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Comparative Studies on Sago Palm Growth in Deep and Shallow Peat Soils in Sarawak

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Abstract Tropical peat soils in South East Asia are mostly oligotrophic, and some are mesotrophic according to the classification by Coulter (1957). The sago palm is exploited as a staple and cash crop in Sarawak, Malaysia. It is a perennial starch crop of some economic importance in Sarawak, and has adapted well to peat swamp areas. However, it is said that sago palms growing in deep peat soils take a longer time to reach maturity than those in shallow and alluvial soils. The differnces in growth rates of sago palms related to the types of soils are discussed.

The comparison of growth rates of the sago palm grown in deep and shallow peat soils was studied in Sungai Talau Peat Research Station, Dalat, Sarawak, Malaysia. Growth of sago palms in deep peat soils and shallow peat soils was measured in terms of several growth parameters, and growth rate data obtained in 1992, 1993, 1994 and 1995 were compared.

There were considerable variations among sago palms in deep peat soil when the trunks emerged from the ground. It took 5–6 years after planting of suckers for the trunk to form. The frond emergence rate differed year by year, ranging from 17 in the initial 3 to 4 years to 19.2 after trunk formation to 12 in the following years. Based on the total number of fronds, the trunk formation periods to be 7–9 years, based on the total number of fronds, the entire maturation period of the sago palm in deep peat soil amounted to 12 to 15 years after planting, revealing that sago palms in deep peat soil have significantly shoter and fewer fronds than those in shallow peat soil. The canopy of sago palms in deep peat soil was not well developed. Therefore, growth of the sago palm in deep peat soil is slower than in shallow peat soil. To compensate for the inferiority of the sago palm in deep peat soil, further investigations are required such as finding new species which reach maturity more rapidly and have higher starch content.

Key words: Deep peat soil, Growth rate, Sago palm, Shallow peat soil

厚さの異なる熱帯泥炭土壌における サゴヤシの生長に関する比較研究 ——マレーシア，サラワク州での例——

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要約 東南アジアに分布する熱帯泥炭土壌はその大部分が貧栄養，もしくは中程度の栄養状態である．マレーシア，サラワク州ではサゴヤシは主要な自給作物として栽培されてきた．サゴヤシは多年生の澱粉作物で泥炭土壌で栽培できる作物として経済的な重要性が増してきている．しかしながら，サゴヤシは生育立地によって生長が異なり，厚い泥炭層を持つ土壌に生育したサゴヤシは収穫に至る年数が，薄い泥炭層を持つ土壌，沖積土壌に生育するサゴヤシより長いという問題点を抱えている．本研究では泥炭層の厚さの異なる土壌におけるサゴヤシの生育について報告する．マレーシア，サラワク州，ダラット地区において，泥炭層の厚さの異なる2地点を設定し，1992年から4年間，樹齢の異なるサゴヤシの生育調査を行った．

厚い泥炭に生育するサゴヤシが，ロゼット状態の生育から幹立ちして幹を形成するようになるまでの期間は供試木によって大きく異なり，サッカー移植後5, 6年を要した．幹形成後1, 2年の幹の伸長速度は著しく，その後，ゆるやかになった(94–127cmyr^{-1})．出葉数も毎年異なったが，幹が形成されて3, 4年は年間17.0から19.2枚(7年生で最大値19.2)，その後は12.0枚であった．幹が形成される期間を全出葉数から7–9年，様の期間を5–6年とすると，厚い泥炭層を有する土壌に生育するサゴヤシの成熟に至るまでの期間は12–15年と見積もられた．

一方，薄い泥炭層を有する土壌に生育するサゴヤシの伸長速度は150–200 cmyr^{-1}であり，5年生で既に幹が形成されていた．その後の出葉速度は13.4–15.5であり，樹齢による顕著な差は見られなかったが，薄い泥炭層のサゴヤシは，厚い泥炭層のサゴヤシに比べ葉柄が長く，展開葉も多く，樹冠も発達していた．このように，厚い泥炭層に生育するサゴヤシは成熟に至るまでの期間が長く年間の単位面積あたりの澱粉生産量は低くなる．しかし，サゴヤシは泥炭土壌地域で大規模な排水を必要とせずに栽培できる唯一の作物であり，この地域の澱粉生産にとって重要な植物である．

泥炭土壌地域におけるサゴヤシをさらに有効に資源化するには，優良品種の選抜と育種育苗(成熟に至るまでの期間の短縮)，および合理的な栽培，管理が必要である．

キーワード 厚い泥炭土壌，薄い泥炭土壌，サゴヤシ，生長速度

Introduction

About 1.5 million ha of peat swamp area are devoted to sago cultivation in Sarawak, Malaysia (Jong 1995). Under natural conditions, a peat swamp area is flooded seasonally and requires drainage before cultivation. Peat soils are generally very acid and their major and minor nutritional element contents are relatively low. Therefore, these huge areas have avoided exploitation. In recent years, extensive utilization of peat swamp areas has started due to increasing population pressure. The sago palm is not found in peat soils in its natural habitat, but it has adapted well to peat swamp areas. In Sarawak, a project has started to establish sago palm plantations on deep peat soil and to manufacture sago starch. However, growth rate of sago palm differs depending on the thickness of the peat layer and on the soil types beneath it. The starch productivity of sago palm in peat soil is considered to be about 25% less than that in alluvial soil (Jong 1995). The average sago (dry starch) yields in Sarawak were reported to be 88–179 kg in peat soil and 123–189 kg in mineral soil (Sim and Ahmed 1991). According to Yamamoto (1996), sago palms reach the flowering stage 8–12 years after planting in fertile soil and 15–17 years in peat soil. Further starch yield investigations in related to the types of peat soil are needed from the physiological and ecological aspects. The objectives of this study are to compare the growth pattern of sago palm in deep and shallow peat soils and to determine its sustainability at an appropriate growth rate in tropical lowland areas.

Material and Method Study site

The relationship between growth rates of sago palm in deep and shallow peat soils was studied in Dalat, Sarawak, Malaysia, from 1992 to 1995 (Fig. 1). To establish a scientific background data set for sago estate management, the Department of Agriculture, Sarawak started a sago palm study in the Sungai Talau Peat Research Station (STPRS),

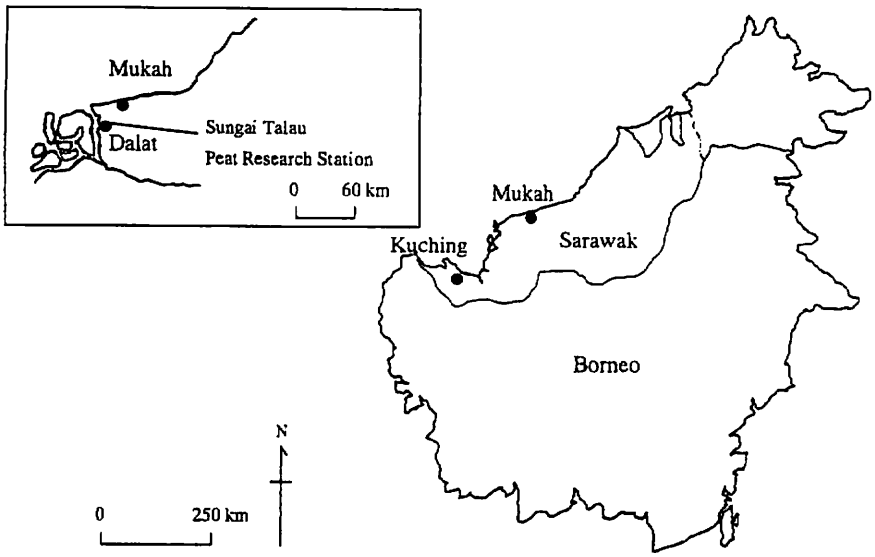

Fig. 1 Study areas

where cultivation practices for sago palm have been tested (Schuiling et al. 1992). All official rights to the research station property in Sarawak were transferred to the semi-governmental agency for land development, the Land Custody Development Authority (LCDA), from 1995. Sungai Talau Peat Research Station is located in the coastal area of Dalat, about 11 km from Dalat Town, Sarawak, where some varieties of sago palms (mainly Metroxylon spp.) were planted to conserve important genes. The mean annual rainfall and the mean annual temperature at Sibu, which is 60 km from the STPRS, are 3194 mm and 26.3 °C, respectively (Okazaki 1992). In this study, soils having 50–150 cm of organic soil materials with non sulfidic clays are called "shallow peat soils", whereas soils having more than 150 cm of organic soil materials are called "deep peat soils".

Growth study of sago palm

Growth of sago palms in shallow peat soils and deep peat soils was measured in terms of several growth parameters, and growth rate data for 1992, 1993, 1994 and 1995 were compared in this study. The trunk formation state can be judged by counting the number of fronds, the number of internodes, the lengths of fronds and the frond emergence rate. The starch content depends on the starch density in the pith and on the trunk size. Trunk volume can be assessed by their girth and height (Flach and Schuiling 1991). The vertical growth rates for deep peat soil were estimated at the STPRS and for shallow peat soil at a farmer's sago palm garden near the STPRS. Samples of sago palms were selected in comparable different growth stages in two types of peat soils. The crown sizes of the sago palms as a growth parameter were assessed by measuring the length from the center of the trunks to the ends of the fronds in four directions: north, south, east and west.

Results and Discussion

Growth rates of sago palms at the STPRS were compared several parameters of vegetative growth in different growth stages from 1992 to 1995. For sago palms in deep peat soil (Table 1), the mean rates of stretching palm heights were 121 $cmyr^{-1}$ during the rosette stage of the first 6 years and then 85 $cmyr^{-1}$ in the following trunk stage of 6 years.

The trunks emerge from the ground several years after the sucker is planted. The number of years varies widely among sago palms, even in the same

Table 1 Sago palm different growth stages in deep peat soil in Dalat, Sarawak, Malaysia

Age (year)	Growth stage	Nomber of samples	Palm height (cm)	Diameter of trunk (cm)	Height of trunk (cm)	Length of longest fronds (cm)	No. of leaf scars	No. of living fronds
1	Rosette	18	145	–	–	nd	–	nd
3		19	252	–	–	nd	–	nd
4		22	442	–	–	452	†15.0	15.0
5		2	501	–	–	588	†14.0	12.0
6	Start of trunk formation	2	860	–	–	798	†18.0	10.0
7	Young trunk growth	4	757	52.0	230	646	47.0	10.0
8		6	1040	50.6	333	780	56.3	10.1
9		4	1350	58.8	506	902	57.8	11.0
10		4	1370	*56.2	564	835	65.3	11.0
11		4	1360	53.8	579	740	75.2	10.5
12		2	1450	46.3	750	735	90.0	9.5
13	Full trunk growth	1	nd	58.0	882	864	63.0	12.0
13	Flowering	1	1650	44.5	1020	810	nd	20.0

* : Diameter at breast height.

† : Includes the number of scars on prostrate stem.

soil. Table 1 shows that it takes 5 or 6 years after planting the sucker for the trunk diameter to reach 50 cm. The trunk diameter ranged from 52 to 59 cm through the trunk stage.

Trunk growth (trunk elongation), calculated from height of trunk, was rather fast in the first 1 to 2 years when the trunk began to form, and then became gradual: approximately 100 $cmyr^{-1}$ (94–127 $cmyr^{-1}$).

Growth rates of sago palms in shallow peat soil are presented in Table 2. The trunk diameter of sago palms in shallow peat soil were larger than those in deep peat soil as shown in Table 1. Most of the trunks were formed within 5–6 years after planting and trunk elongation (150–200 $cmyr^{-1}$) in shallow peat soil was faster than that in deep peat soil. Sago palms in shallow peat soil had significantly longer fronds than those in deep peat soil and had 11.5 to 15.5 fronds per trunk.

Differences in growth rates of sago palms between the different soil conditions were studied by measuring the trunk height and diameter from 1992 to 1995 (Fig. 2). The trunk and diameter growth of sago palms in shallow peat soil are more

Table 2 Sago palm different growth stages in shallow peat soil in Dalat, Sarawak, Malaysia

Age (year)	Growth stage	Nomber of samples	Palm height (cm)	Diameter of trunk (cm)	Height of trunk (cm)	Length of longest fronds (cm)	No. of leaf scars	No. of living fronds
6	Trunk growth	2	1165	57.1	314	896	16	11.5
7		2	1545	71.4	507	1280	33	13.5
8		2	1690	70.2	650	1000	39	14.5
9		2	1735	*63.7	850	930	nd	15.5
10		2	1901	63.7	832	811	68	19.0

* : Diameter at breast height.

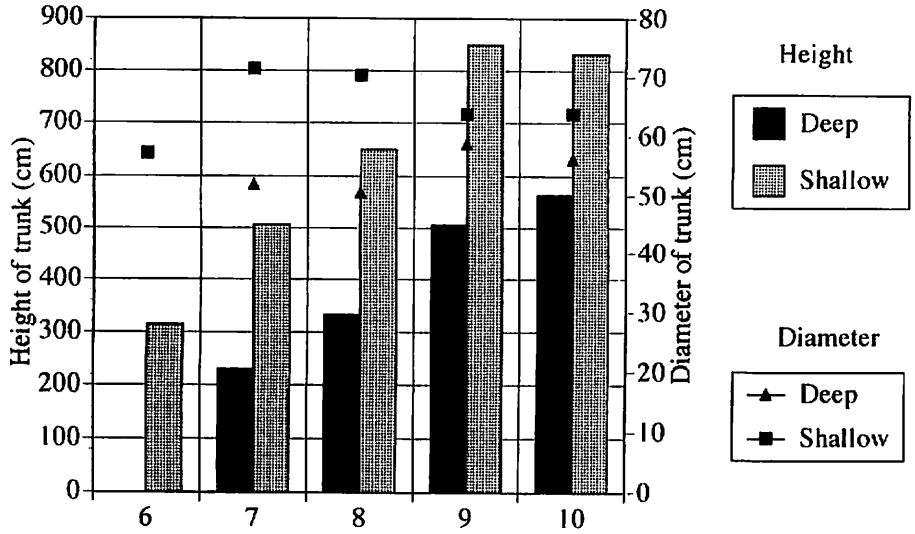

Fig. 2 Comparison of trunk height and diameter of sago palms from 1992 to 1995

rapid than those in deep peat soils. It is speculated that the sago palms in shallow peat soil accumulate more starch at an earlier growth stage than those in deep peat soils.

The age of the sago palms investigated in the STPRS is known from their planting date. And each sago palm in deep peat soil possessed about 11.1 living fronds. Furthermore, we can count the number of leaf scars. Thus, the rate of frond emergence can be calculated from the following equation (a modified version of the equation by Flach and Schuiling 1989):

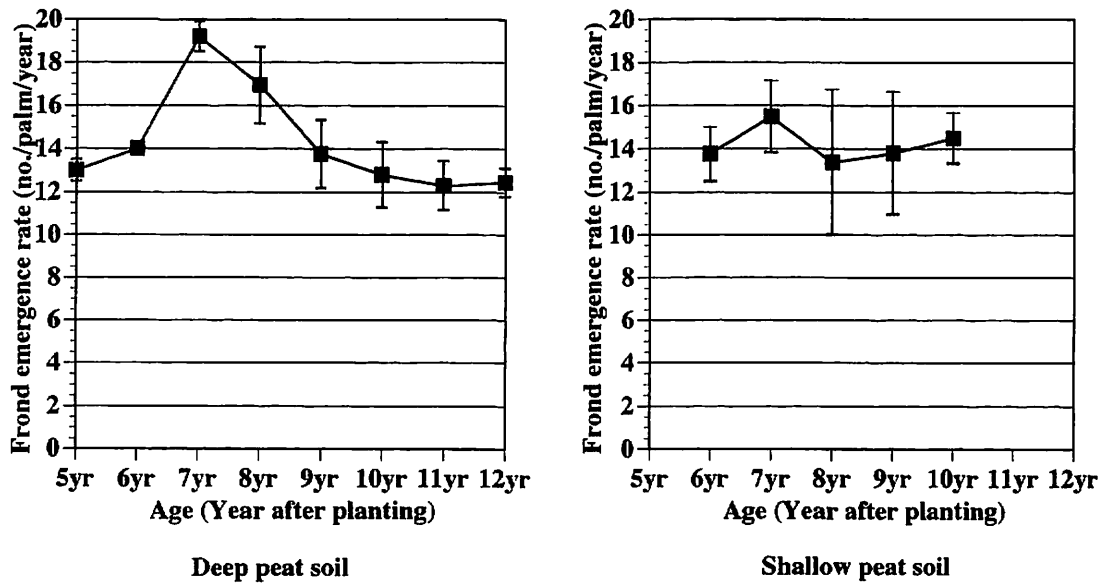

Fig. 3 Frond emergence rate of sago palm growing in two different peat soils

: mean
bar : standard deviation

$$\text{emergence rate} = \frac{[\text{number of leaf scars*+ number of living fronds}]}{\text{Age (yrs)} - 4 \text{ (rosette)}}$$

* includes number of scars on the prostrate stem

The rate of frond emergence of sago palm in deep peat soil differed for each age and sago palm. The mean emergence rate was calculated as 17–19.2 in 3 to 4 years after the start of trunk formation, and then as 12 in the following years with the peak (13–19) of frond emergence from 6 to 8 years (Fig. 3). There were no large inter-age variations in frond emergence rate of sago palm (13.4–15.5) in shallow peat soil.

For cultivated sago palms in Papua New Guinea, Shimoda and Power (1986) reported that the trunks at harvest just before flowering had 65 to 93 leaf scars. Adding the number of living fronds to the number of scars, the total number of fronds was 97 to 107. Assuming a sprouting rate of 12 fronds a years, the trunk formation period was calculated as 7 to 9 years. Including a rossett stage of 5–6 years, the entire maturation period amounts to 12 to 15 years.

It is considered that the flowering of the sago palm will start after an approximate number of fronds has been produced and that it can be influenced by growth conditions such as planting density and soil. This study appears to reveal that the soil condition had a greater influence on growth than the planting density.

Figure 4 indicates the parameters of vegetative growth of sago palms in deep and shallow peat soils. These parameters were based on 3 different ages (7, 8 and 9 years). The growth rate of the sago palms in deep peat soil was slow, compared with that in shallow peat soil in the early stages of trunk formation. Sago palms grew sufficiently in deep peat soils in 13 years (Table 1). However, they took longer to grow in deep peat soil than in shallow peat soil.

The crown sizes of sago palms in deep peat soil and in shallow peat soil in Sungai Talau, Dalat are shown in Fig. 5 and Fig. 6. Sago palms cultivated intensively (planted at 9 m by 9 m) in the STPRS had a small number of fronds. The canopy grew bigger year by year, and began to grow not vertically but horizontally while the number of fronds increased. The crown size of K1 and K2 in Fig. 5 became smaller year by year, and the fronds gradu-

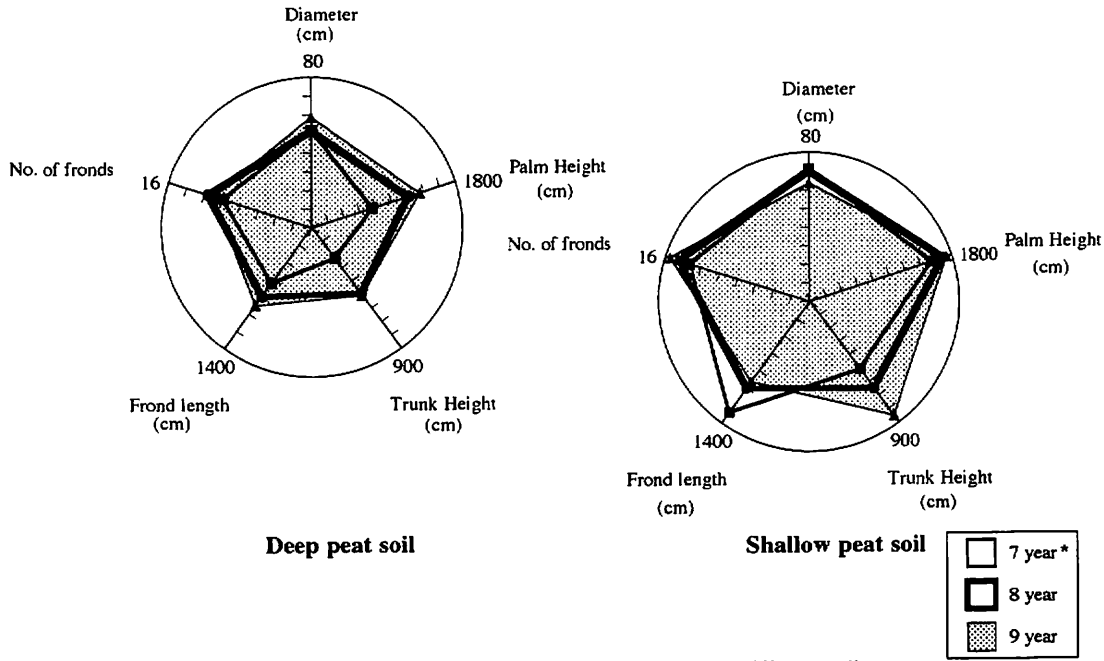

Fig. 4 Parameters of vegetative growth in sago palsm in different soil types

* Years after planting

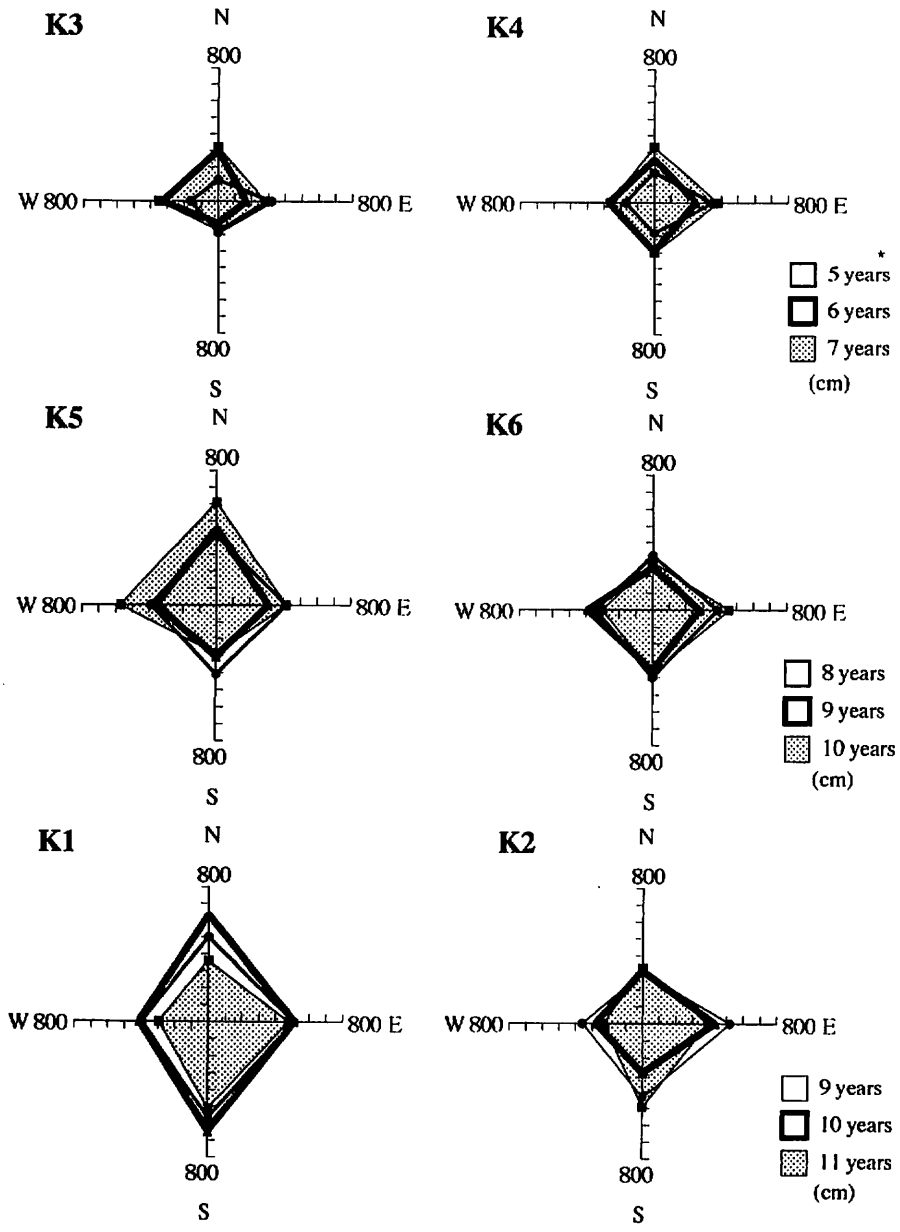

Fig. 5 Crown size of sago palms in deep peat soil in Sungai Talau, Dalat, Sarawak, Malaysia from 1993 to 1995

* Years after planting

ally decreased in size. These features were reflected in the transition from vegetative to generative growth. Sago palms cultivated traditionally in shallow peat soil possessed many fine fronds and the canopy was well developed by 9 years after planting the sucker (Fig. 6).

Thus, the most serious problem is that sago palms in deep peat soils take a longer time to reach

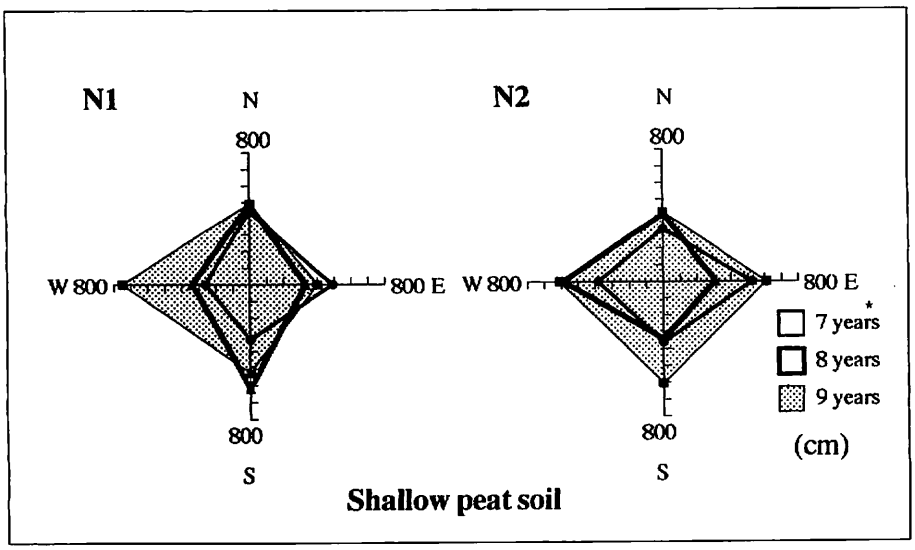

Fig. 6 Crown size of sago palms in shallow peat soil in Sungai Talau, Dalat, Sarawak, Malaysia from 1993 to 1995

* Years after planting

maturity than those in shallow and alluvial soils. Even though starch productivity per unit time and area is low, the sago palm is one of few crops that can grow in deep peat soil without soil improvement. Flach and Schuiling (1991) report that starch productivity per trunk in peat soil appears to differ little from that in clayey soils. To compensate for the inferiority of the sago palm in deep peat soil, further investigations, are for instance, that of finding new species which reach maturity more rapidly and have higher starch content, are required.

Conclusions

There are considerable variations in growth pattern among sago palms when the trunks emerge from the ground. In deep peat soil, it takes 5–6 years after planting to form the trunk. The frond emergence rate differs year by year. It was calculated as 17 to 19.2 in 3 to 4 years after trunk formation and then as 12 in the following years. Estimating the trunk formation periods to be 7–9 years, based on the total number of fronds, the entire maturation period of the sago palm in deep peat soil amounts to 12 to 15 years after planting the suckers. Sago palms in deep peat soil have significantly shorter and fewer fronds than those in shallow peat soil. The canopy of sago palms in deep peat soil is not well developed. Therefore, growth of the sago palm is slower in deep peat soi than in shallow peat soil. A great deal of effort should be made to reduce the immaturity period of sago palms in deep peat soils.

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