Investigation of soil physical properties under *Shorea peltata* sym. in Tengaroh Forest Reserve, Johor Bahru, Malaysia

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Abstract: Soil properties of tropical rain forest in Southeast Asia have been characterized by several researchers. However, empirical data on soil characteristics under rehabilitation program are still limited or even lacking. A study was conducted to characterize the soil physical properties under different densities of *Shorea peltata* species. The objective of the research was to determine the relationship between *Shorea peltata* species and soil physical properties. Twenty observational plots, 50 X 50 m namely, rare (A), low (B), moderate (C) and high (D) densities were established. Each plot was divided into 10 subplots. Five subplots were selected randomly. Soil samples were collected using auger at 0 - 15 cm, and core-ring at 0 - 10 cm depth. The results show that there was a significant difference among the groups. Analysis of the relationship between soil physical properties and site variables showed that moisture content, bulk density, particle density, silt and clay were the important factors in the distribution of *Shorea peltata* species in the study sites.

Keywords: *Shorea peltata* sym, soil moisture content, bulk density, porosity, soil compaction

Mersing-Malezya ormanındaki farklı sıklıkta *Shorea peltata* Sym. altında toprağın fiziksel özelliklerinin araştırılması

Özet: Güneydoğu Asya'da tropikal yağmur ormanlarının toprak özellikleri çeşitli araştırmacılar tarafından araştırılmıştır. Ancak, rehabilitasyon programı kapsamında toprak özelliklerine ait ampirik veriler hala sınırlıdır ve hatta eksiktir. Bu araştırmanın amacı Malezya'daki Johor Bahru, Tenggaroh Ormanı Rezerv Alanında, farklı sıklıktaki *Shorea peltata* ile toprak fiziksel özellikleri arasındaki ilişkinin belirlenmesidir. Yirmi adet 50 x 50 m boyutunda (A) nadir, (B) düşük, (C) orta ve (D) yüksek sıklıkta olmak üzere deneme alanları oluşturulmuştur. Her deneme alanında 10 alt parsel ayrılmış ve bunların içinden 5 alt parsel rastgele seçilmiştir. Toprak örnekleri sonda ile 0 – 15 cm derinlikten alınarak 0 – 10 cm örneklenmiştir. Toprağın fiziksel özelliklerinin sonuçları gruplar arasında önem düzeyinde anlamlı farklılık göstermektedir. Toprağın fiziksel özelliklerinin arasındaki ilişki (korelasyon) için analiz edilen nem içeriği, hacim ağırlığı, tane yoğunluğu, toz ve kil *Shorea peltata* türlerinin dağılımında önemli faktörler olduğunu göstermektedir.

Anahtar Kelimeler: *Shorea peltata* sym, toprak nem içeriği, hacim ağırlığı, gözeneklilik, toprak sıkışması

1. INTRODUCTION

Tropical rain forest area of Malaysia is located in South East Asia and comprises Sabah and Sarawak on the island of Kalimantan (Borneo) and Peninsular Malaysia. Malaysia's tropical rain forest is well known as one of the most complex ecosystems in the world where it is home to more than 8,000 species of flowering plants, 2,500 of which are tree species. Despite increasing recognition of the importance of tropical rain forest, huge areas are becoming degraded forest land as a consequence of deforestation, forest harvesting, shifting cultivation and forest encroachment (Jomo et al., 2004). It was estimated that about 13

million hectares of the world's forests are lost annually due to deforestation (FAO, 2005). According to Butler (2006), approximately 140,200 ha or 0.65% of Malaysia's forested area is lost annually since 2000. In Sarawak alone, besides forest harvesting and forest encroachment, shifting cultivation is the major cause of land degradation. It was reported that 2.25 million ha were under shifting cultivation in the 1960s and by 1985, increased to 3.33 million ha (Jomo et al., 2004).

Many studies of soil in tropical forests have been conducted in Southeast Asia (e.g., Ohta, 1989; Ohta and Effendi, 1992; Takahashi et al., 1994). However, most evaluated was on soil chemistry and nutrient cycling and there has been little detailed study of physical properties. The soil properties most likely to influence species composition in lowland tropical rain forests are, in decreasing order of importance: P availability, Al toxicity, drainage, water-holding capacity, and availability of K, Ca, and Mg.

This research was to investigate the relationship between *Shorea peltata* as an endemic species (An endemic species is one that is only found in a particular region and nowhere else in the world), with soil properties so as to have an overview of factors influencing the distribution of *Shorea peltata* in tropical rain forest and also to provide information for conservation programmes. In this respect, this study was also attempting to observe the relationship between the soil physical of this particular study area and their influence on the vegetation community as well as on the distribution species.

2.MATERIALS AND METHODS

2.1. Description of Study Area

The project was conducted at the Tenggaroh Forest Reserve, Johor Bahru. Johor Bahru is located at 59 m above sea level and at latitude 2º 14' 0" N and longitude 103º 55' 0" E. The State of Johor is located in the Equatorial Line circle as with the other states in Peninsular Malaysia and Mersing is situated on the east coast of Johor, Peninsular Malaysia. It is approximately 136km from the city centre of Johor Bahru. It acts as the main spot of departure of multiple islands in the South China Sea (Figure / Şekil 1).

Figure 1. Location of the study site
Şekil 1. Çalışma alanı

2.1.2. Site Characteristics of Research Area

2.1.2.1. Climate

The climate and humidity is consistently high throughout the year with heavy rainfall. The records show that the state's average annual temperatures are relatively uniform. The average monthly temperature covers around 26°C to 28°C and the lowest temperature recorded is recorded during rainy seasons. The records also show that the average yearly rainfall changes from year to year. The west coast area receives rainfall in the range between 2,000 mm to 2,500 mm while the east coast recorded a higher range. The areas that receive the highest amount of rainfall and recorded as the dampest areas are Endau and Pengerang with average rainfalls of more than 3,400 mm a year. The south-west winds occur during the months of May until September and the months of April and October are the transitional month for the monsoon season. The months of November until March are when the north-east Monsoon occurs.

2.1.2.2. Topography and Hydrology

More than half, 83%, of the State of Johor's topography are of the lowlands. According to the available statistics, about 83% of the state is considered as lowlands and only 17% of higher and steep terrain. The area and type of forests in this state are highly influenced by the topography. However, most of the Peat Swamp Forest has disappeared, leaving small patches of island forest located in the central part of the state. In other places, there have been changes in the use of land such as for oil palms. Mangrove Forests occurs along coastal area and estuaries on the West Coast. In the southern part of the state, a lot of mangrove forests were developed for land development besides forestry. The mangrove forests on the east coast are located on estuaries such as Sungai Sedili Kecil, Sungai Sedili Besar, Sungai Mersing and Sungai Endau, while coastal and fresh swamp forests occur on the east coast of the state which is in the coastal area. The state's central and northern regions are where the dipterocarp hills and mountains originates, which is where hilly and steep slopes occur (Wyatt-Smith, 1961).

2.1.2.3. Geology and Soils

The state of Johor has soil groups from the following main components: (i) Sedentary soil from igneous rocks (ii) Sedentary soil from sedimentation rocks (iii) Soil from matured alluvium soil (iv) Soil from sub-recent alluvium, and (v) Soil from recent alluvium. The parent soil in the state of Johor is divided into three categories namely; alluvium soil, sedentary soil and urban mine soil.

Studies show that most of the main minerals in the state of Johor are located in the Permanent Reserved Forests. The minerals are generally categorized into three such as the earth mineral, kaolin and silica. The location of the minerals in the PRF gives a big impact to the management of permanent reserved forests as mining can give adverse implications to Annual Cutting Rationing and Sustainable Forest Management Practices.

2.1.2.4. Forest Types

The forests in the state of Johor are part of Malaysian Tropical Rainforests that are one of the richest and most complex in the world. As a whole, these tropical rainforests can be divided into eight main types of forests according to the classifications based on the height from sea level (Whitmore, 1998). The classifications are as follows: (i) Mangrove Forest (ii) Peat Swamp Forest (iii) Coastal Forest (iv) Lowland Dipterocarp Forest (v) Hill Dipterocarp Forest (vi) Upper Dipterocarp Forest (vii) Oak Mountain Forest, and (viii) Ericaceous Mountain Forest.

2.2. Methods

2.2.1 Experimental Design

Twenty observational plots of vegetation samples (releves) with each size 20 m x 20 m were carried out randomly at several points in different density of *Shorea peltata*. From these twenty plots, 100 Soil samples

were collected for the analysis of soil physical properties. A preliminary survey in the project area was made to measure the samples plots. Plots were established in this area on 26 December 2009, data were collected from 10 January 2009 - 20 October 2009. The peculiar arrangement and placement of the plots were made base on the distribution of *Shorea peltat*a species in Mersing as an endemic species to provide the relationship between *Shorea peltata* species and soil physical properties under tropical rain forest.

2.2.2. Plot Design

Size of each plot was 20 m X 20 m, divided into 10 subplots. Five subplots were chosen in each plot. Due to the size of the plot and for easy analysis among plots and replications and to avoid missing of data and to minimize and maximize values observed in each plot, an observational study of the plot was made to control the enumeration works and to get actual information for all parameters. An observational study it helps in observing more subjects that perform a task with the intention of describing and comparing particular aspects of their performance and information (Paul, 2002). In each subplot soil samples were collected. All the twenty (releve's) were divided into four groups namely (a) rare, (b) low, (c) moderate and (d) higher density. The size of each plot corresponded to the height of the forest stand and tree (Fujiwara, 1987).

2.3. Data Collection

Soil samples were taken from the exciting field of study from two layers of each sample at depth of (0 - 10 cm) using the core-ring for soil moisture content and bulk density (Figure / Şekil 2) and at (0 – 15 cm) depth with auger for the analysis of porosity, particle density and soil texture (Figure / Şekil 3), meanwhile, soil compaction was done for the same plots used pocket penetrometer (Figure / Şekil 4).

Figure 2. Core-ring used for soil sample (0-10cm)
Şekil 2. Toprak örneklemesinde kullanılan silindirler (0-10cm)

Figure 3. Auger used for soil sample (0-15cm)
Şekil 3. Toprak örneklemesinnde kullanılan sondası (0-15cm)

Figure 4. Pocket penetrometer
Şekil 4. Cep penetrometresi

2.4. Soil Analysis

The soil samples collected from the topsoil (0 - 10 cm) for moisture content and bulk density, and (0 – 15 cm) were analyzed for disturbed and undisturbed soil properties. Soil samples were air dried, passed through the roller mills and then sieved through a 2mm wire mesh and then analyzed for soil moisture content, soil texture, bulk density, particle density and porosity. The percentage of moisture content of the soil sample was calculated as:

$$MC\% = \frac{W_2 - W_3}{W_3 - W_1} \times 100 \qquad (1)$$

Where:
W_1 = Weight of tin (g)
W_2 = Weight of moist soil + tin (g)
W_3 = Weight of dried soil + tin (g)

Particle Size distribution was determined by the pipette method (Day, *et al*. 1965) modified for Malaysian soil as described in the manual of Department of Malaysian Society of Soil Science (1988). The method consists of preliminary destruction of the organic matter by heating with hydrogen peroxide. Absorbed cations were removed by treating the samples with 0.2 M ammonia acid and dispersed with calgon. The sand (50 - 2000 μm) was separated by weighting process, whereas silt content (2 - 50 μm) and clay (<2 μm) was determined by weighting and dried process. The USDA system was used for the textural classification. Bulk density was determined by weighting (mass of dry soil/ total volume of soil), while the particle density was determined by Desiccator method (mass of dry soil/volume of soil particularly). Porosity = Bulk density/ Particle density.

2.5. Statistical analysis

The data analysis is based on the data location for a period of 10 months. Descriptive analysis is employed to explore the data and to show the sample distribution. It is also employed to evaluate the data and to show the forms of samples distribution. Real distribution represents numbers of real values in classes of frequencies and percentage (Dennis, 2002). Descriptive statistics such as frequency means, standard error, maximum and minimum values were applied to present and summarize the data. Standard error was applied to calculate the error of any particular sampling distribution of the sample means. Also community parameter (Ter Braak and Verdanschat, 1995) was followed to cover and estimate the density of *Shorea peltata* species in the plots. Descriptive method was used to make a general observation about the data.

ANOVA was used to test the hypothesis for differences between more than two independent sample descriptions (Bachman and Paternoster, 1997), compare and determine the significant differences based on the quantitative data under different density of *Shorea peltata* species. A SAS programme for correlation was also used to determine the strength of the association among groups in the research area.

3. RESULTS AND DISCUSSIONS

The results were discussed by comparing each site groups namely rare density/ control (A), low density (B), moderate density (C) and high density (D) of *Shorea peltata* species.

3.1. *Shorea peltata* species

Result from the enumeration and identification of the types of *Shorea peltata* species, revealed that there are different stages of *Shorea peltata* in Tenggaroh Forest Reserve, namely (A) dominant trees, (B) understory trees and (C) shrub trees (Figure 5). *Shorea peltata* species were classified as an endemic species. Endemic type or species are especially likely to develop on the islands because of their geographical isolation. The most dominant trees were higher within group C moderate density in each stage of 60 %, 44 % and 21 %, followed by D high density 58 %, 27 %, while in within shrub trees stage was 2 %. The percentage of understorey trees was observed to be higher within D than C. However, the percentage

of shrub layer were higher within C 60 % than D 2 % (Figure /Şekil 5). The percentages depend on the distribution of *Shorea peltata* species on each releves.
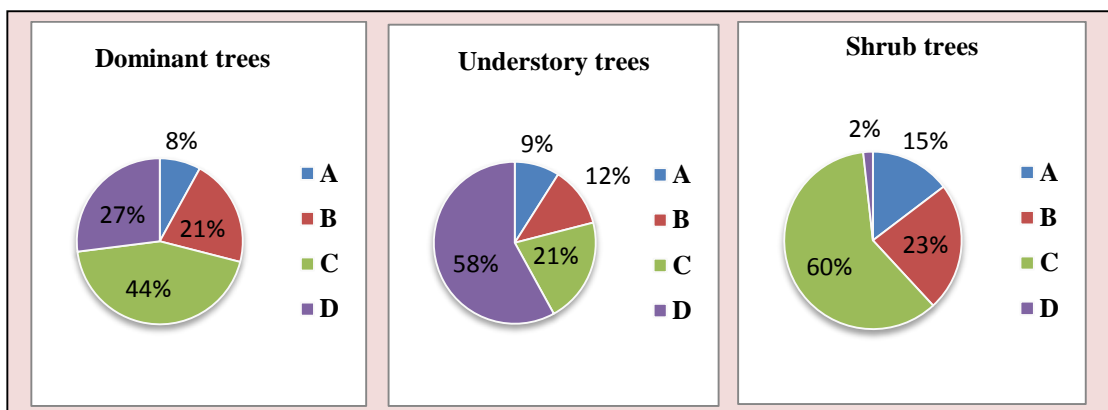
Where A rare density, B low density, C moderate density, D high density
Figure 5. Percentage of *Shorea peltata* types by groups, Tenggaroh Forest
Şekil 5. *Shorea peltata* sıklığının farklı gruplarda dağılımı

3.2. Soil Physical Properties

3.2.1. Soil Texture

The results for soil physical properties of the different groups are presented in (Table / Tablo 1). Textural composition of surface and subsoil comprised three major components namely sand, silt and clay (%). Soil texture is a term commonly used to designate the proportionate distribution of the different sizes of mineral particles in a soil (Gee and Bauder, 1986). The greatest texture soil had more pores and space compared to the poor soil. Whereas clay is hard to aggregate when dry. Some clay is friable and plasticity in all soil moisture conditions (Guggenheim et al., 1995). The presence of the very high content of clay in soil frequently leads to waterlogged, hardening and cracking when dry (Wayne Berry and Quirine Ketterings, 2007). The growth of a tree is very much affected by the presence of clay particles in soil texture after disregarding the factors like nutrient availability and variation in the degree of slope. Greater water holding capacities are also caused by the soil texture (Foth, 1990).

Statistical analysis showed that there were significant differences in sand, clay and silt content among groups (Table / Tablo 2). Sand content in group A was significantly higher as compared to other groups, while the percentage of clay and silt content was significantly higher in groups B, C and D. According to the percentage of sand, silt and clay content, the soil in the study site can be classified under Clay Loam based on the Textural Class. The highest mean clay value was observed in group B (48.23%) followed by group C (47.40 %) and D (47.21 %) at 0 to 15 cm soil depth, meanwhile in group A was observed to be 46.01. The percentage of silt was found almost similar when compared with clay percentage. The mean value of silt percent in group B was 49.46 % followed by groups C (47.54 %) and D (47.37 %), while in group A it was 47.20 %. Statistical analysis showed significant difference among groups. The highest mean value of silt percent was observed in group B at 0 – 15 cm depth (Table / Tablo 2). The mean percentage of sand was recorded in group A (9.998 %) followed by group D (9.602 %) at 0 – 15 cm depth while in group B it was 9.402 % followed by group C 9.316 %. Statistical analysis showed that there is a significant difference among groups. The highest percent was shown in group A as compared to the other groups (Table / Tablo 2).

Table 1. Soil physical properties among density groups for 20 plots
Tablo 1. Yoğunluk grupları arasında toprağın fiziksel özellikleri (20 alan)

Group	Parameters	Plots for each density					Mean	SE
		TF09	TF10	TF11	TF18	TF19		
A	Moisture content (%)	26.61	25.60	24.80	24.41	24.61	25.20	2.050
	Clay (%)	48.37	42.24	51.45	44.62	42.37	46.01	3.057
	Silt (%)	49.31	43.36	52.95	45.45	43.94	47.20	3.061
	Fine sand (%)	9.860	9.760	10.67	8.210	11.49	9.998	1.305
	Bulk density (g/cm^3)	0.810	0.800	0.910	0.820	0.800	0.828	0.000
	Particle density(g/cm^3)	1.310	1.400	1.220	2.000	1.900	1.566	0.466
	Porosity (%)	46.00	39.00	24.00	54.00	54.00	43.30	4.946
	Soil compaction (cm)	0.700	0.800	1.100	1.400	1.200	1.040	0.384
		TF12	TF13	TF14	TF15	TF17		
B	Moisture content (%)	26.00	21.20	24.40	22.20	24.20	23.60	2.077
	Clay (%)	47.88	42.77	52.02	45.92	52.60	48.23	3.176
	Silt (%)	49.12	43.71	53.41	47.07	54.01	49.46	3.231
	Fine sand (%)	8.910	10.62	9.620	9.080	8.780	9.402	1.245
	Bulk density (g/cm^3)	0.800	0.900	0.700	0.900	0.900	0.840	0.000
	Particle density(g/cm^3)	1.300	2.400	2.000	1.700	1.600	1.800	0.509
	Porosity (%)	39.00	56.00	58.00	34.00	31.00	43.60	4.984
	Soil compaction (cm)	1.500	1.510	1.200	0.800	0.810	1.160	0.384
		TF2	TF4	TF6	TF7	TF8		
C	Moisture content (%)	22.20	18.60	16.20	15.40	21.20	18.72	2.023
	Clay (%)	51.82	44.79	47.15	49.84	43.44	47.40	3.000
	Silt (%)	51.09	44.10	47.94	50.83	43.77	47.54	3.036
	Fine sand (%)	9.040	8.410	11.05	9.140	8.940	9.316	1.290
	Bulk density (g/cm^3)	0.800	0.810	0.800	0.820	0.700	0.780	0.000
	Particle density(g/cm^3)	1.500	1.600	1.200	1.610	2.200	1.620	0.466
	Porosity (%)	37.00	23.00	30.00	41.00	32.00	32.60	3.268
	Soil compaction (cm)	1.500	0.800	1.600	1.400	1.200	1.300	0.402
		TF1	TF3	TF5	TF16	TF20		
D	Moisture content (%)	21.40	24.60	15.20	25.00	27.60	22.76	2.479
	Clay (%)	44.37	45.64	5.18	44.97	50.89	47.21	2.978
	Silt (%)	43.25	44.62	50.49	46.08	52.41	47.37	3.082
	Fine sand (%)	10.22	9.610	9.740	8.750	9.602	9.690	1.247
	Bulk density (g/cm^3)	0.810	0.800	0.820	0.800	0.810	0.808	0.000
	Particle density(g/cm^3)	1.200	1.210	1.300	1.100	1.400	1.240	0.408
	Porosity (%)	32.00	33.00	22.00	31.00	42.00	32.00	3.308
	Soil compaction (cm)	1.500	1.200	1.400	1.200	0.810	1.220	0.402

Where: A= Releve Group for Rare Density of *Shorea peltata* species
B= Releve Group for Low Density of *Shorea peltata* species
C= Releve Group for Moderate Density of *Shorea peltata* species
D= Releve Group for High Density of *Shorea peltata* species
SD= Standard error

Soil texture influences many factors of soil properties. Higher content of sand in the soil increases soil porosity that contributes to the soil aeration and drainage. Soil texture influences the soil compaction, bulk density and particle density. The increase of silt and organic matter can improve total water shortage in the soil.

3.2.2. Soil Moisture Content

Mean values for soil moisture content in groups A were 25.20 %, followed by 23.60 % in B, and 22.76 % in D, while in group C it was 18.72 % (Table / Tablo 1). Statistical analysis showed a significant difference among group of releves (Table / Tablo 2).

Table 2. Comparison of mean values for soil physical properties among groups
Tablo 2. Gruplar arasında toprağın fiziksel özellikleri ortalama değerlerinin karşılaştırılması

Parameter	Releves				F. value	P. value
	E1	E2	E3	E4		
Moisture content (%)	25.20a	23.60a	18.72b	22,76a	5.120	0.000
Clay (%)	46.01a	48.23a	47.40a	47.21a	14.02	0.000
Silt (%)	47.20a	49.46a	47.54a	47.37a	13.10	0.000
Fine sand (%)	9.998a	9.402a	9.316a	9.602a	11.20	0.000
Bulk density (g/cm^3)	0.828a	0.840a	0.780a	0.808a	10.62	0.000
Particle density(g/cm^3)	1.566a	1.800a	1.620a	1.240a	8.210	0.000
Porosity (%)	43.30a	43.60a	32.60b	32.00b	7.231	0.000
Soil compaction (cm)	1.040a	1.160a	1.300a	1.220a	7.101	0.000

Means with the same letter are not significant difference at P≤0.05, ns not significant
Where: A= Releve Group for Rare Density of *Shorea peltata* species
B= Releve Group for Low Density of *Shorea peltata* species
C= Releve Group for Moderate Density of *Shorea peltata* species
D= Releve Group for High Density of *Shorea peltata* species

Soil moisture content depends on the topography of the site, environmental factors and sunlight. Soil moisture can increase plant biomass by increasing the rate of microbial processes that can increase plant available nutrients such as nitrogen mineralization (Johnson et al., 2000). Soil moisture can affect plant biomass by changing microbial nitrogen retention, particularly in mycorrhizae (Hobbie and Colpaert, 2003). Increased soil moisture content increases plant N uptake However, it remains unclear if atmospheric CO_2 effects on plant biomass are driven by CO_2 induced changes in soil moisture. The amount of soil water is a critical factor in soil compaction potential. A dry soil which has friction between the soil particles is not easily compacted. Water acts as a lubricant between the particles, making the soil easier to compact. However, as soil water content increases, a point is reached where most pore spaces in the soil are filled with water. Water cannot be compressed, so water between the soil particles carries some of the load of the soil, resisting compaction. Therefore, a wet soil cannot compact as much as a moderately moist soil. According to Armstrong, (1975) the vegetation cover influences the soil moisture content by interrupting precipitation delivered to the soil surface.

3.2.3. Soil Compaction

Statistical analysis for soil compaction among plot showed no significant difference, while comparison among groups showed significant difference (Table / Tablo 1). The highest percentage of soil compaction was recorded in group C (1.300 cm), followed by group D (1.220 cm) and B (1.160 cm), while group A was 1.040 cm (Table / Tablo 2). The result observed that the high rates of compaction shown within groups C and D, these groups were located close to the logging area.

Compaction is the translocation and resorting of textural components in the soil (sand, silt, and clay particles) destruction of soil aggregates and collapse of aeration pores. Compaction is facilitated by high moisture contents. Soil compaction occurs when the weight of heavy machinery compresses the soil, causing it to lose pore space. Soil compaction may also occur due to a lack of water in the soil. Affected soils maynot be able to absorb enough rainfall, thus increasing runoff and erosion. Plants face difficulty in compacted soil because the mineral grains are pressed together, leaving little space for air and water, which are essential for root growth (Hatchell et al., 1970).

The ability of a soil to recover from compaction depends on climate, mineralogy and fauna. The health and structure of trees are reflections of soil health. The ecological processes which govern tree survival and growth are concentrated around the soil and root interface. As soils and associated resources change, tree systems must change to effectively utilize and tolerate changing resource quantities and qualities, as well as the physical space available. Soil compaction is a major tree-limiting feature of community forest managers and arborists (Jones, 1983). The high porosity means less soil compaction. Soil texture also plays an important role in soil compaction.

Soil compaction can be a problem in most soils. Compaction can reduce plant growth, reduce root penetration, restrict water and air movement in the soil, resulting in nutrient stresses and cause slow seedling emergence (Woodward, 1996). The structure of a soil (how well the soil breaks up into small, cohesive clumps when crumbled) also plays a role in its potential for compaction. A soil with higher levels of organic matter generally has better structure and resists compaction better than soils with lower organic matter levels. Organic matter helps create larger and stronger soil aggregates, low organic-matter soils suffer more from compaction than loose, friable, high-organic matter soils. Soil compaction is the most prevalent of all soil constraints on shade and street tree growth. Soil compaction is common in these places where human, machines and infrastructure exist. There are few areas without some form or extent of soil compaction. Soil compaction is a fact of life for trees and tree manager (Greacen and Sands, 1980).

3.2.4. Bulk Density

Statistical analysis for soil bulk density is also summarized in (Table / Tablo 1). The highest mean value for bulk density was recorded in group B (0.840 g cm^{-3}) and the lowest was observed in group C (0.780 g cm^{-3}), there was a significant difference among groups at $P<0.05$ (Table / Tablo 2).

Bulk density is a measure of the weight of the soil per unit volume g/cm^3 usually given on an oven-dry basis. Variation in bulk density is attributable to the relative proportion and specific gravity of solid organic and inorganic particles and to the porosity of the soil. Most mineral soils have bulk densities between 1.0 and 2.0 g cm^{-3} (Blake and Hartge, 1986). Although bulk densities are seldom measured, they are important in quantitative soil studies and measurement should be encouraged.

The suitable bulk density for tree growth ranged from 0.190 to 196 g cm^{-3}. The bulk density is usually influenced by the texture of soil. The lower value of bulk density means soil compaction is lower, the soil has more porosity and the soil aeration and drainage is better. The soil bulk density is also influenced by volume of soil, if the soil volume is higher, the bulk density will also be lower. According to Brady, (1984) bulk density of most of the soil varies between 1.00 to 1.60 g cm^{-3} in clays to 1.80 g cm^{-3} in sands.

Bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction. Soil compaction implies an increase in soil bulk density and associated with this would increase in soil strength and decrease in air permeability and hydraulic conductivity. Severe compaction may increase soil strength to the point where root cannot penetrate the soil (Charman and Murphy, 1998).The bulk density of soil is inversely proportional to the porosity of the same soil, the more pore space in a soil the lower the value for bulk density (Buckman et al., 1960).

3.2.5. Particle Density

Statistical analysis of particle density among plots showed no significant difference (Table / Tablo 1). The mean value of group B was 1.800 g cm^{-3}, followed by group C (1.620 g cm^{-3}) and group A (1.556 g cm^{-3}), while in group D was 1.240 g cm^{-3} (Table / Tablo 2). The result showed that the highest percentages of particle density were observed in term of low density; this means the term of low density is higher in moisture conditions in the sand.

Soil particle density value can influence the porosity of the soil. The higher particle density in soil means the higher percentage of soil porosity and soil drainage will also be higher (Laker and Dupreez, 1982). The particle density of a soil measures the mass of a soil sample in a given volume of particles (mass divided by volume). Particle density focuses on just the soil particles and not the total volume that the soil particles and pore spaces occupy. Particle density differs from bulk density because the bulk density includes the volume of the solid (mineral and organic) portion of the soil along with the spaces where air and water are found. The density of soil particles is a result of the chemical composition and structure of the minerals in the soil. Particle density data are used to better understand the physical and chemical properties of the soil. For example, the particle density indicates the relative amounts of organic matter and mineral particles in a soil sample. Particle density can be used with bulk density data to calculate the pore space (porosity) occupied by air and water in a soil sample.

Organic matter readily influences the soil particle density. Organic matter weighs much less per unit volume than soil minerals. Soils high in organic matter have lower particle densities than soils similar in texture that are low in organic matter. Soil particle density generally increases with soil depth because of the concurrent decrease in organic matter (Hassink and Whitmore, 1997).

3.2.6. Soil Porosity

The results of porosity are summarized in (Table / Tablo 1). Statistical analysis showed significant difference among all the groups. The highest mean value of porosity was recorded in group B (43.60%), followed by group A (43.30%) and group C (32.60%), while in group D it was 32.00% (Table / Tablo 2).

Soil porosity refers to the part of a soil volume that is not occupied by soil particles or organic matter. Pore spaces are filled with air, other gases and water. Large pores (macro pores) allow the ready movement of air and the drainage of water. They are also large enough to accommodate plant roots and the wide range of tiny animals that inhabit the soil. Large pore spaces permit fast infiltration and percolation of water through a soil or soil horizon. Small pores (micro pores) exhibit attractive forces strong enough to hold water in the pore. They are the water retention system of the soil which provides water storage for plant roots. During precipitation, macro pores conduct water into the soil where it fills the micro pores. At field capacity all pores small enough to retain water against the pull of gravity are filled (Brady and Weil, 1999).

Clay soils have numerous micro pores and hold large quantities of water but since they have few macro pores they produce very slow infiltration rates. The pores in the clay soils may be so small and hold water that water will not be available to plants. Sandy soils with numerous macro pores but few micro pores have higher infiltration and percolation rates but a lower water-holding capacity than other soil textures. A lower water-holding capacity means less available water for plant roots. For re-vegetation purposes, plants perform best in intermediate soil textures (loams) where soils contain mixtures of micro- and macro pores (Munshower, 1993). The soil porosity is influenced by the soil texture, bulk density and particle density. Soil with good texture has a higher percentage of soil porosity, soil porosity will control the soil activities especially soil drainage, soil aeration, growth of plant and organisms in soil.

3.2.7. Co-relationship between soil physical properties and site characteristics

The correlation analysis results of 20 plots based on the presence and absence of 100 samples are shown in (Table / Tablo 3). The groups of plots were defined by using different codes. A clear segregation was evident between *Shorea peltata* and soil physical properties of plots in Group a, b, c and d.

Table 3. Variables for Pearson's correlation between the density groups and variables of samples (r= 20)
Tablo 3. Yoğunluk grupları ve değişkenler arasındaki Pearson korelasyon sonuçları (r=20)

Variables	A	B	C	D
Shorea peltata values	4.00	7.82	14.53	22.76
Site Variables	R			
Moisture content	0.004	0.270	1.000	0.631
Clay	0.334	0.231	0.016	0.090
Silt	0.270	0.077	0.098	0.029
Sand	0.019	0.031	-0.055	-0.236
Bulk density	0.650	0.154	0.196	0.041
Particle density	0.250	0.063	0.162	0.091

The different values of Pearson's correlation for the first four variables (a, b, c, and d) were poorly related to *Shorea peltata* characteristics, i.e. 4.00, 7.82, 14.53 and 22.76 respectively. The cumulative variance of soil respiration characteristics relation resulting from groups was 49.11% (Table / Tablo 3).

Out of 6 soil physical property variables taken in this research, the result of the SAS Correlation showed that five factors were the most influential on the distribution of species in Tenggaroh Forest Reserves. The first group was strongly correlated with bulk density (r=0.650) and clay (r=334), meanwhile, the second group correlated with moisture content (r= 0.270). Group C correlated strongly with moisture content (r=1.000). In contrast, one variable had a negative correlation with group C, D via Sand (r=-0.055, -0.055).

Correlation showed that the bulk density ion the first group and particle density, clay, silt and moisture content on the second and third groups contributed in separating the samples. However, based on the correlation coefficient values, it can be postulated that moisture content, bulk density, particle density and silt makes the greatest contribution in determining the variation in the structural composition of *Shorea peltata* communities in the research area.

The relationship between *Shorea peltata* distribution and soil physical property variables is important to consider the scale at which the variables are measured. However, conclusion obtained at one scale may not be valid at another scale. Comparison of the correlation between groups shows that the most variables were found positive. The SAS Correlation analysis also implies that bulk density, particle density, clay, silt and moisture content were the most important factors in species distribution in the research area.

4. CONCLUSION

In this research, the possible changes of soil physical properties balance associated with different density of *Shorea peltata* species for natural forest on the same sites were assessed. Investigation of soil physical properties such as moisture content, bulk density, particle density, clay, silt and soil compaction were examined. The results showed significant differences among the groups.

The research suggested that the distribution of *Shorea peltata* in Tenggaroh Forest Reserve was strong had a relationship with moisture content. The best performance of *Shorea peltata* in Tenggaroh Forest Reserve is probably accounted from the soil characteristics of the reserve area. This study contributes not only to soil physical properties, but also for soils as the basic unit of natural environment and various scientific studies. The study site was characterized as a lowland forest ranging from (250 – 750 m) of altitudes. The importance of altitudes however does not imply a clear predictor for the diversity within a small area as that used during in the present study.

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