International Journal of Botany

ISSN: 1811-9700

science alert

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International Journal of Botany 5 (4): 287-294, 2009
ISSN 1811-9700

Effect of Topography and Soil on the Distribution of under Canopy Trees of *Garcinia* (Guttiferae) in Lowland Forest of Peninsular Malaysia

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Abstract: The distribution and aggregation of species in tropical forests is known to have certain preferences based on the edaphic factors such as topography types and soil series and this study was carried out to see the distribution of 16 *Garcinia* species in lowland dipterocarp forest in Pasoh Forest Reserve with those edaphic factors. Even though there have been many studies in large scale areas with a larger group of species to see the relationship of edaphic factors with species distribution, very few studies have been carried out on individual species especially for under-canopy or lesser known species. *Garcinia* is an under-canopy tree species in tropical South East Asian forests with no commercial values but mostly known because of their edible fruits. Based on published topography and soil series maps in 50 ha plot, the preferences of *Garcinia* trees were analysed and calculated. Results showed that *Garcinia* trees could be found on all types of topography and soil but most trees are distributed very well on the flatland and well-drained alluvium soils rather than other areas. The least number of stems found are in the top (highest) topography and poorly-drained (prone to flood) alluvium soil. However, at species level, there are significant preferences of each *Garcinia* species on the different type of topography and soil. This shows that different type of topography and soil play significant effect on the distribution of *Garcinia* trees in tropical lowland forest.

Key words: *Garcinia*, topography, soil, lowland forest, Pasoh Forest Reserve

INTRODUCTION

In tropical rainforests, tree species are said to be aggregated and the cause might be from dispersal limitation and habitat preferences (Condit *et al.*, 2000). In most cases where spatial variation in the abundance of species of trees has been studied, many studies have shown that there are strong preferences of trees (or species) to certain soil and topography types. For example, Okuda *et al.* (2004) demonstrated that 55% of tree population in lowland forest in Peninsular Malaysia showed habitat preferences to one or more soil types and 38% preferred one or more topography types. Many more studies have reported on species-specific correlation between trees distribution with soil and topography such as by Poore (1968), Ashton (1969, 1988), Austin *et al.* (1972), Lescure and Boulet (1985), Hubbell and Foster (1986) and Palmiotto *et al.* (2004), who showed that the spatial distribution of trees is influenced by edaphic variation.

Most studies on the relationship of edaphic variation with species distribution in tropical rainforests were done for large scale tree forest community and very few studies have been done in term of individual species or at lower taxonomic level. For instance, Yamada *et al.* (2003), who concentrated on large canopy trees or Palmiotto *et al.* (2004) who studied the relationship of mostly timber trees and very few studies have been done for lesser known species or under canopy trees.

The genus *Garcinia* belongs to the family Guttiferae (Clusiaceae) and consist of about 250 species worldwide (Stevens, 2001) of small to medium tree which can be found from seashore to the lowland and up to upper montane forest. In Peninsular Malaysia, there are 49 species of *Garcinia* which could be found in all type of forest (Whitmore, 1973). In lowland forest, most *Garcinia* species fall in the category of non-timber species and under-storey trees with the height less than 25 m tall. Generally, most of under-storey trees are shade-tolerant species with height less than 40 m tall (Whitmore, 1975).

The timber of *Garcinia* basically has no commercial value but perhaps the importance of *Garcinia* might be seen as a source of domestic fruit crops. Several species are known to have been planted for their fruits (Burkill, 1935; Whitmore, 1973) including *G. mangostana* or locally known as manggis, asam gelugor (*G. atroviridis*) and kecupu (*G. prainiana*). Many more species in the wild could have potential for fruit crop

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industry and by knowing their distribution pattern and edaphic preferences could help to understand their ecology and will give a basic data which could be useful for cultivation purposes. Because of that, the aim of this study is to see the effect of different type of topography and soil series on the distribution of under canopy trees particularly *Garcinia* species trees in lowland forest.

MATERIALS AND METHODS

Study site: The study was carried out in the 50 ha research permanent plot in Pasoh Forest Reserve (PFR), Peninsular Malaysia, an area of about 6000 ha of low and hill dipterocarp forests jointly established by Smithsonian Tropical Research Institute (STRI) and Forest Research Institute of Malaysia (FRIM). The plot is situated in core research area of about 650 ha of primary lowland forest and a buffer zone of about 650 ha of logged and regenerating forests and about 1,000 ha of primary hill forest on the West to the Eastern side (Kochummen *et al*., 1990). All trees with ≥ 1 cm at diameter of breast height (dbh) were tagged, mapped and measured of their dbh for long term monitoring programme to see the dynamics of tree in tropical forest (Manokaran *et al*., 1990, 1992).

About half of the 50 ha plot lies within a range of 2 m of topographic change; a hill rises in the centre of the plot to about 24 m above lowest point, the rest are plain area and two intermittent streams were formed during period of heavy rain (Kochummen *et al*., 1990; Manokaran and LaFrankie, 1990). Details of the topographic changes in the 50 ha plot was described by Okuda *et al*. (2004) based on the ground elevation height at 20 m interval which interpolated into 10 m interval. By using the slope degree ratio and index of convexity, the topography type was categorised into 6 group:

- A ridgetop (TOP) areas which distributed at the top of two peaks within the plot
- A higher slope (HIGH)
- A mid-slope (MID)
- A lower slope (LOW)
- A flatland (FLAT)
- Valley (VAL) topography

About 57% of the plot covered by FLAT and VAL topography, whereas slope (HIGH, MID and LOW) and ridgetop (TOP) covered the remaining 43% of the area (Fig. 1).

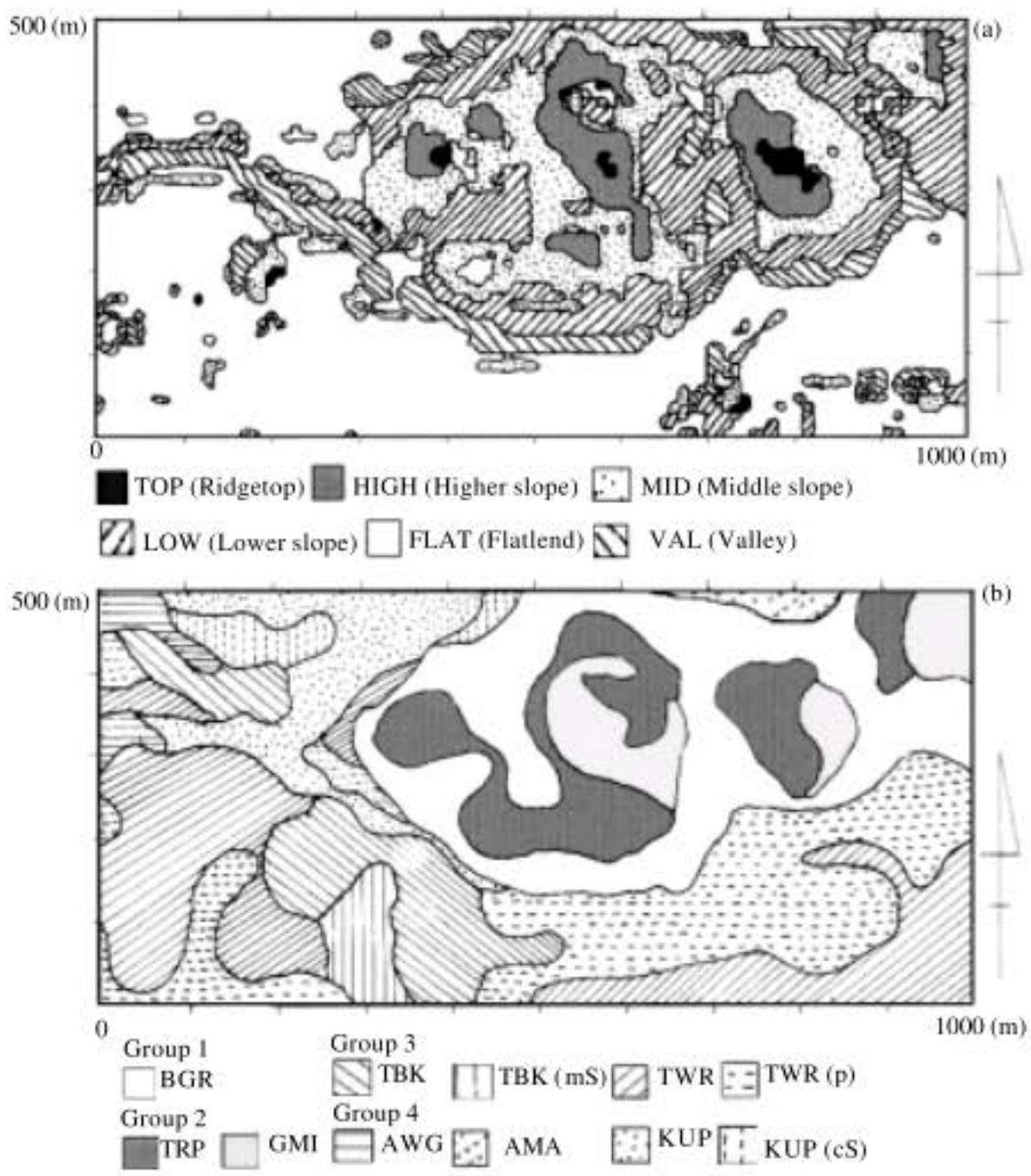

Fig. 1: Topography and soil map in 50 ha plot of Pasoh Forest Reserve, Peninsular Malaysia by Okuda *et al*. (2004), (a) Topography and (b) soil

Table 1: Description of soils series in the 50 ha plot in Pasoh Forest Reserve after Okuda *et al.* (2004) and Yamashita *et al.* (2003)

Groups	Symbol (soil series)	Parent material	Proportion to total area
1	BGR (Bungor)	Shale 20.8	20.8
2	TRP (Terap)	Lateritic 10.8	16.5
	GMI (Gajah Mati)	Lateritic 5.7	
3	TBK (Tebok)	Alluvial 8.6	49.2
	TBK mS (Medium Sand variant of TBK)	Alluvial 2.3	
	TWR (Tawar)	Alluvial 18.9	
	TWR p (Pale variant of TWR)	Alluvial 19.4	
4	AWG (Awang)	Alluvial 1.9	13.5
	AMA (Alma)	Alluvial 1.3	
	KPU (Kampung Pusu)	Alluvial 2.2	
	KPU cS (Coarse sand variant of KPU)	Alluvial 8.1	

Soil type in 50 ha plot of PFR mainly were identified with 11 series and classified into four major groups based on their parent materials as shown in Table 1 (Okuda *et al*., 2004; Yamashita *et al*., 2003). Soil series developed on shale (group 1: BGR), lateritic parent material soil series (group 2: TRP, GMI), moderately well-drained to well-drained soils that developed in riverine alluvium or wet alluvium (group 3: TWR, TBK) and soils that developed on riverine alluvium but imperfect to somewhat imperfect drainage (prone to flooding) or dry alluvium (group 4: AMA, AWG, KPU) (Fig. 1).

Methods: Raw data on the list of *Garcinia* trees and their coordinates in 50 ha plot was obtained from Forest Research Institute Malaysia (FRIM). This distribution map of *Garcinia* trees were based on the field work done in the year 2000 and all the voucher specimens were kept in Universiti Kebangsaan Malaysia Herbarium (UKMB) herbarium. All voucher specimens then were studied again for their taxonomic status in 2006 to confirm their taxonomic status by comparing the herbarium specimens with other specimens lodged in Forest Research Institute Herbarium (KEP) and Universiti Putra Malaysia (UPM).

Distribution map produced by Manokaran *et al.* (1992) were then corrected and all dead and missing trees were excluded from the analysis. Species distribution map was generated using MS Excel and Adobe Photoshop. Tree distribution map for each species then was imposed against two readily available data, detailed topography maps and soil series map (Fig. 1) from Okuda *et al.* (2004). Based on the imposed map, the distribution of the adult and juvenile trees were then calculated and statistically analyzed with Statistical Analysis Software (Barr *et al.*, 1976) to see the relationship between species with soil and topography.

RESULTS

Species identification and stem numbers: From a total of 17 species of *Garcinia* in Pasoh as described by Kochummen (1997) the number of species examined was reduced to 16 species with few changes. *Garcinia malaccensis* Hook. *f.* was identified as *G. penangiana* Pierre, *G. eugeniifoila* Wall *ex* T. Anders. was identified as *G. opaca* Whitmore, *G. pyrifera* Ridley was not found and excluded from the list and unnamed species of *G.* sp. 5 Kochummen was identified as *G.* sp. A2 Whitmore.

The total number of *Garcinia* trees found is 4035 stems with 3835 (95%) trees are considered as juvenile (≤10.0 cm dbh) while the adult trees (≥10.0 cm dbh) only consisted of 200 stems. For *Garcinia maingayi* and *Garcinia* sp. A2, the number of individuals in the plot is too low to study their distribution preferences and further discussion will not be made for both species.

Tree preferences on topography type: In 50 ha plot of PFR, data showed that more than half of *Garcinia* trees or 53.6% (2162 stems) are found on the FLAT topography, followed by 16.0% (645 stems) on MID topography and 15.5% (626 stems) on LOW topography (Table 2). The rest of topography types contained less number of trees such as VAL topography with 397 stems (9.8%), HIGH topography with 178 stems (4.41%), while TOP topography contained the least number of trees with only 27 stems (0.7%) found. In term of species, *G. penangiana* is the most abundant species in FLAT and VAL topography, while *G. opaca* is the most abundant species in LOW, MID, HIGH and TOP topographies.

In term of species diversity, all sixteen *Garcinia* species in PFR could be found on LOW topography. FLAT and MID topographies, on the other hand have one less species compared to LOW topography. The least number of species found is on TOP topography with eight *Garcinia* species, while VAL and HIGH topographies, both have 12 and 13 species, respectively. Some species such as *G. nervosa*, *G. scortechinii*, *G. griffithii*, *G. globulosa* and *G. atroviridis* there is no individual found in TOP topography. Whereas in VAL topography, only two species namely *G. forbesii* and *G. griffithii* are not present.

Based on the juvenile-adult trees distribution on topography, the results showed no differences with stems distribution except for adult trees where no individual is found on the TOP topography. The rest of adult *Garcinia* trees are distributed mainly on FLAT topography which saw that 51.5% of stems (103) are found, followed by MID topography (39 stems), VAL topography (27 stems),

Table 2: Distribution of *Garcinia* trees on the different topography types

Species	Total No. of stems	Stems No. on detailed topography types					
		FLAT	LOW	MID	HIGH	TOP	VAL
G. penangiana	902	550	94	134	9	1	114
G. opaca	757	332	144	155	69	8	49
G. parvifolia	579	347	84	91	24	8	25
G. nervosa	536	311	84	61	14	0	66
G. nigrolineata	378	205	54	61	25	5	28
G. scortechinii	324	155	64	48	14	0	43
G. bancana	116	45	27	25	2	0	17
Garcinia. sp. 2	102	51	19	10	3	2	17
Garcinia. sp. 1	90	43	18	17	6	5	1
G. rostrata	87	61	9	14	2	1	0
G. forbesii	57	17	9	10	5	1	15
G. griffithii	40	21	8	8	3	0	0
G. globulosa	40	16	5	2	2	0	15
G. atroviridis	19	7	5	5	0	0	2
Garcinia maingayi	6	0	2	4	0	0	0
Garcinia sp. A2	2	1	1	0	0	0	0
Juvenile (<10 cm dbh)	3835	2059	601	606	172	31	370
Adult (>10 cm dbh)	200	103	26	39	6	0	22
Total	4035	2162	627	645	178	31	392

LOW topography (25 stems) and lastly on HIGH topography (6 stems). Most juvenile *Garcinia* trees are mostly found on the FLAT topography with 2059 stems followed by the MID topography (606 stems), LOW topography (601 stems), VAL topography (370 stems), HIGH (172 stems) and TOP topography (27 stems).

Analysis of Variance (ANOVA) supported that topography types have significant effect on the distribution of *Garcinia* tree based on p-value which is less than 0.01 (Table 3). Comparison between topography using Tukey honest significant difference also showed that there are significant preferences of *Garcinia* species to different type of topography where FLAT topography is the most preferred by all *Garcinia* species. However, there are differences for the second most abundant species by interchangeable of MID or LOW, VAL or HIGH and or TOP topography. For example, while the most dominant species, *G. penangiana* is abundant on MID followed by VAL, HIGH and TOP topography, *G. parvifolia* and *G. nigrolineata* on the other hand preferred MID followed by LOW, VAL, HIGH and TOP topography.

Tree preferences on soil type: In term of species diversity, all *Garcinia* species are present in group 3 soil while group 4 soil contains least number of species with 12 species and both group 1 and 2 soils contain similar number of species (15 species) (Table 4). *Garcinia griffthii* and *G. atroviridis* are those two species that are not present on certain soil types, i.e., group 4 soil series.

Group 1 and 2 soils are mainly dominated by *G. opaca*, while group 3 by *G. penangiana* and group 4 by *G. nervosa.* However, the preference of all *Garcinia*

Table 3: ANOVA table for number of individuals in the combination of species and topography

Source	Type	Mean	F-value	p-value
Topography	FLAT	135.13a	9.791	0.000**
	MID	40.31b		
	LOW	39.19b		
	VAL	24.50b		
	HIGH	11.13b		
	TOP	1.94b		
Species	*G. penangiana*	150.33a	3.786	0.000**
	G. opaca	126.17ab		
	G. parvifolia	96.50abc		
	G. nervosa	89.33abc		
	G. nigrolineata	63.00abc		
	G. scortechinii	54.00abc		
	G. bancana	19.33bc		
	Garcinia sp. 2	17.00bc		
	Garcinia sp. 1	15.00bc		
	G. rostrata	14.50bc		
	G. forbesii	9.50bc		
	G. griffithii	6.67bc		
	G. globulosa	6.67bc		
	G. atroviridis	3.17bc		
	Garcinia maingayi	1.00bc		
	Garcinia sp. A2	0.33c		

**Highly significant at significance level 0.01

Table 4: Distribution of 16 *Garcinia* species on different soil groups

Species	Total stem No.	Stem No. on soil group			
		G1	G2	G3	G4
G. penangiana	902	102	132	654	14
G. opaca	757	136	177	407	37
G. parvifolia	579	103	106	339	31
G. nervosa	536	114	40	216	166
G. nigrolineata	378	62	92	157	67
G. scortechinii	324	70	39	158	57
G. bancana	116	20	20	67	9
Garcinia sp. 2	102	14	14	38	36
Garcinia sp. 1	90	23	17	47	3
G. rostrata	87	8	13	56	10
G. forbesii	57	16	15	21	5
G. griffithii	40	9	14	17	0
G. globulosa	40	3	3	18	16
G. atroviridis	19	5	6	8	0
Garcinia maingayi	6	4	1	1	0
Garcinia sp. A2	2	0	0	2	0
Juvenile (< 10 cm dbh)	3835	664	668	2084	419
Adult (>10 cm dbh)	200	25	21	122	32
Total	4035	689	689	2206	451

species on soil group is on group 3 soil but subsequent number of trees found on respective soil groups are varies significantly. For instance, *G. penangiana*, *G. opaca*, *G. parvifolia*, *G. griffithii* and *G. atroviridis* the second most abundant trees are found on group 2 followed by group 1 and 4, but for *G. rostrata*, the second most abundant trees is group 2 followed by group 4 and 1. Another group of species consist of *G.* sp. 1 and *G. forbesii* are found with second most abundant species in group 1 followed by group 2 and 4. However, for *G. bancana* the number stems found in group 1 and 2 is similar but the least number of trees are found and in group 4 soil.

Table 5: ANOVA Table for number of individuals in the combination of species and soil groups

Source	Type	Mean	F-value	p-value
Soil group	G 4	28.19b	6.198	0.001**
	G 1	43.06b		
	G 2	43.06b		
	G 3	137.88a		
Species	*G. penangiana*	225.50a	3.271	0.001**
	G. opaca	189.25ab		
	G. parvifolia	144.75ab		
	G. nervosa	134.00ab		
	G. nigrolineata	94.50ab		
	G. scortechinii	81.00ab		
	G. bancana	29.00ab		
	Garcinia sp. 2	25.50ab		
	Garcinia sp. 1	22.50ab		
	G. rostrata	21.75ab		
	G. forbesii	14.25b		
	G. globulosa	10.00b		
	G. griffithii	10.00b		
	G. atroviridis	4.75b		
	Garcinia maingayi	1.50b		
	Garcinia sp., A2	0.50b		

**Highly significant at significance level 0.01

Distribution of juvenile trees are similar with the total stems in which most trees are found on the group 3 soil series (53.3%) followed by group 2 (17.4%), group 1 (17.3%) and group 4 (16.0%). However, there is a slight difference for adult trees, with group 3 as the most abundant (61.0%) followed by group 4 (16.0%), group 1 (12.5%) and group 2 (10.5%).

ANOVA analysis showed that there is a highly significant preference between soil groups and *Garcinia* species based on the p-value that is less than 0.01 (Table 5). Most *Garcinia* trees (54.7%) are found on the moderately well- or well-drained soil types of group 3 which accounted for 2206 stems (Table 4). Tukey honest significant difference also found that soil of group 3 is the most significant where the mean number of individuals are much higher compared to the other soil groups (Table 5). The other two groups of soil which have the equal number of stems (689 stems or 17.1%) a well-drained soil developed from shale (group 1) and a well-drained soil developed from lateritic parent material (group 2). The least number of trees lies on the poor drainage soil or riverine areas that developed from alluvial (group 4) soil series with 11.2% (451 stems) from the total stems.

DISCUSSION

In tropical rainforest, the aggregation due to habitat preferences are said to be more apparent at higher taxonomic level. Ashton (1988) and Webb and Peart (2000) found that habitat specialization did not occur at either genus or family level but there are possibilities that such pattern exist at species level. In lowland forest, distribution of individual *Garcinia* species in the 50 ha plot Pasoh Forest Reserve (PFR) showed that they have a high preference for good drained alluvial soil and on the flat land area. Both percentage value and statistic analysis showed strong preferences, with more than half of the populations of *Garcinia* trees are found on those areas. Even though Webb and Peart (2000) and Condit *et al.* (2000) found that more adult trees (≥10 cm dbh) showed a higher degree of habitat specificity than do saplings, *Garcinia* trees show that both adult and juvenile have similar preferences. This finding supports the idea of Davies *et al.* (2003) that soil and topography have independent effect on forest structure. As an understorey trees in relatively high canopies environment, edaphic factors namely topography and soil types have significant effect with their distribution.

Detailed stand structure in PFR was described by Davies *et al.* (2003) which divided the stand into five type of forest community based on their edaphic factor (swamp, hill, sandy alluvium, mixed alluvium, clay alluvium and mixed alluvium) found that the hill community has the lowest stems density. Similar results were found with the distribution of *Garcinia* trees that the least tree was found on the ridgetop (TOP) of hillside. Some species such as *G. atroviridis*, *G. bancana*, *G. griffithii*, *G. nervosa*, *G. globulosa* and *G. scortechinii* not even a single tree is found within this area. The TOP topography which varies about 30 m from the lowest point in the plot has a well-drained soil of Gajah Mati (GMI) series (Okuda *et al.*, 2004) and probably the ferric materials of the hillside is not preferable for *Garcinia* trees to grow and merit for further research to be studied.

Flat land area in PFR, on the other hand is known to have the densest stocking in stems number rather than at the hilly area (Davies *et al.*, 2003) and *Garcinia* trees seems in accordance with this findings. In contrast Yamada *et al.* (2003) found that distribution of *Scaphium macropodum* and *S. linearicarpum* prefer the slopes on lower middle and higher topography. This result is not surprising considering that edaphically biased distributions of species in tropical rainforest are common. The poor drained soil of valley (VAL) topography, which is situated on the flat land area exhibit a lesser number of stems. Because this area is wetter and sometimes changed to a swampy area especially in the rainy season the soil became more acidic which is not suitable for some *Garcinia* species to grow. However, *Garcinia* trees such as *G. nervosa* and *Garcinia* sp. 2 even though not dominant among the *Garcinia* population, both species could grow in big numbers on the poorly drained alluvial soil of Group 4 and in seasonal

swamp area of VAL topography. Only *G. rostrata* and *G. forbesii* could not to grow on the wet and slightly acidic site area of the VAL topography.

Thomas (2003) classified plants in Pasoh into 2 main types either as a generalist or edaphic specialist (upland, riparian/swamp, alluvial soil and granitic ultisol) and results from this study suggested that even though most *Garcinia* are generalist where they could grow in all types of soil, most trees are found in abundance on alluvial soil. Similar results were found for palm species in PFR which shows strong preferences to grow on well drained (wet) alluvial type of soil because wet alluvium soil contains high percentage of fine sand and silt which is able to retain more moisture and highest level of available phosphorous and exchangeable magnesium, less acidic and low in nitrogen (Supardi, 2003).

Basically, the distribution of *Garcinia* individual species in PFR is in accordance with other previous study where their preferences on topography and soils show significant effects and could be summarized as below:

- ***Garcinia atroviridis*:** Species is widely cultivated in South East Asia for the fruits and commonly found in lowland forest up to 600 m altitude of Peninsular Malaysia. In PFR, the trees are rarely found, from flatland to mid-terrain on the hill side and does not prefer the high slope and with poorly drained alluvial soil
- ***Garcinia bancana*:** A common lowland species in Peninsular Malaysia but occasionally found near streams, peat swamp, hill to lower montane forest. Not a common species in PFR, preferably to grow on flatland to medium slope with wet alluvial soil and less preferences on high slope of poor drained alluvial soil
- ***Garcinia forbesii*:** A common species in Peninsular Malaysia with wide range of distribution from lowland to montane of 1, 700 m altitude. Not a common species in PFR and could be found in all types of topography and soils but most abundant in flatland including the swamp and riverine area. The species has less preference to grow on poor drainage soil and high slope area
- ***Garcinia globulosa*:** A common species in Peninsular Malaysia. An uncommon species in PFR, distributed in all types of topography except on high slope and could grow on type of soil series. However, the species has a less preference to grow on slope areas and, lateric and shale parent material soils
- ***Garcinia griffithii:*** A common species in Peninsular Malaysia and distributed from lowland to lower montane at 900 m altitude (Whitmore, 1973). Not commonly found species in PFR, scattered from lowland to high slope but not found in swamp or riverine and on the top of the slope. This species is not found in poor drained alluvial soil but prefer to grow on well drained alluvial soil and less preference on shale and lateric soils
- ***Garcinia nervosa*:** An uncommon lowland species sometimes found in coastal forest and riverine area in Peninsular Malaysia (Whitmore, 1973). A common species in PFR with most trees are found on the flatland including riverine and swamp area and none are found in top of the slopes. This species able to grow in all soil types but has a less preference on lateritic soil
- ***Garcinia nigrolineata*:** A common lowland species but occasionally found in coastal and peat swamp forest of Peninsular Malaysia (Whitmore, 1973). A commonly found species in PFR, mostly found in flatland and the number of stems become lesser in slopes area. This species could grow on all types of soil but has a high preference on well drained alluvial soil
- ***Garcinia opaca*:** An uncommon species in Peninsular Malaysia and based on the morphology, this species merits a new variety status. A common species in PFR and mostly found in flatland area with decreasing numbers of stems found towards the slopes. This species demands well drained-soil types such and has a less preference to grow on riverine or swamp area and also on the poor drain alluvial soils
- ***Garcinia parvifolia*:** A common species in lowland to hill primary and secondary forests in Peninsular Malaysia. In PFR, *G. parvifolia* is a common species dispersed mostly in flatland and decreasingly towards slopes and also in valley area. More than half of the population are found to grow in well drained alluvial soil series and less preferences to grow on other soil types
- ***Garcinia penangiana*:** A common lowland and hill forest species in Peninsular Malaysia. The most abundant species in PFR and highly distributed in flatland to slopes but does not prefer high and top of slope areas. This species could grow on all type of soil but has low preference on poorly drained alluvium soil
- ***Garcinia rostrata*:** A common species with a wide range of distribution from lowland to upper montane forest of Peninsular Malaysia. In PFR, it is not commonly found species but mostly observed in flatland excluding the valley and less numbers are found on the slopes. This species prefers the well drained alluvial soil and has a less preference to other soil types

- ***Garcinia scortechinii*:** A common secondary and primary lowland to hill forest in Peninsular Malaysia. In PFR, it is a commonly found species distributed mostly in flatland to slopes but none is found on top of the slopes. This species has shown much better distribution on a well-drained alluvial soil rather than other soil types
- ***Garcinia* sp. 1:** A dubious species with little information and so far only recorded in PFR. An uncommon species and could be found mostly in flatland and decreasing numbers towards the slopes area. This species preferred a well-drained alluvial soil and quite well on shale soil but less number are found on other type of soils
- ***Garcinia* sp. 2:** A possibly new species of *Garcinia* but so far only recorded in PFR but not commonly found. The distribution of *G.* sp. 2 is on all types of topography but half of the population are found in flatland and the numbers are decreasing towards the slopes. This species prefers well-drained alluvial soil but can also grow on poorly drained soil and other type of soils
- ***Garcinia maingayi*:** Earlierly identified as *Garcinia* sp. 4 (Kochummen, 1997) and very rare. Only 6 individuals of Garcinia *maingayi* are recorded and all of them are located in the hilly terrain. The soil series that contain those stems are all on the well-drained shale soil (4 stems) and the rest one stem each on well-drained alluvial soil and lateric soil, respectively
- ***Garcinia* sp. A2:** Apart from PFR, this species has also twice been recorded in Johor (Whitmore, 1973). A rare species in PFR with only 2 individuals recorded. Each of them is located separately on the hilly terrain on shale soils and flatland of well-drained alluvial soil

CONCLUSION

This study clearly demonstrated that within species level, there are varied preferences of each species for topography and soil types but in general, it is suffice to say that in natural stand of tropical lowland forest, species distribution for understorey tree of *Garcinia* is vary but have a high preference on the flatland and well-drained alluvial soil rather than on the slopes and poorly drained soils.

ACKNOWLEDGMENT

The authors would like to thank to Haji Ahmed Zainudin Ibrahim, Sani Miran and Shamsul Khamis for their assistance in the field. This work was supported by IRPA grant 09-02-0009 to Universiti Kebangsan Malaysia from Ministry of Science, Technology and Environment, Malaysia.

REFERENCES

Ashton, P.S., 1969. Speciation among tropical forest trees: some deductions in the light of recent evidence. Biol. J. Lin. Soc., 1: 155-196.

Ashton, P.S., 1988. Dipterocarp biology as a window to the understanding of tropical forest structure. Ann. Rev. Ecol. Syst., 19: 347-370.

Austin, M.P., P.S. Ashton and P. Greig-Smith, 1972. The application of quantitative methods to vegetation survey. III. A re-examination of rain forest data from Brunei. J. Ecol., 60: 305-324.

Barr, A.J., J.H. Goodnight, J.P. Sall and J.T. Helwig, 1976. A Users Guide to SAS 76. SAS Institute Inc., Raleigh, North Carolina, pp: 329.

Burkill, I.H., 1935. A Dictionary of the Economic Products of the Malay Peninsula. Vol. 2, Government of the Straits Settlements and Federated Malay States, Crown Agents for the Colonies, London.

Condit, R., P.S. Ashton, P. Baker, S. Bunyavejchewin and S. Gunatilleke *et al*., 2000. Spatial Patterns in the Distribution of Tropical Tree Species. Sci., 288: 1414-1418.

Davies, S.J., M.N.N. Supardi, J.V. LaFrankie and P.S. Ashton, 2003. The Trees of Pasoh Forest: Stand Structure and Floristic Composition of the 50 ha Forest Research Plot. In: Pasoh-Ecology of Lowland Rain Forest in Southeast Asia, Okuda, T., N. Manokaran, K. Niiyama, S.C. Thomas and P.S. Ashton (Eds.). Springer-Verlag, Japan, pp: 35-50.

Hubbell, S.P. and R.B. Foster, 1986. Commonness and Rarity in a Neotropical Forest: Implications for Tree Conservation. In: Conservation Biology. The Science Scarcity and Diversitry, Soule, (M.E.). Sinauer, Sunderland, Massachuset, pp: 205-231.

Kochummen, K.M., J.V. LaFrankie and N. Manokaran, 1990. Floristic composition of Pasoh Forest Reserve, a lowland rain forest in *Peninsular* Malaysia. J. Trop. For. Sci., 3: 1-13.

Kochummen, K.M. 1997. Tree Flora of Pasoh Forest Institut Penyelidikan Perhutanan Malaysia, Kepong, pp: 462.

Lescure, J.P. and R. Boulet, 1985. Relationship between soil and vegetation in a tropial rain forest in frecnh Guiana. Biotropica, 17: 155-164.

Manokaran, N. and J.V. LaFrankie, 1990. Stand structure of pasoh forest reserve, a lowland rainforest in *Peninsular* Malaysia. J. Trop. For. Sci., 3: 14-24.

Manokaran, N., J.V. LaFrankie, K.M. Kochummen, E.S. Quah, J.E. Klahn, P.S. Ashton and S.P. Hubbell, 1990. Methodology for the Fifty Hectare Research Plot at Pasoh Forest Reserve. Forest Research Institute of Malaysia, Kepong.

Manokaran, N., J.V. Lafrankie, K.M. Kochummen, E.S. Quah, J.E. Klahn, P.S. Ashton and S.P. Hubbell, 1992. Stand Table and Distribution of Species in the 50-ha Research Plot at Pasoh Forest Reserve, FRIM Research Data. Forest Research Institute of Malaysia, Kepong.

Okuda, T., N. Adachi, M. Suzuki, N.A. Hussein and N. Manokaran *et al*., 2004. Local Variation of Canopy Structure in Relation to Soils and Topography and the Implications for Species Diversity in a Rainforest of Peninsular Malaysia. In: Tropical Forest Diversity and Dynamism. Findings from a Large-Scale Plot Network, Losos, E.C. and E.G.J. Leigh (Eds.). The University of Chicago Press, Chicago and London, pp: 221-240.

Palmiotto, P.A., K.A. Vogt, P.M.S. Ashton, P.S. Ashton and D.J. Vogt *et al*., 2004. Linking Canopy Gaps, Topographic Position and Edaphic Variation in a Tropical Rainforest: Implication for Species Diversity. In: Tropical Forest Diversity and Dynamism. Findings from a Large-Scale Plot Network, Losos, E.C. and E.G.J. Leigh (Eds.). The University of Chicago Press, Chicago and London, pp: 195-220.

Poore, M.E.D., 1968. Studies in malaysian rain forest: I the forest on triassic sediments in jengka forest reserve. J. Ecol., 56: 143-196.

Stevens, P.F., 2001. Onwards. Angiosperm phylogeny website. Version 6. http://www.mobot.org/MOBOT/research/APweb/.

Supardi, M.N.N., 2003. Palms of Pasoh. In: Pasoh-Ecology of Lowland Rain Forest in Southeast Asia, Okuda, T., N. Manokaran, K. Niiyama, S.C. Thomas and P.S. Ashton (Eds.). Springer-Verlag, Japan, pp: 195-214.

Thomas, S.C., 2003. Comparative Biology of Tropical Trees: A Perspective from Pasoh. In: Pasoh-Ecology of Lowland Rain Forest in Southeast Asia, Okuda, T., N. Manokaran, K. Niiyama, S.C. Thomas and P.S. Ashton (Eds.). Springer-Verlag, Tokyo, Japan, pp: 171-194.

Webb, C.O. and D.R. Peart, 2000. Habitat associations of trees and seedlings in a bornean rain forest. J. Ecol., 88: 464-478.

Whitmore, T.C., 1973. Guttiferae. In: Tree Flora of Malaya, Whitmore, T.C. (Es.). Longman Malaysia, Kuala Lumpur, pp: 162-236.

Whitmore, T.C., 1975. Tropical Rain Forest of the Far East. Oxford University Press, UK.

Yamada, T., T. Okuda and N. Manokaran, 2003. Microhabitat Preference of two Sympatric *Scaphium* species in a 50 ha Plot of Pasoh. In: Pasoh-Ecology of Lowland Rain Forest in Southeast Asia, Okuda, T., N. Manokaran, K. Niiyama, S.C. Thomas and P.S. Ashton (Eds.). Springer-Verlag, Japan, pp: 137-147.

Yamashita, T., N. Kasuya, W.R. Kadir, S.W. Chik, Q.E. Seng and T. Okuda, 2003. Soil and Belowground Caharacteristics of Pasoh Forest Reserve. In: Pasoh-Ecology of Lowland Rain Forest in Southeast Asia, Okuda, T., N. Manokaran, K. Niiyama, S.C. Thomas and P.S. Ashton (Eds.). Springer-Verlag, Japan.