Properties of Cultivated Soil from Mesilou-Kundasang Agricultural Area

Sahibin Abd Rahim#, Ng Siuw Sing, Diana Demiyah Mohd Hamdan, Junaidi Asis, Hennie Fitria Wulandari Soehadi Erfen, Nur Zaida Zahari, Baba Musta

Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, MALAYSIA.
Corresponding author. E-Mail: sahibin@ums.edu.my; Tel: +6088-320000; Fax: +6088-435324

ABSTRACT A study to examine the physical properties of soil used to cultivate Allium plant from Kundasang-Mesilou agricultural area was carried out. Six sampling stations covering different types of parent materials were chosen. Topsoil's samples from these stations were examined for their physico-chemical properties using standard method for soil analysis. From the result of this research showed that sufficient content of organic matter, low soil bulk density indicating a good soil structure, high available macronutrient contents, low cation exchange capacity and a non-saline electrical conductivity. The dominant soil texture were loamy with some were clayey and sandy. In general the physical properties of soil were suitable for vegetables cultivation but the chemical properties shown it required conventional input to satisfy plant needs. The overall physico-chemical properties of soils in the study area at present were less fertile compared to their properties fifteen years ago. The soil physico-chemical properties also deteriorated compared to the forested area.

KEYWORDS: Physico-chemical properties; Mesilou-Kundasang agricultural area; soil; fertility
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INTRODUCTION

Temperate crops such as cabbage, strawberry, tomato and some others that flourish in cool climate are cultivated in the highland of Kundasang-Mesilou agricultural area. Vegetable cultivations are an established activity in these areas besides tourism (The Star, 2019). The unique scenery and activities of vegetables farming in this area also serve as tourist attractions apart from the cool climate and naturally beautiful scenery (Chay, 1988). Since agricultural activities had been practiced for many years, it is anticipated that many changes has occurred in the soil of the vegetables field due to intensive cultivation in order to gain sustainable yield. The glaring changes can be observed from the loss of natural vegetation due to land opening to make way for vegetables cultivation. In the earlier period the soils may still comprises considerable amount of organic matter and nutrient that indicates the good quality of the soil during that time. As time passes by, erosion dominates on the open surface area scouring organic matter and nutrient away, leaving a yellowish soil surface dominating the scenery of the vegetables field as can be seen today (Rendana *et al*., 2014). Due to erosions, soil fertility degraded which pave the way for chemical fertilizer such as Nitrophoska introduction to preserve the fertility of the soil to produce sustainable yield. Nitrophoska provide complete plant nutrition with all important such as nitrogen, phosphate, potash, magnesium, and sulphur (Nitrophoska, 2019). Pesticides and herbicides encroached in the cultivation area to control pest and unneeded herb. These introduced inputs to the vegetables field area may change or modify some of the soil physico-chemical properties of the cultivated vegetables field. This paper evaluates the changes due to farmer's activity in the physico-chemical properties of vegetables cultivation area in Kundasang-Mesilou highland to date.

MATERIALS AND METHODS

This research was carried out in Kundasang-Mesilou highland vegetables cultivation area. About 500 g of topsoil samples (0-30 cm) were taken from five sampling locations with stainless steel Dutch auger. Each sampling locations comprise of three replicates of samples. In the lab the soil samples were air dried and pounded to pass 2 mm sieve. Laboratory works as follow were carried out to determine the soil properties:- Soil pH was analysed by using soil; distilled water ratio of 1:2.5 based on Metson (1956) and was measured by pH meter WTW INOLAB Level 1. Electrical conductivity was extracted using saturated gypsum (Massey & Winsor, 1968) and measured by meter conductivity device Model H 18819 Hanna. The cation exchange capacity (CEC) were obtained by the summation method of base cations (Ca^{2+}, K^{+}, Ca^{2+}, Mg^{2+}) and acid cations (Al^{3+} and H^{+}) (Mclean, 1965). Available nutrients in soils were extracted using 1.0 M ammonium acetate-acetic acid ($C_2H_7NO_2$-CH_3COOH) solution (Rowell 1994) and determined using the ICP-OES instrument. Organic matter content was determined using the gravimetric method (Avery & Bascomb 1982). The soil particle size distribution of the soil samples was determined by using the dry sieving and pipette method (Abdulla, 1966).

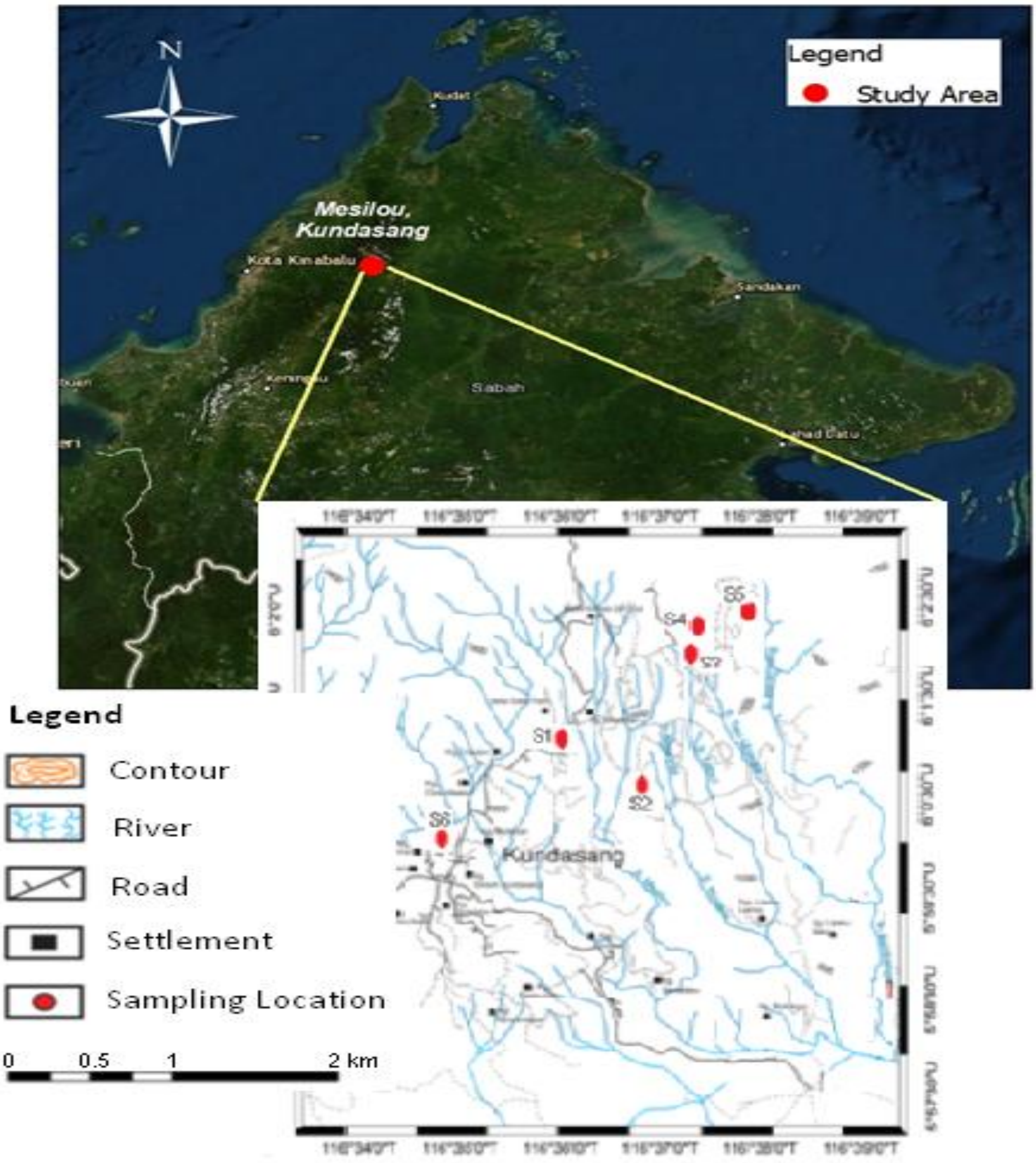

Figure 1. Map showing the study area and sampling locations

RESULTS AND DISCUSSIONS

The physico-chemical properties of the soil are shown in Table 1. The soil organic matter content in this study ranges from 2.69 to 6.97% with mean and standard deviation of 4.85±1.59%. Organic matter makes up just 2-10% of most soil's mass and has an important role in the physical, chemical and biological function of agricultural soils. Organic matter contributes to nutrient retention and turnover, soil structure, moisture retention and availability, degradation of pollutants, carbon sequestration and soil resilience (Griffin & Edwards, 2019). Soil organic matter can elevate the cation exchange capacity of the soil up to 20% to 70% (Kabata-Pendias, 2011).

For the soil bulk density it ranges from 0.79 to 0.91 g/cm^3. Bulk density is an indicator of soil compaction. Total average low bulk density in the study area at 0.85±0.04 g/cm^3 indicates a loose soil befit of a vegetable field in the hilly area which are frequently ploughed with light machinery. Bulk density reflects the soil's ability to function for structural support, water and solute movement, and soil aeration.

The soil contains very high available K, Mg and P (Acres *et al*., 1975; Daniel & Carl, 2016; 2018). For this research the range value of K recorded from 283.69 to 1072.55 mg/kg, Mg from 237.37 to 513.02 mg/kg and P from 292.30 to 1010.11 mg/kg respectively in the soil. The total average of K, Mg and P at 590.11±292.97 mg/kg, 446.33±280.46 mg/kg and 384.20±101.30 mg/kg, respectively are considered high based on Acres *et al*., (1975) classification. High level of available nutrients in soil could be due accumulated salt after long-term application of NPK fertilizer.

Table 1. Mean value of the physico-chemical properties of the soil at different sampling stations

Parameter	Station					
	1	2	3	4	5	6
Organic Matter (%)	2.69±0.32	6.37±0.54	4.76±1.29	6.97±1.39	4.41±0.49	3.88±0.33
Bulk density (g/cm^3)	0.91	0.82	0.85	0.79	0.86	0.87
Available Nutrient (mg/kg)						
K	581.38±122.21	733.49±183.96	283.69±155.69	564.45±569.78	305.12±120.93	1072.55±102.19
P	292.30±55.62	269.59±73.95	381.37±212.90	1010.11±626.95	395.06±232.00	329.53± 5.14
Mg	369.40±55.62	513.02±177.79	237.37±5.47	441.87±230.37	439.97±200.36	303.59±59.97
*CEC (meq/100g)	5.77±1.07	12.44±2.04	6.22±1.20	11.51±3.80	12.22±1.28	9.29±1.50
pH	5.37±0.35	5.53±0.36	5.96±0.12	6.57±0.18	6.78±0.37	5.30±0.28
#EC (µS/cm)	1888.17±51.42	1786.33±55.56	1957.50±100.90	2149.17±396.35	2071.50±99.58	2523.33±85.48
Sand (%)	54	22	66	47	25	52
Silt (%)	24	37	20	26	52	32
Clay (%)	23	41	14	26	23	16
Texture	Clay loam	Clay	Sandy loam	Loam	Silty loam	Loam

*Cation Exchange Capacity; #Electrical Conductivity

The cation exchange capacity (CEC) in soil ranges from 5.77 to 12.44 meq/100g soil. The CEC of the soil in all of the six stations is considered as low with total average recorded at 9.58±2.99 meq/100g soil. Cation exchange capacity (CEC) is the total capacity of a soil to hold exchangeable cations. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification (Sonon *et al*., 2017).

The soil electrical conductivity ranges from 1786.33 to 2523.33 µS/cm. According to USDA classification the total average of soil electrical conductivity in this study at 2062.97±259.86 µS/cm is consider non-saline soil which may not cause any damage to the plant (USDA, 2011). Electric conductivity in all of the sampling area can be put into Index 0 in the ADAS (1973) recommendation. This means that their value is within the normal range usually found in outdoor soil. This will pose no restriction for vegetables cultivation purposes.

The soil pH values ranges from pH 5.30 to pH 6.78. Classification by Acres *et a*l., (1975) categorized the soil pH as near neutral to acidic. Most vegetables grow well in slightly acidic soil pH (Marie, 2014; 2019). Most soils have pH values between 3.5 and 10. In higher rainfall areas the natural pH of soils typically ranges from 5 to 7 while in drier areas the range is 6.5 to 9. Soils become acidic when basic elements such as calcium, magnesium, sodium and potassium held by soil colloids are replaced by hydrogen ions. Soils formed under conditions of high annual rainfall are more acidic than soils formed under more arid conditions.

The topsoil samples were collected from different field which developed from different parent materials. Those soils that are sandier developed from granitic tilloid deposit and those having a high clay content developed from Trusmadi Formation as parent material. In general the clay content from all sampling stations is quite low. Low clay content may produce a soil with low cation exchange capacity which reduces the ability of soil to retain nutrient in the soil for plant use. The overall soil textures in this research are loam. These soils are also susceptible to erosion as generally displayed in the field.

Comparison between the present with the previous study is presented in Table 2. Organic matter in the vegetables field doesn't differ very much between the time and place of sampling. All bulk densities of soil in the area being compared are considered low for silty and clayey textured soil which is normally at 1.1 – 1.6 g/cm^3 (Soil Quality Indicators, 2011). Higher CEC value in the vegetables plot in Cameron Highland compared to forest and vegetables plot in Mesilou is attributed to prior lime application before sampling as shown by high exchangeable Ca^{2+} contents in soil (Sahibin *et al*., 2006).

Table 2. Soil physico-chemical properties comparison with other similar study

Parameter	Present study (2019), Mesilou	Sahibin *et al.* (2003), Mesilou	Sahibin *et al.* (2006), Cameron Highland Veg Field	Sahibin *et al.* (2006), Kg Raja CH Forest
Organic Matter (%)	4.85	5.7	4.13	10.28
Bulk density g/cm^3)	0.85	0.82	0.87	0.72
Available Nutrient (mg/kg)				
K	590.11	-	-	-
P	446.33	-	1.45	0.0018
Mg	384.20	-	-	-
Cation Exchange Capacity (meq/100g)	9.58	-	29.56	4.92
pH	5.92	4.62	5.45	4.53
Electric Conductivity (µS/cm)	2062.27	-	1262.50	1090.03

Available macronutrient in the present study is higher than in Cameron Highland. Their pH is higher because of normal effect of routine lime application by the farmer. Their electrical conductivity is 60% higher than Cameron Highland. Higher electrical conductivity in Kundasang-

Mesilou agricultural area is due high excess salt in the soil which comes from application of fertilizer and liming. This relates to the high concentration of available nutrient in the soil (Table 2). Accumulated salt due to prolong fertilizer application is not yet dissolved by rainfall or irrigaton water during the sampling. This finding is supported by the works of Shi *et al*. (2009) in a vegetable cultivation area in the Yangtze River Delta of China which showed a significant positive correlation between electrical conductivity with nutrient concentration.

CONCLUSION

The organic matter content in the soil is sufficient to form good structure which is indicated by low soil bulk density. Available macronutrients that come from continuous NPK applications are recorded abundant to support plant needs. The cation exchange capacities are recorded low which may need the fertilizing to be applied more frequent with low dosage. Electrical conductivity values are low and considered as non-saline and are suitable and for vegetables cultivation. The soil textures are loamy that are easy to work on for vegetables bed preparation. In term of soil quality, the present vegetables field physical condition is found deteriorated compared to forest condition. This paper enlightens us on the importance of conservations to preserved soil health and fertility despite unavoidable prolonged activity of land cultivation.

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REFERENCES

[1] Abd. Rahim, S., Ongkosing, J., Ali Rahman, Z. A., Lihan, T., Laming, A. & Musta, B. 2003. Heavy Metal Distribution Pattern in Soil Profile Adjacent to Copper Mine at Mesilou Agricultural Station, Ranau, Sabah. *Analytical Chemistry: Application and Current Issues*, 116-122.

[2] Abdulla, A. A. 1966. *A study of the development of podzol profiles in Dovey Forest*. PhD Thesis, University of Wales.

[3] Acres, B. D., Bower, R.P., Burroughs, P.A., Folland, C.J., Kalsi, M.S., Thomas, P. & Wright, P.S. 1975. *The Soils of Sabah*. Vol 1-5. Land Resource Study 20. Land Resource Division. Min. Overseas Development, England.

[4] ADAS. 1973. *Fertilizer recommendations*. Ministry of Agriculture, Fisheries and Food. Bulletin 209, HMSO, London.

[5] Avery, B. W. & Bascomb, C. L. 1982. *Soil survey laboratory methods*. Technical Monograph No. 6. Soil Survey, Harpenden, UK

[6] Chay, P. 1988. *Sabah The Land Below The Wind*. Kuala Lumpur: Foto Technik Sdn. Bhd.

[7] Daniel, E.K. & Carl, J.R. 2016. *Magnesium for crop production* (https://extension.umn.edu/micro-and-secondary-macronutrients/magnesium-crop-production). Last accessed on 22 Dec 2019.

[8] Daniel, E.K. & Carl, J.R. 2018. *Potassium for crop production* (https://extension.umn.edu/phosphorus-and-potassium/potassium-crop-production#plant-analysis-tools-601711). Last accessed on 22 Dec 2019.

[9] Griffin, E. & Edwards, T. 2019. *What is soil organic carbon?* (https://www.agric.wa.gov.au/measuring-and-assessing-soils/what-soil-organic-carbon). Last accessed on 2 May 2019.

[10] Kabata-Pendias, A. 2011. *Trace Elements in Soils and Plants*. Boca Raton: CRC Press.

[11] Marie, I. 2013. *The Timber Press Guide to Vegetable Gardening in the Northeast*. London: Timber Press.
[12] Marie, I. 2019. *Growing Leeks in Vegetable Garden* (https://www.thespruce.com/growing-leeks-in-the-vegetable-garden-1403462). Last accessed on 20 Dec 2019.
[13] Massey, D. M. & Winsor, G. W. 1968. Soil salinity studies. II. The relation of plant growth to salinity in soil and soil mixtures of differing physical properties. *Journal of the Science of Food and Agriculture*, 19, 332-338.
[14] Mclean, E. O. 1965. Aluminium. *In*: Norman, A. G. (Ed). *Methods of Soil Analysis*. Methods of Soil Analysis: Part 2 Chemical and Microbiological Properties
[15] Metson, A.J. 1956. *Methods of chemical analysis for soil survey samples.* Soil Bureau Bulletin Series 12, Department of Scientific and Industrial Research, New Zealand.
[16] Nitrophoska. 2019. Retrieved from Eurochemagro: https://eurochemagro.com /products/nitrophoska/# Accessed on 2 May 2019.
[17] Rendana, M., Sahibin, A. R., Idris, W.M.R., Zulfahmi, A.R. & Tukimat, L. 2014. Gis And NDVI Application for Soil Erosion Potential Modeling Using Rusle Method in Ranau District, Sabah. *Proceeding of The Soil Science Conference of Malaysia 2014*. Putra Palace, Kangar Perlis, 8-10 April, 2014. Pg 104-107.
[18] Rowell, D.L. 1994. *Soil Science: method and applications.* Singapore: Longman Singapore Publishers (Pte) Ltd.
[19] Sahibin, A.R., Zulfahmi, A.R., Tukimat, L., Ramlan. O., Azman, H., Errol, P. & Lai, K.M. 2006. Physico chemical properties of soil under vegetables cultivation in Cameron Highland. *Malaysian Journal of Analytical Science,* 25(1), 31-43.
[20] Shi, Y., Hu, Z. Y., Haneklaus, S., Long, G., Xia, X., Zhao, Y. W., Lin, T. & Schnug, E. 2009. Suitability of soil electrical conductivity as an indicator of soil nitrate status in relation to vegetable cultivation practices in the Yangtze River Delta of China. *Landbauforschung Volkenrode* 59(2), 151-158.
[21] Sonon, L.S., Kissel, D.E. & Saha, U. 2017. *Cation Exchange Capacity and Base Saturation*. UGA Cooperative Extension Circular 1040.
[22] The Star. 2019. *Kundasang set to be net exporter of high-value vegetables* (https://www.thestar.com.my/news/nation/2019/06/30/kundasang-set-to-be-net-exporter-of-high-value-vegetables). Last accessed on 13 November 2020.
[23] USDA. 2011. *Soil Quality Indicators: Soil Electrical Conductivity* (Retrieved from USDA: https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcs142p2_053136&ext=pdf). Last accessed on 20 December 2019.

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