J. Asiat. Soc. Bangladesh, Sci. 23 (2) : 195-204, 1997

EVALUATION OF SOME SOIL TEST METHODS FOR PHOSPHORUS IN SOME BANGLADESH SOILS WITH RESPECT TO WHEAT

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Abstract

Seven extraction methods were tried to evaluate a suitable method for determining available P from eleven soils representing 11 established soil series of Bangladesh with respect to wheat (Aghrani) grown under net-house conditions . 0.002 N H_2SO_4 appeared to be the best method for all soils in extracting available P which gave high correlations with relative yield and P uptake, particularly at the flowering stage. 0.5M $NaHCO_3$ was found to be the second best method in estimating the availability of Phosphorus. The third method that correlated significantly with wheat yield and P uptake was 1M NaC1. Remaining methods also correlated significantly with plant parameters except Morgan and ASI with yield from control at the flowering stage.

Key words : Soil Phosphorus, extractant, wheat plant.

Introduction

Several analytical procedures have been proposed for evaluating the available P status of soil. Since each extractant reacts differently with different types of soils (Colwell 1971) and each crop differs in its P requirement, the methods for predicting the P needs of crops demand to be selected carefully. Knowledge regarding suitable methods for estimating available P is a prerequisite for classifying soils with respect to their P supplying capacity, which in turn determines the doses of P ferlitizers to be applied to crops. However, the relationship between the extractability of a nutrient by various solvents and plant availablity thereof, may be studied and statistical interpretation of the results may suggest a method best suitable for the purpose. Many research workers have tried in the past and are trying to develop suitable chemical methods to assess the nutrient status in

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soil with respect to different crops. Attempts have been made to evaluate the status of available phosphorus of some soils of Bangladesh by Islam and Chowdhury (1967), Islam *et al.* (1975), Anam *et al.* (1976, 1977, 1978, 1979, 1981, 1982) and recently by Rahman *et al.* (1995). 2N KCI, Morgan extractant and Olsen method were found to be the best methods in the study of these authors. Rahman *et al.* (1995) found the extractants' ability to extract P followed the order : Nelson method > Hunter method > Olsen method > Bray & Kurtz No. 1 method. Most works have been done in this purpose with respect to rice plants. No such information was available in response to wheat plant.

The present investigation was therefore, conducted to find out a suitable method or methods for determining the available soil P for obtaining economic responses to P fertilizer application, particularly with reference to upland wheat crop. Seven extraction methods for 11 soils representing 11 soil series of Bangladesh were included in the study.

Materials and Methods

Eleven soils represening 11 soil series from different locations of Bangladesh were selected for the present study. The soil samples were collected at a depth of 0-15 cm. from the surface and were dried, ground and passed through a 2 mm sieve and a 0.6 mm sieve. The 2 mm size samples were used for particle size analysis while the 0.6 mm size samples were used for various chemical analyses. pH of the soils was determined electrochemically at a soil : water ratio of 1 : 2.5 (Jackson 1973) ; texture was determined by using the textural triangle of USDA (1951) after determining the percentage of sand, silt and clay by hydrometer method (Day 1965) ; CEC was determined following the method as described by Black (1965) ; organic carbon was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1973) and the organic matter was calculated by multiplying the organic carbon value with the factor. 1.724 ; total N was determined by alkali distillation of the Kjeldahl digest (Jackson 1973) ; available N was extracted by 1M NaC1 solution at pH 3.0 and determined by alkali distillation (Anam *et al.* 1981) ; available K was determined by flame photometer after its extraction by 1M NH_4OAc (Black 1965). Available P was determined by using seven extractants *viz.* Bray and Kurtz No. 1 (1945), Bray & Kurtz No. 2 (1945), 0.002N

H_2SO_4 buffered at pH 3.0 (Truog 1930), Morgan extractant (Morgan 1941), 0.5M $NaHCO_3$ at pH 8.5 (Olsen 1954), Agro Services International ASI (1984) and 1M NaC1 acidified to pH 3.0 (Anam *et al.* 1981). The corresponding P-values are designated as Bray P_1, Bray P_2, P_{HS}, P_{MG}, P_{NHC}, P_{AS}, and P_{NaC1} respectively.

Pot experiments were conducted in net house on wheat (Aghrani variety) as the test crop. The treatments comprised seven graded levels of P (0, 25, 35, 40, 45, 60 and 65 kg P_2O_5/ha). Depending on the available N and K of each soil, a basal application for the two elements was made according to the Fertilizer Recommendation Guide of BARC (1989) to support normal plant growth. The sources of N, P and K fertilizers were Urea, TSP and MP respectively. The experiments were done in plastic pots of 1 kg size. The pots, replicated thrice, were arranged in a completely randomized design. After seedling emergence, thinning were done twice and an equal number of plants were kept in each pot of the same series. However, the number varied in pots for a particular series. The test plants were allowed tc grow up to maturity. Two samplings (part of the total number of plants in a pot), one after 45 days and the other after 85 days of germination, were made. Dry matter production was recorded pot wise after washing, air drying and drying in an oven at 80-85° C for 48 hours. Plant samples were digested with ternary acid mixture (HNO_3 : H_2SO_4 : $HC1O_4$ :: 5:1:2) for determination of P-content in plant by vanadomolybdate yellow color method (IRRI 1978).

Total P uptake/100 plants (in g) were calculated by multiplying P per gram plant sample with the weight of 100 plant samples. Correlation coefficients between extractable P by different extracts and wheat yield of control, P uptake of control etc., were worked out by the method outlined by Cochran and Cox (1962).

Result and Discussion

The general properties of the 11 soils under study are presented in Table 1. The amounts of available phosphorus extracted by different methods used in this study are presented in Table 2. The dry matter yields and P-uptake/100 wheat plants with and without added phosphorus for both stages of harvest are presented in Table 3.

Table 1. Some properties of the soils under study.

Soil Series	pH	Texture	CEC meq%	O.C. (%)	Total N (%)	C/N Ratio	Avail. N (ppm)	Avail. K (meq%)
Noadda	5.4	SiCL	7.27	0.31	0.08	3.88	42.75	0.13
Ranisankail	5.3	SL	4.62	0.51	0.04	12.75	30.00	0.27
Ghatail	6.5	C	21.80	1.11	0.13	8.54	44.22	0.15
Mirsarai	4.9	SiC	21.80	1.34	0.13	10.31	50.12	0.19
Pirgacha	4.9	SL	7.93	1.07	0.09	11.89	45.70	0.20
Chandina	4.7	SiCL	10.57	1.68	0.11	15.27	63.39	0.50
Sonatala	5.3	SiL	7.27	0.94	0.09	10.93	50.12	0.16
Khadimnagar	5.2	SCL	13.22	1.08	0.12	9.00	72.24	0.19
Kalma	5.1	SiC	18.50	1.84	0.19	9.68	48.65	0.38
Chandra	5.3	CL	7.27	1.08	0.09	12.00	35.43	0.22
Tejgaon	6.0	L	5.95	0.77	0.06	11.85	28.00	0.15

It is apparent from the Table 2 that the amounts of phosphorus extracted from a particular soil by different extractants as well as by a particular extractant from different soils differed appreciably depending on the soils and the extractants used. The dry matter yield varied from 0.17 to 1.34 g/pot and 0.730 to 8.84 g/pot at the flowering and at the harvesting stages respectively in various soils (Table 3), exhibiting a wide variation in the inherent P fertility status of the soils. The content of phosphorus in the plants at the harvesting stage was higher than that at the flowering stage (Table 3). Similar findings have also been reported by Anam *et al.* (1981).

In many cases, it was observed that dry matter yields (either straw or total) were higher at control than at other rates of P application. This indicates that there were very little difference in the supply of available P from the original and P-treated soils. In some cases, yield was found to have increased at low P-applications and then decreased up to 40 to 45 kg/ha P-application but further increase in applications beyond 45 kg/ha again showed yield increase. The reason could be

that, at the medium application rates there were imbalance of nutrients, particularly for K and N, as they were added as a basal dose on the basis of soil analysis while at the higher doses, the basal application rates were suffcient for better utilization of the applied phosphorus.

Table 2. Extractable soil P by different extractants.

Soil Series	Extractable P (ppm)						
	Bray-1	Bray-2	Truog	Morgan	Olsen	ASI	1M NaC1
Noadda	2.39	2.66	0.35	0.78	30.59	5.18	0.09
Ranisankail	33.12	32.59	5.07	0.70	58.96	44.93	0.69
Ghatail	0,73	1.33	0.18	1.04	50.54	3.45	0.17
Mirsarai	5.45	8.65	0.35	0.62	38.57	12.07	0.17
Pirgacha	68.50	62.84	4.37	0.57	59.85	58.75	0.52
Chandina	44.28	28.66	6.99	1.73	128.12	342.14	0.52
Sonatala	5.85	11.97	1.05	0.41	53.20	8.64	0.09
Khadimnagar	2.46	2.00	0.35	0.36	38.57	5.18	0.09
Kalma	58.19	25.27	3.15	1.94	96.20	438.91	0.52
Chandra	3.92	4.66	0.35	0.29	42.56	6.91	0.09
Tejgaon	27.46	31.26	8.74	1.24	63.84	29.38	1.38
Mean	22.94	19.26	2.81	0.88	60.09	86.87	0.39

In the present study, the dry matter yield and P-uptake by wheat were considered as a function of the available P-levels in the soils as determinded by various methods. Comparison among methods, therefore, was made on the basis of correlation with the dry matter yield and P-uptake in wheat at two stages. The correlation values are presented in the Table 4.

The correlation study showed that the dry matter yield was correlated significantly with P_{HS} and P_{NHC} at both stages under control condition. However, the correlation was better at the flowering stage ($r=0.910$ at 1% for P_{HS} and $r=0.830$ at 1% for P_{NHC}) than at the harvesting stage ($r=0.641$ at 5% for P_{HS} and $r=0.678$ at 5% for P_{NHC}). Under the same condition the correlation of P-uptake with P_{HS} and

P_{NHC} were also found to be significant at the 1% confidence level at both stages (Table 4).

Table 3. Wheat yield, P concentration and P-uptake/100 plants at the two stages of growth (a) at flowering stage (straw only) (b) at harvesting stage (total plant).

(a)

Soil Series	Dry matter yield (g)		Percent P in Plant		P uptake/100 plants (g)	
	Control	Fertilized	Control	Fertilized	Control	Fertilized
Noadda	0.206	0.313	0.10	0.12	0.01	0.01
Ranisankail	0.773	0.860	0.16	0.17	0.04	0.04
Ghatail	0.493	0.557	0.10	0.12	0.01	0.01
Mirsarai	0.170	0.267	0.14	0.22	0.01	0.01
Pirgacha	0.640	0.770	0.10	0.13	0.02	0.02
Chandina	1.170	1.340	0.17	0.20	0.05	0.07
Sonatala	0.427	0.603	0.21	0.16	0.02	0.02
Khadimnagar	0.227	0.323	0.10	0.12	0.01	0.01
Kalma	0.590	1.050	0.22	0.22	0.04	0.07
Chandra	0.273	0.393	0.09	0.13	0.01	0.01
Tejgaon	0.903	0.903	0.17	0.20	0.05	0.05

(b)

Soil Series	Dry matter yield (g)		Percent P in Plant		P uptake/100 plants (g)	
	Control	Fertilized	Control	Fertilized	Control	Fertilized
Noadda	0.730	1.733	0.33	0.36	0.03	0.05
Ranisankail	5.660	6.073	0.31	0.32	0.11	0.16
Ghatail	2.133	3.110	0.38	0.39	0.03	0.05
Mirsarai	1.910	3.413	0.35	0.37	0.13	0.15
Pirgacha	3.687	5.610	0.48	0.41	0.16	0.17
Chandina	4.620	7.197	0.35	0.36	0.17	0.19
Sonatala	4.557	5.853	0.29	0.31	0.05	0.08
Khadimnagar	0.963	1.733	0.19	0.23	0.01	0.03
Kalma	8.613	8.840	0.41	0.43	0.18	0.43
Chandra	0.843	3.067	0.24	0.33	0.01	0.04
Tejgaon	5.700	6.300	0.34	0.44	0.14	0.20

1M NaC1 extracted P (P_{NaC1})correlated positively and significantly with dry matter yield and P-uptake at the flowering stage and at the harvesting stage (r=0.729 at 1% at the flowering stage and r=0.637 at 5% at the harvesting stage for dry matter and r=0.819 at 1% at the following stage and r=0.630 at 5% level for P-uptake). Bray P_1 and Bray P_2 were significantly correlated with dry matter yield and P-uptake by wheat at both stages. But in each case, the value of correlation was higher in Bray P_1 than in Bray P_2. The remaining two extractants viz,

Morgan and ASI were correlated significantly with P-uptake at both stages and with dry matter yield at the harvesting but not at the flowering stage. The sequence of efficiency of the chemical extraction methods as arranged on the basis of correlation with dry matter yield and P-uptake by wheat plant at the flowering stage under control condition, therefore, stand as below :

dry matter yield : $P_{HS} \rightarrow P_{NHC} \rightarrow P_{NaCl} \rightarrow$ Bray $P_1 \rightarrow$ Bray $P_2 \rightarrow P_{AS} \rightarrow P_{MG}$

P-uptake : $P_{HS} \rightarrow P_{NaCl} \rightarrow P_{NHC} \rightarrow P_{MG} \rightarrow$ Bray $P_1 \rightarrow P_{AS} \rightarrow$ Bray P_2

In the present study, the Truog method (P_{HS}) was found to be the most suitable for the assessment of available P for most of the soils under study. This might possibly had resulted in the dissolution of the phosphate from A1-P or Fe-P in these soils which bear consistent relationship with yield or P-uptake by wheat.

Table 4. Correlation coefficients (r) between extractable soil P and dry matter yield at control and P uptake/100 plants at control at the flowering stage and at the harvesting stage.

Extractable P	Flowering stage		Harvesting stage	
	Yield	P-uptake	Yield	P-uptake
Bray P_1	0.643*	0.636*	0.708**	0.847**
Bray P_2	0.625*	0.557*	0.556*	0.756**
P_{HS}	0.910**	0.921**	0.644*	0.718**
P_{MG}	0.499ns	0.716**	0.688**	0.671*
P_{NHC}	0.830**	0.794**	0.678*	0.711**
P_{AS}	0.529ns	0.624*	0.691**	0.674*
P_{NaCl}	0.729**	0.819**	0.637*	0.631*

* significant at 5% level, ** significant at 1% level.

Olsen method (P_{NHC}) ranked second in superiority in determining available P. Chang and Juo (1963) and Pratt and Garber (1964) had found Olsen's method to be satisfactory for acidic soils. Generally, this method has been recommended for alkaline calcareous soils. However, in acid soils $NaHCO_3$ at pH 8.5 extracts the soluble P present in the form oF A1-P or Fe-P or that adsorbed on clay surfaces (Khanna and Mahajan 1971). This could be the reason of its suitability for these

soils. According to Anam *et al.* (1978), $NaHCO_3$ appeared to be the best method for some soils of Bangladesh in extracting available P.

Acidified 1M NaC1 (P_{NaC1}) appeared to be the third suitable method in the present study for the determination of available P. Anam *et al.* (1978) reported that 1N NaC1 was the best method in estimating available P of some Bangladesh soils with respect to rice. The results of the present study are in good agreement with the findings of Anam *et al.* (1979, 1981).

The soil test values for Bray P_1 and Bray P_2 were correlated with each other (r=0.902 at 1% level). The NH_4F constituent of Bray's extracting solution removes easily the exchangeable P by its complex formation with A1-P and Fe-P, whereas HCI removes the easily acid soluble phosphates which contribute to the suitability of this method for the present set of soils. The suitability of Bray P_1 method for acidic soils is in line with the observations of Subramanian (1971). According to Anam *et al.* (1979, 1981) and Rahman *et al.* (1995), Morgan and ASI methods respectively were suitable methods for some soils of Bangladesh. But similar observations were not made in the present study among other methods.

To further substantiate the observations, the principle of linear regression was applied, assuming that the relationship between available-P as measured by any one of the methods and the corresponding P uptake by plants to be linear, i.e., y = mx+c. It was observed from the estimated regression lines that most of the observed values (P-uptake) fell more or less closely to the regression lines at both the stages and the proximity of the values to the regression lines suggested that the relationships between Olsen's (P_{NHC}) reagent extractable P with their correspondong uptake by 100 plants at both stages was by far the best.

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