African Journal of Biotechnology Vol. 10(63), pp. 13797-13801, 17 October, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.1144
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Comparative water relation of three varieties of *Hibiscus cannabinus* L. (Kenaf)

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Accepted 18 August, 2011

Kenaf (*Hibiscus cannabinus* L.) is an industrial fiber crop that is being grown increasingly in tropical and subtropical areas. Choosing the proper variety with the most growth rate and biomass content is a critical point for successful commercial cultivation of kenaf. Since growth and biomass production of plants are strictly related to their physiology attribute, it is therefore, necessary to provide knowledge on the physiologic characteristics of kenaf varieties. This study was designated to elucidate water relation characteristics of three kenaf varieties; Guatemala 4 (G4), kohn-kaen 60 (KK60) and V36. 20 plants of each varieties were cultivated in completely randomized design under controled conditions. Throughout a period of 120 days, parameters of gas exchange characteristics were measured within four regular intervals of 30 days. The results of this study showed that varieties significantly differ in water use efficiency so that the greatest value belonged to variety KK60. It was concluded that KK60 could be considered as preferable choice of kenaf variety for cultivation.

Key words: Kenaf, gas exchange, water use efficiency.

INTRODUCTION

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

Crop productivity and yield can be influenced by many physiological processes and environmental factors. It is well known that water deficit affects every aspect of plant growth, modifying anatomy, morphology, physiology and biochemistry (Tanner and Sinclair, 1983; Hsiao, 1973;Foster, 1992; Knapp et al., 1993; Schulze and Hall, 1982; Jackson et al., 1994; Eamus, 1991). Information relating water use efficiency of kenaf cultivars is very scanty and has not been explored in detail, and knowledge on this can hold the better perceptive of kenaf physiology that finally affects its growth and biomass productivity. Therefore, this study was designated to explore water use efficiency of three varieties of kenaf in different stages of their growth.

MATERIALS AND METHODS

Site location

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 greenhouse experiments were carried out with mean greenhouse

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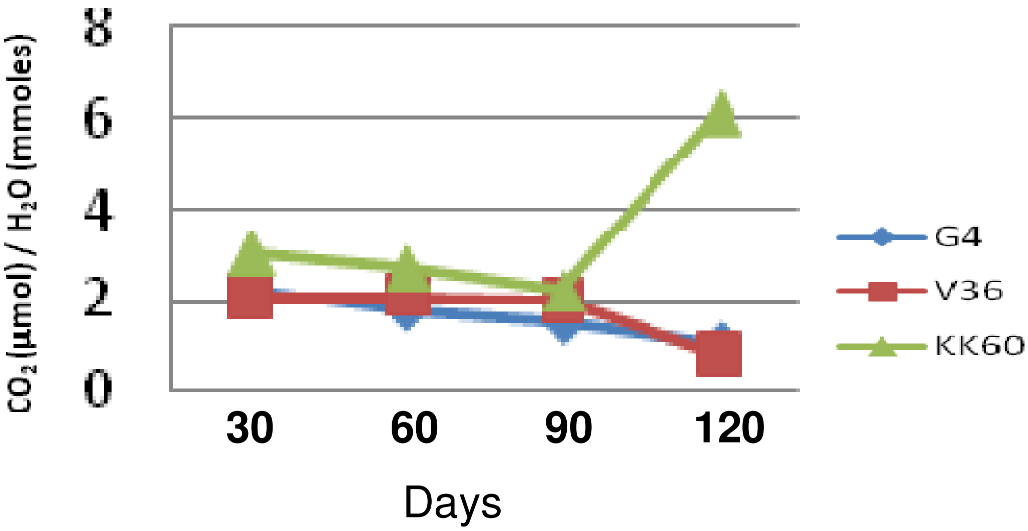

Figure 1. Means comparison of water use efficiency of three *H. cannabinus* varieties; G4, V36 and KK60.

temperatures of approximately 25 and 20°C day and night, respectively.

Plant material and green house experiment

The three 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, Serdang, Malaysia. Seeds were sown in the 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 and 20 cm diameter and height, respectively and 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 weeks. For insect protection, diazinon was 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 varieties. One single measurement per leaf and 3 leaves per varieties were sampled every time. Assimilation rate (*A*), stomatal conductance (*gs*) and transpiration rate (*E*), were recorded at each measurement. Water use efficiency (WUE), Intrinsic water use efficiency (*A*:*gs*) were also calculated. WUE was determined from the ratio of photosynthesis: transpiration, while intrinsic water use efficiency was determined from the ratio of assimilation rate to stomatal conductance.

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 were 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 were expressed as means and 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 water use efficiency and intrinsic water use efficiency for varieties G4, V36 and KK60 are presented in (Figures 1 and 2). WUE measurement in G4 and V36 showed a linear pattern with highest value at first month of growth, which gradually decrease to the last month. Decline in last month for V36 was sharper than G4. Variety KK60, however, showed the same pattern until third month when afterward its WUE sharply increased with the maximum peak in last month of measurement. This increase is obviously different to what was seen in the other two varieties.There was no significant difference between the varieties in term of WUE at day 30 (Table 1). However, KK60 showed highest value of water use efficiency in all of growth month (Tables 2 to 5). Except for the first month, it was significantly different from G4 as well.

More also, V36 significantly showed lowest intrinsic water use efficiency value than the others at day 30 and 60 (Tables 1 and 2). At day 90, however, variety G4 and at day 120 variety KK60, were highest respectively (Tables 3 and 4). At the third month of growth, all three

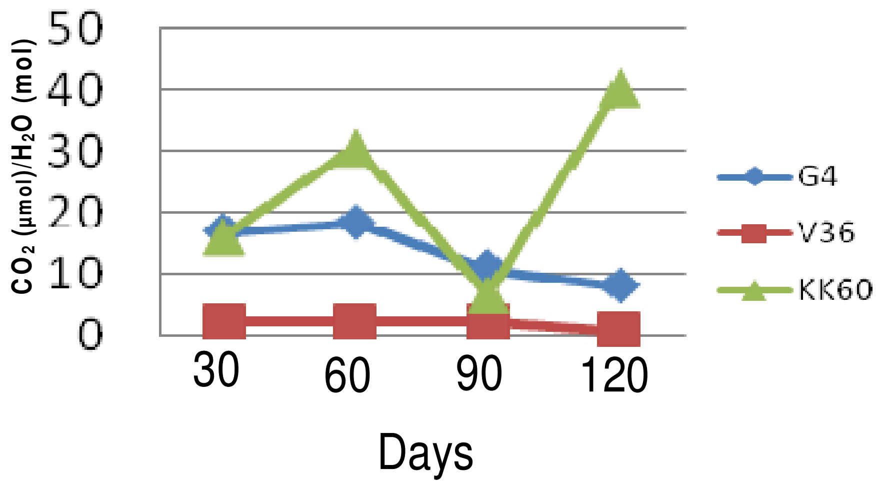

Figure 2. Means comparison of intrinsic water efficiency of three *H. cannabinus* varieties; G4, V36 and KK60.

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

Characteristic	Variety			ANOVA	
	G4	V36	KK60	F-value	Pr > F
WUE	2.25^a	2.05^a	3.06^a	1.669	0.210
A : gs	17.05^a	14.75^b	16.18^a	6.05	0.007

Letters denote significant pair wise comparisons ($P < 0.05$). WUE, Water use efficiency; *A : g*s, intrinsic water use efficiency.

Table 2. Means of physiological characteristics of three 60 days old *H. cannabinus* varieties; G4, V36 and KK60.

Characteristic	Variety			ANOVA	
	G4	V36	KK60	F-value	Pr > F
WUE	1.80^b	2.11^{ab}	2.73^a	5.403	0.012
A : gs	18.47^a	14.90^b	30.57^a	8.35	0.011

Letters denote significant pair wise comparisons ($P < 0.05$). WUE, Water use efficiency; *A : g*s, intrinsic water use efficiency.

varieties significantly showed different value of intrinsic water use efficiency so that the highest value belonged to G4, followed by V36 and KK60, respectively. At the last measurement, intrinsic water use efficiency value of KK60 was significantly greater than others (Table 5). Intrinsic water use efficiency pattern of KK60 was completely different from G4 and V36. These two latest varieties showed a linear pattern of intrinsic water use efficiency, which was high at the first month of growth and low at last measurement. However, KK60 did not follow any linear pattern. It showed a sharp increase at second month of growth in comparison to the first month, and then a sharp decline was observed in the third month that was followed with a very sharp increase at the last month of growth (Figure 2).

The mean overall results therefore showed that KK60 (3.54) had the greatest water use efficiency value, while the lowest water use efficiency belonged to G4 (1.64). These two varieties were significantly different in terms of water use efficiency. Regarding intrinsic water use efficiency, although all three varieties did not show any significant difference, however, KK60 showed the highest value, while the lowest value belonged to V36.

DISCUSSION

Results of this study confirmed that these three varieties have different water use efficiency pattern with time. These differences could be considered as factors

Table 3. Means of physiological characteristics of three 90 days old of *H. cannabinus* varieties; G4, V36 and KK60.

Characteristic	Variety			ANOVA	
	G4	V36	KK60	F-value	Pr > F
WUE	1.48[b]	2.02[ab]	2.24[a]	4.570	0.021
A : gs	10.99[a]	9.74[b]	6.71[c]	11.76	0.000

Letters denote significant pair wise comparisons ($P < 0.05$). WUE, Water use efficiency; *A : g*s, intrinsic water use efficiency.

Table 4. Means of physiological characteristics of three 120 days old of *H. cannabinus* varieties; G4, V36 and KK60.

Characteristic	Variety			ANOVA	
	G4	V36	KK60	F value	Pr > F
WUE	1.01[b]	0.83[b]	6.14[a]	7.841	.002
A : gs	8.03[b]	5.90[b]	40.36[a]	10.35	0.000

Letters denote significant pair wise comparisons ($P < 0.05$). WUE, Water use efficiency; *A : g*s, intrinsic water use efficiency.

Table 5. Means of overall gas exchange characteristics of three *H. cannabinus* varieties; G4, V36 and KK60.

Characteristic	Variety		
	G4	V36	Kk60
WUE	1.64 [a]	1.75[ab]	3.54[b]
A:gs	13.64 [a]	11.32 [a]	23.6 [a]

Letters denote significant pair wise comparisons ($P < 0.05$). WUE, Water use efficiency; *A : g*s, intrinsic water use efficiency.

influencing the outcome of their growth and productivity. KK60 is different from V36 and G4 in terms of water use efficiency, although, it follows almost same pattern of water use efficiency as seen in G4 and V36 until third measurement, after which the value sharply increases. This is inconsistent to what was seen in G4 and V36. Highest amount of water use efficiency belonged to KK60 with sharp increase in day 120. It means KK60 is more economical to grow in area with low amount of water.

There was however, no constancy of characteristic (especially intrinsic water use efficiency) of one variety during the stages of measurement. This means different stage of time has different effect on varieties. These differences could be due to particular response of varieties to intensity of light, temperature or maybe due to some stresses which arise from watering and so on. As there is very little or almost not clear data of water use efficiency of kenaf varieties to compare, these information can be used and continued with more research on further parameters to make a much clearer variety selection.

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