization with and without biofertilizer application. *The Bioscan*. **8(1)**: 149-152.

Patil, B. P. and Jadav, M. S. 1994. Effect of fertilization and rhizobium on yield of greengram on medium black soil of Konkan. *J. Indian Soc. Coastal Agri. Res.* **12(1)**: 17-22.

Ravindra, M. R. and Ananthanarayana, R. 1999. Soil test for available phosphorus and their relation with inorganic P fractions in acid soils of Karnataka. *J. Indian Soci. Soil Sci*. **47(2):** 238-287.

Sarker, M. J. U., Siddiky, M. A., Jahiruddin, M., Main, M. H. and Islam, M. S. 2011. Uptake of different nutrient elements by legume crop in wheat-legume-T.Aman cropping pattern. *Bangladesh J. Agric. Res*. **36(2):** 247-253.

Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for estimation of available N in soils. *Current Science*. **25**: 259-260.

Troug, E. 1930. The determination of the readily available phosphorus in soils. *J. Am. Soc. Agron*. **22**: 874-882.

Walkley, A. and Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* **37**: 29-38.