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NUTRIENT COMPOSITION OF LEAVES AND RHIZOSPHERE SOIL OF GUAVA PLANT (PSIDIUMGUAJAVA) IN THE MARGINAL UPLANDS OF INOPACAN, LEYTE, PHILIPPINES

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Abstract: Guava (Psidiumguajava) grows in many soil types and tolerates in poor soils. This paper presents analysis of bulk, rhizosphere soil and tissue of guava plant for macronutrients/exchangeable basis and micronutrients. It was found out that the soil was acidic with pH of 5.80 and 5.90 for bulk and rhizosphere soil. In bulk soil, average concentration of macro and micronutrients were 0.56%, 4.72, 239.15, 38.13, 2800.92, 77.68, 127.17, 70.21, 6.02 and 4.84 mg/kg for N, P, K, Mg, Ca, Na, Fe, Mn, Cu and Zn. Generally, macro and micronutrients were found to be reduced in rhizosphere soil with average concentrations of 0.13%, 3.50, 227.01, 375.56, 2664.75, 83.19, 111.65, 58.02, 5.92 and 4.77 mg/kg for N, P, K, Mg, Ca, Na, Fe, Mn, Cu and Zn respectively. Whereas concentrations particularly the macronutrients in leaves were higher several times compared to soil, with 1.46, 0.06, 0.75, 0.36, 1.52 and 0.11% for N, P, K, Mg, Ca and Na respectively. Although many of the nutrients in leaves were still found to be deficient with respect to the critical concentration. However, this results support the hypothesis that guava absorbs and accumulates significant amount of nutrients. The plant's ability to absorb nutrients can be one of the reasons why it is widespread in environment.

Keywords: Exchangeable cations, guava, macronutrients, micronutrients, pH, rhizosphere soil.

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1. INTRODUCTION

Psidiumguajava L. commonly known as guava (Family Myrtaceae) is a small, single or multi-trunked trees to 20ft (6.1m) in height with a broad, spreading or upright canopy. Guava are now cultivated and naturalized in the warm subtropical and tropical regions throughout the world (Crane and Balerdi, 2005). The guava fruit has high potential market for its delicious taste, aroma, sweet flavour and fine balance of acid, sugar and pectin (Gautamet al., 2010). However, in few countries, guava is considered as an environmental weed which is described as prominent invasive alien woody plant (Department of Agricultural, Fisheries and Forestry; Queensland, 2014).

Guava tree can adapt in a variety of soil types including sands, loams, rock-based soils, and muck. It prefers a soil pH of 4.5 to 7 and even in high pH (7-8.5). And even it can potentially grow in wastelands (Gautamet al., 2010).The plant thrives in many soil types and conditions and even soils that are already degraded. Thus this study involves nutrient analysis of leaves, rhizosphere and bulk soil of the guava plant to show if it absorbs or accumulates significant amount of nutrients. The result may have a significant implication why this plant is so adaptive and widespread in the environment.

2. MATERIALS AND METHODS

2.1. Description of the Sampling Site

The study site is located in the municipality of Inopacan, Leyte, specifically in one of its barangays, at SitioBatuan Barangay Linaw. The site is marginal grassland dominated with grass species (i.e. Cogon (Imperatacylindrica) and Amorsico) and with scattered Guava (Psidiumguajava) and Melastoma plant (Figure 1).

2.2. Sampling Procedure

The site was divided into three sections; these were lower, middle and upper slope. In each section, four guava plants were randomly selected and uprooted using a knife. Once uprooted, bulk soils were obtained by shaking and rhizhosphere soils were obtained by brushing the adhering soils in the roots. All bulk soils and rhizospheric soils were placed in one plastic bag resulting to a composite sample and obtaining two soil samples for each slope.At the same time, leaves of P. guajava plant were collected obtaining three composite samples.

2.3. Processing and Laboratory Analyses

Collected soils were brought to shed house at Visayas State University and were air dried for three days. After removing soil moisture, soils were pound using a wooden hammer and sieved with mesh size of 2 mm for course and with mesh size of 0.425 mm for fine samples. For leaves, samples were oven dried for 1 day (24 hours) and were ground using the Willey Mill Grinder. Ground tissues were sieved (# 60). Soil and tissue samples were analysed at Central Analytical

Services Laboratory of the university.

The pH of the rhizosphere and bulk soil samples was measured using Potentiometric method wherein it involves the use of a glass, H-sensing (indicator) electrode paired with the reference electrode attached to a suitable meter for measuring emf.

Presence of macronutrient rhizospheric and bulk soil samples were analyzed. For nitrogen (N), Kjeldahl method was employed where organic N was converted to NH4-N by digestion with concentrated sulphuric acid (H2SO4). Then NH4-N was determined from the amount on NH3 liberated by distillation of the digest alkali. P was extracted from the sample using acidified ammonium fluoride (0.03 M NH4F and 0.1 M HCl). Exchangeable cations including potassium (K), calcium (Ca) and magnesium (Mg) were extracted using ammonium acetate (NH4OAc) method. Micronutrients like zinc (Zn), iron (Fe) and manganese (Mn) were extracted using a diluted hydrochloric acid (0.1N HCl). Concentrations of exchangeable cations and micronutrients were quantified using the Agilent 280 FS Atomic Absorption Spectrophotometer (AAS).

Analysis and quantification of N in plant tissue used the also the Kjeldahl method. In determining other macronutrients (P, K, Mg and Ca) and micronutrients (Zn, Fe and Mn) in leaves, digestion procedure was used. Concentrations were read again using the 280 FS Agilent Atomic Absorption Spectrophotometry.

3. RESULTS AND DISCUSSION

3.1. Soil pH

Both bulk and rhizosphere soils were acidic. The pH of the bulk soil ranged from 5.70 to 5.80 with a mean of 5.80. For the pH of rhizosphere soil, it ranged from 5.80 to 6.00 with a mean of 5.90 (Table 1). Even acidic, pH of the soil still fall under the critical value of 5.5 to 7.0 (Asioet al., 2006)necessary for plant's growth.This results clearly show that guava can survive inacidic soils.

3.2. SOIL NUTRIENTS

3.2.1. Nitrogen

The available forms of nitrogen in soil for plants are ammonium-N (NH4-N) and nitrate-N (NO3-N). However, nitrate is easily leached from the soil with high rainfall or excessive irrigation (Horneck et al., 2011). Total nitrogen (N) concentration of bulk soil associated with the guava plant ranged from 0.12 to 1.45% with a mean of 0.56%. Whereas N in rhizosphere soil was lower, ranging from 0.10 to 0.18% with a mean of 0.13% (Table 1). Total N concentrations are beyond and below the critical level of ?0.2 (Asioet al., 2006) for bulk and rhizhosphere soil respectively, which means that N in bulk is in sufficient amount than that of rhizosphere soil (Figure 2-a).

Statistical analysis showed that no significant difference in N concentration between bulk and rhizosphere soil. N concentration of leaves did not significantly differ with bulk soil but significantly different to rhizosphere soil (Figure 2-a).

3.2.2. Soil Available and Leaf Phosphorous

Available phosphorous (P) in bulk soil ranged from 3.01 to 8.13 mg/kg with a mean of 4.72 mg/kg. In rhizosphere soil, P ranged from 1.39 to 6.12 mg/kg with a mean of 3.50 mg/kg (Table1). However concentration of P in both soils are far below the critical concentration of 8 to 15 mg/kg (Asioet al., 2006) .This means that P in the soil is very low and deficient. No significant difference in P concentration between bulk and rhizosphere soil (Figure 2-b).

3.2.3. Exchangeable Basis

Exchangeable potassium (K) in bulk soil ranged from 153.40 to 365.43 mg/kg with a mean of 239.15 mg/kg. K content of rhizosphere soil ranged from 141.25 to 276.15 mg/kg with a mean of 227.01 mg/kg (Table 1). K concentration between bulk and rhizosphere soil did not differ significantly (Figure 2-c). Close to K concentration, exchangeable magnesium (Mg) of bulk soil ranged from 370.00 to 391.17 mg/kg with mean of 380.13 mg/kg. Mg in rhizosphere soil ranged from 358.69 to 390.43 mg/kg with a mean of 375.56 mg/kg (Table 1). Mg concentration between bulk and rhizosphere soil did not differ significantly (Figure 2-d).

Calcium (Ca) concentration of bulk soil was high ranging from 2762.50 to 2845.80 mg/kg with a mean of 2800.92 mg/kg. Rhizospheric Ca ranged from 2567.25 to 2744.00 mg/kg with a mean of 2664.75 mg/kg (Table 1). Ca concentration between bulk and rhizosphere soil did not differ significantly (Figure 2-e). Sodium (Na) concentration of bulk soil ranged from 68.98 to 87.60 mg/kg with an average value of 77.68 mg/kg. For rhizosphere soil, Na ranged from 80.80 to 86.30 mg/kg with a mean of 83.19 mg/kg (Table 1). No significant difference in Na concentration between bulk and rhizosphere soil (Figure 2-f).

3.2.4. Extractable Micronutrients

Iron (Fe) concentration in bulk soil ranged from 112.80 to 136.40 mg/kg with a mean of 127.17 mg/kg. In rhizosphere soil, Fe content ranged from 80.05 to 145.70 mg/kg with a mean of 116.65 mg/kg (Table 1). Fe in soil is in high amount compared to the critical level of ?4.50 mg/kg which means that its concentration is sufficient for the consumption of the guava plant (Asio et al., 2006). No significant difference in Fe concentration between bulk and rhizosphere soil (Figure 3-a). Findings of Nazif et al., 2006 shows that Fe negatively correlates with soil pH.

Manganese (Mn) concentration in bulk soil ranged from 52.02 to 102.95 mg/kg with a mean of 70.21 mg/kg. Whereas Mn in rhizosphere soil ranged from 23.25 to 78.87 mg/kg with a mean of 58.02 mg/kg. With respect to the critical level of Mn in soil that is 0.50 mg/kg, Mn in both bulk and rhizosphere soil is in sufficient quantity (Asioet al., 2006).

Mn concentration between bulk and rhizosphere soil did not differ significantly (Figure 3-b).

Copper (Cu) in bulk soil ranged from 5.80 to 6.15 mg/kg with a mean of 6.02 mg/kg. In rhizosphere soil, Cu ranged from 5.75 to 6.00 mg/kg with a mean of 5.92 mg/kg (Table 2). However Cu concentration in both soils did not differ significantly (Figure 3-c). Guava is known to absorb Cu from soil and accumulate it in fruits (Ang and Ng, 2000).

Concentration of Zinc (Zn) in bulk soil ranged from 4.45 to 5.41 mg/kg with a mean of 4.84 mg/kg. Zn in rhizosphere soil ranged from 3.53 to 5.94 mg/kg with a mean of 4.77 mg/kg (Table 2). Concentration of Zn between bulk and rhizosphere soil did not differ significantly (Figure 3-d). Zinc is one of the essential micronutrients in soil. Inadequate supply of zinc adversely affects the growth of plants that results to stunting (reduced height), interveinal chlorosis (yellowing of the leaves particularly in veins), bronzing of chlorotic leaves, small and abnormally shaped leaves. When Zn is deficient in soil, growth of guava is affected particularly in acidic condition (Alloway, 2008).

3.3. GUAVA NUTRITION

Total nitrogen (N) in guava leaves ranged from 1.25 to 1.63% with a mean of 1.25 % and four times higher compared to that of N concentration of soils (Table 2). However, its concentration is below the critical concentration of two to five (Marschner, 1995). This means that nutrient is deficient in the plant. Phosphorous (P) concentration in the leaves ranged from 0.058 to 0.062% with a mean of 0.06%. This concentration in leaves is very high, 73 times higher than the concentration in the soil (Table 2). In spite its high concentration, P is still deficient relative to the critical level of 0.5% (Marschner, 1995). For potassium (K), its concentration ranged from 0.51 to 0.99% with a mean of 0.75%. In comparison to K content of soil, its concentration is also very high, that is 32 times higher (Table 2). At the same with P, this concentration in leaves is deficient that is below the critical level of two to five percent (Marschner, 1995). This means that the nutrient is in deficient quantity. For magnesium (Mg), concentration ranged from 0.30 to 0.41% with a mean of 0.36%. Mg content of the leaves is also higher (nine times) compared to that of soil (Table 2). Its concentration is in the limit of the critical concentration (Marschner, 1995), suggesting that this nutrient is just sufficient. Calcium (Ca) is high that ranged from 1.17 to 1.88% with a mean of 1.52 percent and five times higher than its concentration in soil (Table 2). Ca concentration in leaves is within the sufficiency level with respect to the critical concentration of 0.1 to 5% (Marschner, 1995). Sodium (Na) concentration was found to be 0.11 to 0.12% with a mean of 0.11% (Table 2).

Out of these five macronutrients with their corresponding critical levels, only two are found to be in sufficient concentration in the leaves of the guava plant, as also depicted in Figure 4. In spite the several times augmented concentration of nutrients in the tissue, still nutrients are deficient.

3.4. NUTRIENT PROPORTIONS IN SOILS AND LEAVES

Considering the proportion of N relative to other macronutrients in bulk soil, large proportion or around 60% was accounted for it. Macronutrients found to have the least proportion include Mg, Na, K and P. Proportions decreased in order of N□Ca□Mg □ Na □ K □ P. Whereas in rhizosphere soil, almost 60% of the total proportion was for Ca. N proportion decreased more than half. Nutrient proportion decreased in order of Ca□N□Mg□Na □ K □ P (Figure 5-a). Large proportion of micronutrient in bulk and rhizosphere soil was accounted for Fe (60%) and followed by Mn (about 30%). Proportion decreased in order of Fe□Mn□Zn □ Cu (Figure 5-b). Proportions of Ca and N in leaves were almost equal (around 30%) and proportion of K had increased. Nutrients in leaves decreased in order of Ca □ N□K□Mg□Na □ P (Figure 5-c).

CONCLUSION

Bulk and rhizosphere soils associated with guava plant was found to be acidic. Concentration of macronutrient/exchangeable basis (N, P, K, Mg, Ca and Na) and micronutrients (Fe, Mn, Cu and Zn) between bulk and rhizosphere soil did not differ significantly. Concentrations of the previous macronutrients/cations in the leaves are augmented compared to the concentration in soil but still deficient with respect to the critical level (except calcium and magnesium that were in sufficient amount).This shows that guava is able to absorb and accumulate nutrients and making the plant to thrive in degraded or poor soils.

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Table 1. Concentrations of macronutrient/exchangeable basis and micronutrients of bulk and rhizosphere soil of P. guajava.

Soil		Soil pH (1:2.5)	Total N (%)	Available P (mg/Kg)	Exchangeable Cations (mg/kg)				Micronutrient			
					K	Mg	Ca	Na	Fe	Mn	Cu	Zn
Non-rhizosphere	Lower slope	5.8	0.12	3.01	198.63	391.17	2762.50	87.60	136.40	52.02	6.15	4.65
	Middle slope	5.9	0.10	3.01	153.40	378.87	2845.50	76.47	132.30	55.66	6.10	4.45
	Upper slope	5.7	1.47	8.13	365.43	370.36	2794.75	68.98	112.80	102.95	5.80	5.41
	Mean	5.80	0.56	4.72	239.15	380.13	2800.92	77.68	127.17	70.21	6.02	4.84
Rhizosphere	Lower slope	5.9	0.18	3.00	276.15	390.43	2744.00	80.80	124.20	71.93	6.00	5.94
	Middle slope	6.0	0.10	1.39	141.25	377.56	2683.00	82.48	80.05	23.25	5.75	3.53
	Upper slope	5.8	0.11	6.12	263.63	358.69	2567.25	86.30	145.70	78.87	6.00	4.84
	Mean	5.90	0.13	3.50	227.01	375.56	2664.75	83.19	116.65	58.02	5.92	4.77
Critical level		5.5-7.0	□0.2	□8-15	(□0.20 cmol/kg)	(□0.50 cmol/kg)	(□0.40 cmol/kg)		□4.50	□0.50		

Table 2. Concentration of macronutrients in P. guajava leaves.

Guava plant	Macronutrient (%)					
	Total N	Total P	K	Mg	Ca	Na
At lower slope	1.63	0.062	0.51	0.41	1.52	0.11
At middle slope	1.48	0.058	0.99	0.30	1.17	0.10
Upper slope	1.25	0.061	0.74	0.38	1.88	0.12
Mean	1.46	0.06	0.75	0.36	1.52	0.11
Critical level	2-5	0.3-0.5	2-5	0.15-0.35	0.1-5	

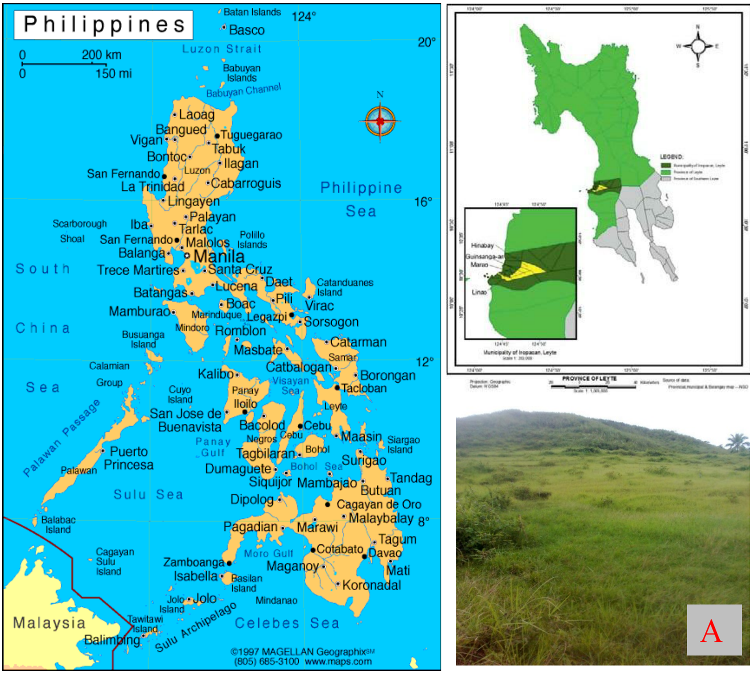

Figure 1. Study area at (A)SitioBatuanBrgy. Linaw(B) Inopacan, Leyte, (C) Philippines

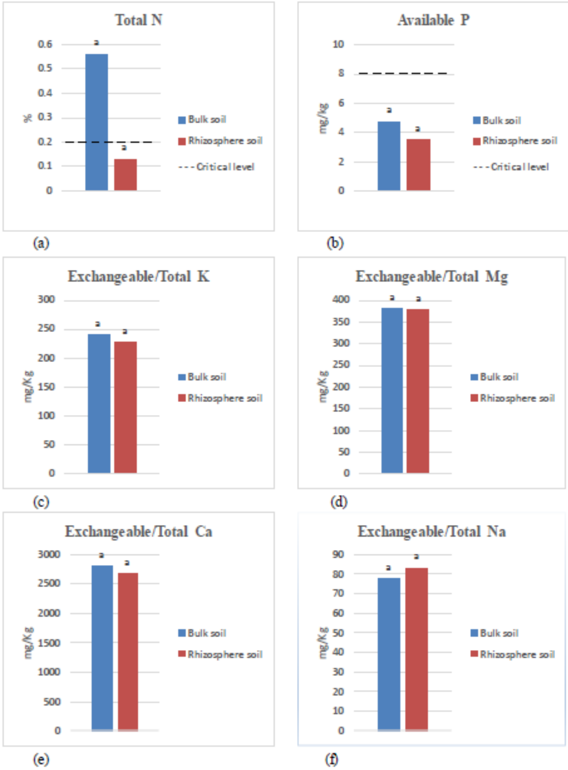

Figure 2. Differences in macronutrient/exchangeable cation concentrations between bulk, rhizosphere soil and with critical level for guava tree. (T-test: α = 0.05)

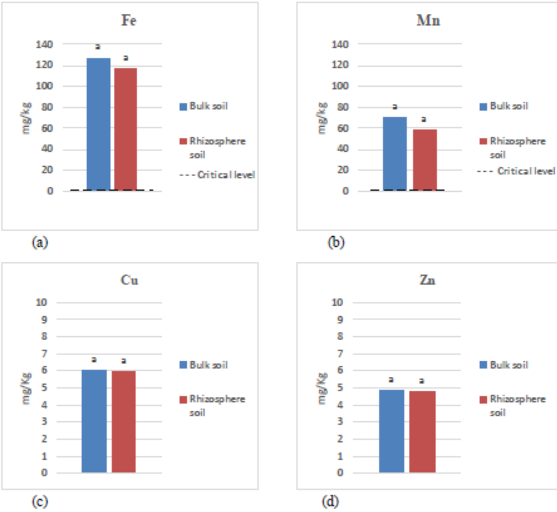

Figure 3. Differences in micronutrient concentrations between bulk and rhizosphere soil and with critical level for guava tree (T-test; α = 0.05).

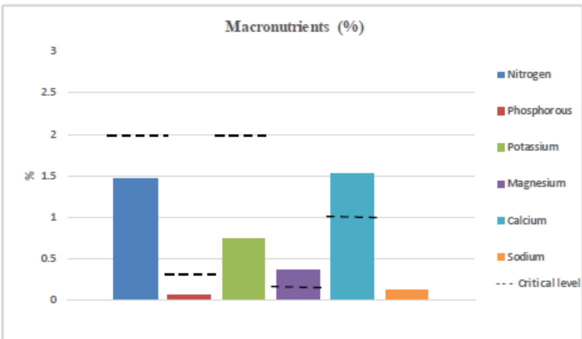

Figure 4. Concentration and critical level of macronutrients in the leaves of P. guajava.

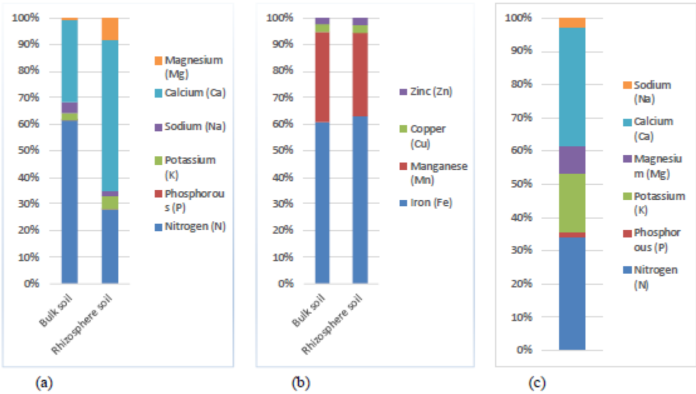

Figure 5. Properties of concentrations of (a) macronutrients/ exchangeable cations in bulk and rhizosphere soil, (b) micronutrients/ exchangeable cations in bulk and rhizosphere soil and (c) macronutrients in leaves