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EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON PHYTOAVAILABILITY OF PHOSPHORUS TO WATER SPINACH (*Ipomoea aquatica* cv. Kankon)

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ABSTRACT

A pot experiment was conducted to investigate the effect of cow manure, city waste, chicken manure and TSP on the growth of water spinach (*Ipomoea aquatica* cv. Kankon) and the phytoavailability of phosphorous (P) in soil. An air dried sandy loam soil was mixed with cow manure, city waste, chicken manure and TSP at rates equivalent to 0, 200, 400 and 800 mg P kg^{-1} soil based on total P. The number of leaf, maximum height, and dry weight of shoot and root of water spinach were influenced by these amendments and their different application rates. The highest leaf number, maximum height, dry weight of shoot and root were obtained with the cow manure treatment of 800 mg P kg^{-1} and lowest with the control (T0). Among the amendments, TSP produced the least dry matter yield. Like dry matter yield, P concentration in the plant parts increased with increasing rates of P from different amendments. Phosphorus concentration in the shoots and in the roots of control plants were 1188 and 1171 mg kg^{-1}, respectively. At the highest rate (800 mg P kg^{-1}) of P application, P concentrations in the shoots were 4894, 3815, 5528 and 6179 mg kg^{-1} in the cow manure, city waste, chicken manure and TSP fertilizer treatments, respectively, while in the roots, the corresponding values were 3704, 4397, 4717 and 4926 mg kg^{-1}. After the plant harvest, Olsen P of the soil was measured. Irrespective of amendments, Olsen P increased with P application rates. The extractability of P from different amendments was in the order: TSP > cow manure > chicken manure > city waste. Olsen P of soil showed very strong positive correlation with both shoot P (r = 0.718, p = 0.000) and root P concentration (r = 0.548, p = 0.000) of water spinach that indicate suitability of Olsen P to predict plant available P. These results imply that cow manure could be recommended to use in the agricultural field for producing optimum yield when no additional chemical fertilizers are applied.

Keywords: water spinach, organic manure, phosphate fertilizer, phytoavailability, olsen P.

1. INTRODUCTION

Soil phosphorus (P) belongs to two broad groups: organic and inorganic. Organic P is found in plant residues, manures, and microbial tissues. Soils low in organic matter may contain less than 3% of their total P in the organic form, but high organic matter (OM) soils may contain 50% or more of their total P content in the organic form (Griffith, 2011). Inorganic forms of soil P consist of apatite, complexes of iron and aluminum phosphates, and P absorbed on clay particles. The solubility of these P compounds, as well as organic P is extremely low and only very small amounts of soil P are in solution at any one time. Most soils contain less than a pound per acre of soluble P, with some soils containing considerably less. Through adequate P fertilization and good crop/soil management, soil solution P can be replaced rapidly enough for optimum crop production (Khasawneh *et al*., 1980).

Rapidly rising prices of P fertilizers and the concern of high crop intensities in our country have stimulated the interest of using different types of organic amendments in our soils. Organic amendments contain considerable amounts of organic phosphorus which are mineralized to available phosphorus for plant growth. Unfortunately, OM status of Bangladesh soil is one of the lowest in the world. The average OM content of Bangladesh soils is less than 1%, ranging between 0.05 and 0.9% in most cases. Organic matter supply in soil is one of the major constraints to the agriculture of the country and hence the release of P from OM is negligible (Banglapedia, 2008). Compost additions can improve the fertility and the physio-chemical properties of soils (Kashem and Singh, 2001; Zheljazkov and Warman, 2003).

The availability of city wastes, cow and chicken manures P to crops and its impact on soil P pool may differ from that of inorganic P fertilizer (Kashem *et al*., 2004a and 2004b; McCoy *et al*., 1986; Gale *et al*., 2000). McCoy *et al*., (1986) found that biosolids (treated city wastes) P was four to seven times less available than triple super phosphate P. In contrast, other studies have suggested that P in organic amendments may be equally or more available than fertilizer P (Meek *et al*., 1979; Gale *et al*., 2000). With this view, this study was conducted to investigate the effect of cow manure, city waste, chicken manure and TSP on the growth of water spinach and the phytoavailability of phosphorous in soil. Water spinach (*Ipomoea aquatica* cv. Kankon) was used as a test plant. It is one of the most important vegetable crops in Bangladesh.

2. MATERIALS AND METHODS

A pot experiment was conducted in the crop field of the Department of Soil Science, University of Chittagong using a Pahartoli Silty Clay Loam surface soil. Soil samples were collected, air dried and passed through

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4-mm sieve for using it in the pots. For laboratory analysis, a sub sample was air dried and passed through a 2-mm sieve and stored. Soil pH was 4.8 (1:2.5 soil to water ratio), organic carbon (Walkley and Black, 1934) was 0.73% and CEC (extraction with 1 M NH_4OAc (pH 7.0; Soil Survey Staff 1992)) was of 6.05 cmol kg^{-1}. The soil contained 68% sand and 18% clay measured by hydrometer method (Bouyoucos 1962). Cow manure was collected from Chittagong University Campus, city waste from Ananda Bazar of Chittagong City and chicken manure was collected from the Veterinary and Animal Sciences University of Chittagong.

Four kilogram (4 kg) air dried soil were mixed with the cow manure, city waste, chicken manure and TSP at rates equivalent to 0, 200, 400, 800 mg P kg^{-1} soil, respectively based on total P. There were 13 treatments and each treatment was replicated three times. The pots were arranged in a completely randomized design. Five water spinach (*Ipomoea aquatica* cv. Kankon) seeds were sown to each plastic (50 cm in diameter) pot. One week after emergence, three seedlings were retained in each pot. Plants were grown for 45 days. The plants were irrigated occasionally up to 25 days of sowing and from then onwards daily. At 45 days of growth, plants were harvested, leaf number, maximum height of water spinach was recorded thereafter, plants were separated into shoots and roots, and air dried for several days. After words, the shoots and roots were oven dried at 65°C for 72 hours and dry mass was recorded. Soil samples were collected from each pot after harvest to measure soil pH and 0.5 M $NaHCO_3$ (Olsen P) extractable phosphorus.

Total phosphorous in the soil, organic amendments and in the plant tissues were determined colorimetrically by ascorbic acid blue color method (Murphy and Riley, 1962) after digestion with H_2O_2-H_2SO_4 (Akinremi *et al*., 2003) and the absorbance was measured by spectrophotometer at wave length of 882 nm. Total phosphorus concentration in the experimental soil was 0.03%, in the cow manure was 0.35%, in the city waste was 0.52% and in the chicken manure was 2.22%. The available phosphorous of the soil were determined by the same procedure as mentioned above after extraction with 0.5 M $NaHCO_3$ (Olsen *et al*., 1954).

Statistical analysis

Microsoft Excel and MINITAB program (Minitab Inc, 1996) were used for analysis of variance and correlation.

3. RESULTS

Plant growth

Height of plants varied from 30 cm in the control to 51 cm in the cow manure (800 mg P kg^{-1} soil). Among the treatments, increase of plant height was higher in the cow manure treated pots and lower in the TSP fertilizer treated pots. Total number of leaves per plant varied from 10 in the control to 18 in the cow manure (800 mg P kg^{-1} soil). Number of leaves was less influenced by the amendments and their different P application rates (Table-1).

Table-1. Effect of different doses of cow manure, city waste, chicken manure and TSP on the leaf number, height, and dry weight of water spinach.

Treatment (kg ha^{-1} P)	**Maximum height of shoot** (cm) **at harvest**	**Leaf number** ($plant^{-1}$)	**Dry weight of water Spinach** (g pot^{-1})	
			Shoot	**Root**
Control (T0)	29.7 c	11 b	1.51c	0.67 c
Cow Manure 200 (T1)	41.0 b	15 ab	3.98 b	1.26 b
Cow Manure 400 (T2)	48.0 a	17 a	5.73 a	2.02 ab
Cow Manure 800 (T3)	51.0 a	18 a	6.12 a	2.53 a
City Waste 200 (T4)	44.7 a	17 a	2.91 b	0.93 c
City Waste 400 (T5)	43.0 ab	15 ab	2.83 b	1.70 b
City Waste 800 (T6)	44.3 ab	16 a	3.02 b	1.42 b
Chicken Manure 200 (T7)	45.0 ab	15 ab	2.84 b	1.27 b
Chicken Manure 400 (T8)	40.3 b	15 ab	2.90 b	1.44 b
Chicken Manure 800 (T9)	42.0 b	15 ab	3.33 b	1.75 b
TSP 200 (T10)	34.4 bc	13 b	1.82 c	1.04 bc
TSP 400 (T11)	41.2 b	15 ab	2.73 c	1.35 b
TSP 800 (T12)	40.3 b	17 a	2.49 c	1.23 b

Means followed by the same letter(s) in a column do not differ significantly from each other at p = 0.05 level.

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Dry weights of shoots and roots were influenced by different amendments and also their rates of P addition. Dry weight of shoot increased from 1.51 g to 6.12 g and dry weight of root from 0.67 to 2.53 g pot^{-1} with increasing rates of cow manure application. In case of city waste, the highest dry weight of shoot and root were found at 800 mg P kg^{-1} and 400 mg P kg^{-1} rates of application, respectively. When chicken manure was applied at 800 mg P kg^{-1} rate, dry weight of shoot and root were 3.33 g and 1.75 g, respectively which were the highest among the treatments of chicken manure. At the 800 mg P kg^{-1} rate of TSP application, the dry weight of shoot and root were 2.49 and 1.23 g (the highest among the TSP application rates). The highest dry weight of shoot and root was obtained with the cow manure treatment of 800 mg P kg^{-1} and lowest with the control (T0) treatment. The second highest value was recorded in the chicken manure treatment (800 mg P kg^{-1}). Dry matter yield was least with TSP application among the amendments. Growth performance was better in the cow manure amended soils than the other amendments (Table-1).

Phosphorus concentration in plant parts

With few exceptions, phosphorus concentration in the shoots of water spinach increased with increasing rates of P application from different amendments. Phosphorus concentration in the shoot of control pot was the lowest of 1188 mg kg^{-1} and the highest of 6179 mg kg^{-1} with TSP (800 mg P kg^{-1} treatment), while in the roots, the corresponding values were 1171 and 4926 mg kg^{-1}, respectively. Phosphorus concentration in the shoots of water spinach increased from 3329 to 4894 in the cow manure amended pots, 3672 to 3815 in the city waste amended pots, 3852 to 5528 in the chicken manure amended pots and 4691 to 6179 mg kg^{-1} in the TSP fertilizer amended pots with the rates of P addition from 200 to 800 mg kg^{-1} soil. The same amendments increased root P concentration from 2864 to 3704, 2953 to 4397, 2516 to 4717 and 2724 to 4926 mg kg^{-1} in the cow manure, city waste, chicken manure and TSP fertilizer treated pots (Table-2).

Table-2. Effect of different doses of cow manure, city waste, chicken manure and TSP on the phosphorus concentration in shoot and root of water spinach, Olsen P and soil pH.

	Phosphorus concentration in plant (mg kg^{-1})		**Olsen P in soil** (mg kg^{-1})	**Soil pH**
	Shoot	Root		
Control (T0)	1188 d	1171 d	3.9 f	4.86 d
Cow Manure 200 (T1)	3329 c	2864 c	40.2 d	4.84 d
Cow Manure 400 (T2)	3729 c	2915 c	80.3 bc	5.11c
Cow Manure 800 (T3)	4894 b	3704 bc	108.2 c	5.45 ab
City Waste 200 (T4)	3672 c	2953 c	29.8 de	5.33 b
City Waste 400 (T5)	3783 c	4132 b	40.2 d	5.44 ab
City Waste 800 (T6)	3815 c	4397 b	54.7 d	5.55 a
Chicken Manure 200 (T7)	3852 c	2516 c	20.5 e	5.41 b
Chicken Manure 400 (T8)	4817 b	4135 b	40.2 d	5.47 ab
Chicken Manure 800 (T9)	5528 ab	4717 a	80.7 bc	5.55 a
TSP 200 (T10)	4691 b	2724 c	109.8 c	5.20 c
TSP 400 (T11)	6062 a	4283 b	205.5 b	5.00 d
TSP 800 (T12)	6179 a	4926 a	302.2 a	4.91 d

Means followed by the same letter(s) in a column do not differ significantly from each other at $p = 0.05$ level.

M $NaHCO_3$ extractable P and soil pH

The amount of P extracted with 0.5 M $NaHCO_3$ (Olsen P) followed the increasing trend of P additions from different amendments. The Olsen P in the soils ranged from 3.9 mg kg^{-1} (Control) to 302 mg kg^{-1} (TSP 800 mg kg^{-1}). It is evident that among the amendments, $NaHCO_3$ extracted highest amount of P from TSP fertilizer amended soil and lowest amount from the city waste amended soil. The P extractability from different amendments was in the order: TSP > cow manure > chicken manure > city waste.

After the harvest, pH measured in the control soil was 4.86, while it increased from 4.84 to 5.45, 5.33 to 5.55, 5.41 to 5.55 in the cow manure, city waste, chicken manure amended soils and decreased from 5.2 to 4.91 in the TSP fertilizer amended soils when the rates of P added from 200 to 800 mg P kg^{-1} soil from different amendments. Among the amendments, the highest changes in pH were observed in the cow manure amended soil and lowest in the chicken manure amended soil. Soil pH changes were almost similar in city waste and chicken manure amended soil.

Correlation coefficient of P concentration of shoot and root of water spinach with Olsen P of soil was calculated to find out the relationship among them. Olsen P showed very strong positive correlation with both shoot (r = 0.718, p = 0.000) and root P concentration (r = 0.548, p = 0.000) that indicate suitability of Olsen P to predict plant available P (Figure-1). Soil pH did not show any relationship with dry matter yield, plant P concentration and with Olsen P in soil in this study.

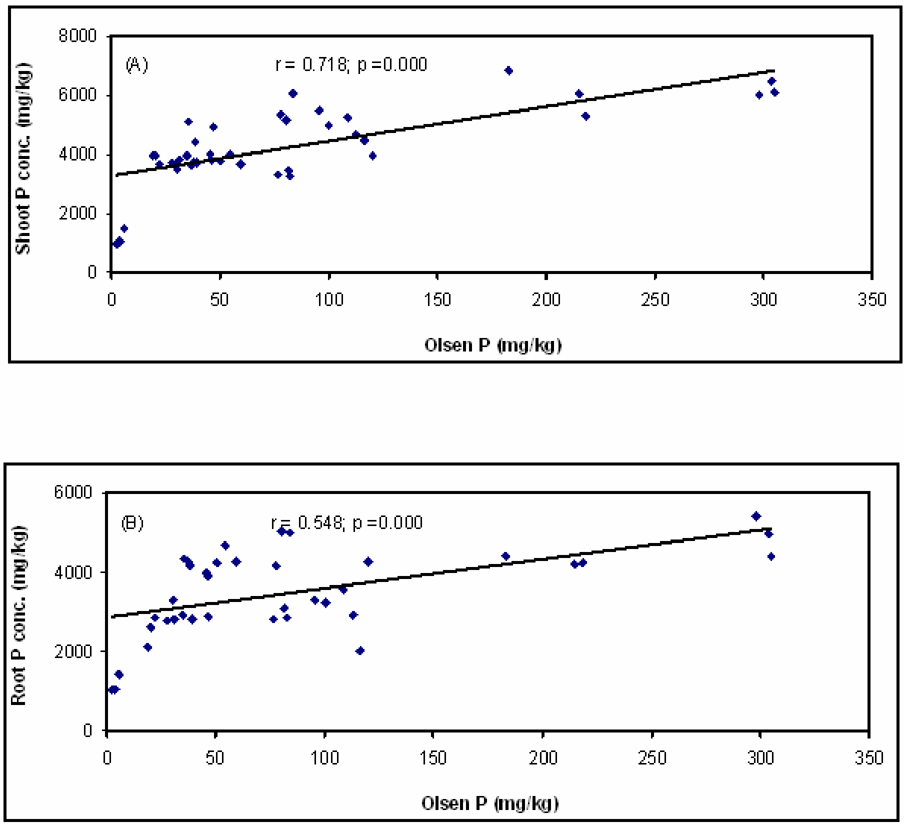

Figure-1. Correlation between (A) shoot P and Olsen P and (B) between root P and Olsen P concentration.

4. DISCUSSIONS

The higher increase in plant growth in the cow manure treated soils than the TSP treated soil might be due to the improved soil physical, chemical and biological properties that enhanced plant growth. The rise in productivity observed after addition of compost is attributed to the increase in the nutrient availability to the plants (Kashem and Warman, 2009; Kashem and Singh, 2001; Zheljazkov and Warman, 2003). Metal phytotoxicity issues associated with an acid soil would also be reduced with compost addition (Kashem and Singh, 2002; Hue and Amien, 1989).

Phosphorus concentration in the plant parts increased linearly with rates irrespective of amendments. It is evident from the result on P content under different treatments that application of TSP is more effective when P uptake is concern. Higher content of P in shoot and root under TSP 800 mg kg^{-1} and TSP 400 mg kg^{-1} is logical as TSP is soluble and immediately supply soluble P for immediate plant uptake and accumulation (Tisdale *et al*., 1985).

5. CONCLUSION

The rates of P addition from different amendments increased biomass production of water spinach significantly except the TSP fertilizer. The TSP fertilizer addition only increased plant P concentration not the growth as did other organic amendments. Higher biomass production in the organic amendments, especially in the cow manure treatments indicate that they provided other essential nutrients beside P and hence growth increased. The results imply that cow manure could be recommended to use in the agricultural field for producing optimum yield when additional chemical fertilizers are not applied.

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