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Full Length Research Paper

Comparative photosynthesis and transpiration of three varieties of *Hibiscus cannabinus* L. (Kenaf)

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Kenaf (*Hibiscus cannabinus* L.) is one of the important fiber crops next to cotton which is cultivated for its core and bast fibres. For successful commercial cultivation of kenaf, we need to choose the proper variety with most growth rate and biomass content. As growth and biomass production of plant are strictly related to their physiology attribute, to meet this, we measured gas exchange characteristics of three varieties of guantemala 4 (G4), V36 and kohn kaen 6(KK60) within characteristics, we measured within four regular intervals of 30 days. The varieties showed different gas exchange pattern in each stage of their growth. However, results of study showed that, there was no significant difference between these three varieties in terms of their net photosynthesis (Anet) and transpiration rate.

Key words: Kenaf, gas exchange, net photosynthesis, transpiration.

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a short-day, annual, herbaceous plant. It belongs to the *Malvaceae*, a family which is important for both its horticultural and economic value (Dempsey, 1975). Because of its rapid growth and elevated fiber content, kenaf is considered as a new choice of natural fiber for industrial uses (Woolf, 1993). It can also be used as biomass for energy and as a substitute of non-renewable resources (Alexopoulou et al., 2005). Recently, kenaf is used for pulp and paper making (Petrini et al., 1994), oil/chemical absorbents and bioremediation, paper board products (Sellers et al., 1993), a substitute for fibreglass, filtration media making, and food and bedding material for animals (Goforth, 1994; Kugler, 1996; Sellers and Reichert, 1999).

For economic efficiency of kenaf fiber production, however, we need to have an increased level of yield production. To achieve this, it is necessary to study factors which affect the yield productivity of crop. Crop productivity and yield can be influenced by many physiological processes and environmental factors. But among them photosynthesis is the major basis for productivity and yield content of agricultural crops. It is well-known that photosynthesis contributes about 90% of total dry matter. So, plants with efficient photosynthetic mechanism could have high products biologically. The basic index of plant photosynthetic activity is net photosynthesis (Dyakow and Perestova, 1975; Eamus, 1996; Farquhar and Sharkey, 1982; Knapp et al., 1993; Redko, 1985; Schulze and Hall, 1982; Wong et al., 1985, 1979). Information relating spatial and temporal photosynthetic activity of kenaf cultivars is very scanty and has not been explored in detail.

Transpiration is the loss of water vapor from parts of plants especially in leaves but also in stems, flowers and roots. Leaf surfaces are dotted with openings called stomata, and usually in most plants, they are more frequent on the undersides of the foliage. The stoma is surrounded by guard cells that open and close the pore (Benjamin, 2007). Leaf transpiration occurs through stomata, and can be thought of as a necessary "cost" associated with the opening of the stomata to allow the diffusion of carbon dioxide gas from the air for photosynthesis. Transpiration cools plants as well and enables mass flow of mineral nutrients and water from roots to shoots. The rate of transpiration is directly related

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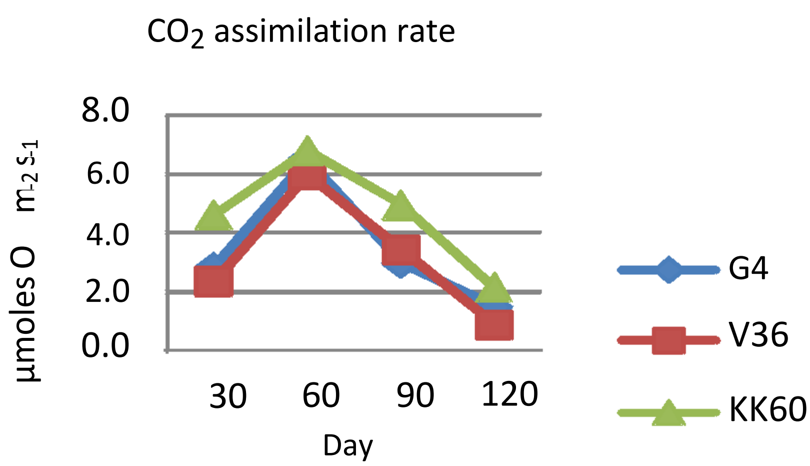

Figure 1. Means comparison of co_2 assimilation rate of three *Hibiscus cannabinus* varieties; G4, V36 and KK60.

to the degree of stomatal opening, and to the evaporative demand of the atmosphere surrounding the leaf. The amount of water lost by a plant depends on its size, along with surrounding light intensity, (Debbie and Michael, 2010) temperature, humidity, and wind speed (all of which influence evaporative demand) (Jarvis and Davies, 1998; Jones, 1998).

Knowledge on gas exchange rate and transpiration can hold the better perceptive of kenaf physiology which finally affects its growth and biomass productivity. Therefore, this study was designate to explore gas exchange characteristics of three varieties of kenaf in different stages of their growth.

MATERIALS AND METHODS

Site position

A pot experiment was conducted at greenhouse in University Putra Malaysia. The experimental site was at latitude of N 02°59', longitude E 101°43' and altitude of 64 m above the sea level. The glasshouse experiments were carried out with mean glasshouse temperatures of approximately 25°C day and 20°C night.

Plant material and green house experiment

The tree kenaf varieties namely Guatemala 4 (G4), V36 and kohn-kaen 60 (KK60) were selected as treatment variables for this experiment. Seeds were obtained from the Laboratory of Sustainable Bioresource Management, Institute of Tropical Forestry and Forest products. Seeds were sown in tray filled with peat soil on 13th January 2009. The experiment was laid out in complete randomized design. The seedlings were transferred into pots containing soils prepared by mixing sandy, clay, and peat soils in 2: 1: 1 ratio. Pots with 25 cm diameter and 20 cm height containing approximately 4 kg of mixed soil were used. Three seedlings were grown in each pot and at trifoliate stage, only one healthy seedling per pot was retained. The plant received N, P and K every two week. For insect protection the Diazinone were used as needed. Pots were watered every other day.

Gas exchange parameters

Photosynthetic gas exchange was measured at days 30, 60, 90 and 120 using a portable photosynthesis system (LI-6200, LICOR, inc. Lincoln, Nebraska USA). Measurement of gas exchange was done following the procedures described by Kubota and Hamid (1992). The fully expanded leaves on two-third above part of plants were selected randomly in each experiment. In each experiment, 10 plants of each variety were measured in the morning at 9 to 10 am as being recommended by Hiromi et al. (1999). Tree leaves of each plant were measured in each experiment giving a total of 30 measurements per variety. One single measurement per leaf and 3 leaves per variety were sampled every time. Assimilation rate (A), and transpiration rate (E), were recorded at each measurement.

Statistical analysis

For all measurements of gas exchange, on each sampling date, the observations on individual leaves per plant were averaged to calculate a single value per plant. All measurements were compared among treatments. Data on different parameters analyzed statistically and effects of developmental stage on each parameter were evaluated by analysis of variance (ANOVA) followed by multiple comparison of means, using Tukey's method. Results are expressed as means differences were assessed as significant at $P < 0.05$. Correlation coefficients (r) of parameters were calculated using Pearson correlation with SPSS 16.

RESULTS

Growing stages trends in net assimilation rate and transpiration rate for G4, V36 and KK60 are presented in Figures 1 and 2. In G4, net assimilation rate tended to increase gradually from 2.8 µmol m^{-2} s^{-1} at first month (DAY 30) to a peak of 6.5 umol m^{-2} s^{-1} on second month (day 60) and then decrease to 3 and 1.5 µmol m^{-2} s^{-1} at third and forth growth month respectively. Value of net

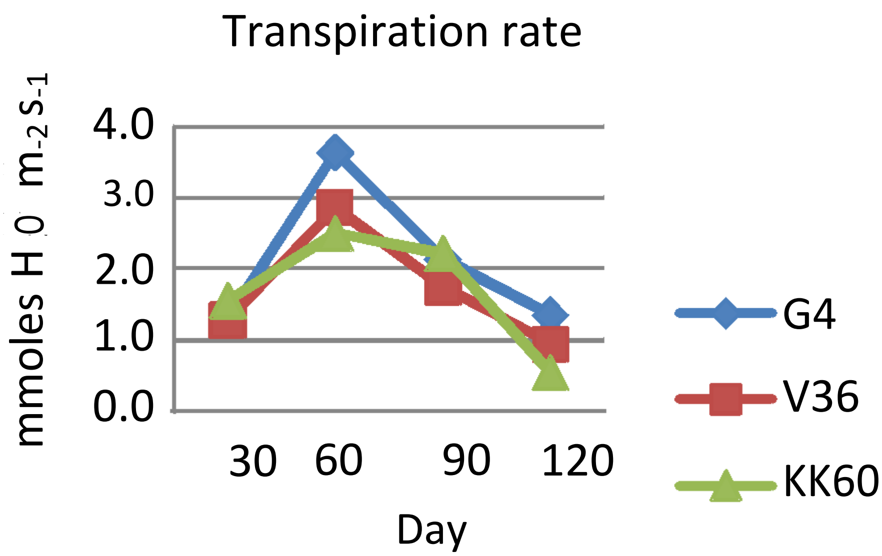

Figure 2. Means comparison of transpiration of three *Hibiscus cannabinus* varieties; G4, V36 and KK60.

Table 1. Means of physiological characteristics of 30 days old of three *Hibiscus cannabinus* varieties; G4, V36 and KK60. The *F*-statistics for ANOVA models comparing varieties differences in each characteristic are presented.

Characteristic	Varieties			ANOVA	
	G4	V36	KK60	F value	Pr>F
A	2.8 [b]	2.3 [b]	4.6 [a]	5.008	0.015
E	1.3 [a]	1.3 [a]	1.6 [a]	1.102	0.349

Letters denote significant pair wise comparisons ($P < 0.05$). Abbreviations: Assimilation rate (*A*), transpiration rate (*E*).

Table 2. Means of physiological characteristics of 60 days old three *Hibiscus cannabinus* varieties; G4, V36 and KK60. The *F*-statistics for ANOVA models comparing varieties differences in each characteristic are presented.

Characteristics	Varieties			ANOVA	
	G4	V36	KK60	F value	Pr>F
A	6.5 [a]	6.0 [a]	6.8 [a]	0.421	0.661
E	3.6 [a]	2.9 [b]	2.5 [b]	19.213	0.000

Letters denote significant pair wise comparisons ($P < 0.05$). Abbreviations: Assimilation rate (*A*), transpiration rate (*E*).

Assimilation rate is the least on last month growth of variety G4 (Figure 1). Other two varieties show different values of net assimilation rate but follow the pattern similar to that of G4 (Figure 1). At first, second, third and fourth month of growth, KK60 significantly showed the highest value of net assimilation rate which followed with variety G4 and V36 respectively.

The variation in transpiration rate followed a pattern similar to that of net assimilation rate (Figure 2). Except the first measurement which all varieties show identical transpiration rate, at other stages of growth, there was difference in the transpiration rate. G4 had highest and V36 had the lowest of transpiration rate in all stages of growth except for day 90 that KK60 showed higher transpiration rate than G4 (Tables 1, 2, 3, 4 and 5).

Results of overall means showed that although there was no significant difference between the varieties in terms of net photosynthesis (Anet), and transpiration rate (Table 6), however, it was found that KK60 has the highest value of net photosynthesis while V36 showed the lowest value net photosynthesis (Anet).G4 was assigned to have the highest transpiration rate, while the

Table 3. Means of physiological characteristics of 90 days old of three *Hibiscus cannabinus* varieties; G4, V36 and KK60. The *F*-statistics for ANOVA models comparing varieties differences in each characteristic are presented.

Characteristic	Varieties			ANOVA	
	G4	V36	KK60	F value	Pr>F
A	3.0 ^{b}	3.4 ^{b}	5.0^{a}	12.875	0.000
E	2.1 ^{a}	1.7^{b}	2.2 ^{a}	4.305	0.025

Letters denote significant pair wise comparisons ($P < 0.05$). Abbreviations: Assimilation rate (*A*), transpiration rate (*E*).

Table 4. Means of physiological characteristics of 120 days old of three *Hibiscus cannabinus* varieties; G4, V36 and KK60. The *F*-statistics for ANOVA models comparing varieties differences in each characteristic are presented.

Characteristic	Varieties			ANOVA	
	G4	V36	KK60	F value	Pr>F
A	1.50^{ab}	0.89^{b}	2.14^{a}	3.140	.061
E	1.35 ^{a}	0.94^{ab}	0.53 ^{b}	5.207	.013

Letters denote significant pair wise comparisons ($P < 0.05$). Abbreviations: Assimilation rate (*A*), transpiration rate (*E*).

Table 5. Means of overall gas exchange characteristics of three *Hibiscus cannabinus* varieties; G4, V36 and KK60. The *F*-statistics for ANOVA models comparing varieties differences in each characteristic are presented.

Characteristics	Varieties		
	G4	V36	Kk60
A	3.45 ^{a}	3.15 ^{a}	4.64 ^{a}
E	2.09 ^{a}	1.71 ^{a}	1.71 ^{a}

Letters denote significant pair wise comparisons ($P < 0.05$). Abbreviations: Assimilation rate (*A*), transpiration rate (*E*).

Table 6. Means of overall gas exchange characteristics of three *Hibiscus cannabinus* varieties; G4, V36 and KK60. The *F*-statistics for ANOVA models comparing varieties differences in each characteristic are presented.

Characteristics	Varieties		
	G4	V36	Kk60
A	3.45 ^{a}	3.15 ^{a}	4.64 ^{a}
E	2.09 ^{a}	1.71 ^{a}	1.71 ^{a}

Letters denote significant pair wise comparisons ($P < 0.05$). Abbreviations: Assimilation rate (*A*), transpiration rate (*E*).

lowest transpiration rate belonged to both of V36 and KK60 (1.71). (Table 6)

DISCUSSION

Results of this study confirmed that these three varieties have different physiologic attribute during time. Although not significant, some physiologic characteristics were highest in one variety while others were lowest in other varieties. These differences could be considered as factors influencing the outcome of their growth and productivity.

Regarding net photosynthesis (A net) as a major factor of productivity, the highest intensity of all three varieties occurred at day 60, afterwards with increasing plant age, A net gradually decrease, which sounds normal as it agrees with previous studies. The noticeable point is that the highest amount of A net belongs to KK60 in all measurements. As A net is closely related with growth and biomass content, it could be interpreted that KK60 is a more efficient variety than G4 and V36 in terms of yield and productivity.

All the three varieties show same pattern of transpiration rate. As there is scanty or, almost no clear data of gas exchange characteristics of kenaf varieties to compare, this information can be used and improved with more research on further parameters to make a better and clearer variety selection.

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