

Soil Fertility Assessment of Sugarcane Farms in Barangay Aglayan, Malaybalay, Bukidnon, Philippines

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Abstract

A soil fertility assessment survey was conducted at Barangay Aglayan, Malaybalay, Bukidnon on selected farms to assess the soil chemical properties (pH, OM, Extractable P and Exchangeable K) of sugarcane farms. A survey questionnaire was used to gather information among farms and a total of twenty-two (22) sugarcane farms were collected for soil samples and analyzed at the Soil and Plant Analysis Laboratory, College of Agriculture, Central Mindanao University. The 22 sugarcane farms surveyed in of Barangay Aglayan, Malaybalay, Bukidnon were identified as very strongly acidic, have medium organic matter content, low extractable phosphorus and very low in exchangeable potassium. These results demonstrated that the sugarcane farms in Bukidnon need amendments to meet the recommended soil test values for sugarcane. The results of this study have provided basic information to generate a soil nutrient map of those sugarcane farms.

Introduction

The province of Bukidnon has a total land area of 1,049,859 hectares, 92% of its alienable and disposable lands that account for 380,332.75 hectares is utilized for agricultural production. These agricultural areas are physically distributed with sugarcane lands dominating the landscape of Bukidnon followed by corn, pineapple and irrigated rice (Provincial Government of Bukidnon, undated).

Sugarcane is grown in appreciable quantities in thirteen of the twenty-two municipalities in Philippines (Sugar Regulatory Association, 2015). As one of the major anchors in crop production, Bukidnon is moving forward towards establishing its position as a principal trader of sugar and many other commercial and industrial crops. Sugarcane in the Philippines is grown mainly for sugar, but presently ethyl alcohol (biofuel) production is widely spreading, along with it's by products such as molasses and fiber (bagasse).

The plant cane (PC) crop is normally followed by two to four ratoon crops, and in certain cases up to a maximum of seven crops, like in Latin America, is taken. A ratoon is the cane that grows from buds remaining in the stubble left in the ground after a crop has been harvested. Good average cane production is $>70 \text{ ton}\cdot\text{ha}^{-1}$ with sugar production of $9 \text{ ton}\cdot\text{ha}^{-1}$ (Velasco, 2013).

Sugarcane has long been regarded as a crop with agro-industrial importance of the country. Apart from sugar, its product could also be used for ethanol production which could be further used to produce "gasohol", the alternative source of energy of utmost importance at the time the world is confronted with energy crisis due to both fluctuation and continuous increase of fuel price. Enlargement of the sugarcane growing has taken place both in response to the energy crisis and to the price increase of sugarcane product without taking land potential and suitability into consideration.

Sugarcane is a tropical crop, it requires warm and humid climate for growth while cool, sunny and dry climate for ripening. Rainfall deficiency produces a fibrous cane, whereas too heavy rainfall reduces sugar content (Season, 2011). Sugarcane can be grown on wide range of soils. However, it grows best on well drained, fertile, and medium to heavy soils. Soils rich in organic matter and leveled are most suitable. James (2003) stated that sugarcane is heavy feeder crop so it should not be grown on light soils. Expansion of the sugarcane growing has taken place both in response to the energy crisis and to the price increase of sugarcane product without taking land potential and suitability into consideration. This misconduct has led to all sorts of problems including land misuse, environmental problems and debt increase. Soil fertility is the status of a soil with respect to its ability to supply elements essential for plant without toxic concentrations of any elements. Fertile soils have an adequate and balanced supply of element sufficiently labile or available to satisfy the needs of plants (Carver, 2007). Digitized map are

being developed to prepare soil fertility map using global positioning system (GPS) to identify actual locations (latitude, longitude, data collection) of sample points. The developed soil fertility maps could be used to distribute/channelize fertilizers and more priority may be attached towards districts with poor fertility.

The objective of the study is to assess the soil chemical properties (pH, OM, Extractable P and Exchangeable K) of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon, Philippines, to provide information on soil fertility levels of this area.

Materials and Methods

Field Survey Location

The research is mainly a field survey that was conducted in 2016 at Barangay Aglayan, Malaybalay, Bukidnon, Philippines (8.15° North latitude, 125.08° East longitude). Soil samples were collected from different randomly selected sugarcane farms of Barangay Aglayan, Malaybalay, Bukidnon (Figure 1). The soil samples were analyzed as to its chemical properties (soil pH, organic matter, extractable phosphorus, and exchangeable potassium) at the Soil and Plant Analysis Laboratory (SPAL) of the Department of Soil Science, College of Agriculture of Central Mindanao University.

The materials that were used in the study were cellphone as GPS, cellophane, marker, wooden, mallet, soil auger, triple beam balance, laboratory equipment apparatus, bolo/knife, and survey questionnaire.

Survey and Collection of Soil Samples

The research focuses on the study of soil fertility assessment for sugarcane grown in Barangay Aglayan, Malaybalay, Bukidnon. Slovin's formula is used in collecting the required number of samples to be gathered statistically. Sampling criteria was determined based on the size of the farms, i.e. three to five hectares, and had been cultivated for at least 10 years. Based on the data of the number of sugarcane farmers in Bukidnon, a total of 22 farmers were selected for the study.

Soil sample was collected by collecting 10 to 15 soil sub samples from each site. The farm from which the soil samples collected was recorded for its topography, slope, texture, drainage properties, and history of the crops grown.

Composite samples were obtained by mixing the soil sub samples after they were cleaned from grass or plant residues. A soil auger was used to a depth of 20 cm and placed it in a sampling bag, a thin slice was removed from the vertical side of the soil about 3 cm thick and about 20 cm deep. Afterwards the sides of the soil slice were trimmed, leaving about 3 cm or 1 inch strip at the middle. When deep-rooted crops were planted, composite subsoil should also be collected. To collect this sample, the pit left after the collection of soil sample from the surface were continued to a desire depth usually from 60-90 cm as the subsoil sample and placed in a separate sampling bag. The samples were taken randomly at equal distant points throughout the lot in a zigzag direction. The soils collected were mixed in a clean plastic sheet and was divided into four quadrants. The two quadrants were then discarded and two quadrants were retained. The process was repeated until the remaining sample was about one kilogram.

The composite surface and sub-soil samples were placed separately inside plastic bags. Attached to the sample was soil information sheet with the following information: farmers name and address, location of the farm, area of farm, surface or sub-soil sample, date collected, crops grown or to be grown, yield record of past crop, past treatments including fertilization and liming, length of time the land was cultivated for a particular crop, other physical features of the lot.

Prior to soil analysis the composite soil samples were spread on a drying board in a soil preparation room. The clods were crushed occasionally during the drying process which took seven days to completely dry out. Soil samples were pulverized using wooden mallet and passed through a 2 mm sieve. The particles that did not pass through the sieve were discarded including stony materials (gravel or other special features). The sieved samples were stored in a plastic bag with the appropriate labels. Collected soil samples were tested in the Soil and Plant Laboratory Analysis (SPAL) at Central Mindanao University using references in Table 1, and methods listed in Table 2. The parameters from collected samples were analyzed twice.

Table 1. Soil chemical properties references

Soil chemical properties	Value	Category	References
Soil pH	<4.5	Extremely acidic	US Department of Agriculture (1962)
	4.5 – 5.0	Very strongly acidic	
	5.1 – 5.5	Strongly acidic	
	5.6 – 6.0	Medium acidic	
	6.1 – 6.6	Slightly acidic	
	6.6 – 7.5	Neutral	
Organic matter (%)	<2	Deficient	PCARRD,1999
	2.1 – 4.5	Marginal	
	>4/5	Adequate	
Extractable P (mg.kg ⁻¹)	<4.1	Very deficient	Crizaldo, 1981
	4.2 – 8.1	Slightly deficient	
	8.2 – 16.3	Deficient	
	16.2 – 20.5	Adequate	
	>20.5	Highly adequate	
Exchangeable K (cmol.kg ⁻¹)	<0.10	Low	Rice et al., 2002
	0.20 – 0.30	Medium	
	0.30 – 0.40	High	
	>0.5	Very high	

Table 2. Soil analysis methods

Soil properties	Method of analysis	References
Soil pH	Potentiometric Method (1:5 soil:water ratio)	Biddle et al., 1995
Extractable P	Bray P2 (0.1 NHCl + 0.03 NH4F)	PCARRD, 1991
Exchangeable K	Flame Photometer (1N NH4OAc extraction)	PCARRD, 1991
Organic Matter	Walkey-Black Method	PCARRD, 1991

Results and Discussion

Soil Chemical Properties

Soil pH value of the sugarcane farms in Bukidnon is presented in Table 3. Eight or 36.36% farm land were found to have a very strongly acidic soil having a soil pH of 4.5 to 5.0. Eight farms (36.36%) were medium acidic having a soil pH of 5.6 to 6.0. The remaining five farms (22.73%) were categorized as strongly acidic with soil pH of 5.1 to 5.5, and one farm has a neutral soil pH value of 6.6 to 7.5. The optimum soil pH is about 6.5 but sugarcane can tolerate considerable degree of soil acidity and alkalinity (James, 2003). Hence, most of the soils in farms were categorized as very strongly acidic and suggested that macro and micro nutrients of the soil were likely to be affected.

Organic matter content of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon is presented in Table 4. There were five of the farms (22.73%) that

are found to be deficient in organic matter having a low reading at <2 %. However, majority of the farms (about 17 or 77.27%) are marginal in organic matter that had a medium in reading in organic matter at 2.0-4.5 %.

The soil pH can also influence plant growth by its effect on activity of beneficial microorganisms that decompose soil organic matter.

Extractable Phosphorus

The extractable phosphorus of sugarcane farms in Barangay Aglayan, Malayabalay, Bukidnon is presented in Table 5. Most of the farms (18 or 81%) are low in phosphorus content which valued at <15 mg.kg⁻¹. The remaining 4 (18.18%) of the farms are medium in extractable phosphorus content of 15 to 50 mg.kg⁻¹.

Phosphorus is a critical macronutrient in the early

Table 3. Soil pH values of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon

Category	Value	No. of farms	Percentage (%)
Extremely acidic	< 4.5	0	0
Very Strongly acidic	4.5 – 5.0	8	36.36
Strongly acidic	5.1 – 5.5	5	22.73
Medium acidic	5.6 – 6.0	8	36.36
Slightly acidic	6.1 – 6.5	0	0
Neutral	6.6 – 7.5	1	4.55

Table 4. Organic matter content of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon

Category	Soil organic matter (%)	No. of farms	Percentage (%)
Deficient	< 2.0	5	22.73
Marginal	2.0 – 4.5	17	77.27
Adequate	> 4.5	0	0

stages of sugarcane growth as it stimulates root growth. It is essential in the storage and transfer of energy, and is an important component of several biochemical processes that control plant growth and development (Albuquerque, et al., 2016). Phosphorus need of sugarcane is greater during the generative phase of the crop. Thus, the optimum time of P application is during initial stages of crop growth. Study by Albuquerque et al. (2016) reported that application of P_2O_5 at 100 kg per ha significantly increased sugarcane stem diameter and yield.

Exchangeable Potassium

The exchangeable potassium of sugarcane farms

Potassium has important roles in regulating the uptake of water and leaf stomatal opening particularly in regions with periodic drought conditions (Wood and Schroeder, 2004). Potassium deficiency inhibits the ability of the plant to use available water and makes them more susceptible to drought stress (Wood and Schroeder, 2004).

Survey Information

Majority of the sugarcane farmers (54.55%) have cultivated their farms for 10 to 15 years. Moreover, 16 to 20, 21 to 25, and >31 years of cultivation had least 2 (9.09%) farms of each year range. Four farms

Table 6. Exchangeable potassium of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon, Philippines.

Category	K content (cmol.kg ⁻¹)	No. of farms	Percentage (%)
Very Low	<0.10	5	22.73
Low	0.10 – 0.20	6	27.27
Medium	0.20 – 0.30	5	22.73
High	0.30 – 0.50	6	27.27
Very High	>0.50	0	0

in Barangay Aglayan, Malayabalay, Bukidnon is presented in Table 6. Five of the farms (22.73%) were found to be very low in exchangeable potassium of <0.10 cmol.kg⁻¹ while there were six of the farms (27.73%) had a low exchangeable potassium of 0.10 to 0.20 cmol.kg⁻¹ followed by medium exchangeable potassium with a total of 5 (27.73%) farms having a reading of 0.20-0.30 cmol.kg⁻¹. Six (27.27%) of the remaining farms are categorized to have high exchangeable potassium of 0.30 to 0.50 cmol.kg⁻¹.

(18.18%) had cultivated the farms for 26-30 years.

The different types of inorganic fertilizer used by the sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon are presented in Table 8. The combination of urea plus complete (14-14-14) were used by 36.37% of the farmers whereas 31.82% of the farmers used the combination of urea plus mono-ammonium phosphate. On the other hand, 4.54% farmers used the combination of urea plus muriate

Table 7. Years of cultivation of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon, Philippines.

Years of cultivation	No. of farmers	Percentage (%)
10-15	12	54.55
16-20	2	9.09
21-25	2	9.09
26-30	4	18.18
>31	2	9.09

of potash while another 4.54% of farms used the combination of urea, complete (14-14-14) and mono-ammonium phosphate. Additionally, 4.54% of farms used the combination of urea plus (12-12-17). Even though impacts of inorganic fertilizers are generally spatially limited, they may strongly affect soil microbial biomass and community composition in the short term (Geisseler and Scow, 2014). Maintenance of proper physical, chemical and biological conditions of the soil is very important for sugarcane growth, yield and quality.

Sugarcane Yield per Hectare

The sugarcane yield of the selected farms in Barangay Aglayan, Malaybalay, Bukidnon is presented in Table 9. There were 11 or 50% of farms that yield 50 to 55

yield for sugarcane in the Philippines, which was generally lower than those reported in Australia of 70 to 80 tons per ha (Australian Sugarcane Industry, 2016). However, most of the farms are deficient in those parameters mentioned above and had been in consecutive numbers of years in cultivation. It is possible that the reported yield may have been a result of excessive fertilizers used during the cropping season.

Picul Sugar Per Ton Cane Yield

The picul sugar per ton cane (PS/TC) distribution of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon (Table 10) shows that majority of the sugarcane farmers (68.18%) has the PS/TC value ranges from 1-1.50. Moreover, 27.28% of the

Table 8. Types of inorganic fertilizer applied to sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon, Philippines.

Types of inorganic fertilizer (N-P-K)	No. of farms	Percentage (%)
46-0-0	7	31.82
16-20-0		
46-0-0	8	36.37
14-14-14		
46-0-0	1	4.54
0-0-60		
46-0-0	1	4.54
14-14-14		
16-20-0	4	18.19
46-0-0		
14-14-14		
0-0-60	1	4.54
46-0-0		
12-12-17		

Finally, there were 18.19% of the farms used urea, mono-ammonium phosphate and muriate of potash.

ton per ha of cane stalk and another eight or 36.36% farms that yield 56 to 60 ton per ha. There were only 13.64% farms that yield 66-70 tons per ha of cane stalk. Currently, sugarcane farmers in Philippines generally produce an average of 55 tons per ha (Sugarcane Regulatory Administration, 2015). Majority of the surveyed sugarcane farms belongs to the average

sugarcane farms have the PS/TC values of 1.50 to 2.0, 21-and 4.54% of the sugarcane farms has a PS/TC value of <1. Sugar Regulatory Association (2015) stated that the higher the PS/TC value indicates a quality and high yield of sugarcane.

The results of this study demonstrated that most

Table 9. Yield distribution of sugarcane farms in Barangay Aglayan, Malaybalay, Bukidnon, Philippines.

Cane yield (ton per ha)	No. of farms	Percentage (%)
50-55	11	50.00
56-60	8	36.36
61-65	0	0
66-70	3	13.64
> 71	0	0

Table 10. Picul sugar per ton cane (PS/TC) in Barangay Aglayan, Malaybalay, Bukidnon, Philippines.

PS/TC	No. of farms	Percentage (%)
<1	1	4.54
1 – 1.50	15	68.18
1.50 – 2.0	6	27.28
2.0>	0	0

sugarcane farms in Bukidnon need amendments to meet the recommended soil test values for optimum growth of sugarcane. According to Bell (2014), the basis for best practice nutrient management for sugarcane production includes understanding the soil physical and chemical properties, understanding and managing nutrient process and losses, regular soil tests, adoption of soil-specific nutrient management guidelines, and regular crop testing to check on the adequacy of nutrient inputs. Records of these properties will provide guidelines for sustainable and balanced nutrition across the sugarcane industry by applying scientific principles as well as recognizing the site, soil, and regional differences.

Conclusion

The analysis of the soil chemical properties showed that the soil pH mostly ranged from 4.5 to 5.0 and categorized as very strongly acidic with a total 36.36%, whereas 36.36% of the soils are medium acidic. Majority (77%) of the farms had organic matter value of 2.0 to 4.5%. Twenty-seven percent of the farms had very low exchangeable potassium of 0.10 cmol.kg^{-1} while there were (27.27%) of farms had high exchangeable potassium of 0.30 to 0.50 cmol.kg^{-1} . Most farms (81%) had low extractable phosphorus was low (<math><15\text{ mg.kg}^{-1}</math>). There were 18.18% of the farmers who had cultivated sugarcane for 26 to 30 years, and 50% for 10 to 15 years. Most surveyed farms used urea (46-0-0) and complete fertilizer (14-14-14) with cane yields of 50 to 70 tons per ha. This study has provided basic information for development of soil fertility mapping and fertilizer recommendations for sugarcane farms in Bukidnon, Philippines.

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