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Maturity stages for stalk-cut burley tobacco and their relationships with leaf chlorophyll content

(Tahap kematangan untuk memotong tembakau burley dan hubungannya dengan kandungan klorofil daun)

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Key words: burley tobacco, chlorophyll, maturity stages, stalk cutting, SPAD 502, yield, quality

Abstrak

Kaedah yang cepat dan tepat bagi menentukan tahap kematangan yang optimum untuk memotong tembakau burley perlu dikaji. Dua varieti burley, TAUM 4 dan Burley 64 telah dinilai setiap minggu antara 60−88 hari selepas menanam (HSM). Hasil, gred daun awetan, kandungan nikotin, panjang daun ke-16 dan kandungan klorofil ditentukan. Kandungan klorofil di dalam daun ke-4, 8, 12 dan 16 disukat dengan menggunakan meter klorofil SPAD 502 untuk melihat perhubungannya dengan tahap kematangan daun.

Memotong tembakau burley pada 74 HSM memberikan hasil dan mutu yang terbaik serta kandungan nikotin yang boleh diterima (3–5%). Memotong awal mengurangkan hasil dan kandungan nikotin kerana daun atas masih membesar dan belum matang. Lewat memotong juga mengurangkan hasil dan mutu kerana daun bawah telah terlalu masak dan mula mengering.

Memotong tembakau burley pada waktu optimum ini (74 HSM) menghasilkan kandungan klorofil antara 28–32 unit SPAD (daun ke-16), 24–26 unit SPAD (daun ke-12), 18–20 unit SPAD (daun ke-8) dan 8–10 unit SPAD (daun ke-4). Nilai-nilai ini dapat digunakan sebagai panduan di ladang untuk menentukan masa yang optimum untuk memotong tembakau burley.

Abstract

The need for rapid and accurate method to determine the optimum maturity stage for stalk cutting burley tobacco prompted an investigation. The plants of two burley varieties, TAUM 4 and Burley 64, were assessed weekly between 60 days and 88 days after transplanting (DAT). Yield, cured leaf grade, nicotine content, 16th leaf length and chlorophyll content were determined. The chlorophyll contents in the 4th, 8th, 12th and 16th leaves were measured using a portable SPAD 502 chlorophyll meter to relate it with the maturity stages.

Stalk-cutting burley at about 74 DAT produced the best yield, quality and acceptable nicotine content (3–5%). Early stalk-cutting reduced yield and nicotine content because the top leaves were not fully developed and matured. Late stalk-cutting also reduced yield and quality because the bottom leaves had begun to over mature and dry up.

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Stalk cutting at 74 DAT produced leaves with chlorophyll content between 28–32 SPAD units (16th leaf), 24–26 SPAD units (12th leaf), 18–20 SPAD units (8th leaf) and 8–10 SPAD units (4th leaf). These values can be used as a guide in the field to determine the optimum time for stalk cutting burley tobacco.

Introduction

The demand for burley tobacco (*Nicotiana tabacum* L.) increased from 0.8 million tonnes in 1990 to 1.2 million tonnes in 1996. However during this period, the usage of local burley was reduced from 41% to 30% (Anon. 1998). According to cigarette manufacturers, the local burley did not fulfill the requirement for quality. Thus, an improvement in yield and quality of local burley tobacco is needed to increase the usage of local tobacco and reduce the production cost.

Ripeness of leaves during priming (by plucking individual leaves from the plant) and stalk cutting (harvesting by cutting at the base of the main stem together with the whole leaves) will affect physical quality and chemical content of the cured leaf. Normally, the leaf is ripe for priming when it is yellow-cream in colour with tinges of green along the main veins. At stalk cutting, the lowest leaves should be ripe, the middle leaves a mottled yellow and light green, and top leaves a light green colour (Anon. 1970; Davis and Peedin 1980). Leaf nicotine content increases as maturity and leaf position increase (Bowman et al. 1958; Bowman and Nichols 1968; Sievert 1978; Suggs 1986).

Maturity in burley tobacco is associated with leaf senescence and concomitant decrease in chlorophyll concentration (Tso 1972). Jeffrey and Griffith (1947) reported that the chlorophyll contents in the top leaf of KY 16 variety were 5.96, 3.62 and 2.00 mg/g of dried weight for tobacco, and were judged by experienced growers to be immature, mature and overmature, respectively. This method required destructive sampling and complicated analysis.

Recently, a chlorophyll meter has been developed and is widely used to measure relative chlorophyll content and greenness in intact leaves non-destructively (Yadava 1986; Marquard and Tipton 1987; Himelrick et al. 1992; Wood et al. 1993). There are strong correlation values between the extractable method and the SPAD 502 portable chlorophyll meter reading for strawberry and ornamental plants (Himelrick et al. 1992; Ramlan et al. 1999).

Judging maturity stages just by plant age is not accurate because other factors such as fertilization, cultural practices and weather also influence maturity. Hopefully, based on these findings, the chlorophyll meter can be used as a guide in determining the relationship between the relative level of the chlorophyll content and the optimum maturity stage for stalk cutting burley tobacco.

Thus, the objectives of this study were to determine the optimum maturity stage for stalk cutting burley tobacco using leaf chlorophyll content so that yield and quality of the local burley can be improved, and the usage of local burley increased. The relationship between the chlorophyll content and the maturity stages were studied to determine whether it can be used as a guide for the rapid determination of the optimum stages for stalk cutting burley tobacco in the field.

Materials and methods

This study was conducted on alluvial soil at the MARDI Research Station Bukit Tangga from October 1996 to December 1998. Two burley tobacco varieties, TAUM 4 and Burley 64 (potential commercial varieties in Malaysia), were used to determine whether there were differences in response between different varieties.

Plants were assessed at 60, 67, 74, 81 and 88 days after transplanting (DAT) as the stalk cutting time. The normal stalk cutting time is between 70 and 80 DAT depending on plant growth. The field trial was carried out using a 2 x 5 factorial experiment in a randomised complete block design, and replicated three times. Burley tobacco varieties were the first factor and stalk cutting times the second factor. Each plot consisted of three rows of 32 plants each, with the outer two rows and one plant on each end of the middle row as guard rows. Standard recommendation for cultural practices was followed (Kamarudin 1996, 1997; Kamarudin et al. 1997). The trial was repeated in 1997 and 1998.

Plants in each specific plot were stalk cut at the various stalk cutting times and air-cured in burley barn. Yield and cured leaf grade were assessed and recorded after curing was completed around 45 days. Cured leaf grading was based on the commercial grade description of Malaysian air-cured (burley) tobacco *(Appendix 1)*. Average leaf price as an indication of physical leaf quality was calculated using the following formula:

Average leaf price = ∑(Weight of each grade x Price/kg) / Total plot weight

Ten percent of the cured leaves from all plant positions of each plot were sampled and combined to estimate the whole plant nicotine content.

The chlorophyll contents in the 4, 8, 12 and 16th leaves, counted from the bottom, were measured using a portable SPAD 502 chlorophyll meter (Minolta, Japan) from five randomly sampled plants just before each stalk cutting time. The readings were taken 3 cm from the edges of the widest part of the leaf on both sides. The length of the 16th leaf was measured from the same five randomly sampled plant used as an indicator for top leaf development.

Statistical analysis was carried out on all the variables measured. The 16th leaf length and the relative chlorophyll contents at all four plant positions were plotted against stalk cutting times to observe any trend of top leaf development and changes in the chlorophyll content with increasing maturity.

Results

There were no significant differences in yield, average cured leaf price and the nicotine content between the two varieties tested *(Table 1)*.

Table 1. Relationship between times for stalk cutting and yield, average leaf price and nicotine content for two burley varieties

	Yield (kg/ha)		Av. leaf price (RM/kg)		Nicotine content (%)	
	1997	1998	1997	1998	1997	1998
Variety						
Burley 64	1 651a	2 559a	10.31a	10.62a	3.4a	3.8a
TAUM 4	1 867a	2 472a	10.34a	10.63a	3.5a	4.1a
Stalk cutting time (DAT)						
60	1 958ab	1 924c	10.52a	10.65a	2.5d	2.2d
67	2 000ab	2 576ab	10.35b	10.65a	3.1c	3.5c
74	2 268a	2 819a	10.41ab	10.67a	4.4a	4.3b
81	1 445ab	2 765ab	10.31b	10.66a	3.4bc	4.5b
88	1 125b	2 493b	10.03c	10.48b	3.8b	5.3a
c.v. (%)	36.6	9.6	1.0	0.2	16.2	15.8

Means followed by a common letter in the same column are not significantly different at $p = 0.05$ by DMRT

Note: Average leaf price = ∑(Weight of each grade x Price/kg) / Total plot weight

The cured leaf yield increased from 1 958 to 2 268 kg/ha in 1997 and from 1 924 to 2 819 kg/ha in 1998 with increased stalk cutting time from 60 to 74 DAT. Further increase in stalk cutting time beyond 74 DAT reduced yield. The same trend was observed for cured leaf quality as indicated by the average price of the cured leaf. Stalk cutting at 88 DAT produced significantly lower quality leaf. Yield and leaf quality were at its peak when burley tobacco was stalk cut at about 74 DAT. Nicotine content in the cured leaves increased significantly with an increase in stalk cutting times from 60 to 88 DAT except in 1997 when stalk cutting at 74 DAT gave the highest nicotine content *(Table 1)*.

Top leaf growth as indicated by 16th leaf length increased significantly with an increase in stalk cutting times from 60 to 74 DAT. After 74 DAT, there was no significant increase in leaf length *(Figure 1)*.

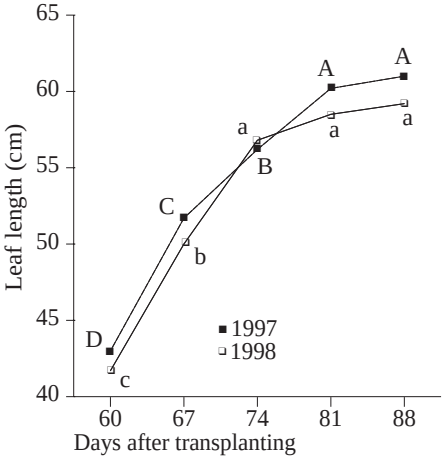
Leaf chlorophyll content at each stalk position reduced significantly with a delay in stalk cutting time from 60 to 88 DAT. Chlorophyll content in the 16th leaf reduced from 35.1 to 16.6 SPAD units in 1997 *(Figure 2a)* and from 39.1 to 18.3 SPAD units in 1998 *(Figure 2b)* with the delay in stalk cutting from 60 to 88 DAT. In the 8th leaf the chlorophyll content reduced from 31.2 to 4.0 SPAD units in 1997 and from 30.5 to 9.3 SPAD units in 1998 over the same period. After 81 DAT the four bottom most leaves had already dried up. It was observed that leaves with SPAD meter reading less than 10 SPAD units were already over-mature. There was a reduction in chlorophyll content in the leaves with changes in leaf position from the top to the bottom *(Figure 2)*.

Discussion

The results indicated that stalk cutting at about 74 DAT produced the best yield and quality of burley with acceptable nicotine content (3–5%). The middle and top leaves were fully developed and matured, and yellow to light green in colour *(Plate 1)*. Early stalk cutting reduced yield because the top leaves were not fully developed and matured as indicated by the top leaf length, which was still increasing. Leaves from all stalk positions were dark green in colour *(Plate 1)*. This indicated that those leaves were still vegetatively active. Harvesting immature leaves produced an unripe grade when cured and such product fetched a lower cured leaf price. The cured leaves also had low levels of nicotine because dry matter and nicotine accumulations were still in progress.

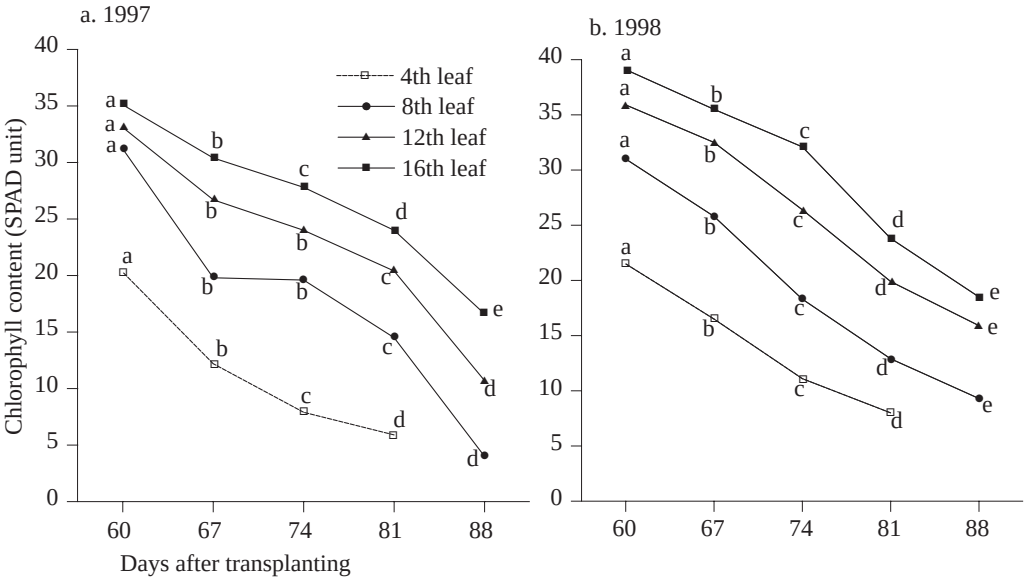
Late stalk cutting also reduced yield and leaf quality because the bottom most leaves had become overmature and begun to dry up. Curing these leaves would produce an overripe grade, which were thin and trashy, and also fetched a lower price. However, the nicotine level kept increasing because the top leaves were fully developed and mature. Similar results were reported in other studies in which nicotine level increases with plant maturity (Bowman et al. 1958; Bowman and Nichols 1968; Sievert 1978; Suggs 1986).

At the last two stalk cutting times in 1997, there were sharp drop in yield and



Means followed by a common letter in the same line are not significantly different at $p = 0.05$ by DMRT

Figure 1. Average leaf length of the 16th leaf at different stalk cutting times



Means followed by a common letter in the same line are not significantly different at $p = 0.05$ by DMRT

Figure 2. Relative leaf chlorophyll content at different leaf positions and stalk cutting times in 1997 and 1998

Plate 1. Leaf maturity stages from various leaf positions at 60 days and 74 days after transplanting (DAT)

average leaf price and also some reduction in nicotine content. This was due to incidence of leaf spot disease, which was quite serious at the later stages of the crop. This incident induced the leaves, especially the lower leaves to become senescence earlier than normal. The effect was also shown in SPAD meter readings and top leaf development *(Figures 1* and *2a)*.

The results showed that the optimum time for stalk cutting was around 74 DAT. At this stalk cutting time, the chlorophyll contents were between 28–32 SPAD units in the 16th leaf, 24–26 SPAD units in the 12th

leaf, 18–20 SPAD units in the 8th leaf and 8–10 SPAD units in the 4th leaf. These values can be used as a guide in the field to determine the optimum time for stalk cutting burley tobacco to optimize yield, leaf quality and acceptable nicotine level.

The results also indicated that while waiting for the top leaves to be fully developed and mature, the bottom leaves became overmature (<10 SPAD units) and dried up. To overcome this, they have to be primed earlier when their colour reached yellow-cream to prevent yield loss and deterioration in leaf quality.

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Appendix 1. Grade description for Malaysian air-cured (Burley) tobacco

Grade	Meaning and description	Price (RM/kg)
NC	Nipis cerah 1st quality: Bottom leaves, pale brown, ripe, thin bodied, >25 cm and spots, blemishes and injury <30%.	8.50
N2C	Nipis cerah 2nd quality: Same as above except spots, blemishes and injury >30%.	7.50
NG	Nipis gelap 1st quality: Bottom leaves, mahogany to dark brown, thin bodied, >25 cm and damage <30%	8.75
N2G	Nipis gelap 2nd quality: Same as NG except damage >30%	7.50
SC	Sederhana cerah 1st quality: Lower leaves, moderate light brown, mature, medium bodied, >35 cm and damage <20%	9.50
S2C	Sederhana cerah 2nd quality: Similar to SC except damage >20%	8.75
SG	Sederhana gelap 1st quality: Similar to SC except mahogany to dark brown in colour.	9.75
S2G	Sederhana gelap 2nd quality: Similar to SG except damage >20%	8.75
TC	Tebal cerah 1st quality: Middle leaves, moderate light brown, mature to ripe, fleshy bodied, elastic, >40 cm, damage <15%	10.75
T2C	Tebal cerah 2nd quality: Similar to TC except damage >15%	10.00
TG	Tebal gelap 1st quality: Similar to TC except brown to dark brown in colour and strong indication of oils.	10.50
T2G	Tebal gelap 2nd quality: Similar to TG except damage >15%	10.00
BC	Berat cerah 1st quality: Top leaves, light brown to brown, mature and firm, heavy bodied, moderate indication of oils, >25 cm, damage <10%	9.75
B2C	Berat cerah 2nd quality: Similar to BC except damage >10%	9.75
BG	Berat gelap 1st quality: Similar to BC except dark brown color, unripe to mature leaf	10.00
B2G	Berat gelap 2nd quality: Similar to BC except damage >10%	9.75
WW	Warna-warni: Variegated with mix of brown, dark brown and green. Under ripe to ripe, >30 cm, damage <20%, green tint <20%.	7.25
H	Hijau: Variegated with mix of green, brown, and dark brown. Immature to unripe, fleshy bodied and tight leaf structure, damage >20%, >30 cm, green tint >25%	6.00
DP1	Mixed of light brown to dark tobacco, stem <20%, fleshy to heavy bodied come from upstalk position	6.00

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