AGRIVITA Journal of Agricultural Science. 2023. 45(2): 278-287

AGRIVITA
Journal of Agricultural Science
www.agrivita.ub.ac.id

Physicochemical Properties of Soil Cultivated with Durian (*Durio zibethinus* Murr.) in Gua Musang, Kelantan

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ARTICLE INFO

Keywords:
Durian
Elevation
Soil physical
Soil physicochemical

Article History:
Received: October 25, 2021
Accepted: March 21, 2023

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ABSTRACT

This study was carried out in an area cultivated with durian in Gua Musang, Kelantan with a soil series of Rengam-Jerangau. The objective of this study was to determine the physicochemical properties of soil cultivated with durian at different elevations and samplings. The soil composite sampling was determined at three elevations (top, middle and bottom elevation) marked using GPS coordinate with two different depths (0-15 cm and 15-30 cm). The United States Department of Agriculture (USDA) of the soil texture is clay with bulk density ranging between 0.98 to 1.11 g/cm^3. Significant parameters at alpha value of 95% include total carbon content (0.903% until 1.389%), total sulphur content (0.059% to 0.100%), exchangeable bases calcium, potassium and sodium at 3.520 cmol$_c$/kg to 5.582 cmol$_c$/kg, 0.380 to 0.581 cmol$_c$/kg and 0.101 to 0.155 cmol$_c$/kg respectively. From the significant parameters, only exchangeable potassium was affected by the by both elevation and depth of the sampling while the other parameters were only affected by the elevation. As some of the nutrients had been classified as low, extensive measures need to be done for healthy growth performance.

INTRODUCTION

Soil is a complex matter and comprises of minerals, soil organic matter, water, and air. In evaluating the soil's suitability for agricultural and environmental, soil physicochemical properties play an important role. Supporting capability for root penetration as the retention, movement, availability of plant water and nutrients, and heat and airflow are directly related to the soil's physical properties (Phogat, Tomar, & Dahiya, 2015).

Physicochemical properties of soil vary in their characteristics primarily because of topography, which modifies soil water relationships and large extent influences on rainfall, drainage, soil erosion, textural composition and other soil properties that affect plant growth within a field (Atofarati, Ewulo, & Ojeniyi, 2012). The topography of agricultural fields can influence soil physicochemical properties (soil depth, texture, and mineral contents), biomass production, incoming solar radiation, precipitation and affect crop production. As an increased topography or elevation significantly increased soil moisture, precipitation, soil organic matter and labile carbon, whereas bulk density, pH and soil temperature were significantly lower at a higher elevation.

Topography plays a vital role in biogeochemical processes, which performs key environmental, economic and social functions. As

ISSN: 0126-0537

Cite this as: Amran, A., Ariffin, M. R., Isa, I. M., Ahmed, O. H., Herman, G., Muhamad, S. H., Nor, N. A. M., & Khairuddin, M. N. (2023). Physicochemical properties of soil cultivated with durian (*Durio zibethinus* Murr.) in Gua Musang, Kelantan. *AGRIVITA Journal of Agricultural Science, 45*(2), 278-287.http://doi.org/10.17503/agrivita.v45i2.3601

the landscape is undulating, soil characteristics at different topographic positions differ. Physical properties also determined the chemical and biological properties. Soil chemical properties such as cation exchange capacity (CEC), soil pH, organic matter and available phosphorus (Yan & Hou, 2018). Hence the most important of soil physicochemical properties were relevant to its usage as a medium for plant growth.

Durian (*Durio zibethinus* Murr.), a tropical fruit from Bombaceae family is considered as the “King of Fruits” and grown commercially at most Asian countries including Thailand, Malaysia, and Indonesia (Ketsa, Wisutiamonkal, Palapol, & Paull, 2020). By the year 2030 durian production in Malaysia is projected to increase up to 443,000 metric tonnes (4% annually). According to Department of Statistics Malaysia (2019), exports of durian (includes fresh, frozen, pulp and paste) registered an increase of 32.2 per cent in 2019 or RM423.7 million as compared to RM320.5 million in 2018. The main destinations in 2019 were China (61.8%), Singapore (14.8%) and Hong Kong (8.4%). The increase in forecasted production is due to the joint efforts of the government of Malaysia and the Government of China in signing the Durian Export Protocol to enable more durian products to be exported to China. The Durian Export Protocol enables more durian products to be exported to China. Thus, this phenomenon has attracted many parties to involve in durian cultivation and increased in demand for high-quality durian seedlings.

With optimum nutrient fits the durian requirement and adequate water management, durian crop will have a good establishment in giving a high yield as a return. Durian specifically preferred a rich, deep, well drained sand to clay loams soil texture. This factors ensure that there is a less occurrence of root rot as durian’s root is sensitive towards the standing water (Diczbalis & Darren, 2005). Too much water will also cause the tree to bear new leaves at the expense of the fruits.

Durian thrives well in soil with pH 5.5 to 6.5. Malaysia as a tropical country commonly has a weathered soil (Kostov, 2016) accounts to about 72%, majorly in upland areas (Shamshuddin & Daud, 2011). The humid tropical climate with high rainfall and temperatures favours rapid dissolution and leaching of weatherable minerals. For intance, resultant soils are rich in kaolinitic clays and sesquioxides, which possess pH-dependent charges. Degree of weathering involves the primary sources of H^+. It dissociates the carbonic acid formed when carbon dioxide dissolved in water or oxidation of pyrites to sulphuric acid. Increased time of exposure in a humid climate generally causes greater accumulation of soil acidity. To increase the alkalinity of the soil and make pH-favourable to durian establishment, liming material and organic fertilizers can aid to obtain the desired result (Anderson, et al., 2013). These amendments can improve crop performance (Horneck, et al., 2007) as nutrient and be available for crop to takeup because soil pH is suitable for nutrient absorbtion by the roots.

This study was done at a durian plantation which was converted from secondary forest of a hilly area 439 m and 410 m above sea level with its highest and lowest points respectively. The soil physicochemical properties cultivated with 2-year old durian tree were studied. The objective of this study specifically was to identify soil physicochemical properties and fertility status of the durian cultivated area in a relation to durian growth nutrients requirements. This physicochemical properties study of soil is based on various parameters such as pH, electrical conductivity (EC), soil texture, exchangeable bases, total nitrogen, total carbon and available phosphorus.

MATERIALS AND METHODS

Study Sites

This study was conducted in an orchard known as Durian Valley owned by M7 Plantation Berhad in Gua Musang, Kelantan, in 2020. This durian orchard was planted with 2-years old durian trees (*Durio zibethinus* Murr.) at the time of soil sampling. The soil type in Gua Musang is Rengam-Jerangau soil series. Generally, the topography of these areas was undulating and hilly. The average annual temperature in Gua Musang, Kelantan was around 26.4°C and its average rainfall was approximately 2365 mm annually. The durian trees were planted in a sloped area with its highest point was at 439 m above sea level and the lowest point was at 410 m above sea level.

The sampling of soil covered the areas with latitude N 05º04’57.9” to N 05º05’55.3” and longitude E 101º40’49.8” to E 101º40’58.1”. Each soil at a specific coordinate was taken at two different depths (0 – 15 cm and 15 – 30 cm) by using an auger and wrapped tightly in plastic. Selection of soil sampling was based on the condition of durian tree planting that were in a good health condition and located away from the main road. Few soil samples were taken by using a core ring at the top, middle, and bottom elevation and secured with air-tight plastic bags.

Experimental Design

In this experiment, 60 subunits of soil samples were digged under the durian tree canopy range from three different elevations at the top, middle, and bottom elevation. Each elevation had two different soil depths sampling at 0 – 15 cm and 15 – 30 cm making up a total of 20 samples. Randomized Complete Block Design (RCBD) was used in this experiment to arrange 10 replicates at three elevation with two depths. There were also six samples of soil taken by using core ring (two samples from each of the top, middle and bottom elevation).

Analysis of Soil Physicochemical Properties

In this experiment, soil series were identified according to USDA soil classification (Paramananthan, 2020; Staff of the Soil Survey Division, 2002; Kettler, Doran, & Gilbert, 2001). Soil samples from each elevation and depth were collected for physicochemical analysis and two core ring samples in each elevation were used for the analysis of soil moisture and bulk density. The moisture content analysis and bulk density of the sample were determined immediately after soil sample arrived in the lab in a securely packed plastic. Soil pH was analysed using water suspension technique, with soil to water ratio 1:2.5 (Zhang, Silong, Zongwei, & Qingkui, 2009). Soil electrical conductivity (EC) was analysed by water suspension with soil to the water of ratio 1:5. Exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, Na^+) and cation exchange capacity (CEC) were determined using leaching method NH_4 buffered at pH 7.0 and by later on using Perkin Elmer Model AAS 3110 atomic absorption spectrophotometer (AAS). CNS analysis was to determine the total nitrogen (TN), total carbon (TC) and total sulphur (TS) (5 g) using the CNS analyser (LECO TruMac CNS Analyzer, USA). Available phosphorus was analysed by the Bray and Kurtz II method (Landon, 2014).

Statistical Analysis

All data collected were analysed statistically using one-way analysis of variance (ANOVA) using SAS version 9.4 (SAS Institute, Cary, NC) and (Pr<0.05) was used to determine the levels of significant followed by means separation using Tukey's Honest Significant Difference (HSD).

RESULTS AND DISCUSSION

It has long been known that soil classification in Peninsular Malaysia, the Gua Musang has a classification of Rengam-Jerangau soil series. Under soil taxonomy, this study area was classified with Ultisols order with Typic Kandiudults subgroup (Paramananthan, 2020). Table 1 showed that the soil texture was clay at both depths of 0 – 15 cm and 15 – 30 cm. The result obtained was closer to Jerangau soil series at 0 – 15 cm and 15 – 71 cm depth with 1.10 to 1.11 g/cm^3 respectively of clay textural class according to Paramananthan (2020). Factors of several clay minerals formation in acidic soils of Malaysia may due to the parent materials and the pedogenetic stage of the soils, where clay minerals leached from the upper soil profile and concentrated to the lower part of it. Higher clay content rise issues where hard lumps or clods forms. It is dry and sticky when wet, obstructing easy tillage and causes poor internal drainage (Soong & Lau, 1977). In a comparison of erosion, soil with higher clay contents become the most susceptible to it, followed by soil with higher silt and sand content (Yusof, Abdullah, Azamathulla, Zakaria, & Ghani, 2011).

Table 1. Soil particle size distribution and class according to USDA in durian cultivated area, Gua Musang

Elevation	Particle size distribution (microns)								Total (microns)			Soil texture class (USDA)
	Clay	Silt		Very fine sand	Fine sand	Medium sand	Coarse sand		Clay	Silt	Sand	
	0-2	2-20	20-50	50-100	100-250	250-500	>500	Total	<2	2-50	>50	
B	56.29	19.27	7.58	5.73	5.41	2.06	3.66	100	56.29	26.85	16.86	Clay
M	57.28	23.53	7.89	5.78	3.12	0.85	1.55	100	57.28	31.42	11.3	Clay
T	47.54	22.29	9.64	7.54	5.31	2.3	5.38	100	47.54	31.94	20.52	Clay

Remarks: B = Bottom, M = Middle, T = Top

Soil in Malaysia, as a tropical country commonly has a bulk density between 0.8 to 1.9 mg/m^3 (Sung, et al., 2017). In addition, bulk density of the soil in this study was in acceptable range between 0.99 – 1.11 g/cm^3 (Table 2). Bulk density is associated with soil compaction. Compaction of the soil restricts roots for penetrating because less pore spaces are available for water infiltration and drainage (Olubanjo & Yessoufou, 2019). Lower bulk density at the 0 -15 cm depth compared to 15 – 30 cm may be contributed by the decomposition of organic matter (Sujaul, Ismail, Tayeb, Muhammad Barzani, & Sahibin, 2016). In addition, compaction also occured when deforestation and logging activity were done to establish a plantation orchard. This activity also reduces soil organic matter at the top layer of the soil (Amlin, Suratman, & Md Isa, 2014). Lower bulk density is considered a well-structured soil as it has more pore spaces for aeration purpose, water infiltration and drainage, irrigation and ease the plant's root penetration (Sarchidanand, Mitra, Vinod, Richa, & Mishra, 2019).

Soil organic matter (SOM%) was observed not significant (Pr<0.05) with higher value observed at the 15-30 cm for every studied elevation (0.416%, 0. 606% and 0.574%) (Table 3). The formation and decomposition of soil organic matter are life-promoting processes that store (nitrogen, phosphorus and sulphur nutrients) and release energy and become available for plant uptake. Humic substances account for 70 to 80% of the organic matter in soils, forming from the decomposition of plant residues. Clay contents are said to have the most soil organic matter and highly formed in temperate places (Gaskell, et al., 2007). SOM influence carbon storage in the soil stored as mineral-associated microbial residues and impact soil stability. As the soil texture of the study area was clay, the clay content aids to protect more organic matter for decomposition compared to the sandy soil. More pore spaces will aid in water infiltration and helps the roots to spread without being constricted (Sarchidanand, Mitra, Vinod, Richa, & Mishra, 2019). As durian roots are sensitive to standing water and soil compaction, having soil that helps the roots to growth will contribute to a healthy crop growth and a higher yield.

Table 2. Soil physical and chemical properties in durian cultivated area, Gua Musang

Soil Properties	**Elevation:**	**----- Top -----**		**----- Middle -----**		**----- Bottom -----**		**Pr>F**
	Soil Depth (cm):	**0 – 15**	**15 – 30**	**0 – 15**	**15 – 30**	**0 – 15**	**15 – 30**	
Bulk density (g/cm^3)		1.00	1.08	0.98	1.00	1.11	0.99	0.6383$^{n.s}$
Soil moisture content (%)		37.25	35.92	33.14	28.44	14.20	45.19	0.8535$^{n.s}$
pH		4.91	4.95	5.06	5.28	4.83	4.95	0.2047$^{n.s}$
EC (mS/cm)		0.172	0.153	0.280	0.194	0.198	0.178	0.3064$^{n.s}$
C (%)		0.903	0.954	1.191	1.389	1.266	1.317	0.0234*
N (%)		0.087	0.093	0.157	0.166	0.107	0.112	0.1051$^{n.s}$
S (%)		0.059	0.059	0.072	0.070	0.092	0.100	<.0001*
Extractable bases (cmol$_c$/kg):								
Ca		4.233	4.204	5.330	5.582	3.520	3.815	0.0015*
Mg		1.643	1.763	1.585	1.715	1.355	1.458	0.0947$^{n.s}$
K		0.508	0.380	0.748	0.510	0.581	0.429	0.0071*
Na		0.122	0.101	0.155	0.130	0.146	0.129	<.0001*
CEC (cmol$_c$/kg)		22.186	24.579	26.000	26.286	24.143	26.650	0.3803$^{n.s}$
Base saturation (%)		29.65	29.07	31.80	31.87	23.74	23.07	0.1449$^{n.s}$
Available P (mg/kg)		1.624	2.981	1.845	3.137	2.779	2.175	0.1091$^{n.s}$

Remarks: Mean values with * are significantly different at p < 0.05 according to Tukey's Honest Significant Difference (HSD); * = significant, n.s. = not significant at p < 0.05; Alpha value=0.05

Table 3. The C/N ratio, total organic carbon (TOC)% and soil organic matter (OM)% in durian cultivated area, Gua Musang

Elevation:	**---------- Top ----------**		**---------- Middle ----------**		**---------- Bottom ----------**	
Soil Depth (cm):	**0 – 15**	**15 – 30**	**0 – 15**	**15 – 30**	**0 – 15**	**15 – 30**
C/N Ratio	7.800	7.715	5.710	6.280	8.933	8.801
TOC%	0.679	0.717	0.896	1.045	0.952	0.990
SOM%	0.394	0.416	0.520	0.606	0.552	0.574

Soil microbes utilize carbon to form new cells and nitrogen to synthesize proteins. It plays a significant role to control soil carbon and nutrient cycling by fixing the nitrogen in the soil ensuring unavailable nutrients to be readily available for plant to uptake (Toor & Adnan, 2020; Wan, et al., 2015). When the average C/N ratio is above 20, this indicates slower decomposition with lesser immobilisation of N and this affect negatively on plant growth as microbes compete with roots to secure nutrients supply. In contrast, lower C/N ratio may enhance quick degradation and stimulate decay processes, which is available for plant uptake (Hamad & Abdelnasir, 2016). In this study, average C/N ratio was at 5.7 to 8.9, defining that there is 6 g carbon for each 1 g of nitrogen in that organic matter and this level is considered under acceptable range. However, the result contradict with a previous study that indicates C/N ratio which is less than 15 is considered at low level and intervention to increase the ratio need to be done to enhance plant growth (Amlin, Suratman, & Md Isa, 2014).

Total carbon (C) in the study area showed there was no significant difference between the depths but there was a significant difference between the elevation of the slope, Pr>F (0.0234) (Fig. 1). This may due to the differences in root dynamics and mycorrhizal communities that can partially result in the increment of soil total C at different elevation (Girardin, et al., 2010). There was a significant difference in total nitrogen (N) content at different elevation level, Pr>F (0.0186). The Tukey's test (α=0.05) showed the highest and lowest total N content is in the middle and top elevation. This result implying the shortage of N at the top elevation may be contributed by a slightly higher temperature caused by direct sun exposure compared to the rest of the elevation because of the deforestation and establishment of plantation crop in the study area.

A lower temperature is a major factor to reduce the N availability through the inhibition of soil microbial activities and decreased the N mineralization of soil total nitrogen, these limits the plant root growth (Gilliam, Galloway, & Sarmiento, 2015; Liu, et al., 2016) because of the undulating terrain (hilly) of the study area. Total N content of Malaysian soils was considered at a medium level of over 1.5%. The result showed the middle elevation has a low level of N for ideal plant growth, as the total N content is lower than 1.5%. However, the optimum range requirement of N content in the soil can be potentially increased by amendment of organic fertilizers and/or planting legumes crop that has nodules for nitrogen fixation (Nin, et al., 2016).

Soil moisture content (%), pH and soil electrical conductivity (EC) were not significant at both elevation and depth of the sampling. The soil moisture content (%) ranged from 14.20% to 45.19%. The soil moisture content showed that the top elevation and the middle elevation had higher soil moisture content at depth 0 – 15 cm compared to 15 – 30 cm. Generally, acidic soil in Malaysia, has a volumetric soil water content at saturation 36% to 89%, from sandy soil to clayey soil and influenced greatly by soil management practices instead of soil texture (Sung, et al., 2017). For new shoots establishment of durian (more than 90% establishment), soil moisture content needs to be maintained minimally at 80% (Bahagian Hortikultur - Seksyen Buah-buahan, 2009).

The pH was less than pH 5.5, which was acidic and for durian growth, the optimum pH is 5.5 to 6.0 (Asia-Pacific Association of Agricultural Research Institutions - APAARI, 2018). Electrical conductivity (EC) refers to the soil salinity. According to Bahagian Hortikultur – Seksyen Buah-buahan in 2009, the optimum level of EC for durian planting is less than 1 mS/cm, which in this study showed that the EC level was at an acceptable range. Acidic soil indicated by low pH represented the number of hydrogen ions in the soil and the varying amount of the ions will probably affect the EC level (Bruckner, 2012). However, the relevance of the linear relationship will depend on the presence of hydrogen ions in comparison to other concentrations contributing by non-pH determining ions such as soil mineral, porosity, soil texture, soil moisture and soil temperature (United State Department of Agriculture - USDA, 2011).

For total sulphur (S) content, the study showed that there was no significant difference ($P<0.05$). This result opposed the previous study that showed total S decreased with depth due to the decline in organic C content (Dolui & Pradhan, 2007). The weathering process of the topsoil layer may reduce the total S content t that is mobile in the soil and exists in the form of organic matter (Prasad & Shihav, 2018). Fig. 1 showed that the amount of total C was higher at different elevation and depth in comparison with total N and total S. C/N ratio decreased with increasing depth at only bottom elevation. However, the total organic carbon (TOC%) was observed higher at 15 – 30 cm in soil sampling.

Exchangeable bases calcium (Ca) was not significant between the depth but there was a significant difference between the elevation of the slope, Pr>F (0.0015). Adequate Ca nutrition is important for respiration and growth development (Halman, Schaberg, Hawley, & Hansen, 2011). One of the primary roles assigned to calcium in the plant cell is for environmental signal that enables cells to sense and react to stress (Schaberg, Miller, & Eaga, 2010). Considering this, depletion of Ca could impair plant response systems and predispose trees to decrease growth and promote declination. In particular, soil Ca often decreases when elevation increases due to the presence of thinner soils and higher acid deposition inputs that leach Ca from soils (Schaberg, Miller, & Eaga, 2010). However, from this experiment, significantly greater Ca was found in middle elevation horizons compared to the top and bottom elevations. This is because elevation can be confounded with gradients in other environmental factors such as more generalized low-temperature exposures or water availability that results in exposure to differential stress (Halman, Schaberg, Hawley, & Hansen, 2011).

Exchangeable potassium (K) is readily exchanged with other cations and readily available for plant absorption (Mouhamad, Alsaede, & Iqbal, 2016). The exchangeable K was significant with 0.0071 (Pr<0.05), where the result showed that the amount of exchangeable K was higher at depth 0 – 15 cm compared to 15 – 30 cm depth at every elevation. The study from Soong and Lau in 1977 shows that the total K contents are greater at the sub-surface soils (15 – 45 cm) compared to the topsoils because of the properties of K that easily leached out and more mobile compared to other macronutrients. However, the exchangeable K might differ due to the clayey contents of the soils that inhibit the potential of the plant to absorb potassium. Without the presence of evidence, these suggested that the existence of added K in an exchangeable form below 15 – 30 cm soil layer is reasonable to assume that K was fixed in the nonexchangeable form at the topsoil profil. According to Swapan, Anuar, Kamaruzaman, Desa, & Ishak (2001), the exchangeable K of the study area is at low to a moderate level at the lowest value of 0.380 mg/kg to the highest value 0.748 mg/kg.

The study showed that there was no significant difference of exchangeable sodium (Na) between the depths but there was a significant difference between elevations of the slope, Pr>F (< 0.0001). Total exchangeable Na was more concentrated at the middle terrain whereas at top terrain was the lowest. Differences in soil nutrient availability along elevation gradients are considered the major drivers of this shift, caused by changes in soil weathering, turnover rates and temperature constraints (Nottingham, et al., 2015). Sodium could improve root, shoot biomass, improve colour such as greener leaves and its maintenance at later growth stages, and prevent nutrient deficiency (chlorosis or necrosis). Besides, sodium also benefits of the ion for higher-plant growth and increase yield (Kronzucker, Coskum, Schulze, Wong , & Britto, 2013).

Fig. 2 showed that the amount of Ca was the highest compared to other bases followed by Mg elements. These two elements are essential to crops in larger amounts compared to the other cations. Unfortunately, even though Ca and Mg in this study area were higher than commonly found in Rengam and Jerangau soil series, the amount of high exchangeable Ca ion in the soil may affect K or Mg uptake due to its dominancy held by soil clay and organic matter. The occurrence of imbalance nutrients will occur as Ca uptake is much higher compared to other cations (Afandi, et al., 2002). Another factor contributing to low basic cations in the soils was due to the low pH, indicating the exchange cations in surface soils were dominated by acidic cations like Al and H (Sujaul, Ismail, Tayeb, Muhammad Barzani, & Sahibin, 2016). The electrostatic affinities of the ions for the exchange sites were also cited as the reason for the trend (Na>K>Mg>Ca).

Cation exchange capacity (CEC) of this study area was observed more than 20 $cmol_c$/kg higher than commonly found in Ultisols and Oxisols at an average value less than 10 $cmol_c$/kg (Shamsuddin & Fauziah, 2010). To retain exchangeable cations such as Ca, Mg and K from leaching via groundwater runoff, CEC is important to be maintained at an optimum level. The study had a higher CEC level at depth 15 – 30 cm compared to the surface at all elevations. This opposed the previous study stated that CEC was found higher on the surface than in the subsurface horizons and decline when depth increases due to the organic matter content (Zhenghu, Honglang, Zhibao, Gang, & Drake, 2007). However, because the study area was cultivated for planting, therefore, the organic matter might only be available in the subsurface horizons. Addition of organic amendment and application of compost from fruit wastes might increase the organic matter in the soil.

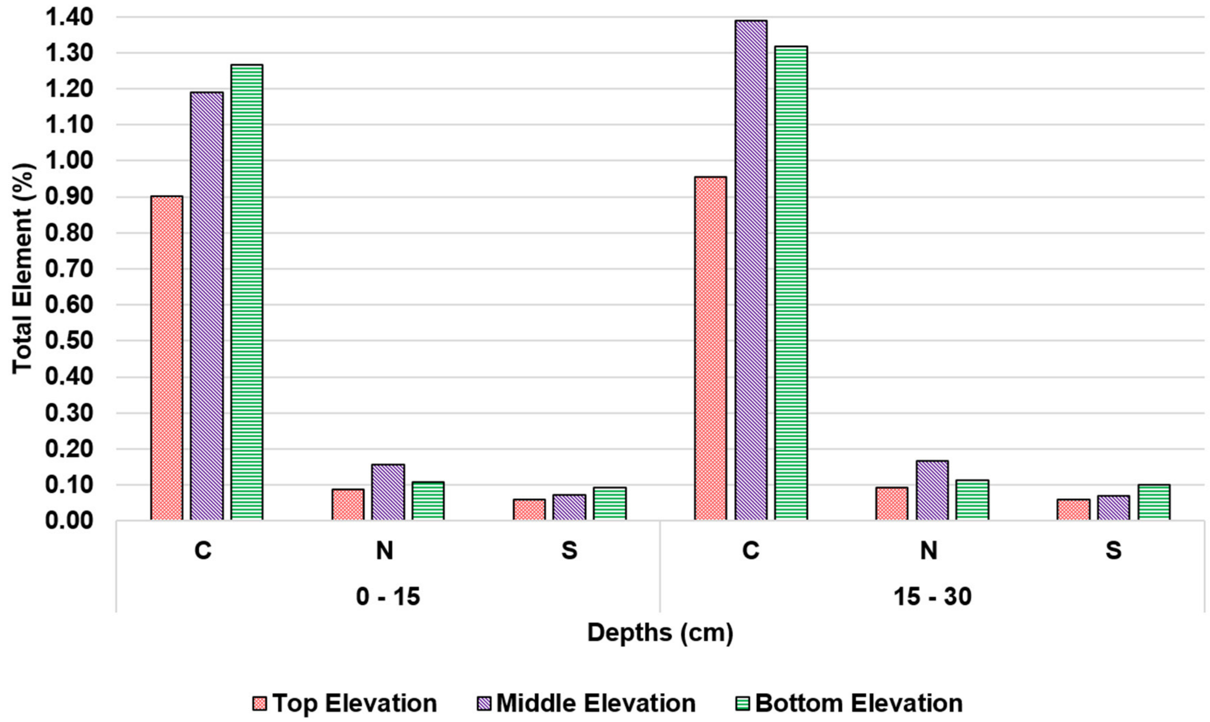

Fig. 1. The total carbon (C), nitrogen (N) and sulphur (S) at different elevations and depths in Gua Musang

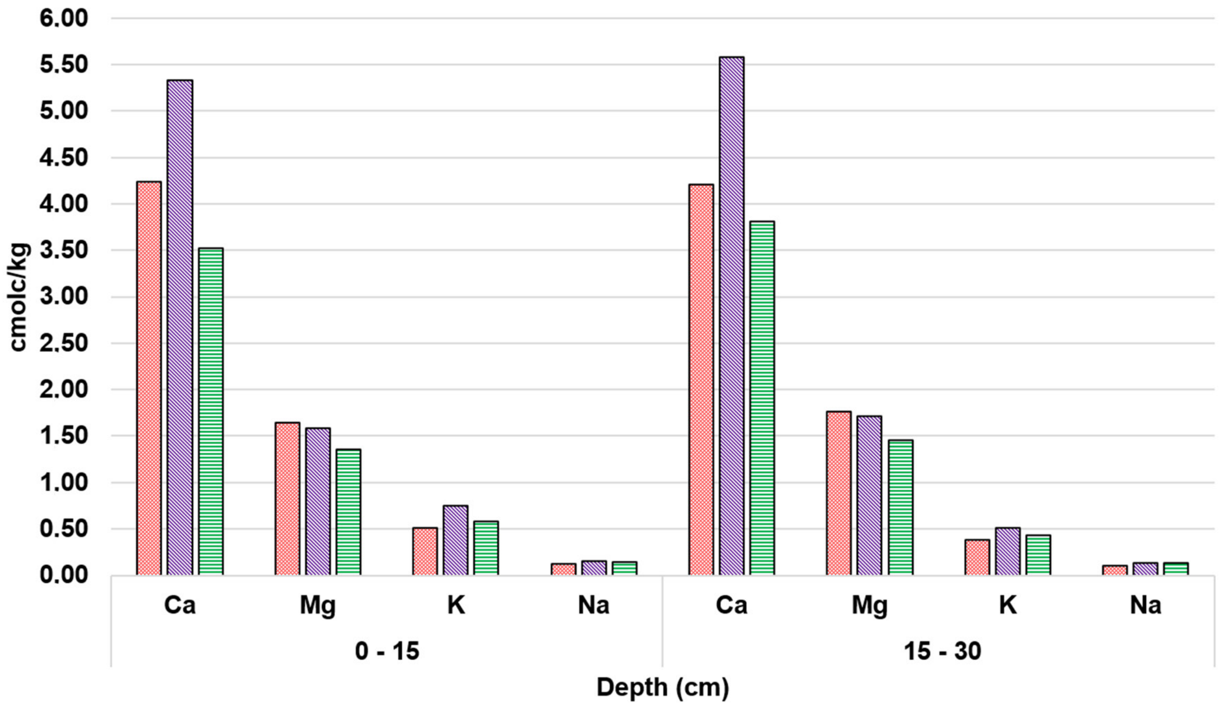

Fig. 2. The exchangeable bases in different elevations and depths in Gua Musang

Base saturation (BS%) of the study area showed no significant difference, Pr<F (0.05) with less than 32%. The value was concomitant with acidic soils in tropical countries such as Malaysia that had less than 35% BS. For healthy growth performance, BS needed is more than 35% (Shamsuddin & Fauziah, 2010). A suggestion had been made to increase these basic cations, which is increasing Ca and Mg by using liming material such as dolomite or known as ground magnesium limestone (GML) and zeolite (Sakya, Syamsiyah, & Panji, 2019). The liming material elevates the soil alkalinity level and turns it into an acceptable range for the nutrients exchange and absorption by plants. To increase K-level in the soil, application of fertilizers with K-nutrients added is recommended (Shamsuddin & Fauziah, 2010).

Analysis of available phosphorus (P) showed that there was no significant difference, both at elevation and depth of the sampling (Pr<0.05). Except at the bottom elevation, available P was observed higher at 0 – 15 cm compared to the 15 – 30 cm depth in the top and middle elevation. However, available P of the study area was 1.624 to 3.137 mg/kg that is at a very low to a low level (Swapan, Anuar, Kamaruzaman, Desa, & Ishak, 2001). The productivity is commonly low due to iron or aluminium fixation by the oxides or hydroxides causing the depletion level of available P (Shamsuddin, Fauziah, Roslan, & Noordin, 2018). The factors influencing available P concentration patterns are typically very complex and both the hydrological system and soil parent material play important roles in deciding P concentration (Hu, Li, Xie, Deng , & Chen, 2018).

CONCLUSION

In conclusion, the nutrient for parameters studied were low with only the exchangeable bases and CEC were higher compared to the common soil texture found in that area. The hilly and undulating terrain of the area might affect the difference in soil physical and chemical properties. Therefore, extensive classification of soil taxonomy in the area is suggested for a better understanding in the soil properties, amending it to suits durian establishment and growth.

ACKNOWLEDGEMENT

We would like to express our gratitude to M7 Plantation Berhad for providing the fund for this research.

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