PHOSPHORUS AVAILABILITY IN RELATION TO SOIL pH IN CANE BELT AREAS OF FIJI

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Abstract

Sugarcane (Saccharum officinarum L.) is an economically important crop in Fiji since the 1880’s. It is an important source of income and employment for the farming communities of the country. Sugarcane is cultivated in tropical and sub-tropical regions of the world, in a range of climates from hot dry environment near sea level, to cool and moist environment at higher elevations. It is a heavy feeder of nutrients such as nitrogen, phosphorus and potassium, hence, soils has to be continuously tested for its available nutrient contents for its potential to produce optimum cane and sugar yields. Phosphorus is an essential nutrient required for growth and development of sugarcane plants. Availability of phosphorus is primarily dependent on the pH through interaction of minerals; iron, aluminum, and calcium with phosphorus in the soil. Three hundred and seventy six (376) soil samples from sugarcane growing fields were collected for analysis of available phosphorus and soil pH. The results of the samples were grouped into 50 soils from each soil reaction categories and the correlation between soil pH and available phosphorus were calculated. The study revealed that there is not any strong positive correlation between the soil pH and available phosphorus. The correlations were positive in all soil reaction categories, however, all were non-significant.

Keywords: Sugarcane, Saccharum officinarum L., Phosphorus, pH, Fiji.
INTRODUCTION

Soil analysis is a valuable tool for soil scientists, agronomists and farmers worldwide. Soils undergo change constantly and the soil analysis provides a measure of the soil’s ability to supply nutrient elements needed for optimum plant growth. The quantity and availability of plant nutrient elements in the soil change due to removal by harvesting crops, leaching, erosion, and addition of fertilizers (Baggett 2012). Thus, soil analysis reveals the current fertility status of soil and recommendations are made to meet the nutrient requirements for any particular crop.

One of the most important factors in determining availability of plant nutrients in the soil is soil pH. According to Netafim’s agriculture department (n.d), the optimum soil pH required for growing sugarcane (Saccharum officinarum L.) is 6.5; however, sugarcane has been found growing in very acidic soils in Fiji (Hartemink 2008). Several plant nutrients are not easily available in very strongly acidic or very strongly alkaline soils. This is due to the various reactions in the soil that fix the nutrients and convert them to the form that is unavailable to the plants. (Pandey 2013).

Phosphorus is an essential macronutrient that promotes root growth, stimulates tillering, influences millable cane growth, and impacts on the sugarcane yield per hectare. Bokhtiar and Sakurai (2003) observed significant and profitable increases in sugarcane yields due to phosphorous fertilization. Sugarcane will grow slowly with low levels of phosphorus in the soil (Watson and Mullen 2007). Sugarcane is a heavy feeder of phosphorus and removes about 0.4 – 0.8 kg phosphorus per ton of cane when harvested.

Phosphorus is found largely in its oxidized state as orthophosphate mostly as complexes with calcium, iron, aluminum and silicate minerals. The ability of soil to provide phosphorus to plants is determined by the quantities of orthophosphates in the soil solution and the solubility of iron and aluminum phosphates with hydrous oxide and clay minerals in acid soils (Stevenson 1986). Phosphates are readily precipitated as the highly insoluble iron and aluminum phosphates or adsorbed to oxide surfaces. At low pH, iron and aluminum metallic ions are more available. The solubility improves as the pH approaches nearly neutral conditions. The maximum solubility and plant availability of phosphorus is at pH 6.5 (Hopkins and Ellsworth 2005). Hossain et al (2014), and Pandey et al (2013), observed that phosphorus availability was higher in slightly acidic soil than in the very strongly acidic soil. The aim of this study is to study the correlation of available phosphorous with soil pH at different soil reaction categories on soil under sugarcane cultivation in Fiji.

MATERIALS AND METHOD

The weather of the sugarcane belt is characterized by tropical climate with mean annual rainfall of about 2,000 mm (Fiji Meteorological Service 2006). The wet season is from November to April, and a dry season from May to October. Rainfall is usually abundant during the wet season. In Fiji, sugarcane is planted from March to May and August to October. Prior to planting, soil samples are taken out for chemical analysis which is used to recommend fertilizer rates for the field. Most of phosphorus fertilizer is applied into furrows at the time of planting. Additional phosphorus fertilizer is added in 4 - 6 weeks old ratoons.

Study site
A total of 376 soil samples were collected from fallow fields from 38 sugarcane sectors within four sugar mill areas (Lautoka, Rarawai, Labasa & Penang) prior to land preparation between March-June, 2014.

Figure 1. Map of Vitilevu showing sugarcane sectors within three mill areas (Lautoka, Penang & Rarawai)
For each field, 20 subsamples were collected at a depth of 0 - 20 cm from an area of 0.4 ha. These subsamples were mixed thoroughly to prepare a representative sample. Soil samples were collected from cane belt area and were analyzed at Sugar research institute of Fiji’s analytical laboratory. From these samples, 200 samples were randomly selected for the study. The categories of different soil reactions selected, number of samples under each category and range of parameter under study is shown in Table 1.

**Table 1.** The selected category of soil reactions, number of soil samples.

<table>
<thead>
<tr>
<th>Categories of soil reaction (pH)</th>
<th>pH range</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very strongly acid</td>
<td>4.0 - 4.4</td>
<td>50</td>
</tr>
<tr>
<td>Strongly acid</td>
<td>4.5 - 4.8</td>
<td>50</td>
</tr>
<tr>
<td>Acid</td>
<td>4.9 - 5.4</td>
<td>50</td>
</tr>
<tr>
<td>Moderately acid</td>
<td>5.5 - 6.1</td>
<td>50</td>
</tr>
<tr>
<td>Total number of samples</td>
<td></td>
<td>200</td>
</tr>
</tbody>
</table>

Collected soil samples were air dried, grounded to <2 mm and stored in properly labeled plastic bags for analysis. Soil pH was recorded by Meterohm 867 pH module from soil water suspension at the ratio of 1:5. Available phosphorus (P) was determined by Modified Troug available phosphorus method using 0.02 N Sulphuric acid (H₂SO₄) and 0.3 % Ammonium Sulphate (NH₄)₂SO₄. Phosphorus was determined using Flow Injection Analysis. After the analysis, the mean values of available phosphorus content was classified into very low, low, medium, high and very high (Table 2).

**Table 2.** Classification of phosphorus content in the soil.
The linear correlation of the available phosphorus with pH of the soil was calculated within the four different soil reactions categories separately using excel worksheet and their significance were tested at 0.05 and 0.01 levels of probability. The mean for the pH and available phosphorus content of the different categories of the soil under the study were also calculated (Table 3).

**RESULTS AND DISCUSSION**

The soil pH statuses were classified under four descriptive ranges such as very strongly acid, strongly acid, acid, moderately acid (Damuni *et al.* 1996). Fifty (50) soil samples were analyzed for each of the category.

**Table 3.** Means of different parameters of four different soil reaction categories.

<table>
<thead>
<tr>
<th>Soil Parameters</th>
<th>Very strongly acid</th>
<th>Strongly acid</th>
<th>Acid</th>
<th>Moderately acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.2</td>
<td>4.7</td>
<td>5.2</td>
<td>5.7</td>
</tr>
<tr>
<td>Available Phosphorus (ppm)</td>
<td>14</td>
<td>21</td>
<td>34</td>
<td>78</td>
</tr>
</tbody>
</table>

Available phosphorus ranges from very low to very high in all soil reaction categories. The mean available phosphorus is highest (78 ppm) in moderately acidic soil while it is lowest (14 ppm) in very strongly acid soil (Table 3). Phosphorus availability increased from slightly acidic to strongly acidic soil (Table 3).
**Graph 1.** Correlation of pH with available phosphorus at very strongly acid category.

**Graph 2:** Correlation of pH with available phosphorus at strongly acid category.
Soil pH was correlated with phosphorus availability in soil at different soil reactions. The correlation of soil pH with available phosphorus was non-significant in all the soil reactions (Figures 1-4). The correlation is positive in all the categories. The correlation is the highest in acid category ($r = 0.409$) while it is lowest in very strongly acid category ($r = 0.089$). The study showed that phosphorus availability is higher in moderately acidic soil (Fig. 4). This concurs with Hossain et al (2014) who observed that phosphorus availability was higher in slightly acidic soil than in very strongly acidic soil. Furthermore, there was a non-significant correlation of soil pH with available phosphorus (Hossain et al. 2014). Similarly, Pandey et al (2013) reported non-significant correlations of soil pH with available phosphorus at all soil reactions. The highest correlation value being $r = -0.458$ and the lowest $r = -0.013$. Correlations of soil pH with available phosphorus was found to be non-significant in all soil reactions.

CONCLUSION
The study revealed that the correlations of soil pH with available phosphorus are non-significant in all soil reaction categories. However, positive correlation were obtained in all soil reaction categories with the highest value in acid category ($r = 0.409$) and the lowest in very strongly acid category ($r = 0.089$). Phosphorus availability increased from slightly acidic to strongly acidic soil.

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REFERENCES


