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Short Communications

Growth and Phenology of Kenaf (*Hibiscus cannabinus* L.) Varieties

Nor Aini Ab. Shukor[1*], Mohd Basri Hamzah[1], Hazandy Abdul Hamid[2], Ghizan Salleh[3] and Mohd. Fadzhel Mohd Nasir[4]

[1]*Laboratory of Sustainable of Bioresource Management, Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia,*
[2]*Department of Forest Production, Faculty of Forestry, Universiti Putra Malaysia,*
[3]*Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia*
[4]*National Tobacco Board, Ministry of Plantation Industries and Commodities Malaysia, Kubang Kerian, Mail Box 198, 15720 Kota Bharu, Kelantan, Malaysia*
[*]*E-mail: anishukor@yahoo.com*

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) holds a promising potential in the Malaysian biocomposite industry, as its long fibres are suitable in the process of making a number of products such as pulp and paper, fibre and particle boards, as well as fibre reinforced plastic components and chemical absorbent.

It can grow to a height of 4 to 6 m in about 4 to 5 months and yield up to 13-24 tonnes/ha total dry matter production (Angelini *et al.*, 1998; Alexopolou *et al.*, 2000; LeMahieau *et al.*, 2003). The late maturity varieties (e.g. Everglades 41 and Tainung 2) are more productive than the early ones (e.g. PI 3234923 and PI 248901) because they have longer vegetative phase (Alexopoulou *et al.*, 2007). Alexopoulou *et al.* (2000) also reported that the early-maturity varieties could grow up to 267 cm tall and produce 6-9 tonnes/ha of dry matter, while the late maturity varieties could go up to 330 cm tall and produce 13-24 tonnes/ha, respectively. In addition, Danalatos and Archontoulis (2004) stated that the final production and quality of fibres were associated with the duration of its growing period.

Early floral initiation and seed production were found to decrease the vegetative rate which resulted in lower stalk and fibre yield (Dempsey, 1975). According to Gray *et al.* (2006), the early maturing varieties (e.g. Line 42) took 72 days, intermediate varieties (e.g. Line 21 and Line 29) between 85 – 86 days, whereas the late varieties (e.g. Tainung 1, Pandora and Endora) took about 121 to 136 days to flower. The mean value of the seed production for the late flowering varieties (Guatemala 4 and Everglades 71) was 12.8 seeds per capsule and the average seed yield at maturity 0.60 and 1.04 tonnes/ha, respectively (Muchow, 1980; Muchow and Wood, 1983). A definite dry season is necessary to achieve high and good quality seeds. The study was conducted to evaluate growth, as well as to study some flowering and seed production characteristics of nine kenaf varieties.

MATERIALS AND METHODS

Nine kenaf varieties were classified into three groups according to their flowering habits, namely early, intermediate and late maturing. These involved two early (i.e. Q-Ping and KK60), five intermediate (i.e. V19, V132, V36, NS and V12) and two late varieties (i.e. V133 and TK). The field trial utilized a complete randomized block design (RCBD) with three replications, established at the Serdang campus of Universiti Putra Malaysia, in Malaysia. The varieties were randomly assigned to five lines, and each

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[*]Corresponding Author

consisted of 50 plants, with a spacing of 10 cm between plants and 75 cm between lines per block. Due to different flowering patterns, the planting of these varieties was carried out one month later in different blocks. The growth characteristics and biomass of these varieties were measured and monitored on monthly basis. Ninety samples per variety were selected to measure the height and basal stem diameter, while fifteen samples per variety were assessed for their biomass. Other parameters include flowering characteristics, such as initiation, duration and 50% flowering and seed production (i.e. the number of pods/plant, weight of pods/plant, the number of seeds/pod and the weight of seeds/plant). Data was analyzed for the analysis of variance (ANOVA) and the Duncan's Multiple Range using the Statistical Analytical System (SAS) package, version 6.12.

RESULTS AND DISCUSSION

The ANOVA tests showed that there were significant differences between the varieties, in terms of height, basal stem diameter and biomass (Table 1). In more specific, Variety V133 outperformed the others by producing the highest mean total height and basal stem diameter of 286.60 cm and 21.87 mm respectively, in four months. All the varieties (except NS) displayed good growth in the first two months but slowed down in subsequent months. However, growth reduction intermediate and late-flowering varieties was in much less than those for early-flowering varieties (*Fig. 1*).

V133 also took longer time to initiate and achieve 50% flowering at 88 and 146 days respectively and generated more energy used mainly for its prolific vegetative growth (*Fig. 2*). Such postulation is supported by Alexopoulou *et al.* (2000) who found that the late-maturing varieties grew taller (330 cm), exhibited a higher growth rate and developed larger stem diameters (15.36mm) as compared to the early-maturing ones (height-267cm, diameter–13.3mm). The vegetative growth of all varieties continued with time. However, growth was gradually decreased at the onset plants UPM flowering growth deaudelaties with age initiated flowering of the flowering phase. According to Petrini *et al.* (1994), kenaf has an indeterminate type of growth, where grew rapidly in the beginning but gradually decreased. The trend in mean height and basal stem diameter increments of these varieties showed that (*Fig. 1*).

TABLE 1
ANOVA and Duncan's Multiple Range Test of growth of *Hibiscus cannabinus* L. varieties

Variety	Height (cm)	Basal stem diameter (mm)	Leaf dry weight (g)	Branch weight (g)	Stem weight (g)	Root weight (g)	Total dry weight(g)	Yield (t/ha)	CR
Q-Ping	244.4^{abc}	14.23^{c}	21.4^{b}	9.5^{b}	59.6^{bc}	9.9^{b}	100.3^{bc}	13.7	6
KK60	221.11^{cd}	15.30^{c}	22^{b}	8.6^{b}	52.4^{bc}	4.8^{b}	87.7^{c}	12.0	7
V19	252.6^{ab}	20.26^{a}	28^{ab}	11.3^{ab}	68.8^{abc}	13.4^{ab}	121.4^{abc}	16.6	2
V132	231.9^{bcd}	18.56^{ab}	33.9^{a}	10.9^{b}	89.1^{a}	14.3^{ab}	148.1^{a}	20.3	2
V36	239.9^{bcd}	18.89^{ab}	23.5^{b}	10.7^{b}	60.1^{bc}	10.7^{b}	105^{bc}	14.4	5
NS	229.7^{cd}	16.69^{cd}	21.6^{b}	8.8^{b}	44.6^{c}	8.4^{b}	83.4^{c}	11.4	8
V12	197.3^{d}	14.91^{d}	27^{ab}	13^{ab}	43.7^{c}	7.5^{b}	91.2^{c}	12.5	8
V133	286.6^{a}	21.87^{a}	24.7^{b}	12.4^{ab}	78.6^{ab}	11.1^{b}	126.9^{ab}	17.4	1
TK	243.5^{abc}	16.59^{bc}	33.5^{a}	16.3^{a}	56.8^{bc}	23.5^{a}	129.9^{ab}	17.8	4
ANOVA (between varieties)	*	*	*	*	*	*	*		

*significance at p ≤ 0.05, CR= Composite ranking

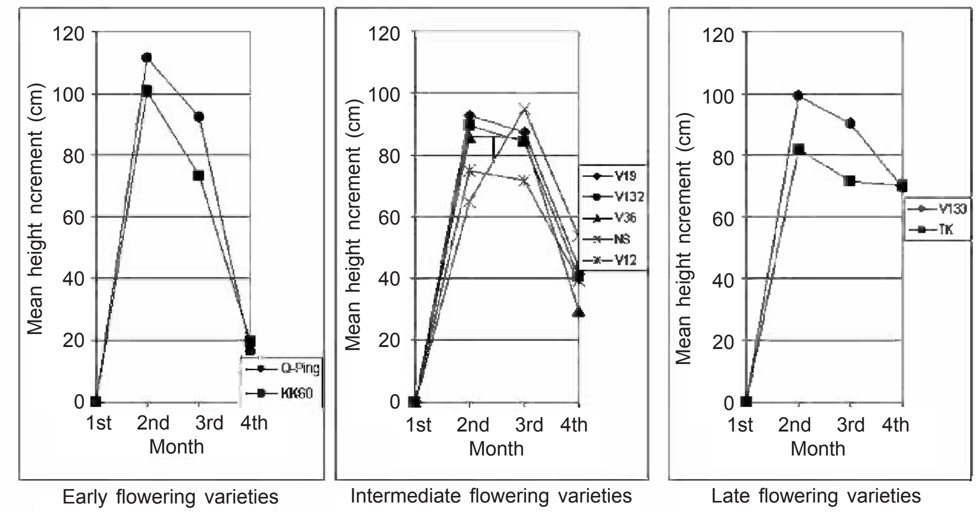


Fig. 1: The mean height increment of Hibiscus cannabinus *L. varieties over 4 months*

Concurrently, all the the early, intermediate and late-flowering varieties on average, initiated flowering within show 43-54, 66-76 and 85-101 days, respectively (Table 2). The days to flowering initiation recorded in this study were earlier than the ones by Gray *et al.* (2006) who reported that the early, intermediate and late maturing varieties took 72, 85–86 and 121–136 days, respectively.

The reduction in growth (height, basal stem diameter and biomass) was particularly marked in early-flowering variety since a subdtantrial growth portion of its energy was allocated for reproductive. In comparison, the intermediate and late-flowering varieties were shown to achieve higher growth due to the fact that they remained vegetative, one and two months longer respectively, than the early ones. This finding was supported by Dryer (1967), Petrini *et al.* (1994) and Alexopolou *et al.* (2000) who stated that flower initiation caused reduction in vegetative growth of kenaf.

Biomass and growth, as given in Table 1, were found to vary considerably according to the maturity type of the kenaf varieties. Biomass (dry matter) for these varieties ranged from 12.0 (KK60-early) to 20.3 tonnes ha^{-1} (V132-intermediate). Biomass of the early varieties gradually declined UPM flowering until the end of the reproductive period. In contrast with the early varieties, the intermediate and late ones exhibited a higher biomass. For example, V132 (an intermediate variety) was found to be the most productive in the third to the fourth month as compared to other varieties (Table 1). This is due to the fact that this variety initiated flowering in the third month. Petrini *et al.* (1994) also reported that there was a positive relationship between the productivity of kenaf and the absence of the flowering phase. Similarly, Alexopoulou *et al.* (2000) also reported that the kenaf variety produced a higher biomass before the beginning of the anthesis stage.

The ANOVA test showed significant differences between the varieties in terms of seed production. The early flowering varieties, especially Q-Ping, were found to produce the highest seed yield in terms of the number of pods/plants, weight of pods/plant, and the number of seeds/pod and weight of seeds/ plants. On the contrary, both the late- (e.g. TK) and intermediate-flowering varieties (e.g. V19) produced the lowest yields (*Fig. 3*). Moreover, the production of seeds for the intermediate- and late-flowering varieties coincided with the wet season, i.e. during September to November. These varieties were assumed to be sensitive to relative humidity and moisture, affecting the final development of seeds and reducing its production.

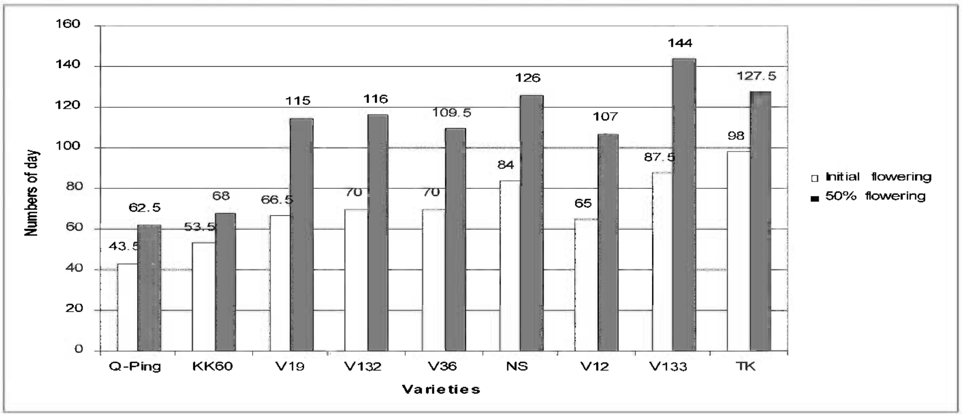
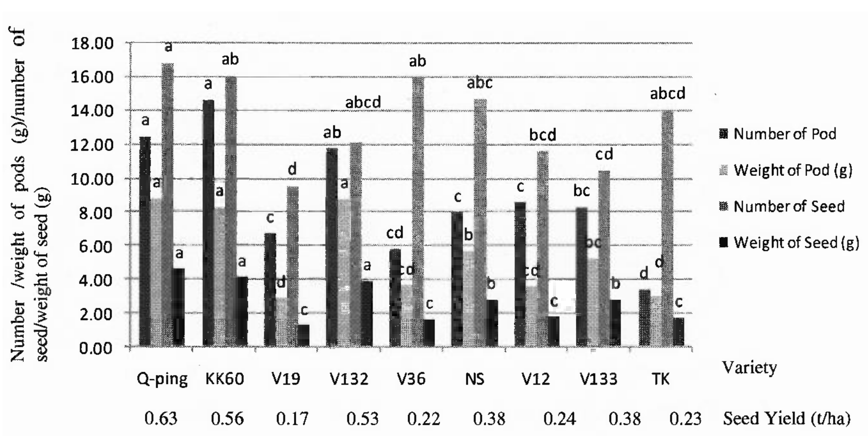


Fig. 2: The average number of days for flower initiation and 50% flowering of Hibiscus cannabinus *L. varieties*

TABLE 2
The number of days taken for flowering initiation, flowering duration and 50% flowering of kenaf varieties

Variety		Range (Days)		
		Flowering initiation	Flowering duration	50% flowering
Q-ping	Early	40-47	40-113	59-66
KK60		46-61	46-119	60-76
V19	Intermediate	64-69	64-154	98-132
V132		64-76	64-143	102-130
36		66-74	66-145	83-136
NS		75-93	75-143	113-139
V12		62-68	62-139	94-120
V133	Late	82-93	82-159	138-150
TK		88-108	105-158	106-149



Note: Pod = Capsule

Fig. 3: The mean number of pods, weight of pods, number of seeds per pods and the weight of seeds of Hibiscus cannabinus *L. varieties*

The seed yields varied from 0.17-0.63 tonnes/ha, within the range reported by Muchow (1980) who found that a late flowering variety (Guatemala-4) produced 0.49 tonnes/ha during the wet season. Its yield could however reach three times higher during dry season (1.6 tonnes/ha) under similar planting density. Furthermore, Fehr and Hadley (1980) reported that these varieties differed in their ability to withstand any excess or deficiency in moisture. Despite the confounding influence of rainfall and moisture, both number and weight of seeds varied within the same classification and showed no linear relationship within them, except for the early variety. This suggests that differences in yield could be explained in terms of availability assimilate and/or dry matter partitioning during seed filling (Muchow and Wood, 1983).

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