GAS EXCHANGE AND STOMATAL BEHAVIOUR IN KENAF (*HIBISCUS CANNABINUS* L.) AS AFFECTED BY ARTIFICIAL LIGHT INTENSITY DURING NIGHT MEASUREMENTS*

E. Riggi[1], S.L. Cosentino[2], M. Mantineo[2]

[1] CNR - ISAFOM Sez. Colture Erbacee Strategiche [2] Sezione di Scienze Agronomiche del Dipartimento di Scienze Agronomiche, Agrochimiche e delle Produzioni Animali - Università di Catania, via Valdisavoia, 5 - 95123 CATANIA, tel. ++39 95 234480, fax 234449, e-mail: cosentin@unict.it

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ABSTRACT: The high biomass yield and the elevated fibre content of Kenaf (*Hibiscus cannabinus* L.) justify the growing interest on this multipurpose crop (biomass for energy, natural fibre for industrial uses) for its potential role in agro ecosystems involving biomass production as substitute of non-renewable resources. In the framework of the study of the physiological, biological and agronomic response of Kenaf to different soil water conditions, in Mediterranean environment (Enna, 480 m a.s.l.) stomatal behaviour and leaf gas exchange during the night ware studied. Field night time measurements have been conducted using an open system IRGA on kenaf crop in vegetative stage with two different soil water content treatments (full irrigated and irrigated only at sowing).

Stomatal opening have been observed in both the treatments and increasing in stomatal conductance have been registered from the 2:00 to 5:15 am. The increasing of leaf transpiration rate during the night has been reported as well. Conversely, artificial light affected stomatal conductance only at 2:00 o'clock am, but not at 5:00 o'clock am. The relations between artificial light intensity and photosynthetic rate, for both soil water content treatments, as it was expected, were linear and positive with highly significant regression coefficients.

Keywords: Irrigation, CO_2 balance, Kenaf,

1 INTRODUCTION

In consideration of its high growth intensity and to the elevated fibre content, Kenaf (*Hibiscus cannabinus* L.) can represent a multipurpose crop (biomass for energy, natural fibre for industrial uses) potentially interesting also in terms of environmental performance related to carbon storage capacity acting as sustainable 'sink' for atmospheric carbon dioxide and as substitute of non-renewable resources[1]. Knowledge on gas exchange rate and stomatal conductance can support the better understanding of Kenaf physiology affecting its water requirements and its ability in light conversion in carbonaceous molecules influencing the biomass production and, indirectly, the carbon sequestration activity.

Few literature references report experimental results on the physiology of this crop. Nevertheless, some authors carried out field experiment observing stomatal opening during the night that can affect water requirement and leaf transpiration [2]. However the data reported could not explain the nature of this behaviour (endogenous or environment inducted). Anyway night stomatal opening observed can contribute to explain the night time evapotranspiration reported for different crop [2,3] up to 20% of total diurnal transpiration.

Within field experiment conducted in internal hilly areas of Sicily during summer 2003, night measurement of stomatal conductance and gas exchange have been carried out aiming at studying carbon dioxide assimilation capacity, leaf transpiration and stomatal conductance in relation to different environmental condition in kenaf crop. Responses to artificial light intensity of the different physiological variables adopted (stomatal conductance, leaf transpiration and carbon exchange) have been stressed as well.

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2 MATERIALS AND METHODS

Measurements on leaf gas exchange have been conducted on kenaf cv Tainung 2 on a field experiment in internal hilly areas of Sicily during summer 2003. Two different soil water contents, respectively, 100%, of Etm restoration during the whole crop cycle (I_{100}) and irrigated only at sowing treatment (I_0) were studied. A randomised block design three time replicated has been adopted.

Using the open system IRGA of the Analytical Development Com. LTD (LCA4) gas exchange at leaf level and stomatal conductance have been measured from 2:00 up to 5.15 am on the night of the 6th of September at the end of vegetative stage, on last fully expanded leaves.

The responses of stomatal conductance, leaf transpiration, and carbon exchange rate to different artificial light intensities have been measured using the Leaf Microclimate Controller of Analytical Development Com. LTD connected to the leaf chamber of IRGA open system and imposing the Photosynthetic Photon Flux Density (PPFD) at the following levels: 0, 1000, 1300, 1500, and 2000 μmoles $m^{-2}s^{-1}$ of PAR. At each step, gas measurements have been recorded with thirty seconds intervals for four minutes after achieving steady state conditions (ranging from 2 up two 5 minutes). At least, about 45 minutes have been requested to obtain a complete curve for each leaf, imposing all the adopted light levels starting from 0 up to 2000μmoles $m^{-2}s^{-1}$ of PAR.

Differences between treatments and regression slopes were evaluated by the Student's *t*-test

3 RESULTS AND DISCUSSIONS

During night measurements leaf temperatures ranged between 20.0 and 22.7°C and no dew formation have been observed during all the observation period.

3.1 Stomatal Conductance

Stomatal conductance increased during the night for all the adopted light intensity levels and for both studied treatments (fig.1). First measurements have been conducted on unirrigated treatment at 0 PPFD level at 2:00 am and substantially no stomatal conductance has been observed (0.02 moles $m^{-2}s^{-1}$). However, data registered at 3:00 am with no artificial light, shown an increase of stomatal opening and stomatal conductance equal to 0.24 moles $m^{-2}s^{-1}$.

For the irrigated treatment, in relation to the wider observation interval (ranging from 3:20 to 5:15) a relevant increase in stomatal conductance and so in stomatal opening has been observed especially for the lower PPFD levels. Respectively at 0, 1000 and 1300 μmoles $m^{-2}s^{-1}$ of PAR, increments equal to 300%, 800% and 600% have been registered, while less evident growing in stomatal conductance have been observed for the highest PAR levels (respectively 140 and 160% for 1500 and 2000 μmoles $m^{-2}s^{-1}$ of PAR).

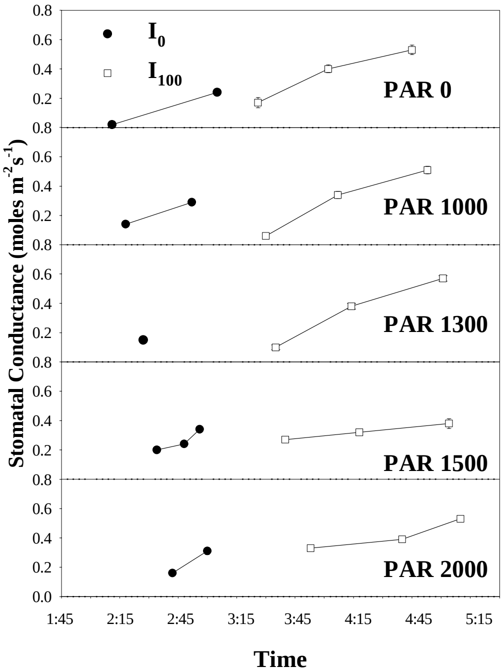

Figure 1: Stomatal Conductance in response to different artificial light intensity during night measurements for the unirrigated (●) and irrigated (□) treatment.

In order to study separately the influence of light intensity and night time on stomatal behaviour, stomatal conductance measured in the full irrigated (I_{100}) have been split in three different thirty minutes intervals respectively ranging from 3:20 to 3:50 am, from 4:00 to 4:30 am and from 4:45 to 5:15 am and plotted against light intensity (fig. 2). In this way it was possible to emphasise evident positive relation between PPFD and stomatal conductance only in the earlier interval, while after 4:00 am no response have been observed to light intensity: at 4:00-4:30 am interval stomatal conductance at all light intensity ranged between 0.3 and 0.4 moles $m^{-2}s^{-1}$ while in the last interval it ranged between 0.48 and 0.59 moles $m^{-2}s^{-1}$. Accordingly with Muchow results [2], the reported data suggest night stomatal opening incrementing during the nyctoperiod.

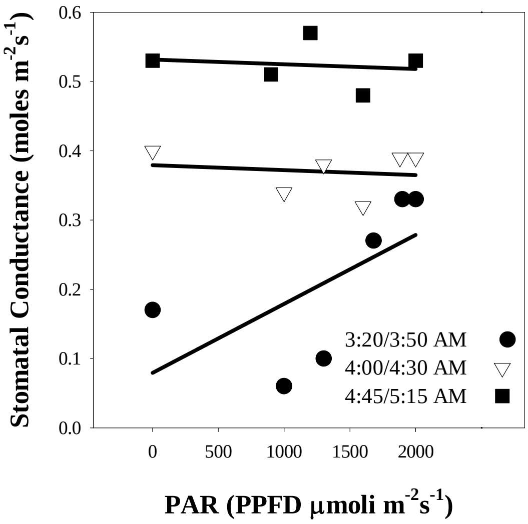

Figure 2: Stomatal Conductance during three different night periods under growing light intensity.

3.2 Leaf Transpiration

In relation to night time stomatal opening observed, leaf transpiration have been reported as well. Within each soil water content treatment, transpiration rate grown during the night and the highest values have been registered on the last measurement interval (fig. 3).

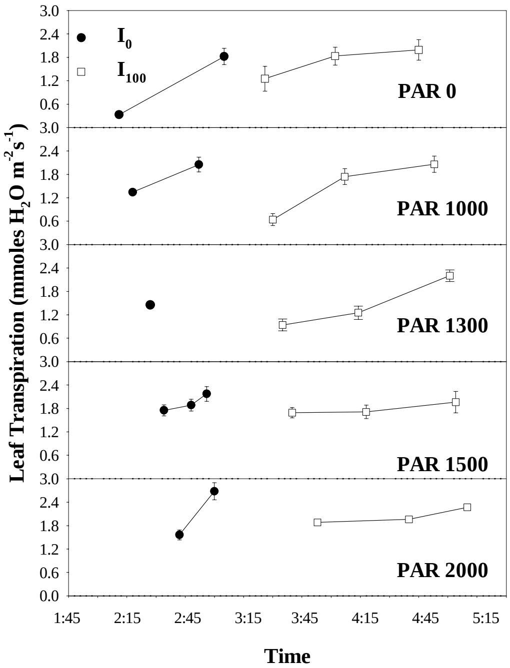

Figure 3: Leaf Transpiration in response to different artificial light intensity during night measurements for the unirrigated (●) and irrigated (□) treatment.

In natural condition, at 0 μmoles $m^{-2}s^{-1}$ PPFD level, the first value registered for I_0 treatment at 2:00 am resulted very low (0.33 mmoles H_2O $m^{-2}s^{-1}$) due to the stomatal closing observed. However, on the measurement reported one hour later (3:00 am), the transpiration rate increased up to 1.82 mmoles H_2O $m^{-2}s^{-1}$. A slighter increment has been observed for irrigated treatment as well moving from 1.25 mmoles H_2O $m^{-2}s^{-1}$ reported at 3:20 am to 1.99 mmoles H_2O $m^{-2}s^{-1}$ registered at 4:45am.

Under all the artificial light levels studied, unexpected high leaf transpiration rates have been observed in the unirrigated treatment, and for the latest data collected within each treatment (irrigation treatment and PAR levels) no statistical differences have been reported.

3.3 Net Photosynthesis

Negative values observed at 0 μmoles $m^{-2}s^{-1}$ PPFD levels for both soil water content treatment, evidenced respiration activity (fig.4).

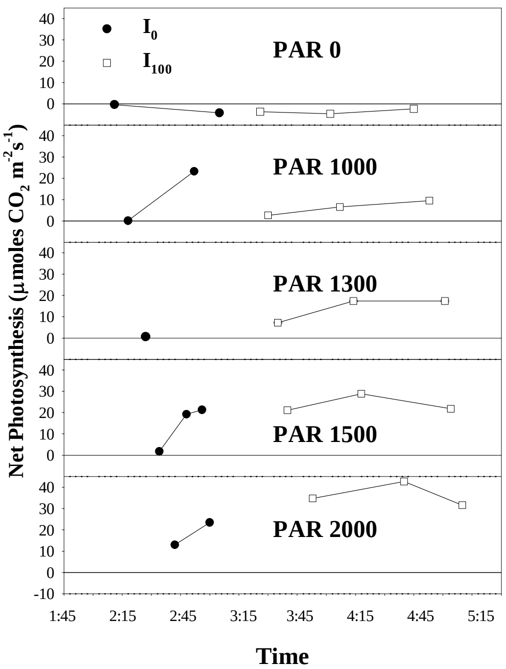

Figure 4: Net Photosynthesis in response to different artificial light intensity during night measurements for the unirrigated (●) and irrigated (□) treatment.

Within I_0 treatment the highest value and so the lowest respiratory activity (-0.38 μmoles CO_2 $m^{-2}s^{-1}$) has been observed in the first measurement (2:00 am) with closed stomata, while at 3:00 am respiration grown up to -4.3 μmoles CO_2 $m^{-2}s^{-1}$. For the fully irrigated treatment values reported in the three different measurement intervals ranged between -2.39 and 4.73 μmoles CO_2 $m^{-2}s^{-1}$ reported respectively at 4:45 and 4:00 am. However no statistical differences have been observed between data reported in the three intervals

Within each level of artificial light conditions, different behaviour has been observed for the two irrigation treatments: while for I_0 thesis statistical differences have been always reported between the first and the last measurement (respectively 0.02 and 23.27 μmoles CO_2 $m^{-2}s^{-1}$at 1000 μmoles $m^{-2}s^{-1}$ of PAR, 1.68 and 21.22 μmoles CO_2 $m^{-2}s^{-1}$at 1500 μmoles $m^{-2}s^{-1}$ of PAR and 12.98 and 23.4 μmoles CO_2 $m^{-2}s^{-1}$at 2000 μmoles $m^{-2}s^{-1}$ of PAR), no difference have been observed in net photosynthetic rate data reported for I_{100} treatment, within the different PPFD levels.

Aiming at studying relation between artificial light intensity and photosynthetic rate, for both soil water content treatments net photosynthesis data were plotted against PAR levels and linear regression curves have been fitted (fig. 5)

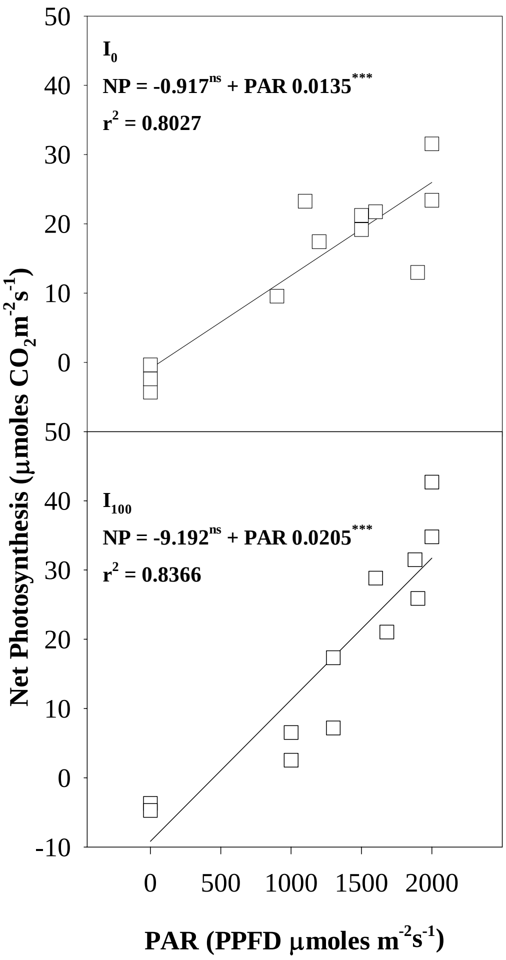

Figure 5: Net Photosynthesis in relation to PAR for the unirrigated (●) and irrigated (□) treatment.

As it was expected, positive relation have been obtained for both adopted treatments with highly significant regression coefficients equal to 0.0135 and 0.0205 μmoles CO_2 $m^{-2}s^{-1}$ for each μmoles $m^{-2}s^{-1}$ of PPFD respectively in I_0 and I_{100} treatment.

Anyway, the kind of relation obtained in artificial light conditions, seems to differ from the exponential curves observed in day natural light conditions usually reported in literature for other crops and obtained in the same field trial during day time measurements [4].

4 CONCLUSIONS

The observed nocturnal stomatal conductance and transpiration rate determine water looses also during the night probably affecting the water requirement of the crop.

The observed relation between night time and stomatal opening for both soil water content treatments, not influenced by artificial light intensity, seems to suggest an endogenous control of stomatal behaviour. However more data are needed aiming at verifying the real nature of the observed phenomena.

Relating to assimilation activity, measurement of respiratory rate can help in improving carbon exchange balance at leaf level for gross photosynthesis evaluation as well.

The observed linear relation between net photosynthesis and PAR level in artificial light conditions, contrasting with other data reported in day time measurements [4] need to be more stressed in future experiments.

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