

## Botanical Composition, Yield and Nutritive Value of Herbage under Mature Oil Palm Plantation

**Key words :** oil palm plantation, herbage, botanical composition,

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### Abstract

Botanical composition, yield and nutritive value of herbage in the mature oil palm plantation at the ages of 9, 13, 16 and 21 years were determined. From the study, five botanical groups of herbage were found in oil palm plantation, namely, grasses, broad leaf plants, legumes, ferns and oil palm seedling. Grasses were found in abundance throughout all plantation ages followed by broad leaf plants legumes, ferns and oil palm seedling. From the study, *Asystasia instrusa*, *Mikania cordata* *Axonopus compress*, *Ottochloa nodosa* and *Paspalum conjugatum* were the main herbages found under the mature oil palm canopy. The dry matter yield of herbage under oil palm plantation at the age of 9, 13, 16 and 21 years were 110.9, 75.4 62.2 and 50.8 kg/DM/ha/month respectively. The decline in herbage dry matter was related correspondingly to the increase in plantation age and the decrease in the light intensity. The nutritive value of herbage such as DM, CF and ADF contents significantly increased with the age of plantation while CP and DMD decreased significantly. The metabolisability (q-value) of herbage under mature oil palm canopy was low (0.36) and probably caused poor energy utilisation in grazing ruminants.

### บทคัดย่อ

ชนิด ผลผลิต และคุณค่าทางโภชนาของพืชที่เติบโตในสวนปาล์มน้ำมันที่มีอายุ 9 13 16 และ 21 ปี จากการศึกษาพบว่าหญ้าเป็นพืชกลุ่มที่พบมากที่สุดในทุกอายุของสวนปาล์ม รองลงมาคือ พืชใบกว้าง ถั่ว เฟิร์น และ ต้นปาล์มน้ำมันอ่อน ตามลำดับ โดย *Asystasia instrusa*, *Mikania cordata*, *Axonopus compressus*, *Ottochloa nodosa* และ *Paspalum conjugatum* เป็นพืชหลักที่เติบโตได้ริมเงาของต้นปาล์มที่มีอายุมาก ปริมาณผลผลิตแห้งของ ต้นพืชได้ริมเงาของต้นปาล์มน้ำมันที่สุ่มสำรวจจากสวนปาล์มอายุ 9 13 16 และ 21 ปี มีค่าเท่ากับ 110.9 75.4 62.2

และ 50.8 กิโลกรัม/วัตถุแห้ง/เฮกตาร์/เดือน ตามลำดับ ปริมาณผลผลิตแห้งของพืชในสวนปาล์มน้ำมันมีความเกี่ยวข้องกับอายุของปาล์มน้ำมันและระดับความเข้มของแสงที่ส่องผ่านใบปาล์มลงไปในพื้นที่ล่าง ทั้งนี้ระดับของโภชนาการของพืชได้รับมาจากต้นปาล์ม ได้แก่ วัตถุแห้ง (DM) เยื่อใย (CF) และเยื่อใยที่ละลายในกรด (AFD) มีปริมาณเพิ่มขึ้นเมื่ออายุของปาล์มมากขึ้น ขณะที่ปริมาณของโปรตีน (CP) และความสามารถในการย่อยได้ของวัตถุแห้ง (DMD) กลับลดลงอย่างมีนัยสำคัญ ความสามารถในการใช้พลังงานเมทาโบไลซ์ (q-value) ของพืชที่เติบโตได้รับเงาในสวนปาล์มน้ำมันที่มีอายุมากมีค่าต่ำ (0.36) จึงอาจจะเป็นสาเหตุทำให้ร่างกายของสัตว์เคี้ยวเอื้องสามารถใช้ประโยชน์พลังงานได้น้อย

## Introduction

Herbage or ground vegetation under oil palm plantation is the main feed resource for ruminants production in the oil palm plantation system (Chin, 1995). Nevertheless, the natural botanical composition and quality of the herbage are constantly changing due to the tremendous influence of many interacting factors, for instance, the amount of sunlight, the soil type, palm age, species interaction and also plantation management (Chin, 1995; Dahlan, 1989; Dahlan *et al.*, 1993; Chen *et al.*, 1996). Generally, the contents of crude protein (CP), acid detergent fibre (ADF), metabolisable energy (ME) and the metabolisability in the herbage ranged from 11.0 to 16.3%, 42.1 to 57.7%, 4.6 to 7.0 MJ/kg DM; and 0.17 to 0.56 respectively (Dahlan *et al.*, 1993). The green vegetation yield is abundant at the immature stage and dramatically declines when the palm matures (Chen *et al.*, 1991). Thus, it becomes inadequate for animal requirements. In order to integrate ruminants in the mature oil palm plantation, it is essential to investigate the botanical composition, yield and chemical composition of the green vegetation under the

mature oil palm canopy. The result of this study can be associated with the intake and grazing preference of ruminants under oil palm plantation.

## Materials and Methods

### Location of study

This study was conducted at the Sungai Seraya Plantation, Far East Holdings Bhd., Pahang State, Malaysia with a plantation size of 376 ha. The plantation was divided into four ages of 9, 13, 16 and 21 years. Each plantation sector of a different age had five experimental plots each which were randomly set in between four adjacent palm trees and fenced with bulb wire in order to avoid animal and human intervention. The sizes of the plots were different according to the tree spacing, for example, 3.5 x 3.5 m<sup>2</sup> for 9 year old plots and 4 x 4 m<sup>2</sup> for 13 to 21 year old plots.

### Botanical Composition of Herbage

Identification of herbage species was carried out for each experimental plot. After cutting all the fresh herbage, the fresh weight was recorded. About 1 kg of fresh herbage was randomly taken and separated into five botanical

groups, namely, grasses, legumes, ferns, broad leaf plants and oil palm seedling. Each botanical group was weighed, then the species were identified according to the reference collection of herbarium specimens. The herbarium specimen references were made by collecting each green vegetation from the oil palm plantation and comparing these with a known herbage herbarium at Department of Biology, Universiti Putra Malaysia prior to the commencement of the experiment. A scoring technique was applied to determine the composition of herbage group under oil palm plantation. This score ranged from 0 to 100 percent.

### Herbage Yield Measurements

The herbage yield was collected from all experimental plots. The measurement of herbage was determined by cutting all the green vegetation at about 1.5 inches above the ground at monthly intervals of 4 months (January - April). The fresh weight of the sample was recorded and then each 1-kg sub-sample was taken randomly for dry matter weight by drying at 60°C for 2 days. The herbage sampling technique was done according to Marnette (1978).

### Chemical Composition of Herbage

Chemical compositions such as dry matter (DM), crude protein (CP), crude fiber (CF), acid detergent fiber (ADF), ether extract (EE), gross energy (GE) and ash of mixed herbage at different ages of the oil palm plantation were determined according to AOAC (1990). The dry matter digestibility (DMD) of mix herbage was

determined according to Goto and Minson (1977).

### Percentage of Light Penetration

The light intensity under the oil palm canopy is one of the factors that influence the growth of green vegetation under the canopy. The level of light penetration (LP) is normally related to the age of tree crop and can be estimated by using the empirical model of Dahlan (1989) as shown below:

$$\%LP = 1.98 * 10^{-5} * e^{(0.58*(PA-3))} + 106.17 * e^{(-0.14 * (PA-3))} \quad [4]$$

where, PA = palm age

### Statistical Analysis

Analysis of variance was carried out with the data on DM, CP, CF, ash, GE, ME, q-value, DMD, herbage DM yield (HDMY), botanical composition according to the method described by Steel and Torrie (1980). The differences between the means were tested for significance using Duncan's Multiple Range Test. However, the difference between the actual and predicted data of HDMY was tested by using Student *t*-Test. All computations were done by using Statistic Analysis System (SAS) programme (SAS, 1988).

### Results and Discussion

#### Botanical Composition and Herbage Species

As shown in Table 1, broad leaf plants were normally found throughout all ages of plantation. No change was seen in the proportion of broad leaf plants between the age of 9 to 16

years of plantation but was found to be reduced at 21 years old ( $P < 0.01$ ). Differences of the herbage groups were related to the decrease in the light intensity under the oil palm canopy. In agreement with Wong *et al.* (1985) and Dahlan *et al.* (1993), the composition of grasses, particularly, *Axonopus compressus*, *Ottochloa nodosa*, *Paspalum conjugatum* were found in abundance throughout all plantation ages. It can, therefore, be concluded that most of the grasses in the plantation were shade tolerant (Dahlan *et al.*, 1993; Wong *et al.*, 1985). However, the proportion of grasses under oil palm canopy declined with the increased in the age of the plantation ( $P < 0.01$ ).

Although the proportion of legumes were abundant during the early ages of the oil palm plantation but they decreased significantly when the plantation aged. Similar to legumes, the oil palm seedling dramatically decreased when the plantation aged while the proportion of ferns were found to increase ( $P < 0.01$ ). This was due to the shady, cool and humid conditions prevalent in the mature oil palm plantations. The main fern species found in this study were *Nephrolepis sp.* and *Davallia sp.*

The results in this present study were similar to those of Dahlan (1989), Chin (1991) and Chen *et al.* (1991). Thus, both grasses (*Axonopus compressus*, *Ottochloa nodosa* and *Paspalum conjugatum*) and broad leaf plants (*Asystasia intrusa* and *Mikania cordata*) were the main green vegetation under mature oil palm canopy. The relationships between herbage group are shown in Figure 1 and 2.

### Herbage yield

Although the herbage DM yield was slightly high as compared to the report of Dahlan (1989), Chen *et al.* (1991) and Dahlan *et al.* (1993), all reports showed decline in herbage DM yield as the oil palm aged. The average HDMY under oil palm plantation at the age of 9, 13, 16 and 21 years old were 110.9, 75.4, 62.2 and 50.8 kg DM/ha/month respectively (Table 2). As shown in Table 2, the %LP under oil palm canopy declined from 45.8% for 9 years old oil palm to 9.2% for 21 years old oil palm (Figure 2). Light penetration is a major constraint in the exploitation of forage under tree-crop canopy (Chen *et al.*, 1991; Dahlan *et al.* 1993). When the age of tree-crops increases, the photosynthesis is affected adversely with the decrease in the %LP and will delay the regeneration of green vegetation after defoliation.

In agreement with Dahlan (1989) and Chen *et al.* (1991), this study indicated that the HDMY declined as the plantation aged (Table 2; Figure 3). In order to estimate the herbage DM yield under this condition, the simulated model of the herbage DM yield (PHDMY) was developed as follows:

$$\text{PHDMY} = 833.81 * \text{PA}^{(-0.9277)} \\ (R^2 = 0.9932) \quad [5]$$

where, PHDMY = Predicted herbage DM yield  
(kg DM/ha/month);

PA = Palm age (year)

This model gave a similar estimated value to the actual value. When testing both values within the same period by using Student *t*-Test, they showed a non-significant difference between

actual and the predicted herbage DM yield (PHDMY) data. However, in comparison of the mean value of the actual DM yield with the Dahlan model (Dahlan, 1989) using the same method, it was indicated that there was significant difference between the actual data and the data of Dahlan model (Table 2). The estimated mean value from the Dahlan model was about 12.7% lower than the mean value of the actual value while the mean value of the PHDMY model showed only 0.1% difference. Thus, the present prediction model showed a better fit with the actual DM yield than the Dahlan model. This model is applicable to estimate the herbage DM yield of the 9 to 21 year old oil palm plantations.

#### Nutritive value of herbage

As shown in Table 3, the nutritive value and the metabolisability (q) of herbage under oil palm plantation changed as the age of plantation increased. The average DM, CP, CF, ADF and ash of herbage were 21.6, 10.1, 25.9, 50.0 and 11.9% respectively, while the GE and ME were 16.1 and 5.9 MJ/kg DM respectively. The CP of herbage decreased ( $P < 0.01$ ) while the DM, CF and ADF increased significantly with the increase in age of the plantation. This finding was similar to that found by Chen and Chee (1993).

The GE value found was slightly lower compared with the report of Dahlan *et al.* (1993) (16.1 vs. 17.5 MJ/kg DM) while the ME content was lower (5.9 vs. 6.3 MJ/kg DM). The average q-value of the herbage in this study was 0.36. When compared with the ARC (1980), the q-value was

poor in ME concentration and caused poor energy utilisation in grazing ruminants.

The DMD of herbage in oil palm plantation ranged from 46.9 to 42.6%. This DMD decreased with the increase in the age of plantation ( $P < 0.01$ ) (Figure 2). The decrease of the herbage DMD was related to the increase of the ferns, which increased the CF and ADF contents. This was explained by Chen *et al.* (1991) that the DMD value of the herbage under oil palm tree canopy was dramatically decreased due to the ratio of non-edible herbage such as ferns and woody shrubs, which were not palatable and low digestibility for the animal, was increased.

#### Conclusions

The botanical composition of herbage under oil palm plantation changed as the age of plantation increased. The main herbage species that were normally found in every age of plantation were *Asystasia instrusa*, *Mikania cordata*, *Axonopus compressus*, *Ottochloa nodosa*, *Paspalum conjugatum*, *Nephrolepis sp.* and *Davallia sp.* The decrease in herbage DM was correspondingly related to the increase in plantation age and the decrease in light intensity as well. This light intensity mainly affected the composition of herbage species and the yield. When the sunlight dramatically decreased from 45.8% of a 9 year old plantation to 9.2% at a 21 year old plantation, the shade tolerant plant species such as woody shrubs and ferns increased. Thus, the DM, CF and ADF contents significantly increased while

the CP, DMD and HDMY significantly declined. The model that was used to predict the herbage of DM yield in oil palm plantation was PHDMY ( $833.81 * PA^{(-0.0277)}$ ), where PA was the palm age. This model is applicable to estimate the herbage DM yield in oil palm plantation age from 9 to 21 years old.

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**Table 1** Percentage of major herbage groups and its predominant species at 4 ages of oil palm plantation

Herbage species	Age of oil palm plantation (years)				LS
	9	13	16	21	
	← — — — — Percentage — — — — →				
(1) Broad leaf plants (%)	28.5 <sup>a</sup>	29.7 <sup>a</sup>	28.2 <sup>a</sup>	25.5 <sup>b</sup>	P<0.01
<i>Ageratum coryzoides</i>	**	**	**	*	
<i>Asystasia intrusa</i>	**	**	**	**	
<i>Borreria latifolia</i>	**	*	*	*	
<i>Clidernia hirta</i>	*	*	*	-	
<i>Hedyotis sp.</i>	*	**	**	**	
<i>Melastoma sp.</i>	*	*	**	*	
<i>Mikania cordata</i>	**	***	**	**	
<i>Passiflora foetida</i>	**	**	*	*	
<i>Sidarbombifolia</i>	*	*	*	-	
(2) Grasses (%)	65.5 <sup>a</sup>	62.0 <sup>b</sup>	57.0 <sup>c</sup>	51.2 <sup>d</sup>	P<0.01
<i>Axonopus compressus</i>	**	**	**	**	
<i>Brachiaria mutica</i>	*	-	-	-	
<i>Imperata cylindrica</i>	*	*	*	-	
<i>Ottochloa nodosa</i>	**	**	**	**	
<i>Panicum nodusum</i>	*	*	-	*	
<i>Paspalum brevifolium</i>	*	*	*	*	
<i>Paspalum longifolium</i>	**	**	*	-	
<i>Paspalum conjugatum</i>	**	**	**	**	
<i>Polygala paniculata</i>	**	*	*	-	
<i>Sporobolus sp.</i>	*	*	-	*	
<i>Rhynchelytrum rosea</i>	**	*	*	-	
(3) Legumes (%)	1.0 <sup>a</sup>	0.1 <sup>b</sup>	0.3 <sup>b</sup>	0.1 <sup>b</sup>	P<0.01
<i>Centrosema pubescens</i>	*	*	*	-	
<i>Mimosa pudica</i>	***	***	***	***	
<i>Pueraria phaseoloides</i>	**	**	**	**	
(4) Ferns (%)	3.0 <sup>a</sup>	7.2 <sup>b</sup>	13.2 <sup>c</sup>	22.0 <sup>d</sup>	P<0.05
<i>Davallia sp.</i>	*	**	**	***	
<i>Nephrolepis sp.</i>	*	**	***	***	
<i>Selaginella willdenovii</i>	*	*	**	**	
(5) Seedlings of oil palm (shoot/ leave)	2.0 <sup>a</sup>	1.0 <sup>b</sup>	1.5 <sup>ab</sup>	0.9 <sup>b</sup>	P<0.01

Mean of mixed herbage from five experimental plots per age of plantation; The composition of herbage species described as follows: - = < 1 % ; \* = 1 to 20 % ; \*\* = 21 to 40 % ; \*\*\* = 41 to 60 % ; \*\*\*\* = 61 to 80 ; \*\*\*\*\* = > 80 % of green vegetation found under oil palm canopy ; LS = Level of significant

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**Table 2** The actual herbage DM yields (kg DM/ha/month) compared with predicted model and Dahlan's model and the %light penetration under oil palm canopy

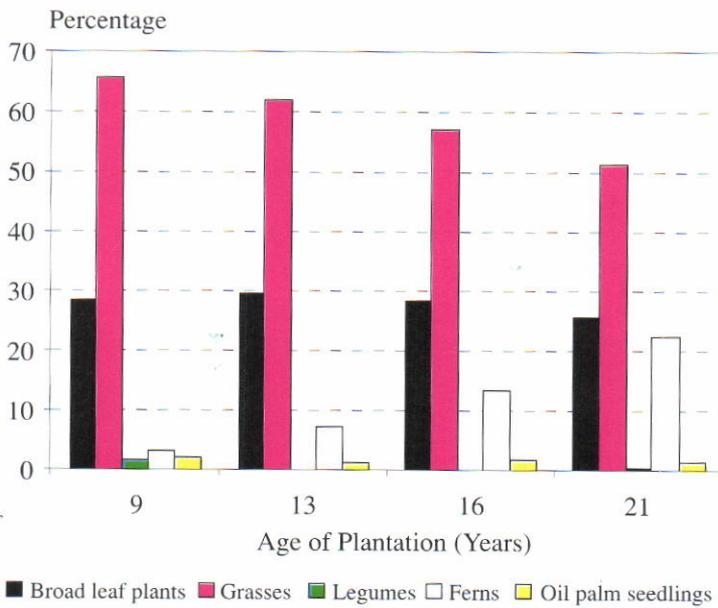
Age of Palm	Herbage DM Herbage yield				LP (%)
	Actual	PHDMY	Dahlan's	% Diff.	
9 year	110.9 <sup>aA</sup>	108.6 <sup>A</sup>	101.7 <sup>B</sup>	+9.0	45.8
13 year	75.4 <sup>bA</sup>	77.2 <sup>A</sup>	66.2 <sup>B</sup>	+13.8	26.2
16 year	62.2 <sup>cA</sup>	63.7 <sup>A</sup>	52.6 <sup>B</sup>	+18.3	17.2
21 year	50.8 <sup>cA</sup>	49.5 <sup>A</sup>	46.3 <sup>A</sup>	+9.7	9.2
Mean	74.8	74.7	66.7	+12.7	24.6

Actual DM percentage was calculated from 5 plots/palm age; PHDMY = Predicted herbage DM yield =  $833.81 * PA^{-0.9277}$ ; Estimated herbage DM of Dahlan =  $1.813 * PA + 46.832 * PA * e^{(-0.266(PA-3))}$  (Dahlan, 1989); % Diff. =  $[(\% \text{ Actual DM} - \% \text{ Estimated DM}) / \text{Estimated DM} * 100]$ ; % LP = percentage of light penetration; <sup>a,b</sup> Means within column with different superscripts differ significantly ( $P < 0.01$ ); A,B Means within row with different superscripts differ significantly ( $P < 0.05$ )

**Table 3** The chemical compositions of herbage under oil palm plantation

Age of Palm	DM (%)	CP	CF	ADF	Ash	GE (MJ/kg)	DMD (%)	TDN (%)	ME (MJ/kg)	q-value (ME/GE)
9 year	18.9 <sup>a</sup>	12.7 <sup>a</sup>	24.9 <sup>a</sup>	43.9 <sup>a</sup>	12.7	16.0	46.9 <sup>a</sup>	39.8	5.8	0.3632
13 year	19.8 <sup>b</sup>	10.7 <sup>b</sup>	26.9 <sup>bc</sup>	44.6 <sup>a</sup>	12.5	16.2	46.7 <sup>a</sup>	42.5	6.0	0.3704
16 year	22.8 <sup>c</sup>	9.2 <sup>c</sup>	23.2 <sup>b</sup>	50.1 <sup>b</sup>	10.7	16.1	44.1 <sup>b</sup>	40.9	5.7	0.3578
21 year	25.0 <sup>d</sup>	7.6 <sup>d</sup>	28.4 <sup>c</sup>	57.3 <sup>c</sup>	11.7	16.3	42.6 <sup>c</sup>	41.5	5.9	0.3613
Mean	21.6	10.1	25.9	50.0	11.9	16.1	45.1	41.2	5.9	0.3632
LS	P<0.01	P<0.01	P<0.05	P<0.05	NS	NS	P<0.01	NS	NS	NS

DM = dry matter; CP = crude protein; CF = crude fibre; GE = gross energy (MJ/kg DM); q-value = metabolisability; TDN =  $37.937 - 1.018(CF) - 4.886(EE) + 0.173(NFE) + 1.042(CP) + 0.015(CF)^2 - 0.058(EE)^2 + 0.008(CF) * (NFE) + 0.119(EE) * (NFE) + 0.038(EE) * (CP) + 0.003(EE)^2 * (CP)$  (Devendra, 1979); ME = metabolisable energy (MJ/kg DM) calculate by  $4.184 * (0.036154 * TDN)$  (NRC, 1985); LS = Level of significant; NS = Non-significant



**Figure 1** Botanical composition of herbage under the oil palm canopy at different ages of oil palm



**Figure 2** Percentage of DMD (%DMD) of herbage in oil palm plantation and light penetration percentage (%LP) at different ages of oil palm canopy

### Dry Matter Yield (kgDM/ha/month)

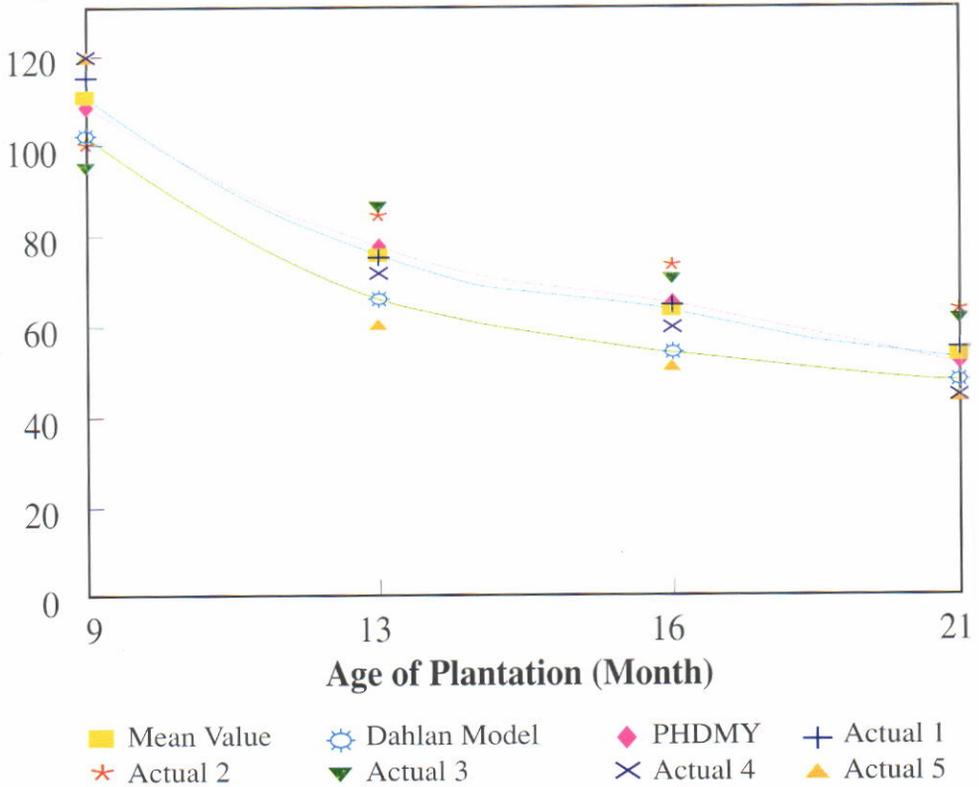


Figure 3 Herbage dry matter yield (kg DM/ha/month) under various of palm ages