Soil properties under *Orthosiphon stamineus* (Benth) intercropped with *Durio zibethinus* (Murr) and treated with various organic fertilizers

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Abstract
Orthosiphon stamineus (Benth) is a herb that can be intercropped under shade trees. There is a lack of information the soil properties for *O. stamineus* intercropped with durian. In this study, the soil was tested to determine nutrient levels with respect to the organic fertilizer treatments such as chicken dung, cow dung and oil palm empty fruit bunch (EFB). The study was carried out in the fields of smallholder's rubber at Papar, Sabah. The soil series of this area belongs to Inanam family (Gleyic Acrisol) as it is characterized with a gleyic horizon. The objective of this study was to determine the physico-chemical soil properties growing *O.stamineus* for the various fertilizer application regimes. The field planting distance used was 1.5 m x 0.45 m. Higher rate of fertilizer application gave higher yields of *O. stamineus*. Chicken dung was the best fertilizer followed by oil palm EFB and cow dung. The productivity using oil palm EFB and cow dung was smaller compared to chicken dung. Soil physical properties did not show any influence on the growth and yield of *O. stamineus*. However, the soil chemical properties influenced growth and were dependent on the type of fertilizer applied.

Key Words
Intercropping, organic fertilizer, soil physical and soil chemical properties.

Introduction
There is a lack of information about the soil properties for *O. stamineus* intercropped with durian. In this study, the soil was tested to determine the nutrient levels with respect to the organic fertilizer treatments. Previously, Affendy (2009) found that the best rate of fertilizer that can be applied was 0.9 kg per plant of *O. stamineus* intercropped with durian compared to 0.6 kg per plant. With this rate of fertilizer, the yield (dry matter) of *O. stamineus* intercropped with durian using chicken dung, cow dung, oil palm empty fruit bunch (EFB) and control (without fertilizer) were 253, 43, 56 and 31 kg/ha respectively.

Materials and Methods
Soil Sampling and Analysis
In this study, soil samples were taken before and after fertilizer application for each treatment at soil depths 0-5cm, 5-15cm and 15-30cm. One block contained 12 samples resulting in 144 samples in total. The samples were taken three times at month 0 (before fertilizer application), month 6 (after six months of the first fertilization) and month 12 (after second fertilization). Soil samples were air-dried at room temperature (Carter 1993; Tan 2005). The samples were then analyzed for physical and chemical properties. The soil physical properties were soil texture and soil moisture (% MC). Soil texture was determined by the pipette method (dispersion, sedimentation and decantation), while soil moisture content was determined by gravimetric method which involves the measurement of water lost after it is dried at 105-110℃ (Tan 2005). Soil chemical properties included pH using 1:2.5 soil:water solution by a pH meter (Bantex, Digital pH meter, A 300), total nitrogen (N), available phosphorus (P), available potassium (K), magnesium (Mg) and calcium (Ca). The total nitrogen in soil was determined using the block digester technique (QuickChem, Method 13-107-06-2-D) as detailed by David (2001). Available phosphorus was determined by the Mehlich 3 method (1984) as detailed in Carter (1993). Exchangeable K, Mg and Ca in the soil were also determined by Mehlich 3 method (Mehlich 1984).

Statistical Analyses
The data were subjected to one-way Analysis of Variance (ANOVA), for soil physical properties under durian, two-way ANOVA for soil chemical properties for different organic fertilizer treatments.

Results and Discussion

Soil Physical Properties

Table 1 shows the results of physical properties (% MC, temperature, % sand, % silt and % clay) of 3 soil depths in the durian with *O. stamineus* intercropping system. The results show that the mean values for soil moisture increase with depth. This is because the topsoil is subject to more evaporation. The lower moisture content of the topsoil can be attributed to a greater exposure of the topsoil to direct radiation from the sun which can increase the soil temperature and the evaporation of water (Soo 1990). Nardi *et al.* (2006) found that *Artemisia rothrockii* or also called Sagebrush (Herbaceous meadow) used deeper water on average than most herbs, but it also acquired 10-30% of its water from shallow (< 30cm) soil. Also the higher soil temperature as shown in the results for the topsoil will result in higher evaporation. The results are similar to those of Zahari (2005). The soil had a high percentage of sand. According to Tan (2005), when sand is dominant, the soil exhibits coarse or light textures which are loose and friable and easy to plow.

Table 1 Physical properties for 3 soil depths for the *O. stamineus* and durian intercrop

Property	Depth (cm)	Mean[A]
MC (%)	0-5	0.30^{c}
	5-15	0.40^{b}
	15-30	0.54^{a}
Temperature (℃)	0-5	27.4^{a}
	5-15	26.9^{b}
	15-30	26.3^{c}
Clay (%)	0-5	21.8^{ns}
	5-15	21.4^{ns}
	15-30	23.1^{ns}
Silt (%)	0-5	12.2^{ns}
	5-15	11.6^{ns}
	15-30	11.7^{ns}
Sand (%)	0-5	66.0^{ns}
	5-15	67.0^{ns}
	15-30	65.3^{ns}

[A]Mean values with different letters were significantly different at 5% level probability ($p<0.05$) using ANOVA and DMRT (ns= not significant).

Soil Chemical Properties

Table 2 shows the results of chemical properties for the soil on which is growing durian and *O. stamineus* for the four fertilizer treatments. There were no significant differences between the fertilizer treatments for total N at 5% level ($p>0.05$). However, there were significant differences for available P, exchangeable K, Mg, Ca and CEC at 5% level ($p<0.05$).

For available P, the chicken dung contained the highest available P which was 37%, 6.1% and 88.4% more than cow dung, oil palm EFB and control respectively. For exchangeable K, the chicken dung contained the highest exchangeable K which was 60%, 61.3% and 88.9% more than cow dung, oil palm EFB and control respectively. For exchangeable Mg, the chicken dung contained the highest exchangeable Mg which was 15%, 6.1% and 31.8% more than cow dung, oil palm EFB and control respectively. However, for exchangeable Ca, the cow dung contained the highest exchangeable Ca which was 8.8%, 8% and 55% more than chicken dung, oil palm EFB and control respectively. For CEC, the chicken dung had the highest CEC which was 20.1%, 21% and 57% more than cow dung, oil palm EFB and control respectively.

Table 2. Chemical properties of soils sampled from the *O. stamineus* - durian intercrop system for the different fertilizer treatments

Treatments	Property[A]					
	Total N	Available P	Exc. K	Exc. Mg	Exc. Ca	CEC
	%	(---------- mg/kg ----------)				cmol/kg
Chicken dung	0.11^{ns}	132.9^{a}	257.7^{a}	77.8^{a}	154.9^{a}	20.8^{a}
Cow dung	0.12^{ns}	83.8^{b}	102.9^{b}	66.1^{c}	169.8^{a}	16.6^{b}
Oil Palm EFB	0.10^{ns}	124.8^{a}	99.7^{b}	72.9^{b}	156.3^{a}	16.5^{b}
Control	0.10^{ns}	15.4^{c}	28.6^{c}	53.1^{d}	77.0^{b}	9.0^{c}

[A]Mean values with different letters were significantly different at 5% level probability, $p<0.05$ using ANOVA and DMRT (ns= not significant).

Generally, the soil N in the present study was low compared to soil N under *Eurycoma longifolia* in natural forest which ranged between 0.18 to 0.27% (Zahari 2005). This is because the roots of *O. stamineus* compete with roots of rubber or durian to absorb the nutrients and water. Furthermore, in natural forests the soil is rich in soil organic matter. According to Zahari (2005), the soil P of natural forest growing *Eurycoma longifolia* ranged from 104.61 to 170.69 mg/kg. Affendy (2005) found that soil P under *Azadirachta excelsa* was 152.4 mg/kg at Pasoh Forest Reserve, Negeri Sembilan. It can be concluded that the available P in this study area was comparatively higher if substantial fertilizer is applied compared to the results of previous studies. For exchangeable K, the results are in agreement with a previous study done by Yusop (2003) who found that the exchangeable K concentration was 326.69 mg/kg for samples from Pasoh Forest Reserve, Negeri Sembilan. The lower K concentration might be due to the characteristics of K as it is highly mobile and easily leached (Liu and Bates 1990). Furthermore, K is a monovalent cation while Ca and Mg are divalent. Therefore, the bond or force of attraction between K and soil micelle is weaker, and so the cation is much more susceptible to leaching than the exchangeable Ca and Mg (Olowolafe 2008). The higher soil K in the chicken dung treatment is due to higher potash in chicken dung.

In terms of soil Mg, the higher values were only for chicken dung and oil palm EFB with slow release characteristics. Affendy (2005) found that soil Mg under indigenous species ranged from 317.49 to 799.92 mg/kg. The indication of higher content might be partly due to the presence of organic matter and the sedimentary nature of the soil. The low content could be due to rapid leaching as a result of magnesium release from weathering (Shao 1979). Azani (1998) also reported that indigenous tree species in a planting area accumulate high Ca concentration in the soil. In contrast, Affendy (2005) and Zahari (2005) found that soil Ca was lower ranging between 32.34 to 60.05 mg/kg and 51.32 to 60.12 mg/kg respectively.

For CEC, Zahari (2005) found that the CEC of soil on which growing *Eurycoma longifolia* under natural forest was lower ranging from 7.20 to 7.47 $cmol^{+}$/kg. The reason might be due to the difference in forest types and the fertilizers used in the present study. Furthermore, a previous study by Olowolafe (2008) reported that the exchangeable bases have their highest values in the surface horizons, and then somewhat decrease down the profiles, particularly in the soils to which town waste has been applied and organic fertilizer as used in the present study.

The higher N concentrations in the present study affected the yield of *O. stamineus* especially under chicken dung (0.11 – 0.12%). This is in agreement with a previous study which showed that the height growth and leaf number production of rattan manau seedlings are affected when the seedlings are deficient in nitrogen (Raja Barizan and Aminuddin 1992).

Conclusion

In conclusion, soil physical properties do not show any influence to the growth of *O. stamineus*. The soil type for both sites was sandy clay loam which is suitable to the *O. stamineus*. However, the soil chemical properties influenced growth in relation to the type of fertilizer applied. Chicken dung is high in nutrient content as evidenced from previous studies. Oil palm EFB was second best but cow dung was not suitable due to its poor nutrient content.

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