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ABSTRACT

Phosphorus (P) correlation experiment has been done in Ultisol soil in Nanggung District, Bogor, Indonesia from 2006-2007 to find the best P extraction method which suitable for vegetables i.e Amaranth (*Amaranthus sp*), Kangkong (*Ipomoea aquatica L*), Eggplant (*Solanum melongena L*), Chili (*Capsicum annum L*), Tomato (*Lycopersicon esculentum Mill*), Green Bean (*Pahaseolus vulgaris L*), and Yard Long Bean (*Vigna unguilata L*). Treatments were P rate : 0, 45, 90, 135 dan 180 kg P₂O₅ha⁻¹ or equal to 0, 125, 250, 375 dan 500 kg SP36 (36% P₂O₅) ha⁻¹. Treatments were arranged in Randomized Complete Block design with three replications. Soil samples were taken from every plot and analized with five extraction methods. The extraction methods are HCl 25%, Morgan vanema, Bray 1, Mehlich and Olsen. Soil analysis result were correlated with each vegetable relative yield. The best soil extraction method is the soil extraction method that showed highest correlation with vegetable relative yield. Olsen method showed highest correlation with amaranth, chili and tomato relative yield, while HCL 25% showed highest correlation with yard long bean and eggplant. Morgan Vanema showed highest correlation with kangkong reative yield and Bray I for green bean.

INTRODUCTION

Phosphorus (P) is macro nutrient for plant. The amount of P needed by plant is second highest after Nitrogen. P nutrient have a role in carbohydrate, fat and protein metabolism. Phosphorus act as intermedier, to keep and supply energy for metabolism process like respiration and fermentation (Soepardi, 1983). P also also arranges enzymatic process, closely related to compilation of crop essential part like nucleic acid at cell core, increases resilience to disease and increases crop quality.

Sufficient amount of available P can increase root development, assist forming of flower initiation and other reproductive organ and quickens ripening process of fruit (Nyakpa, *et al.*, 1988; Rosmarkam and Yuwono, 2002). Addition of P into soil can increase production and dry matter of the plant. P nutrient in plant also help to reduce nitrogen stimulating fungus effect. P deficiency unabled plant to absorb other element, hence P deficiencies can lead to growth degradation.

Phosphor is immobile in soil. Most of it in unavailable form for plant which cause P availability is critical compared to other kind of nutrients. High soluble Al in soil also reduce P availability for plant, because Al can bond P in soil. Adiningsih (1988) showed that only

10-20% of P fertilizer given to the soil, that can absorbed by plant, the rest of it stay in soil and bond with Fe, Al and Ca.

Indonesia has many soil type with varies level of fertility. Ultisol soil is second largest soil type for agricultural use. Ultisol has acid soil reaction with pH level around 4.1-5.5 (Subagyo *et al.*, 2000). Hakim *et al.*, (1986), express that general constraint faced in acid mineral soil are low soil pH, unavailable N and P, lack Ca, Mg, K, and Mo, excessive Mn and Fe also high dissolved Al. All the problem faced in acid mineral soil are major problem which will inhibit plant growth and production

Rational and proportional P fertilizer can be reach by paying attention in nutrient status and dynamic in soil, and crop requirement to reach optimum production. Determination of fertilizer recommendation can be strived through soil testing, because this activity refers to soil condition and crop nutrition requirement. Soil testing can increase fertilizer use efficiency, soil productivity and farmers earnings also reduce contamination level of agricultural area.

Soil testing experiment can give fertilizer recommendation for a crop at various soil nutrition status (low/medium/high). This recommendation can be applied in other soil in the same family (Nursyamsi *et al.*, 2004) . Soil test consisted three steps, first phase is correlation test, continued with calibration and optimization of fertilizer. Correlation test is part of soil test to get recommendation of specific location, crop production and crop type.

Various methods of P soil at sub tropical area for specific commodity and crop production technique has developed, but in Indonesia soil P method done for paddy crop and some other field crop. Soil test method still seldom be done for vegetable commodity. This experiment conducted for seven kind of vegetable which are amaranth, kangkong, eggplant, chili, tomato, green bean and yard long bean.

For good P soil management, it is important to know soil P status and factors influencing it. One of way to determine soil nutrient status can be done by using soil extraction method. Many extractants are applicable to specify soil ability to provide P for crop, but the extractants are not always compatible with soil type, crop production technique and climate. Methods which commonly use to extract P from soil are Bray 1, Bray 2, Mehlich, Morgan, Truog, HCl 25% and air. Each of the method has different ability to extract P from soil. Hence need to be done experiment about soil correlation to determine that most suitable soil extraction method for specific crop and soil type so that usable as reference in building of P fertilizer recommendation. Best extraction method is the method showing highest correlation between P nutrient content and relative crop yield. Correlation is one of important phase to build fertilizer recommendation. Correlation experiment choose extraction method which suitable for specific nutrient, crop and soil type.

MATERIALS AND METHODS

Research was carried out at the SANREM Base camp at Hambaro Village, Nanggung Sub-District, Bogor, West Java, Indonesia from December 2006 to September 2007. The soil type in the location is *Ultisol*, which typically have low pH and high P-fixation by Aluminum.

The experiment is a randomized complete block design with three replications. Blocking is based on the field slope. The treatments are five rate of P fertilizer; 0, 125, 250, 375, 500 kg SP36/ha (SP36 content 36% P₂O₅) or equal to 0, 45, 90, 135 and 180 kg P₂O₅/ha.

Pre treatment soil samples were taken with a soil probe from the top 15 cm. Fertilizers were applied at pre plant, 3 and 6 weeks after planting (WAP). Pre plant fertilizer were 199 kg/ha Urea (45% N) and 90 kg/ha KCl (60% K₂O), applied 1 week before planting. At 3 and 6 WAP each 100 kg/ha Urea and 45 kg/ha KCl were applied. Phosphor rate were applied base on the treatments.

Preplant applications were applied of fertilizer broadcast and rototilled into raised bed approximately 0.9 m wide and 20 cm high. The plot size were 1.5 x 4 m, with 1.0 m for raise bed and 0.5 m as a ditch. Seven vegetables used in this experiment were Tomato (*Lycopersicon esculentum* L) var Ratna Chili (*Capsicum anuum* L) var. Gada, Eggplant (*Solanum melongena*) var. Mustang, Kangkung (*Ipomoea reptans* L) var Grand, and Yard Long Bean (*Vigna unguilata* L) var. 777, Amaranth (*Amaranthus* sp) var. local, Green Bean (*Phaseolous Vulgaris* L) var low land. Chili, Tomato, and Eggplants were spaced 0.5 m within row and 0.5 between rows (double rows). Yard long bean and Green bean were spaced 0.25 m within row and 0.5 between rows (double rows). Kangkung was spaced 0.15 m within row and 0.25 between rows (four rows) and Amaranth was spaced 0.25 m between rows without space within row.

The observation parameter divided into two, which are yield of the vegetables and soil P content analyzed with five different extraction methods. The result of Soil-P-content will be correlated with vegetable yield to determine the best soil analysis method that shows the highest correlation. Vegetable yields for amaranth and kangkung were measured from total crop weight and yield from eggplant, chili, tomato, green bean and yard long bean were measured from fruit weight per plant and per plot.

RESULTS AND DISCUSSION

Soil Analysis.

Pre plant soil analysis showed that soil acidity (pH) was low (5.20) that was mean the soil reaction was acid. Soil P₂O₅ concentration extracted from Hcl 25% and Bray 1 methods showed high soil P, but availability for the plant was low because Al bond. Soil Analysis is presented at Table 1

Table 1. Pre plant Soil Analyses for Ultisol at the Experimental Site.

Soil Character	Soil Index	Methods
pH H ₂ O	5.20	pH meter
pH KCl	4.10	pH meter
C-org (%)	1.70	Walkley and Black
N-org (%)	0.21	Kjeldahl
P HCl (mg/100 g)	39	HCl 25%
P Bray-1 (ppm)	10.8	Bray-1
K ₂ O Morgan (ppm)	167	Morgan
Ca (cmol/kg)	18.45	1 N NH ₄ Oac pH 7.0
Mg (cmol/kg)	4.63	1 N NH ₄ Oac pH 7.0
K (cmol/kg)	0.33	1 N NH ₄ Oac pH 7.0
Na (cmol/kg)	0.07	1 N NH ₄ Oac pH 7.0
CEC	27.98	1 N NH ₄ Oac pH 7.0
Al (me/100 g)	1.14	1 N KCl
H (me/100 g)	0.40	1 N KCl
Tekstur :		
Pasir (%)	10	Pipet
Debu (%)	30	Pipet
Liat (%)	60	Pipet

Result

Result of the experiment showed that Amaranth, Kangkong,, Eggplant, Chili, Tomato and Green Bean Crop Relative Yield linearly increased with an increase in P rate from 0 to 180 kg P₂O₅ ha⁻¹ (Table 2).

Table 2. The Effect of P Rate on Plant and Fruit Weight per Plant

P Rate (kg/ha P ₂ O ₅)	Amaranth	Kangkong	Total Fruit Wight per Plant (gram)				
	Plant Weight	shoot weight	Eggplant	Chili	Tomato	Green Bean	Yard Long Bean
	-----g-----						
0	247.00	3.69	80.54	66.64	95.67	27.33	62.51
45	1304.83	2.6	75.56	102.70	150.39	86.44	101.96
90	1999.33	5.14	167.79	86.58	204.97	36.21	85.96
135	2179.67	6.67	44.68	144.17	176.29	96.48	39.63
180	2804.31	7.99	176.47	140.49	315.76	102.96	84.91
Regression	L*	L*	L*	L**	L**	L*	ns

Amaranth (*Amaranthus sp*)

From five extraction methods used to extract soil P content in amaranth-cultured soil, Olsen method showed the highest correlation value, which is 0.91. But, Mehlich 1, HCl 25%, Bray 1 and Morgan Vanema also show high correlation with amaranth relative yield, each showed more than 0.50 correlation value. The closer the correlation value to 1, the higher the correlation between two compared variables (Table 3.).

Table 3. Correlation Coefficient between Extracted P Value of 5 Extraction Methods with Amaranth Relative Yield

Extraction Methods	Linear Equation	Coefficient Correlation
HCL 25%	$Y = -12.125 + 0.118 P$	0.76416
Olsen	$Y = 1.192 + 3.445 P$	0.90706
Bray 1	$Y = 14.508 + 1.044 P$	0.76033
Mehlich	$Y = 16.639 + 1.577 P$	0.78158
Morgan Vanema	$Y = 13.457 + 22.851 P$	0.69082

Kangkung (*Ipomoea aquatica* L.)

From the data in table 4, we can see that Morgan Vanema method showed the highest correlation value compared to kangkung relative yield, followed by Olsen. The other methods show small correlation values (under 0.50).

Table 4. Correlation Coefficient between Extracted P Value of 5 Extraction Methods with Kangkung Relative Yield

Extraction Methods	Linear Equation	Coefficient Correlation
HCL 25%	$Y = 23.986 + 0.088 P$	0.40556
Olsen	$Y = 46.360 + 1.659 P$	0.59191
Bray 1	$Y = 54.621 + 0.323 P$	0.37589
Mehlich	$Y = 52.918 + 0.499 P$	0.47877
Morgan Vanema	$Y = 21.960 + 14.078 P$	0.69361

Eggplant (*Solanum melongena* L.)

Table 5. Correlation Coefficient between Extracted P Value of 5 Extraction Methods with Eggplant Relative Yield

Extraction Methods	Linear Equation	Coefficient Correlation
HCL 25%	$Y = 47.745 + 0.042 P$	0.72355
Olsen	$Y = 60.189 + 1.032 P$	0.66928
Bray 1	$Y = 63.510 + 0.311 P$	0.56725
Mehlich	$Y = 63.222 + 0.479 P$	0.44726
Morgan Vanema	$Y = 63.069 + 1.158 P$	0.37536

Eggplant relative yield showed the highest correlation value when compared with HCl 25% method. Olsen and Bray 1 Methods showed relative higher values than Mehlich and Morgan Vanema that showed less than 0.50 correlation values (Table 5).

Chili (*Capsicum annuum* L.)

Like in Amaranth, Olsen method also showed highest correlaton with Chili relative yield. The correlation value is 0.90 (Table 6). The Olsen value followed by Mechlich, Bray 1, HCl 25% and Morgan Vanema. All the extraction methods showed more than 0.50 correlation value.

Table 6. Correlation Coefficient between Extracted P Value of 5 Extraction Methods with Chili Relative Yield

Extraction Methods	Linear Equation	Coefficient Correlation
HCL 25%	$Y = 2.417 + 0.082 P$	0.78478
Olsen	$Y = 25.991 + 1.923 P$	0.90242
Bray 1	$Y = 30.141 + 0.674 P$	0.82256
Mehlich	$Y = 28.213 + 1.113 P$	0.87930
Morgan Vanema	$Y = -15.970 + 10.881 P$	0.71011

Tomato (*Lycopersicon esculentum* L)

Phosporus application from 0 to 180 kg P₂O₅ ha⁻¹ inczased linearly fruit weight of tomato (Table 7). The best method to extract Soil P from Tomato-cultured soil is Olsen, like for amaranth and eggplant. The correlation value followed by Bray 1 and Mechlich methods. However, HCl 25% method and Morgan Vanema showed very little correlation value.

Table 7. Correlation Coefficient between Extracted P Value of 5 Extraction Methods with Tomato Relative Yield

Extraction Methods	Linear Equation	Coefficient Correlation
HCL 25%	$Y = 15.070 + 0.055 P$	0.46952
Olsen	$Y = 24.034 + 1.144 P$	0.80757
Bray 1	$Y = 33.579 + 0.378 P$	0.59688
Mehlich	$Y = 33.461 + 0.474 P$	0.56113
Morgan Vanema	$Y = 34.812 + 2.531 P$	0.16587

Green Bean (*Pahaseolus vulgaris* L)

Table 8. Correlation Coefficient between Extracted P Value of 5 Extraction Methods with Green Bean Relative Yield

Extraction Methods	Linear Equation	Coefficient Correlation
HCL 25%	$Y = -20.334 + 0.110 P$	0.74633
Olsen	$Y = 15.476 + 0.551 P$	0.49675
Bray 1	$Y = 15.932 + 0.545 P$	0.84214
Mehlich	$Y = 20.162 + 0.757 P$	0.59180
Morgan Vanema	$Y = -10.165 + 7.936 P$	0.64503

The effect of P application to Green Bean relative yield correlated with soil extraction methods showed that Bray 1 give the best correlation value (Table 8). The value followed by Morgan Vanema, HCl 25% and Mechlich. The correlation value of Olsen showed the smallest value than other methods.

Yard Long Bean (*Vigna unguilata*)

HCl 25% method showed the highest correlation value compared to yard long bean relative yield (0.86). The correlation value followed by Mechlich, Olsen, Bray 1 and Morgan Vanema. All extraction methods showed more than 0.50 correlation value (Table 9).

Table 9. Correlation Coefficient between Extracted P Value of 5 Extraction Methods with Yard Long Bean Relative Yield

Extraction Methods	Linear Equation	Coefficient Correlation
HCL 25%	Y = 10.853 + 0.082 P	0.85964
Olsen	Y = 34.689 + 0.549 P	0.77968
Bray 1	Y = 41.158 + 0.509 P	0.74870
Mehlich	Y = 41.875 + 0.739 P	0.79835
Morgan Vanema	Y = 36.941 + 4.618 P	0.64050

CONCLUSSION

From the experiment can be cloncluded

1. In the level of soil P concentration of 10.8 ppm (Bray-1) of Ultisol, application of P fertilizer up 180 kg P₂O₅ ha⁻¹ increased linearly plant weight of amaranth, kangkong, eggplant, chili, tomato and green bean.
2. Olsen method showed highest correlation with amaranth, chili and tomato relative yield, while HCL 25% showed highest correlation with yard long bean and eggplant. Morgan Vanema showed highest correlation with kangkong and Bray I for green bean.

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