ПАРАМЕТРИ НА ХЛОРОФИЛНАТА ФЛУОРЕСЦЕНЦИЯ ПРИ РАЗЛИЧНИ ГЕНОТИПИ ТВЪРДА ПШЕНИЦА
PARAMETERS OF CHLOROPHYLL FLUORESCENCE IN DIFFERENT DURUM WHEAT GENOTYPES

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Резюме

С цел интегриране на физиологичен подход в селекционната програма по твърда пшеница са изследвани някои параметри на хлорофилната флуоресценция при светлинно адаптирани листа. Проучено е варирането по тези показатели в колекция от голям набор генотипи - селекционни линии, стари и съвременни български и чужди сортове твърда пшеница. Генотипите са отглеждани в конкурсен сортов опит при полски условия в ИПК – Чирпан през 2010-2011 г. Параметрите на хлорофилната флуоресценция са измервани на флагов лист по време на наливане на зърното с преносим хлорофилен флуориметър MINI-PAM – WALZ-GmbH- Germany. Установени са статистически достоверни различия между изследваните генотипи по отношение на показателите стационарна (*F*) и максимална флуоресценция *(F'm)*. Стойностите на показателя актуален квантов добив (Y) варират в по-малка степен между отделните генотипи – от 0,289 при сорта "Деяна" до 0,493 при сорта "Гергана". Установените генотипни различия по отношение на параметрите на хлорофилната флуоресценция демонстрират различията в капацитета на изследваните генотипи да абсорбират и използват светлината и показват, че хлорофилната флуоресценция може да бъде използвана и за характеризиране на генетичния полиморфизъм.

Abstract

With a view to integrating a physiological approach into the durum wheat breeding program some chlorophyll floresсence parameters of light-adapted leaves were investigated. The variability for these parameters in a collection of large numbers of durum wheat genotypes – breeding lines, old and modern Bulgarian and foreign cultivars, was studied. The genotypes were cultivated under field conditions during 2010/2011 at the Field Crops Institute in Chirpan. The chlorophyll fluorescence was measured on flag leaves during the grain filling stage with a portable chlorophyll Fluorometer - MINI-PAM – WALZ-GmbH – Germany. Significant differences were found between durum wheat genotypes for both parameters - momentary fluorescence yield (*F*) and maximal fluorescence yield *(F'm)*. The quantum yield (Y) varied less between the genotypes in comparison with other studied fluorescence parameters and ranged between 0.289 for cultivar *Dejana* to 0.493 for cultivar *Gergana*. The established differences in the fluorescence parameters of durum wheat genotypes revealed the significant differences in the capacity for absorption and use of light of the studied genotypes and indicated that chlorophyll fluorescence might be a useful tool for characterising genetic polymorphism.

Ключови думи: твърда пшеница, селекция, физиологичен подход, хлорофилна флуоресценция.
Key words: durum wheat, breeding, physiological approach, chlorophyll fluorescence parameters.

INTRODUCTION

Plant physiologists use chlorophyll fluorescence for estimation of functional state of the photosynthetic apparatus. It is an integrative trait, reflecting both light and dark reactions of photosynthesis. The measuring chlorophyll fluorescence is a non-destructive way to assay efficiency of photosynthesis (Maxwell and Johnson, 2000). Parameters of chlorophyll fluorescence provide information about the level of biotic and abiotic stress to which plants are exposed (Van Kooten and Snel, 1996).

Chlorophyll fluorescence is quick indicator of the reaction of plants to water deficit, high and low temperature, salt stress, nitrogen deficient (Clement and van Hasselt, 1996), which is used in modern plant breeding programs to evaluate the tolerance of genotypes.

Furthermore, parameters of chlorophyll fluorescence may also serve as physiological criteria for indirect selection for high yielding genotypes. The use of physiological criteria as part of an integrated approach to breeding can contribute to improve the efficiency of plant breeding process (Reynolds, 2002). For now there are limited and contradictory information about correlation between grain yield and chlorophyll fluorescence inhibition in wheat (Berger and Planchon, 1990; Araus et al., 1998; Bogale et al., 2011)

At adoption of physiological traits into a breeding programme, it is necessary the degree of genetic variability for the traits of interest to be established (Reynolds, 2002). The assessment of variation for chlorophyll fluorescence parameters in breeding materials is very important for conducting of genetic study for heritability of the traits, too. Up to now, many researches have been reported on chlorophyll florescence parameters from physiological point of view, however genetic studies of these traits are limited (Zhang et al., 2010)

The aims of this investigation are to analyze some chlorophyll florescence parameters of light–adapted leaves and to assess the variability for these parameters in a collection of large numbers of durum wheat genotypes with a view to integrate a physiological approach in the durum wheat breeding program.

MATERIAL AND METHODS

In the investigation are involved 21 different durum wheat genotypes –breeding lines D-8138 and D-8116, old – A-233, Gergana, Zagorka and modern durum wheat cultivars – Progres, Beloslava, Vazhod, Victoria, Zvezdica, Dejana, Deni, Predel, Elbrus created in the Field Crops Institute – Chirpan, Bulgaria; cultivar Saturn and Severina – created in the Dobroudja Agricultural Institute – Bulgaria and 5 foreign cultivars – Betadur, Selendur, Karur, Claudio and Superdur. The genotypes were cultivated in field conditions during 2010/2011 in the Field Crops Institute – Chirpan. The trial was conducted as a randomized block design in three replications.

The chlorophyll fluorescence was measured on flag leaves by portable chlorophyll fluorometer- MINI-PAM – WALZ-GmbH - Germany. The minimal fluorescence yield of the illuminated samples (*F*) and the maximal fluorescence yield *(F'm)* of the illuminated light-adapted sample were measured with every saturation pulse. The variable fluorescence yield of the light-adapted leaf was calculated was estimated according to (F*v=F'm-F*). The quantum yield of photochemical energy conversion of PS II was estimated according to:

$Y = F_V / F'm$ (Genty et al., 1989).

All measurements were carried out during the grain filling stage of the durum wheat in the morning to 11 a.m.

The presented dates are means of three replications. For each replication were measured 10 flag leaves. For comparison of the means one-way analyses of variance (ANOVA) followed by the Duncan's multiple range test was used.

RESULTS AND DISCUSSION

The values of fluorescent parameters characterized the functional state of photosynthetic apparatus of different durum wheat genotypes during the grain filling stage are presented in table 1. Significant differences were found between durum wheat genotypes for all studied fluorescence parameters. The values of momentary fluorescence yield (*F*) of the illuminated samples range between 635.2 at cultivar Gergana to 1498.7 at cultivar Karur. The maximal fluorescence yield (*F'm*) measured of the illuminated light-adapted sample in our experiment grow from 1278.1 at cultivar Gergana to 2103.5 at cultivar Karur. The values of fluorescencce yield (*F'm*) higher than 2000 were detected in cultivars – Saturn, Dejana, Victoria and Karur. The higher fluorescence during the grain filing stage of durum wheat indicates that these cultivars are not efficient at utilizing electrons as they move to a higher energy level in the light reactions of photosynthesis. The cultivars with lower fluorescence under the same conditions (environment and stage) most likely hold high leaf water potential which leads to a reduction in photosynthetic activity (Reynolds, 2002).

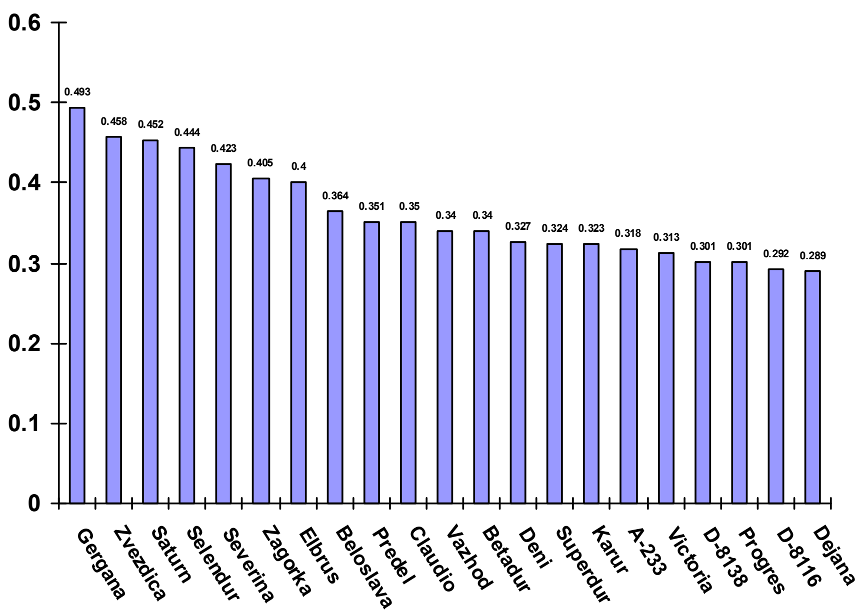
The variable Fluorescence (Fv) is very important parameter characterizing rapid fluorescence kinetics, involved in calculation of the trait quantum yield of PS II. The declining slope of Fv/F'm is a good indicator for photo-inhibition of plants exposed to environmental stresses (Araus et al., 1998). The quantum yield of photochemical energy conversion (Y) varies less between genotypes in comparison with other studied fluorescence parameters and ranges between 0.289 at cultivar Dejana to 0.493 at cultivar Gergana (figure 1). Genetic variation for quantum yield was also observed in common and durum wheat under drought and cold stress (Balouchi, 2010; Zlatev and Kolev, 2010).

It is considered that the *Fv/ F'm* ratio in light adapted plants grown in suitable conditions is around 0.55-0.60 and is higher than ratio *Fv/ F'm* under stress conditions (Balouchi, 2010). The ascertained in our experiment values of quantum yield between 0.289 to 0.493 indicate that all studied genotypes during the grain filling stage during the first half of June of 2011 year for region of Chirpan – Bulgaria were developed in water stress conditions that promoted observed photoinhibition. According to Willits and Peet (2001) the cause of fluorescence decrease is related to decline in the functioning of primary photochemical reactions, primarily involving inhibition of PSII, located in

Таблица 1. Параметри на хлорофилната флуоресценция в светлинно адаптирани проби от генотипи твърда пшеница
Table 1. Chlorophyll fluorescence parameters for light-adapted sample of durum wheat genotypes

Genotypes	Chlorophyll fluorescence parameters		
	F_0	F_m	Y
Gergana	635.2 ^{a*}	1278.1^{a}	0.493^{a}
Zvezdica	723.8^{a}	1317.4^{a}	0.458^{ab}
Severina	960.5^{b}	1660.3^{b}	0.423^{bc}
Zagorka	1050.5^{bc}	1764.7^{bcde}	0.405^{bcd}
Elbrus	1052.4^{bc}	1719.6^{bc}	0.400^{bcd}
Selendur	1074.5^{bc}	1905.4^{bcdefgh}	0.444^{ab}
Claudio	1123.3^{bcd}	1849.3 ^{bcdefg}	0.350^{def}
Beloslava	1143.9^{bcd}	1910.4 ^{bcdefgh}	0.364^{cde}
Saturn	1169.4^{bcde}	2098.64^{gh}	0.452^{ab}
Betadur	1220.3^{cdef}	1719.6^{bc}	0.340 ^{def}
A-233	1229.1 ^{cdef}	1783.8^{bcde}	0.318^{ef}
D-8138	1229.2 ^{cdef}	1731.63^{bcd}	0.301^{ef}
Vazhod	1253.9 ^{cdefg}	1869.9 ^{bcdefgh}	0.340 ^{def}
Superdur	1273.5 ^{cdefg}	1872.8 ^{bcdefgh}	0.324 ^{ef}
Deni	1287.2 ^{cdefg}	1829.4^{bcdefgh}	0.327 ^{ef}
Predel	1300.8 ^{cdefg}	1973.2^{cdefgih}	0.351^{def}
Progres	1367.2^{defg}	1981.6^{defgih}	0.301^{ef}
D-8116	1408.5 ^{efg}	1965.2 ^{cdefgih}	0.292 ^{ef}
Dejana	1429.0^{efg}	2009.1^{efgih}	0.289^{f}
Victoria	1434.6^{fg}	2051.4^{fgih}	0.313 ^{ef}
Karur	1498.7^{g}	2103.5^{h}	0.323 ^{ef}

** For each parameter, values flanked by the same letters are not significantly different at P = 0.05*



***Фиг. 1.** Квантов добив (Y) в генотипи твърда пшеница*
***Figure 1.** Quantum yield Y of durum wheat genotypes*

the thylakoid membrane system. Further water stress experiments are needed to determine the possibility for using of chlorophyll fluorescence parameters as an early test for screening of drought tolerant genotypes in our durum wheat breeding program.

CONCLUSIONS

The detected differences of chlorophyll fluorescence parameters between durum wheat genotypes reveal the significant differences between them in the capacity of absorption and use of light and indicate that chlorophyll fluorescence might be useful tool for characteristics of genetic polymorphism.

The presented results are only initial step of our efforts to integrate physiological criteria into a durum wheat breeding program. The presence of variation for fluorescence parameters between studied durum wheat genotypes is precondition for seeking of correlation between grain yield and chlorophyll fluorescence parameters in the next stage of our research. The identification of durum wheat genotypes with significant differences of some chlorophyll fluorescence parameters will facilitate further genetic studies of heritability of these traits.

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