

THE STUDY OF PHOTOSYSTEM II EFFICIENCY ON SELECTED SYNANTHROPIC PLANT SPECIES

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Abstract

Chlorophyll fluorescence represents an indicator of the energy conversion in the photosynthesis process, offering information regarding the PS II efficiency. This determining method is rapid, precise, and inexpensive. The experiments have been realized with six synanthropic plants species: *Polygonum aviculare*, *Conyza canadensis*, *Erigeron annuus*, *Lactuca serriola*, *Cichorium intybus*, *Echinochloa crus-galli*, dominant species on the wastelands around the cities of Pitesti, Mioveni and Maracineni. Chlorophyll fluorescence values were obtained in 2008, using an OS 30 (Opti-Sciences) chlorophyll fluorometer and in 2009 with FP 100 hand-held fluorometer, OJIP test (Photon Systems Instruments) by placing leaves in dark (15 minutes). The following indicators were determined: F_0 , F_m , F_v/F_m , F_t . The PS II efficiency in the dark environment (F_v/F_m) registered higher values during the cited period in the cities of Pitesti and Mioveni at the species *Polygonum aviculare* and *Cichorium intybus*, which are better adapted to the urban climatic factors (light, temperature, water etc.) The F_v/F_m ratio had maximum values during the month of September 2008 for all six researched species. The PS II efficiency recording the highest values in Maracineni, soil conditions (0,797). The PS II efficiency has been correlated with the main environmental factors affecting the photosynthesis process among which an important role was played by mean soil temperature (r partial = -0.077*) and rainfall deficit (r partial = -0.060*).

Keywords: F_v/F_m , PS II efficiency, OJIP test, ambient stress

1. INTRODUCTION

Chlorophyll fluorescence is an indicator of the energy conversion in the photosynthesis process and it can be determined using a relatively new technology [2,5] through which the results can be obtained in the field. Chlorophyll fluorescence is part of the physiological measurements category which quantifies the photosystem II (PS II) light absorption efficiency. Functioning of photosystem II (PSII) is the most sensitive indicator of environmental stress in plants [7]. Changes in PSII activity can be assayed rapidly and non-destructively by measurement of chlorophyll fluorescence.

2. MATERIALS AND METHOD

The experiments were executed on six synanthropic plants species: *Cichorium intybus* L., *Conyza canadensis* (L.) Cronq., *Erigeron annuus* L. (Pers.), *Lactuca serriola* Torn., *Polygonum aviculare* L. and *Echinochloa crusgalli* (L.) Beauv, on three locations: Pitesti, Mioveni and Maracineni.

The fluorescence measurements were done during the months of July, August and September 2008 using an OS-30 (Opti-Sciences) fluorometer with the following settings: two seconds for the action time of the light spot and 2000 micromole/m²/s for the source intensity. The subjected leaf of the experiment were dark adapted for a minimum of 15 minutes in order to determine the F_v/F_m ratio. With the help of the fluorometer the following leaf indicators were determined: F_0 - minimum fluorescence, (while the collecting antennas were opened for the receiving of light quantum – the leaf being adapted to dark conditions); F_m - maximum fluorescence registered after exposure to the exciting source while the collecting antennas were saturated with light and closed; F_v/F_m - the fluorescence amplitude variation and maximum fluorescence ratio (maximum photochemical yield of PS II). This is an indicator of maximum efficiency of exciting energy transfer and is calculated with the following formula: $F_v/F_m = (F_m - F_0)/F_m$. F_t – in-time fluorescence, measured in field, at

the time of the experiment.

For this six species, in July and August 2009, the Chlorophyll Fluorescence Induction Kinetics (OJIP) and Non-photochemical Quenching (NPQ) tests were also conducted. The two tests were conducted using the the FluorPen FP 100. The OJIP test permitted to computing of the 25 indicators. All measurements and tests were conducted in the field; the temperature and humidity were recorded using a digital datalogger (Mannix DL8829).

The polifactorial experience variance analysis was the statistical method applied for processing the experimental data. The Duncan test (for the confidence level of $\alpha=0.05$) was used for establishing the statistic significance and the partial correlation coefficients were used to establish the significance of the correlative dependence.

3. RESULTS AND DISCUSSIONS

The 1038 values of the sample represent the total number of experimental values of the indicators F_o , F_m , F_v/F_m și F_t . The average value of the simple for F_v/F_m was 0.744, meaning that it was very close to the maximum value for F_v/F_m (0.80-0.83) and it indicates an optimal parameter functioning of the reaction centers of PS II. Besides average for determining the central tendency was also calculated the median (the value of an ordered statistical series which divides the series into two parts) which has the value of 0.770 and the mode (the value with the highest frequency) which has the value of 0.796.

The variation of the maximum amplitude was 0.770 (the minimum was 0.225 and the maximum was 0.995). The standard deviation was 0.132 and the variation coefficient 17.8%. The skewness coefficient had a value of 1.263 which indicates a left asymmetry (with the dominating values higher than the average) and, at the same time, with a longer tail to the left (with more distant and smaller values). The kurtosis coefficient (the excess) had a value of 1.516, which means that the distribution is leptokurtic (excess of numbers near the average and far from it, with empty distribution flanks).

The average is representative for the sample only if homogeneity is accepted. The normality was tested using the Shapiro-Wilk test. The W indicator was 0.897, a value which led to the acceptance of normality.

The histogram associated reveals the frequency distribution of the F_v/F_m values by class ($0,2/8 = 0,025$) (figura 1).

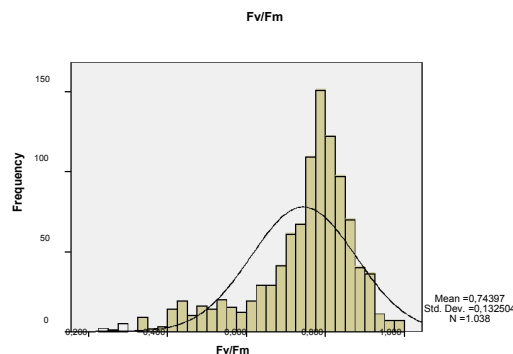


Figure 1. Frequency distribution of the F_v/F_m values by class

Table nr. 1 shows the correlation between the chlorophyll fluorescence indicators. We observe the existence of a significantly negative correlation between F_v/F_m and the other indicators (F_o , F_m and F_t). In all cases the significance threshold is $p < 0.01$.

Table 1. The Correlation Matrix of the Chlorophyll fluorescence Indicators (Pearson Coefficient)

Fluorescence indicators	F_o	F_m	F_v/F_m	F_t
F_o	1	0.748(**)	-0.757(**)	0.704(**)
F_m	0.748(**)	1	-0.234(**)	0.948(**)
F_v/F_m	-0.757(**)	-0.234(**)	1	-0.202(**)
F_t	0.704(**)	0.948(**)	-0.202(**)	1

** The correlation is significant at $P < 0.01$

The results graphically presented in the below charts show that the photo-system II efficiency is determined in the dark environment (F_v/F_m) by the experimental factors. Analyzing figure 2 which shows the chlorophyll fluorescence variation F_v/F_m by species on constant levels for the month during which the experiment was conducted, we notice the existence of three homogenous groups – the best results showing the *C. intybus* and *P. aviculare*, which were homogeneous amongst themselves while the *E. crus-galli* presented a weaker activity at the PS

II level. During the month of July 2008 the F_v/F_m values recorded for *C. canadensis* were the highest together with those of *C. intybus* and *P. aviculare*. During the month of August 2008 no significant differences were recorded among the species which had a homogenous behavior; this translated into a significant departure from the average tendency (due to a strong interaction between the species influence on the fluorescence and the determination time). During the month of September 2008, although the species showed a rising value for the F_v/F_m for *E. annuus* and a drop in the values recorded for *C. canadensis* and *P. aviculare*, those values followed the general average tendency of the F_v/F_m factors.

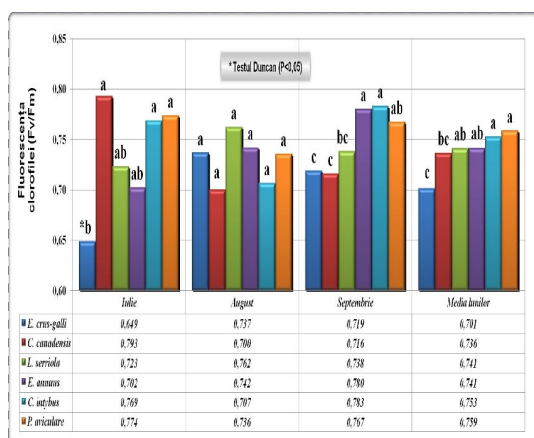


Figure 2. Chlorophyll fluorescence (F_v/F_m) variance by species on constant levels for the recorded months

Analyzing figure 3 which reveals the chlorophyll fluorescence variation F_v/F_m by species, on constant levels at the locations in which the experiments were conducted, we realize the existence of two homogenous classes the best interacting *C. intybus* and *P. aviculare* which are homogenous amongst themselves while *E. crus-galli* had the smallest F_v/F_m value.

We also observe that on the locations in Pitesti and Mioveni the species effect on F_v/F_m was amplified while in Maracineni the influence was diminished (except for the *C. intybus*).

In Pitesti were recorded higher F_v/F_m values for *E. annuus* (0.756), at Mioveni for *C. canadensis* (0.762), and at Maracineni, for *E. crus-galli* (0.766) with lower values than the average tendency for *C. canadensis* (0.688).

Analyzing figure 4 (which shows the chlorophyll fluorescence F_v/F_m based on the recorded month and on constant levels of species) we observe that the photo-system II had maximum values during the month of September 2008 – significantly different from the values recorded during the months of July and August 2008. Higher F_v/F_m values were recorded for *C. intybus* and *C. canadensis* in July, for *E. annuus* and *E. crus-galli* in August and for *L. serriola* and *P. aviculare* during the months of July and August 2008.

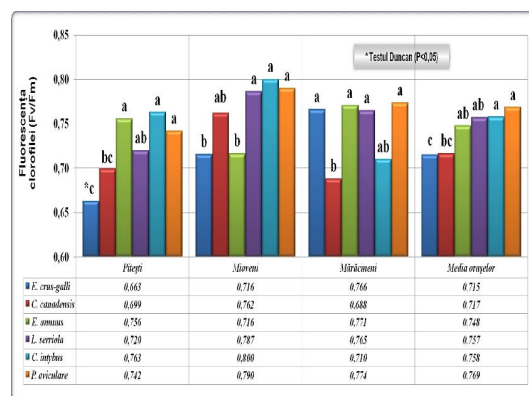


Figure 3. Chlorophyll fluorescence (F_v/F_m) variance by species on constant levels at the recorded locations

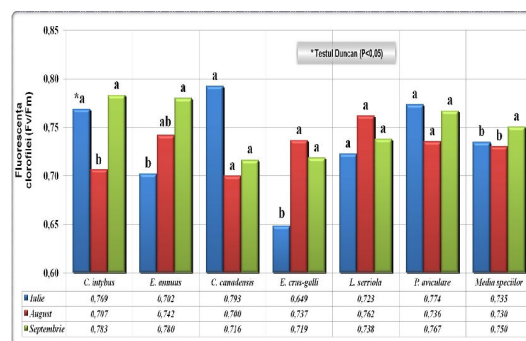


Figure 4. Chlorophyll fluorescence (F_v/F_m) variance by recorded month and on constant species levels For *C. canadensis*, *L. serriola* and *P. aviculare*, the month during which the F_v/F_m experiment was conducted is not significant Generally, for the period during which the tests were conducted (July, August, and September 2008) the F_v/F_m values were between 0.730 and 0.750. The fluorescence parameters are sensitive to the environmental stress factors.

According to the data from literature it was demonstrated that the fluorescence is influenced by the plant's water supply [3], mineral nutrition [6], frost [1] and light intensity [4, 8].

The PS II efficiency must be correlated with the main environmental factors which influence the photosynthesis process. We presented the results obtained following the calculation of the correlation coefficients between the efficiency of the FS II in dark conditions (Fv/Fm) and the main meteorological factors for 2008. We concluded that the Fv/Fm ratio oscillation from 0.025 and 0.995 was determined (on the average of the six analyzed species) significantly negative by average temperature of the soil surface (with values between 11.6° – 32°C; r partial = -0.077*) and by the water deficit ET_0-PM –rainfall expressed in mm/previous decade of the measurements, with values between -45.7 and 49.2 mm; r partial = -0.060*). This means that the higher the soil temperature and the water deficit was, the smaller was the productive potential of the photochemical maxim of the PS II. For the six species from the experiment the meteorological factors were classified downward in importance of their influence over the Fv/Fm as follows: first was (based on the frequency of influence) the recorded evaporation with the instrument Bac class A (0.9 – 7.2 mm/day) – three species had negative correlations; second was the average temperature on the soil surface (11.6 – 32°C) – two species had negative correlations; third was the water deficit with negative influence and last was the minimal air humidity and the maximum amplitude of air temperature with inconsistent, positive and negative, influence.

In 2009, analyzing chlorophyll fluorescence indicators of leafs adapted to dark conditions the following were observed:

- by analyzing figure 5, which introduces the PS II efficiency variance by the environment in which the experiment was conducted, on constant species levels we observed the existence of four homogenous classes for the values F_v/F_m , the PS II

efficiency recording the highest values in Maracineni, soil conditions, (0,797). Generally, the average tendency was kept for *C. intybus* and for *L. serriola* at which the asphalt's positive effect was accentuated, regardless of the location, over the Fv/Fm. For *E. annuus* the differences between species, with respect to the anthropic's environment influence of the PS II efficiency, (Fv/Fm), have vanished. In the case of *C. canadensis*, the Pitesti conditions have a favorable influence on the chlorophyll fluorescence (Fv/Fm) in contrast to the average effect. In the same environment, *E. crus-galli* is positively influenced photosystem II maximum efficiency while, the same species, the unfavorable influence of the Mioveni environment, soil conditions, is accentuated. *P. aviculare* is prospering when vegetating in asphalt cracks ($F_v/F_m=0.766$).

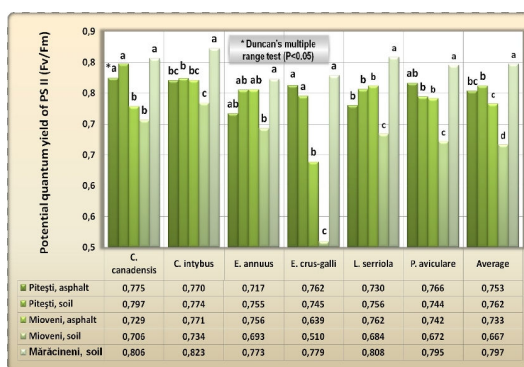


Figure 5. The PS II efficiency variance by the environment in which the experiment was conducted, on constant species levels

Figure 6 presents the maximum efficiency variance of PS II adapted for darkness by species, on constant levels in the environment where experiments were conducted and it shows that, on the experiment average, two homogenous classes had formed for the computed F_v/F_m values. The first class of values has five species while the second contains *E. crus-galli* with the lowest PS II efficiency (0.687). *E. crus-galli* is doing well in Pitesti, asphalt conditions, in contrast with the average findings were values were unfavorable for *E. annuus* and *L. serriola* (which, on average, had higher F_v/F_m values). Also in

Pitesti but in soil conditions, *C. canadensis* had the highest Fv/Fm value, significantly different than that of other species which had a uniform behavior. In Mioveni, asphalt conditions, the differences among species had accentuated, *C. canadensis* registering a decrease in its PS II efficiency over the average tendency. The soil conditions in Mioveni, had kept the average tendency and the lowest PS II efficiency was recorded for *E. crus-galli*. Also, the species effect over Fv/Fm had amplified so *E. annuus* și *P. aviculare* had been less efficient while *E. crus-galli* more efficient, with respect to the activity of the photosystem II (adapted to darkness – F_v/F_m), over the average tendency.

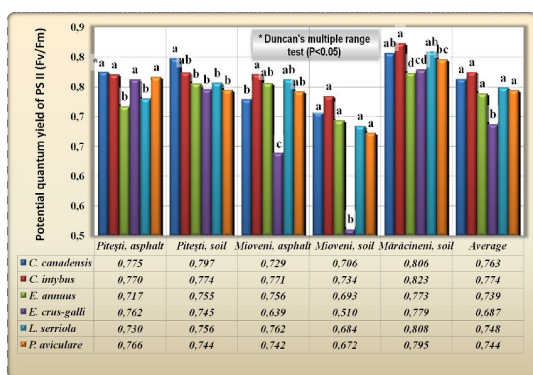


Figure 6. The maximum efficiency variance of PS II adapted for darkness by species, on constant execution environment levels

4. CONCLUSIONS

Chlorophyll fluorescence represents a precise and inexpensive method which can provide immediate information regarding the PS II dilution of energy. The PS II efficiency in adapted dark conditions (F_v/F_m) had higher values in the case of *Cichorium intybus* and *Polygonum aviculare* during the experiment and in Maracineni soil condition than asphalt conditions. The maximum efficiency of the PS , Iași, XLVII, I (48): 645-652, 2005

II leafs adapted to dark conditions had maximum values during the month of September 2008 in the case of the six species of researched plants. The parameters of chlorophyll fluorescence were significantly negatively influenced by the mean temperature of the soil surface and by the water deficit.

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