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Selected Soil Physico-chemical Properties in the *Acacia mangium* Plantation and the Adjacent Heath Forest at Andulau Forest Reserve

Matali, S and F. Metali*

Environmental and Life Sciences Group, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, BE1410, Brunei Darussalam

ABSTRACT

Invasions by exotic plants and the establishment of plantations have been associated with the enrichment of nutrients in the soil. The first aim of this study was to examine soil physico-chemical properties of the *Acacia mangium* plantation and the nearby undisturbed heath forest (HF) at the Andulau Forest Reserve, Sungai Liang, Brunei Darussalam. The second aim was to determine the most influential soil properties that accounted for the most variation in the *Acacia* plantation and HF plots. A total of six pairs of 20 m x 20 m plots were established along two parallel transects (260 m each) in the *Acacia* plantation (6 plots) and the HF (6 plots). Each of the twelve plots were subdivided into four 10 m x 10 m subplots and one soil core (0 – 15 cm depth) was sampled in each subplot. Soil pH, gravimetric water content (GWC), organic matter (OM), organic layer depth, texture and major nutrient concentrations were determined for each soil core. Significantly higher total Ca concentrations and organic layer depth were found in the soils of the HF than in the *Acacia* plantation. However, the *Acacia* plantation soils had significantly higher total N concentrations than the HF soils. Non-native *A. mangium* trees have the ability to change the soil physico-chemical properties to improve their growth. Total Ca concentration and GWC were the most influential soil properties in the HF, whilst for the *Acacia* plantation plots, pH was most influential. Studying soil properties of both native forests and plantations of exotic species provides insights into how non-native plants change soil properties in ways different from native plant species.

Keywords: **Soil properties, *Acacia mangium* plantation, native forest, nutrients enrichment**

INTRODUCTION

The last few decades have seen rapid and continuing development of tree plantations in Asia, particularly in Southeast Asia (Sheil *et al.*, 2009; Krisnawati *et al.*, 2011). In Brunei Darussalam, several plantations of local commercial dipterocarp species (e.g., *Dryobalanops beccarii*), high quality tropical hardwoods (e.g., *Araucaria hunsteinii*), and fast growing exotic tropical hardwoods (e.g., *Acacia mangium*)

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*Corresponding author : E-mail: faizah.metali@ubd.edu.bn were established to meet the country's demand for timber (Anderson and Marsden, 1984). Whilst many studies show that tree plantations can improve soil friability and permeability of degraded land (Prinsely and Swift, 1986; Mishra *et al.*, 2003; Sharma and Sharma, 2004), the changes in physical and chemical properties of soils depend on the type of vegetation planted on the land (Binkley and Giardina, 1998; Bonifacio *et al.*, 2008). Significant changes in soil properties such as pH, organic matter (OM), and exchangeable bases can be observed when a population of plant species is replaced by a different plant species (Sharma and Sharma, 2004).

A one km^2 *A. mangium* plantation was established within the heath forest (HF) of the Andulau Forest Reserve of Brunei Darussalam in 1998 because of its high relative growth rates and potential as a source of timber (A. Cheng, pers. comm.). After 12 years, the *A. mangium* trees in the plantation were harvested leaving juvenile *Acacia* trees to regrow without any further management. Soils at the nearby HF habitats were characterised as being acidic and sandy, and often lacking nutrients, particularly N (Forestry Department, 2011). The soils sit mainly over sandstone plateaus and ridge formations on dip slopes (Whitmore, 1984) overlying a Pleistocene marine terrace (Brünig, 1974).

The Food and Agriculture Organization of the United Nations (FAO) reported that the genus *Acacia* to be the most widespread invasive species found in more than ten countries in Southeast Asia, including Indonesia and Malaysia (FAO, 1999; 2010). A majority of *Acacia* species, including *A. mangium, A. auriculiformis* and *A. cincinnata*, are native to Australia. Outside its natural habitats, *Acacia* is renowned for its wide range of impacts that transform ecosystems and alter ecosystem services (Osunkoya *et al.*, 2005; Le Maitre *et al.,* 2011). The key traits of *Acacia* species are their rapid growth rates as well as their ability to outcompete native plants, fix N, accumulate high biomass and generate massive seed banks (Osunkoya *et al.*, 2005; Morris *et al.*, 2011). These features enable them to become a dominant species upon habitat disturbance and can cause serious consequences for the biodiversity and regeneration of native plant communities (Le Maitre *et al.*, 2011; Morris *et al.*, 2011). Many studies report that, on average, alien invasive plants increase nutrient pools and fluxes in novel ecosystems (Xiong *et al.*, 2008; Le Maitre *et al.*, 2011; Osunkoya and Perrett, 2011; Jeddi and Chaieb, 2012). However, not very much is known about the impact of planting *Acacia* species on soil properties in Brunei Darussalam.

Acacia mangium Willd. of the family Fabaceae is one of the most widely used fast-growing tree species in plantation forestry programmes throughout Asia and the Pacific due to its rapid growth, good wood quality and tolerance to a wide range of soils and environments (Krisnawati *et al.*, 2011). Large scale plantations of *A. mangium* are estimated to have a net area of about 453,000 ha with about 99% of *A. mangium* plantations being located in tropical Asia where they are established for industrial purposes. Asian countries with major areas of *Acacia* plantation are Indonesia (67%) and Malaysia (14%) (FAO, 2002).

The aims of this study were two-fold. Firstly the study compared selected soil physico-chemical properties of the *A. mangium* plantation and the adjacent heath forest of Andulau Forest Reserve at Sungai Liang. Secondly, it identified the influential soil properties that accounted for the most variation in plots from the *A. mangium* plantation and HF.

MATERIALS AND METHODS

The soils were sampled from two study sites: the 1 km^2 *A. mangium* plantation (*Acacia* plantation hereafter) (4^{o}35'41.79"N, 114°31'3.15"E, elevation 32-56 m) and the heath (Kerangas) forest (HF hereafter) (4^{o}37'60"N, 114°31'59"E, elevation 21-37 m) at the Andulau Forest Reserve in Sungai Liang of the Belait district in Brunei Darussalam, northwest Borneo from September to October 2013. In 2013, Brunei Darussalam had an average temperature of 33.2^{o}C and a mean annual rainfall of 2704 mm with dry periods from February to April and again in July to September (records from Sungai Liang Agricultural Station; Department of Agriculture and Agrifood, Brunei Darussalam, unpublished data). The *Acacia* plantation was located within the Andulau Forest Reserve but separated from the primary HF by either a 5 m wide gravel pathway or fire breaks. The *Acacia* plantation consisted of many juvenile trees, but some areas were bare and were only dominated by bushy ferns and dead logs, which were probably left after the first harvest in 2010.

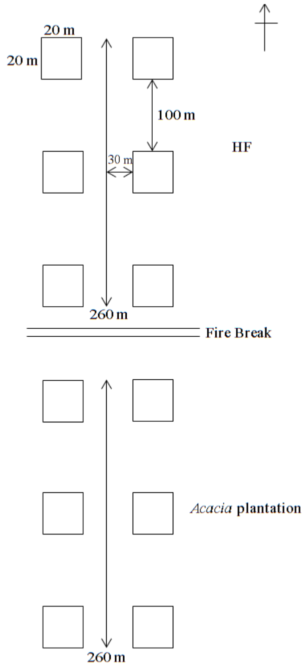


Figure 1: Illustration of the transects and plot establishment in Acacia mangium plantation and the nearby heath forest at the Andulau Forest the Reserve of Brunei Darussalam

Two line parallel transects 60 m apart (running in a north-south direction) from the HF into the *Acacia* plantation were established as shown in *Figure 1.* The line transects in the *Acacia* plantation were located about 340 m away from the line transects in the HF. A total of six pairs of 20 m x 20 m plots were set up along the line transects with Plots 1-6 set up at the HF and Plots 7-12 at the *Acacia* plantation. Each 20 m x 20 m plot was further subdivided into four 10 m x 10 m subplots (48 subplots in total) and one soil core (0-15 cm depth) was sampled from a randomly selected location within each subplot in the HF and *Acacia* plantation, respectively. A total of 48 soil samples were collected. Prior to soil coring, the depth of organic layer was measured using a ruler at each sampling point. Soil pH, with the soil being suspended in distilled water in a 1:2 ratio,was measured in the laboratory using a portable pH meter (Hanna instruments Ltd, UK) on the day of sampling. Gravimetric water content (GWC) and organic matter (OM) content were determined following the procedure by Allen *et al.* (1989). The texture of the soil samples was determined using the pipette method of the Department of Agriculture (2006).

Soil chemical analysis was conducted following the procedure by Allen *et al.* (1989) with slight modifications.The soils were analysed for total P and total N, and total Ca, total Mg and total K after digesting each soil sample (1.0 g soil for total P and total N and 0.3 g soil for total Ca, total Mg and total K) using concentrated H_2SO_4 and concentrated HNO_3, respectively. Soil exchangeable Ca concentrations were determined following extraction with 1 M KCl, whilst soil exchangeable K was determined following extraction with 2.5 % v/v acetic acid (2.0 g soil for Ca and 2.5 g soil for K).

Total P and total N concentrations in the acid-digests were measured using a flow injector analyser (FIAstar 5000, Sweden). Total Ca, total Mg and total K concentrations, and exchangeable Ca, and K concentrations were measured using a flame atomic absorption spectrophotometer (Thermo Scientific iCE 3300, Australia) after diluting the acid-digested samples with $LaCl_3$ ($LaCl_3$:HNO_3 in the ratio of 1:100, which is only applicable to Ca and Mg). Available P in soils was determined following the methods of the Department of Agriculture (2006). Soil samples (2.0 g) were extracted with Bray's solution (0.03 N NH_4F in 0.025 N HCl). The absorbance of each solution was read at 880 nm wave length using an ultraviolet spectrophotometer (UV-1800, Shimadzu, Japan).

All statistical analysis were conducted in R version 2.14.2 (R Development Core Team, 2012). Differences in soil properties between the *Acacia* plantation and the HF were determined using unpaired t-tests. Data for GWC and OM content were transformed using arcsine transformation. Other remaining data were explored to confirm the normality of residuals and homogeneity of variances, and where necessary, data were log-transformed. The physical and chemical soil variables between the *Acacia* plantation and the HF of Andulau Forest Reserve were then subjected to principal component analysis (PCA) to determine the variables which accounted for the most variations in the dataset.

RESULTS AND DISCUSSION

Soil Physical Properties

The textures of soils in all sampled plots in the *Acacia* plantation and the HF were sandy with a range of sand content between 32% to 98% and 54% to 93% in the plantation and HF, respectively (Table 1). Sandy soils are characterised by the predominance of rigid coarse particles that are associated with a small amount of clay and this soil type spans a range of rainfall regimes from the arid to the humid tropics (Ghazoul and Sheil, 2010). Fine textured soils or clayey soils tend to have more organic matter content than coarse soils (Schimel *et al.*, 1985; FAO, 2005). Nutrients are held better in coarse sand, providing good conditions for plant growth; however, the main problem with coarse sand is that nutrients can be leached very easily (FAO, 2005; Wang *et al.*, 2014). Coarse soils are also better aerated, and the presence of oxygen results in a more rapid decay of organic matter (FAO, 2005). The low clay content of the sandy soils in the dry grassland in Sudan had poor minerals, low organic matter content, water holding capacity and cation exchange capacity (El Tahir *et al.*, 2009).

TABLE 1

Means (mean ± standard error of means, SEM) of selected soil physico-chemical properties in the *Acacia mangium* plantation (*n*=6 plots) and the heath forest (*n*=6 plots) at Andulau Forest Reserve.

Soil properties	*Acacia* plantation	HF	t	*P*
Total N (mg g^{-1} dry mass)	0.72 ± 0.03	0.37 ± 0.06	-2.67	**< 0.05**
Total P (mg g^{-1} dry mass)	0.08 ± 0.004	0.07 ± 0.01	-1.23	> 0.05
Available P (mg g^{-1} dry mass)	0.01 ± 0.001	0.01 ± 0.001	-1.82	> 0.05
Total Mg (mg g^{-1} dry mass)	0.08 ± 0.01	0.06 ± 0.01	-1.04	> 0.05
Total Ca (mg g^{-1} dry mass)	0.02 ± 0.003	0.08 ± 0.01	4.29	**< 0.01**
Total K (mg g^{-1} dry mass)	0.02 ± 0.01	0.05 ± 0.01	1.37	> 0.05
Exchangeable Ca (mg g^{-1} dry mass)	0.01 ± 0.002	0.02 ± 0.002	1.44	> 0.05
Exchangeable K (mg g^{-1} dry mass)	0.02 ± 0.004	0.04 ± 0.01	1.24	> 0.05
pH	4.03 ± 0.08	3.87 ± 0.01	-0.87	> 0.05
Gravimetric water content (%)	14.11 ± 1.22	23.80 ± 3.70	1.07	> 0.05
Organic matter content (%)	6.32 ± 4.09	2.97 ± 0.34	0.93	> 0.05
Organic layer depth (cm)	5.29 ± 0.33	7.46 ± 0.36	3.9	**< 0.01**
Soil texture				
Silt (%)	6 – 33	1 – 66	NA	NA
Clay (%)	1 – 30	1 – 29		
Sand (%)	54 – 93	32 – 98		

NA=data not available.

HF soils had a significantly greater organic layer depth than those of the *Acacia* plantation (Table 1). However, GWC and OM content did not differ between the soils in the *Acacia* plantation and HF ($P > 0.05$, Table 2).

The presence of herb and understorey layer in the HF provided shading, which contributes to the modification in temperature regimes and high moisture content leading to a decline in the decomposition rate (Butterfield, 1999; FAO,

TABLE 2

Variations from principal component analysis (PCA) of selected soil physico-chemical variables across *Acacia* plantation (*n*=6 plots) and heath forest plots (*n*=6 plots) and percentage of total variation explained by each principal component axis.

Parameters	Principal component axes	
	1	2
% of total variation explained	39.6	22.0
Cumulative % variation explained	39.6	61.6
Loadings of soil nutrients and physical traits		
pH	0.09	**-0.49**
Organic matter content	0.10	-0.11
Gravimetric water content	-0.12	**0.42**
Organic layer depth	**-0.37**	0.20
Total N	**0.39**	0.24
Total P	**0.38**	-0.12
Total Mg	0.26	**0.35**
Total Ca	**-0.42**	-0.16
Total K	-0.26	-0.20
Available P	0.22	**0.34**
Exchangeable Ca	**-0.34**	0.18
Exchangeable K	-0.27	**0.35**

*Loadings and signs of the correlation coefficient (trait loading) of each nutrient and physical trait for the first two principal component axes were presented.

**Variables with the highest loadings are indicated in bold.

2005; Singwane and Malinga, 2012). The establishment of plantations comprising invasive plants reduces tree and shrub layers, exposes the leaf litter layer in this habitat to high temperatures (Smith *et al.*, 1998). If this happens, the breakdown of leaf litters will be accelerated (Smith *et al.*, 1998) and faster decomposition rates could contribute to a decrease in OM content (Butterfield, 1999; Singwane and Malinga, 2012). Additionally, *Acacia* leaf litter is known to have a high decomposition rate (Bernhard-Reversat, 1993; Morris *et al.*, 2011) and the high foliar N of the litter may substantially contribute to high amounts of N in the soil, thus increasing the microbial activity for decomposition (Bernhard-Reversat, 1993; FAO, 2005; Wang and Wang, 2011). However, the effects of the leaf litter layer and its nutrient concentrations cannot be confirmed as these variables were not determined in this study. Despite the possible correlation between OM content and organic layer depth, this study found no significant differences between the OM contents of the two forest types. *Acacia* and HF leaf litter are acknowledged to be quite thick and fibrous, and their leaf physico-chemical properties may cause slow decomposition (O'Connell and Sankaran, 1997).

The organic layer and OM content can impact the water absorption capability at the soil surface, for example, low OM content can increase water leaching or surface run-off resulting in low soil moisture content (Smith *et al.*, 1998; Khormali *et al.*, 2009). An increase in OM content could subsequently lead to an increase in soil fauna and greater pore space, thus making water to infiltrate more readily into and be held in the soil (FAO, 2005; Khormali *et al.*, 2009; Gajik, 2013).

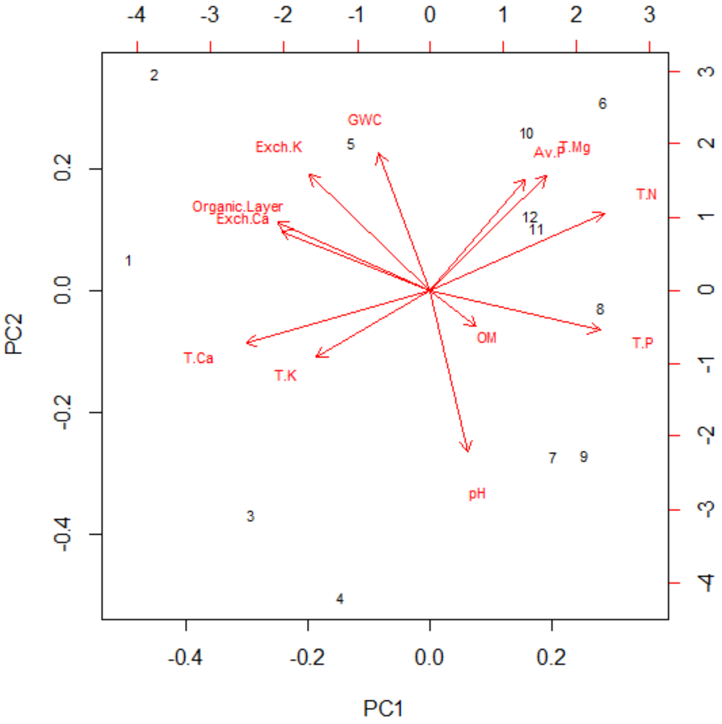
Soil pH and Nutrient Concentrations

The pH values were high in the *Acacia* plantation but were not significantly different from the HF (Table 1). *Acacia* plantation soils had significantly greater total N concentrations than those of the HF (Table 1). In contrast, concentrations of total Ca were significantly higher in the HF soils than those in the *Acacia* plantations, but concentrations of total P, total Mg and total K, exchangeable Ca and K, and available P did not differ between soils from the *Acacia* plantation and the HF (Table 1).

The PCA of the soil properties showed that the first two axes accounted for 61.6 % of the variation (Table 2). The principal component axis 1 (PC1) and the principal component axis 2 (PC2) explained 39.6 % and 22.0 % of the variation, respectively (Table 2). Concentrations of total N and total P were positively intercorrelated and associated with PC1 (Table 2). On the other hand, organic layer depth, concentrations of total and exchangeable Ca were negatively intercorrelated and associated with PC1 (Table 2). Concentrations of total Mg, exchangeable K, available P and GWC were positively intercorrelated and strongly associated with PC2. PC2 also represented a gradient of decreasing pH values (Table 2).

A biplot of the PC1 and the PC2 showed that the *Acacia* plantation and HF plots were partitioned in ordinate space and differentiated on the basis of soil nutrient concentrations *(Figure 2)*. The variables with the longest arrow in the PCA biplot were pH, GWC and concentrations of total Ca *(Figure 2)*. This indicated that these were the most influential set of variables and associated with plots from the *Acacia* plantations for pH and, HF plots for GWC and total Ca concentrations *(Figure 2)*. The second most influential set of variables were organic layer depth, and concentrations of total N and total P. Concentrations of total N and total P were associated with *Acacia* plantation plots, whereas organic layer depth variables were associated with the HF plots. The third influential set of variables were concentrations of total Mg and available P, which were associated with plots from the *Acacia* plantation and, concentrations of exchangeable Ca and K, which were associated with plots from the HF *(Figure 2)*. Concentrations of total K and OM content were the least influential variables *(Figure 2)*.

The biplot of the PCA showed soil pH as the most influential variable in plots from the *Acacia* plantation. The pH ranged between 3.8-4.1 across the HF and *Acacia* plantation plots and the mean pH values in HF and plantation plots were more acidic than those plots in mixed dipterocarp forest (MDF) which had a mean pH of 4.42 ± 0.03 in Andulau Forest Reserve (Metali *et al*., 2014). Vijayanathan *et al*., (2011) and Yamashita *et al*., (2008) also found that the soils of *Acacia mangium* plantations were more acidic compared to the MDF and the Imperata grassland. The soil acidification in the *Acacia* plantation and HF plots was probably caused by a decrease in the concentrations of exchangeable cations or bases in soils and it was presumed to be due to translocation of base cations from soil to plant biomass (Yamashita *et al.*, 2008; Gonzales-Munoz *et al*., 2012; Perrett *et al.,* 2012) or leaching of nutrients (Katagiri *et al*., 1991). This was evident in this study as total and exchangeable Ca concentrations were lower in



*Numbers denote the 12 plots censused; plot 1 to plot 6 are plots in the HF and plot 7 to plot 12 are plots in the *Acaciamangium* plantation.
**OM, GWC, T.N, T.P, T.Mg, T.Ca, T.K, Av.P, Exch.Ca and Exch.K represents organic matter (OM) content, gravimetric water content (GWC), total soil N, P, Mg, Ca and K concentrations, and available soil P concentrations, and exchangeable soil Ca and K concentrations, respectively.

Figure 2: Biplot of principal component axes 1 and 2 from principal component analysis (PCA) of selected soil physicochemical variables across Acacia plantation (n=6 plots) and heath forest (HF) plots (n=6 plots).

Acacia plantation and HF plots in Andulau Forest Reserve (Table 1) than in MDF plots in Andulau Forest Reserve (total Ca = 0.15 ± 0.26 mg g^{-1} and exchangeable Ca = 0.01 ± 0.32 mg g^{-1}) (Metali *et al*., 2014).

Li *et al*., (2001) also suggest that acidic pH in the *A. mangium* plantation was probably due to high rates of nitrification from the *A. mangium* litter decomposition and that protons were released in exchange for nitrate uptake by the N-fixing legumes, thus causing soil acidification. Xiong *et al.* (2008) explained that high production of ammonium from plant material decomposition caused soil acid neutralisation. Another factor which could result in acidic soil pH was the accumulation of humic acids as a result of high soil OM content and slow decomposition rates caused by less microbial activity in acidic soils (Augusto *et al*., 2002; FAO, 2005; Yousefi and Darvishi, 2013). Further research on forest litter decomposition and microbial biomass in the present study sites would improve the understanding of their importance in nutrient cycling in forest ecosystems.

The mean concentrations of total N in the soils of HF in Badas and Bukit Sawat as reported by Metali (2010) was 6-fold and 3-fold higher than in the soils of the HF and *Acacia* plantation, respectively, in this study. Moran *et al.* (2000) investigated the nutrient status of the HF and MDF and report that the turnover rate of litter fall was significantly low in the HF, which suggests that the HF might experience a more closed N cycling. The present findings on total N concentrations in soils also seem to suggest that the HF is experiencing a more closed cycle of N than in the *Acacia* plantation. Another reason for the low levels of N in the soils was probably due to the water-logged condition in the HF and the subsequent reduction in OM decomposition (Moran *et al*., 2000). Leaves in tropical HFs were thicker and tougher than leaves in MDFs (Turner *et al*., 2000). The rapid uptake of N into the plant biomass in the HF is probably because the typical HF plants need to invest more of their resources in protecting their relatively long-lived leaves (Turner *et al*., 2000). The rapid uptake into the plant biomass subsequently caused the soil N concentration to be very low.

Another important reason for the higher amount of total N concentration in the *Acacia* plantation was the ability of the plant to fix atmospheric N (Osunkoya *et al.*, 2005; Morris *et al.*, 2011). *A. mangium* has N-fixing ability through a symbiotic relationship with bacteria in its root nodules, so they can produce leaves that are more N-rich than other tropical leguminous trees (Krisnawati *et al*., 2011; Morris *et al.*, 2011). This capability of *Acacia* trees results in a substantial input of N-enriched litter, which can lead to increased soil N concentrations (El Tahir *et al.*, 2009; Morris *et al.*, 2011; Jeddi and Chaieb, 2012). Vijayanathan *et al*. (2011) had also found a higher concentration of total soil N in the second-rotation of a 0–6-month-old *A. mangium* plantation in Peninsular Malaysia compared to a MDF. The formation of new roots of N-fixing legumes in the second rotation of the plantation helped to boost the soil N content. The plantation in this study was planted with *A. mangium* in 1998 and harvested in 2010, so it was not surprising that the total N was higher in *Acacia* plantation than the HF at the Andulau Forest Reserve. However, this cannot be validated as the nutrient content of the leaf litter was not analysed.

The HF plots also had significantly higher concentrations of total Ca than the *Acacia* plantation. Moran *et al*. (2000) found that the tropical HF in Badas was richer in soil Ca concentrations compared to the MDF. *A. mangium* is a fast -growing species, so the low total Ca, concentrations in the soils of the *Acacia* plantation could be due to higher proportions of these elements being retained in the plant biomass and not returned to the soils (Yamashita *et al*., 2008) or leaching of nutrients in HF (Katagiri *et al.*, 1991).

Total and exchangeable K concentrations in the soil of the *Acacia* plantation investigated in this study was not significantly different from that in the soil of the HF. Yamashita *et al.* (2008) also found that there was lack of difference in the exchangeable K in the soil between an *A. mangium* plantation, a secondary forest and an Imperata grassland. This is probably due to high mobility of K in the soil-plant system, which can easily be leached to deeper soil layers (Moran *et al.*, 2000; Xiong *et al*., 2008).

The concentrations of total P and total Mg, available P and exchangeable Ca in the soil of the *Acacia* plantation were also not significantly different from that in the soil of the HF. The generally low concentrations of these nutrients in the HF and the *Acacia* plantation could be due to plant uptake and sequestration of P in the tree biomass (Hagar *et al.*, 1991) or nutrient leaching in the sandy soils. Additionally, Fisher and Binkley (2000) state that the low available P in soil correlates with the acidic pH and as shown in this study, soils from the *Acacia* plantation and the HF were very acidic, so available P in the soil could be very limited. El Tahir *et al.* (2009) found high total P concentration in the *Acacia senegal* plantation soils in Sudan and it was suggested that the ultimate source of P in soils could be from the decomposition of leaf litter and the weathering of parent rock materials. Leaf litter decomposition and nutrient mineralisation are known to be the key components of ecosystem nutrient cycling (Smith *et al.*, 1998; Owusu-Sekyere *et al*., 2006; Perrett *et al*., 2012; Boudiaf *et al*., 2013; Versini *et al.*, 2014).

CONCLUSION

This study has demonstrated that non-native *Acacia* trees have the ability to change some soil physico-chemical properties when compared to native and tropical primary forests. It was found that the soils in the *A. mangium* plantation had a significantly lower organic layer and total Ca concentrations, and significantly higher total N concentrations than the soils of primary HF. The N-fixing ability of the *Acacia* trees produced N-rich leaves, thus resulting in N-enriched soils in the *A. mangium* plantation. The N-poor HF appeared to experience more closed nutrient cycling than the *Acacia* plantation due to the deeper organic layer in the HF than in the *Acacia* plantation soils. Total Ca concentrations and GWC were the influential soil properties which accounted for the most variation in the HF plots, whilst pH was the most influential soil variable associated with *Acacia* plantation plots.

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