CROP DIFFERENT SENSIBILITY TO PHOTOSYNTESIS QUANTUM EFFICIENCIES FROM FAST CHLOROPHYLL *a* FLUORESCENCE IN KENAF

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ABSTRACT: Increasing leaf photosynthetic rates seems to be a strait-forward way of increasing crop yield [1]. Fluorescents measurements can be useful to check out differences in kenaf crop. JIP-test method can control the stress in experimental kenaf field trials in comparison with real kenaf yield crop development. The parameters developed [2] can be analyzed in random field blocks checking out the ones as dependent variables who better represents the field treatments studied in each case. Kenaf (Hibiscus cannabinus L.) [4] is an annual plant that can be useful as a source of low cost natural fibre. It is a fast-growing plant, and can be used in the industry for a wide range of products, especially for his fibre content useful for the paper production industry. To the farming point of view this crop can be also seen as a useful alternative to the irrigated summer crops in our zone. However, there are few data about the plant kenaf agronomy during the last decade for our continental climate in relation with their biomass plant production. Anova and Discriminant analysis was done in about 42 JIP-test variables and ratios between variables.
Key words: agriculture, biomass production, biomass resources

1 INTRODUCTION

The JIP-test provides adequate information about the behavior (structure, conformation and function) of the photosynthetic apparatus being affected at different field conditions: irrigation (feed and tunnel without irrigation) plant density varieties and sowing date as physiological different states affecting PSII system, in quantum efficiencies and fluxes. Kenaf (Hibiscus cannabinus L.) [5]is a C_4 plant and can be expect to have better use efficiency crop in water consumption. Kenaf can be also a good alternative crop for our region in Central-Plateau, Madrid (Spain) during summer having the optimum crop yield at high temperatures ~30ºC [4]

2 MATERIAL AND METHODS

2.1 Location and design

The field study was carried out on a sandy clay loam soil (Calcic Haploxeralfs) at the experimental farm "La Canaleja" from INIA (Alcalá de Henares, Madrid) in order to determine the appropriate effect of the following treatments on the trial field crops: water stress & varieties, plant density, and sowing date. Being the following 3 varieties: Everglades-41, Salvador, Tainung-2; Sowing date: 30 of May, 14 of June; Plant density: 200.000 pl/ha, 400.000 pl/ha; Water stress: rain tunnel versus full irrigated= 100% potential evapotranspiration (PET) along the 3 varieties. The rest of standards for the field lay-outs, plant density and sowing date are: variety, sowing date and plant density: (Tainung-2), (30_May), (200.000 pl/ha).[7] [8]

Fluorescents signals from [6] Kenaf crop were measured on top mature leave plants during summer of 2004 in a 3 randomize block design as row field trials in each of the treatments studied. All plots were kept well-watered until 7 days after sowing (DAS) to ensure good crop establishment.[9] [10]

2.2 Chl *"a"* fluorescence transients measurements.

Measurements at ambient temperature were done on leaf by a fluorimeter (Plant Efficiency Analyser, Hansatech Instruments, King's Lynn, Norfolk (UK), and (Handy_PEA). During measurement, the sample is shielded from the dark adapted state (30 min dark adaptation imposed by a clip system) and illuminated with 660 nm light from LED's source built into the fluorimeter sensor. Continuous light excitation (at 3000 µmol/m2s) was provided by an array of six light-emitting diodes focused on the leaf surface to provide homogeneous irradiation over a 4 mm diameter leaf surface. [2]

The rapid switch of the LED's light allows data sampling at very high resolution: 40 fast fluorescence transients were recorded *in situ* on the leaf crown of the Kenaf plants to characterise their vitality under each field studied conditions.

Fluorescence levels at 50 µs, 100 µs, 300 µs, 2ms and 30 ms were used to calculate the JIP test parameters (Strasser et al., 2000). The software *Biolyser*, developed in the Laboratory of Bioenergetics, University of Geneva, http://www.unige.ch/ is used for loading the full fluorescence transients, calculating the JIP parameters.
Some of the used different yields of absorbed energy and specific fluxes at time zero can be derived according to the JIP-test [3] as follows:

$$TR_0/ABS = \phi_{Po} = (1 - F_0)/F_M = F_V/F_M; \quad ET_0/TR_0 = \psi_o = 1 - V_J; \text{ Where: } V_J = (F_{2ms} - F_0)/ (F_M - F_0)$$

$$TR_0/RC = M_0.(1/V_J); \quad ABS/RC = M_0(1/V_J).(1/\phi_{Po});$$

$$ET_0/ABS = \phi_{Eo} = \phi_{Po} . \psi_o; \quad M_0 = (dV/dt)_0 = 4. (F_{300\mu s} - F_0) / (F - F_0)$$

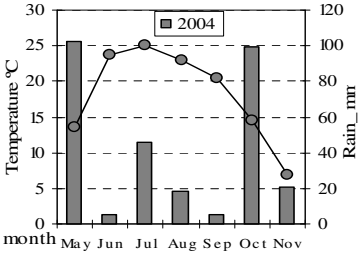

Figure 1: Rain and mean temperatures growing period Rain and mean over cycle growing temperatures are showing in Figure 1.

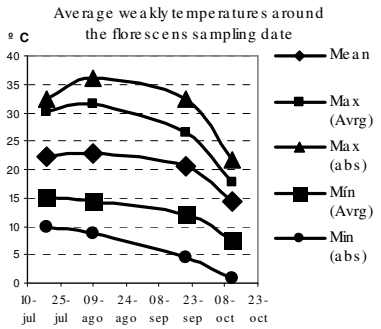

Figure 2: Average weakly temperatures round the florescens sampling date

Two measures per plant and 3 plants per block were made in each of the designed randomize blocks.

The dependant variables:(DV) measured by Handy_PEA on kenaf field, JIP-tests were: Sum K, Kn, Kp, ABS_RC, Tro_RC, ETo/RC, Dio_RC, RC_CSo, ABS_CSo, Tro_CSo, Eto_CSo, Dio_CSo, RC_CSm, ABS_CSm, Tro_CSm, Eto_CSm, Dio_CSm, SFIabs, PHIo_I_PHIo, PSIo_I_PSIo, PIabs, PIcso, PIcsm, D.F, sampled at the following growth period dates: 19 July, 09 Aug, 30 Aug, 20 Sep, 11 Oct. by the different treatments: Water stress/full irrigation; plant density (200.000 pl/ha)/(400.000pl/ha); Sowing date: 30 May/14 June.

3 RESULTS

3.1 Rank temperatures.

Figure 2: Shows adequate rang of temperatures for kenaf early mourning sampling because the kenaf better growing range is: 25<tºC<33 and Max (abs) round 37ºC. Sampling florescens was done to the local clock hours between (8-12h).

3.2 Varieties & Water Stress & Growth period lay-out.

The Table I shows the Multivariate ANOVA who includes 3 treatments: (varieties & water stress): the total watering the regular plot was 743 l/m^2 against the stressed varieties who ware sowed under the rain-tunnel all the growing period. The ANOVA with the factors analyzed is in Table II

Table I: Anova: Varieties & Water stress & Growth period. λ W= lambda of Wilks

Effect	Statistic tests	Val	F	Err d.f.	Sig.
Groth_	Trace of Pillai	3,4	10,9	232,0	,00
	λ W	,00	15,7	221,4	,00
Treatm	Trace of Pillai	2,4	2,76	232,0	,00
	λ W	,01	4,02	221,4	,00
Variet	Trace of Pillai	1,2	2,70	112,0	,00
	λ W	,14	2,77	110,0	,00
Groth_ *Treat	Trace of Pillai	6,3	1,74	952,0	,00
	λ W	,00	2,45	760,2	0,00
Groth *Varie	Trace ofPillai	3,6	1,64	496,0	0,00
	λ W	,00	1,80	444,7	0,00
Treatm *Vari	Trace ofPillai	3,6	1,65	496,0	0,04
	λ W	,00	1,74	444,7	0,04
Groth *treat* Varie	Trace of Pillai	8,9	1,24	2187	0,43
	λ W	,00	1,39	1284	0,43

The Table II shows post hoc tests which test the difference between each pair of means of varieties. We see the dependant variables implicated are different significantly at 0,05% level: Area and Sm. In fact this two are functional related by: Sm = Area/F_m-F_0. The energy necessary to close all the reactions centers.

Table II : Varieties, Multiple Comparitions (Tamhane)

Depend. Variable	(I) Var.	(J) Var.	Mean diff. (I-J)	Stad. Error	Sig %95
Area	Tain.	Everg41	-4549*	231,4	0,02
		Salvador	-1219*	228,1	0,04
Sm	Tain.	Everg41	-4,195*	1,243	,001
		Salvador	-3,353*	1,225	,005

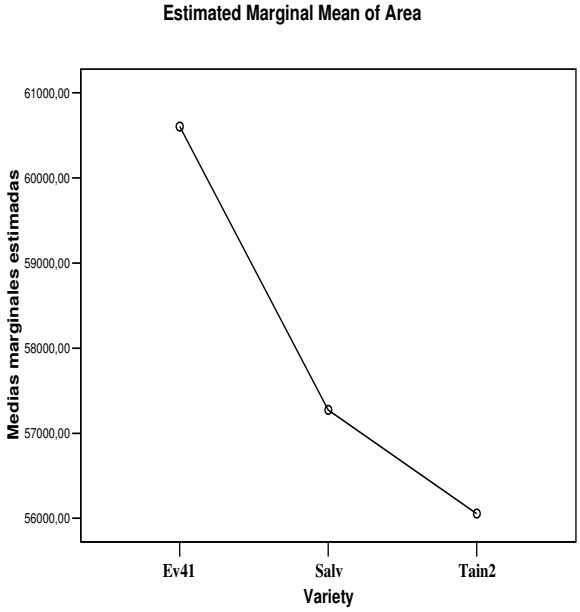

Figure 3: Estimated marginal mean (EMM). (DV): Area=Energy needed to close all the reaction centers

Comparing the results showed in Figure 3 and Figure 4 with the yielding of varieties collected as stem biomass in Figure 5 they are congruent with the range obtain here by florescens data and calculations of Area and S_m . Being the both Area and S_m significantly at 0,05% in the Table II Varieties, Multiple Comparison (Tamhane)

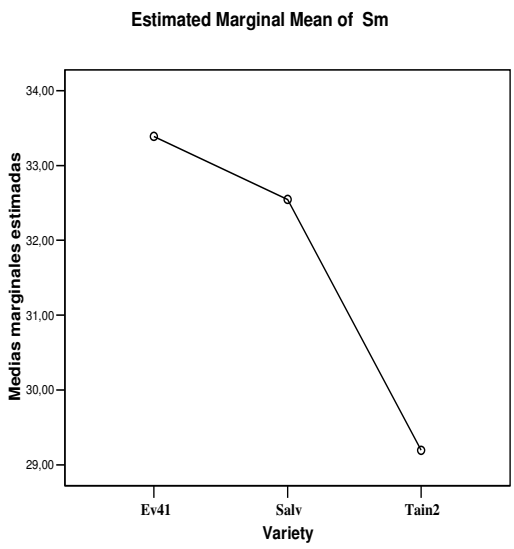

Figure 4 (EMM) (DV): S_m =Energy needed to close all the reaction centers(RC's) normalized by (F_m-F_0)

Data from the varieties experimental field was join with the one of the rain tunnel with the same 3 varieties.

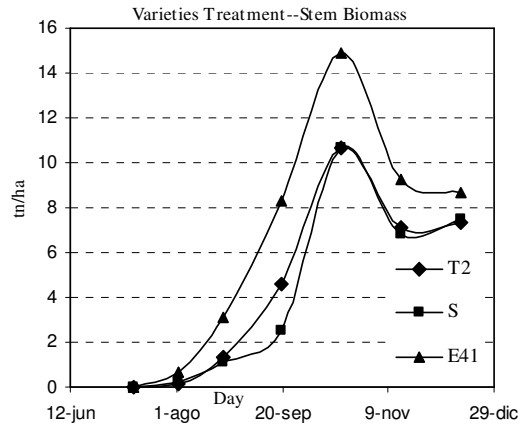

Figure 5 Varieties; Stem Biomass

Table II displays two multivariate tests of significance of the treatments in the model. We found that the growth period, stress treatments and varieties are statistical different under this JIP-test variables studied.

Lambda, of Wilks (λ W) ranges between 0 and 1, with values close to 0 indicating the group means are different so treatments inside the ANOVA: Water Stress (plenty Irrigation 100% PET and rain tunnel), varieties: (Everglades 41, Salvador and Tainung2) and growing period: (19 July, 09 Aug, 30 Aug, 20 Sep, 11 Oct) react with marginal means that they are statistically different to the florescens signals and derived JIP-tests dependent variables calculated.

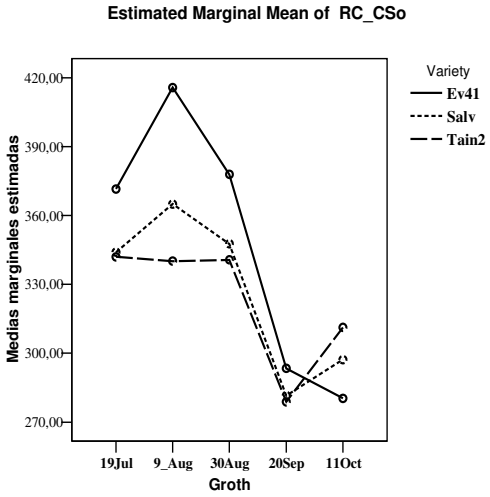

Figure 6 (EMM) (DV): RC_CSo= Density of (RC's)

The density of the reaction centers in the interaction between growth period and varieties are showed in Figure 6. The estimated marginal means of dependent variable (DV) = RC_CSo at the cell combinations of Growth period and Varieties shows certain parallelism until 20 Sep. of the growth period and after that is lost. The meaning of the parallelism lack is the interaction between the Growth and Varieties treatments.

3.3. Checking the process by Discriminant Analysis

The ANOVA process before done to the JIP-test dependant variables (DV) can be controlled by discriminant analysis. The couples of mean marginal estimated to be significantly different in the ANOVA analysis Table II now are the retained variables by in Discriminant Analysis.

Used to modelice the value of a dependent categorical variable based on its relationship to one or more predictors. This Table III displays the 4 discriminant functions and there JIP-test predictors, the variables entered or removed at each step also are: Area & S_m from Table II. The estimate of the classification function for group I = -,006. Tmax+ 2,09.Vi+ 0,18619. S_m +…..

Then we can modelice the equation for belonging an JIP-test characterized individual to a determinate centroide.

Table III Discriminant analysis, classification function coefficients. Growth: grouping variable. Both variables Area and S_m appears.

JIP-test	C. Discriminant Función			
	1	2	3	4
Tmax	-,006	-,004	,003	-,001
Area	,000	,00	,00	,000
Vi	2,09	19,43	-6,96	2,49
S_m	,186	,030	-,064	,027
Kp	-1,40	,645	,485	-4,48
Tro_RC	-,234	-3,08	6,02	,863
RC_CSm	,003	-,002	,004	,000
PIcso	,000	,00	,000	,000
(Const.)	-2,41	-8,56	-7,86	-1,16

Using the coefficients (1) & (2) and the JIP-test values from Table III can be one individual plotted in the plane represented in Figure 7

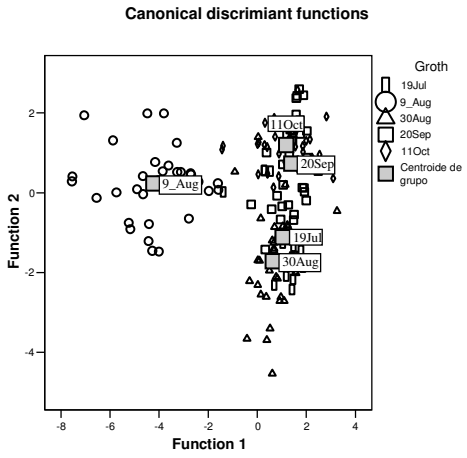

Figure 7 : Canonical representation of the kenaf plants on the canonical axes I and II by the gruping variable growth with group centroids.

4 ACKNOWLEDGMENT

This research was supported by UE (BIOKENAF QLK5-CT2002-01729)

5 DISCUSSION

Field stem biomass were recorded on 3 kenaf varieties during the summer of 2004. The growing period was under water stress rain tunnel. The pattern showed by the experimental field data were agree with some of the florescens JIP-test dependant variables studied. That is showed in Figure 5 in relation with Figures 3 – 4 and Figure 6.

The analysis done by ANOVA using [10] SPSS package announced who dependant variables of the JIP-test represent our lay-out design in the field under the variety treatments as factor. The dependant variables extracted by ANOVA analysis were: AREA and S_M in association with other variables: Tmax Tmax Kp Tro_RC RC_CSm PIcso. Definitely discriminant analysis [11]can also asses the relevance of the presence of: AREA and S_m like is showed in Table III. Interesting plotted period is 9-Jun sampling date period with the highest canonical variable coordinates on the canonical: axis 1, axis 2.

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