World Journal of Agricultural Research, 2015, Vol. 3, No. 2, 70-73
Available online at http://pubs.sciepub.com/wjar/3/2/6

DOI:10.12691/wjar-3-2-6

Assessment of Soil Phosphorus and Phosphorus Fixing Capacity of Three Vegetable Farms at Cabintan, Ormoc City, Leyte

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Received February 02, 2015; Revised March 04, 2015; Accepted March 27, 2015

Abstract Three vegetable farms in Cabintan, Ormoc City – a primary source of vegetables in Leyte Province, Philippines were carefully and randomly selected for the principal concern of this study. It aimed to determine and investigate the Available Soil Phosphorus and Soil Phosphorus Fixing Capacity in vegetable farms located in a mountainous area which soil mainly developed from volcanic tuff, basaltic and andesite materials. Five hundred grams (500g) of aggregate soil sample were collected from each farm. Result revealed that soil samples had low pH values ranged from 5.24 to 5.79 and high organic matter (OM) content which ranged from 10.852% to 22.502%. The available soil phosphorus is low but the Phosphorus fixing capacity of the soil is very high (92.46%-99.15%).

Keywords: *available soil phosphorus, phosphorus fixing capacity, soil test p level*

Cite This Article: Mary Chris P. Nierves, and Felix M. Salas, "Assessment of Soil Phosphorus and Phosphorus Fixing Capacity of Three Vegetable Farms at Cabintan, Ormoc City, Leyte." *World Journal of Agricultural Research*, vol. 3, no. 2 (2015): 70-73. doi: 10.12691/wjar-3-2-6.

1. Introduction

Not all plant problems are caused by insects or diseases. Sometimes an unhealthy plant is suffering from a nutrient deficiency or even too much of any one nutrient. Plants require a mix of nutrients to remain healthy. Nutrients that are needed in relatively large amounts are called the macronutrients and phosphorus (P) is one of the essential macronutrients required by plants [4]. It plays a role in photosynthesis, respiration, seed and fruit production, energy production, storage, transfer, cell division and enlargement. Adequate supply of P promotes or enhances early root formation and better growth of plants, water use efficiency, while early maturation of fruit and grain has been observed in cold temperate regions [4]. The biological function of P in living organisms is most notable in the ubiquitous ATP/ADP energy transport and storage compounds [2]. It is obvious that without DNA plants cannot reproduce, which means that they cannot produce the seed and fruit that people harvest from many crops.

Phosphorus exists in soils in organic and inorganic forms. Organic forms of P were found in humus and other organic material which is released by mineralization process involving soil organisms. Primary P minerals including apatites, strengite, and variscite are very stable, and the release of available P from these minerals by weathering is generally too slow to meet the crop demand although direct application of phosphate rocks (i.e. apatites) has proved relatively efficient for crop growth in acidic soils. In contrast, secondary P minerals including calcium (Ca), iron (Fe), and aluminum (Al) phosphates vary in their dissolution rates, depending on size of mineral particles and soil pH [10,11]. Phosphorous is a highly reactive element, and as such, does not exist in the elemental form in the soil [7]. Phosphorus reacts readily with positively charged iron (Fe^{3+}), aluminum (Al^{3+}), and calcium (Ca^{2+}) ions to form relatively insoluble substances. The particular forms that are created depend on other soil factors such as the soil pH, temperature, moisture, and other elements. In most situations there is very little soluble P in the soil at any point in time. When this occurs, the phosphorus is considered fixed or bound and tied up. The solubility of the various inorganic phosphorus compounds directly affects the availability of phosphorus for plant growth. Likewise, the unavailability of phosphorus might signal its interaction with other metallic pollutants in the soil [13]. It can serve as an indicator for proper nutrient management in vegetable farms as well as the status and condition of the soil. For this reason, to determine the Available Soil Phosphorus and investigate the Soil Phosphorus Fixing Capacity is necessary.

2. Materials and Method

2.1. Study Site Selection and Description and Soil Sampling

Three (3) vegetable farms within Brgy. Cabintan, Ormoc City, Leyte were carefully and randomly chosen for the principal concern of this study. The site is located approximately 18 km Northeast of Ormoc City in Leyte Province with an elevation of around 900m above sea level characterizing a soil in mountainous area mainly developed from volcanic tuff, basaltic and andesitic materials which were ejected during the period of active volcanism [1]. Agro-climatic pattern of the area indicated a wet climate with annual rainfall greater than 2500 mm, slightly dry season moisture deficit, and a growing period of 270-320 days in hilly, mountainous to highlands area [10].

In each farm, twenty five grams (25g) of soil sample from 0-20cm depth was collected from each 10 randomly selected points and was homogenized to represent the surface soil of the whole farm and another 25 g in 20-40cm from each 10 randomly selected points was collected and homogenized to represent the subsurface of whole farm (Figure 1). The soil samples were air dried, grounded and passed through 2 mm sieve and were placed in zip locked plastic container prior to phosphorus analysis.

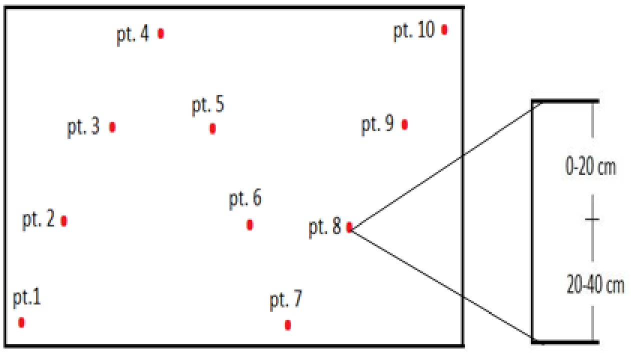


Figure 1. Experimental Layout for soil sample collection in 10 randomly selected points in each selected farms

Soil OM, pH and phosphorus content were analyzed by the Central Analytical Services Laboratory, PhilRootcrops Complex and Soil Research, Testing and Plant Analysis Laboratory (SRTPAL) of the Department of Agronomy and Soil Sciences, College of Agriculture, Visayas State University, Visca, Baybay City, Leyte.

2.2. Extractable Soil Phosphorus and P-Fixing Capacity Determination

Two and a half gram (2.5 g) of air dried sieved soil was taken for each treatment in 125 mm Erlenmeyer Flasks (Table 1). One milliliter (1ml) of different concentrations (0 µg/cc, 150 µg/cc, 300 µg/cc, 450 µg/cc, 600 µg/cc,) of soluble phosphorus, in the form of potassium dihydrogen phosphate (KH_2PO_4) was carefully added to each flask as per treatment so as to wet the soil uniformly. The Erlenmeyer flasks were then covered with parafilm and incubated at room temperature (30°C) for 2 months. The samples were sent to PhilRootcrops laboratory for available phosphorus analysis. The P- Fixation Capacity of soil was calculated using the equation formulated as shown below [9]:

$$b = \frac{\sum xy - N\dot{x}\dot{y}}{\sum x^2 - N(\dot{x})^2} \quad (1)$$

where, *b* represents the fraction of added P, which remained available under the condition of the experiment. Added P, released P and number of concentrations of P added (5) are represented by *x*, *y* and *N* respectively. The percent of P-fixation of added P was thus given by:

Phosphate fixation capacity (%),

$$\mathrm{P} = 100 - b * 100 \quad (2)$$

Table 1. Treatment details for P-fixation capacity determination

Concentrations of P added as KH_2PO_4 (µg/cc)	Soil Taken (g)	Effective concentration on addition of 1 cc P solution in 2.5 g of soil (µg/g)
0	2.5	0
150	2.5	60
300	2.5	120
450	2.5	180
600	2.5	240

3. Results and Discussion

3.1. Soil pH, Organic Matter and Available Phosphorus

The values of chemical characteristics of experimental soils in three different vegetable farms are presented in Table 2. Soil pH values range from 5.24 to 5.79 which implies that all soil samples were acidic. Farm C is said to be the most acidic among the three with 5.37 pH in soil samples from 0-20 cm depth and 5.24 pH in soil samples from 20-40cm depth. There are factors that enhance the acidity of the soil these includes: the decomposed organic matter producing humic acid, nitric acid and sulfuric acid that increases the H^+ ion in the soil; rainfall which causes leaching that tends to wash away the basic cations like Mg^{2+}, Ca^{2+} and K^+ that are replaced by acidic cations like H^+ making soil acidic; and, microbial and root respiration because of the CO_2 which is slightly acidic [12]. The particle size distribution of % clay, silt and sand indicated that the soil from Cabintan is dominated by sandy loam soil [12]. This characteristic would facilitate the leaching of nutrients especially during heavy rain fall. An acidic soil is an unfavorable media for crop production since they commonly result in low productivity due to deficiencies of essential macronutrients as well as toxicities of micronutrients. This high acidity of soil is the driving factor why farmers in the area practiced intensive fertilizer application.

Organic matter content in soils ranged from 10.85% to 22.50 %. Surface soils of the three farms have higher OM content than those of the sub-surface soils. This high level of OM content could be attributed to the high application of chicken manure as part of their practice in vegetable farming.

The Available Phosphorus Content which was the corrected amounts of extracted P through subtracting the value of available P in 0 pmm from the values of available P in other added P level (150, 300, 450, 600 ppm) ranged from 1.2225 ppm to 10.14 ppm. The availability of phosphorus is related to soil pH, phosphorus levels in soil, its fixation by the soil, and placement of added phosphorus [5].

Table 2. Soil pH, Organic Matter and Available Phosphorus

FARM	SOIL	pH (1:2.5)	ORGANIC MATTER (%)	EXTRACTED P (ppm)
A	SURFACE (0-20cm)	5.79	22.502	8.1
	SUBSURFACE (20-40cm)	5.65	20.77	1.2225
B	SURFACE (0-20cm)	5.58	21.728	1.505
	SUBSURFACE (20-40cm)	5.70	10.852	6.5675
C	SURFACE (0-20cm)	5.37	22.216	10.14
	SUBSURFACE (20-40cm)	5.24	11.912	2.93

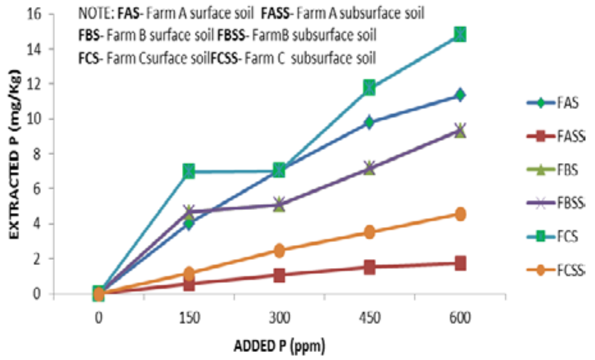
3.2. Soil P-fixing Capacity

The availability of the phosphorus is controlled by the fixation mechanism [8]. The fixation of phosphorus in subsurface soils (20-40cm) of farm A and C was higher than in the surface soils (0-20cm). This may be attributed by the presence of more OM in the surface as compared to subsurface soil as well as the higher acidity in subsurface soil than in surface soil. Organic matter on decomposition releases organic molecules, which form complexes with Fe and Al ions thereby blocking the sites which are mainly responsible for fixation of phosphorus [6]. Mineralization of organic matter provides significant portion of P for crops [14]. The finding is also underpinned with the fact that the availability of the major elements, nitrogen, phosphorus and sulfur is reduced when cycling of organic matter is slower due to acidic soil [5]. Acidity severely restricts plants responses to applications of other nutrients, by reducing either the availability of essential nutrients or the effectiveness of the roots to obtain nutrients and moisture [5]. In acidic soil, phosphate fixation is higher because of the presence of iron and aluminum which resulted in the precipitation of insoluble iron and aluminum phosphates [8]. However, reverse situation was observed in farm B where surface soil has higher pH and percent fixation of phosphorus than subsurface soil. This is a special situation where added P tends to be fixed by the soil where it is applied allowing for little movement down through the soil [15]. Under such circumstance where there is low availability of phosphorus in soils, the P Fixation Capacity must be overcome by application of P fertilizer at higher rate or by applying slow releasing P fertilizers as phosphate rocks to have enough P left over for plants to increase productivity.

Table 3. Soil Phosphorus Fixing Capacity of the Vegetable Farms in Cabintan, Ormoc City, Leyte

FARM	SOIL PROFILE	P-FIXING CAPACITY (%P)
A	SURFACE	94.30
	SUBSURFACE	99.15
B	SURFACE	99.04
	SUBSURFACE	95.03
C	SURFACE	92.46
	SUBSURFACE	98.04

The P-fixing Capacity of soil can be drawn from the relationship of added phosphorus and extracted available phosphorus. The amounts of P that were extracted in different experimental soils which had been treated with five (5) different concentrations of soluble P in the form of KH_2PO_4 after two (2) months of incubation were plotted against respective P addition. Figure 6 indicated that the relationship between available and added phosphorus is seemingly linear [9].



4. Conclusions

Base on the data obtained the following conclusions can be drawn:

1. The available phosphorus extracted from the experimental soils in 3 farms ranges from 1.505 ppm to 10.14 ppm and 1.2225 ppm to 6.5675 ppm in surface and subsurface soil respectively.
2. Phosphorus Fixing Capacity in the three vegetable farms is very high. A maximum phosphorus fixation of 99.15% and a minimum of 92.46% were observed in soil samples.

Statement of Competing Interest

The authors have no competing interest.

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