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CHLOROPHYLL FLUORESCENCE IN DIFFERENT WHEAT GENOTYPES GROWN UNDER SALT STRESS

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Abstract

To assess the genotypic variation for efficiency of photo-system-II (Fv/Fm) in wheat genotypes containing introgression from chromosomes 1D, 3D and 5D of *Aegilops tauschii* and whether it could be used as a selection criteria for salt tolerance, 32 wheat genotypes were grown under field conditions and subjected to varying levels of salinity stress (10, 15 and 20 dS m^{-1}). For most of the wheat genotypes, we observed Fv/Fm value greater than 0.8 at higher salinity levels compared to that of control. The minimum value of 0.8 for the efficiency of PSII (Fv/Fm) shows the health and vigor of the plant. A lower value indicates that a proportion of PSII reaction centers are damaged, a phenomenon called photo-inhibition, often observed in plants growing under stress conditions. Although salt stress reduced grain yield in all wheat genotypes, it is not positively associated with F_v/F_m. In conclusion, F_v/F_m can not be referred as a selection criterion for salt tolerance in wheat genotypes examined in the present study.

Keywords: Chlorophyll fluorescence, Fv/Fm, Photosynthesis, salinity

Introduction

Photosynthesis often reduces in plants growing under abiotic stresses such as salinity (Ashraf, 2004), water deficit (Athar & Ashraf, 2005). Photosynthesis is particularly reduced when plants are grown under saline conditions, which leads to reduced growth and productivity, e.g., in wheat (Raza *et al*., 2006), *Ammi majus* L (Ashraf *et al*., 2004). Since photosynthesis occupies the central position in providing link between the internal metabolism of plant and the external environment, therefore, any change in external environment will affect photosynthetic ability of a plant in both negative and positive ways. Chlorophyll fluorescence has proved particularly useful in salinity-tolerance screening programs (Jimenez *et al.*, 1997) because the effects of salt damage can be detected prior to visible signs of deterioration (West, 1986). Analysis of fluorescence characteristics such as the nature and intensity of the emission bands, quantum yield, and induction kinetics, reflects the properties of the chlorophyll molecules and their interaction with the external environment and also with associated physiological processes (Hall & Rao, 1999). It has been used since long by crop physiologists to evaluate response of various crop species to determine the influences of abiotic stresses at various stages of plant growth to have a quantitative assessment to be used in ranking plant species for their tolerance and/or sensitivity towards environmental stresses (Maxwell & Johnson, 2000). While working with canola (*Brassica napus* L.) cultivars, Kauser *et al*. (2006) suggested that F_v/F_m can be used as an efficient selection criterion to discriminate canola cultivars for water stress tolerance.

In the present study, 32 wheat genotypes containing introgression from chromosomes 1D, 3D, and 5D were tested using chlorophyll fluorescence. The objectives

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were to rank them on the basis of F_v/F_m ratio and to know whether or not F_v/F_m possesses some relationship with grain yield obtained under saline environment.

Materials and Methods

Wheat genotypes comprising 32 wheat introgression lines (WILs) containing genetic material from chromosomes 1D, 3D and 5D of *Aegilops tauschii* were tested for their salt tolerance at salinity levels ranging between 0 (control), 10, 15 and 20 dS m^{-1} obtained by dissolving commercial NaCl in water. This saline solution was applied as irrigation water to maintain desired salinity levels in the field. The efficiency of chlorophyll fluorescence (F_v/F_m ratio) was measured on dark adapted flag leaves of three randomly selected plants from each genotype with the help of Plant Efficiency Analyzer (Hansatech Instruments Ltd, Kings Lynn, U.K.). The dark-adaptation of leaves was achieved by covering the leaves for 30 minutes under plastic clips provided with PEA (Plant Efficiency Analyzer). The present experiment was conducted in field blocks (457.2 x 609.6 cm^2 and 609.6 x 609.6 cm^2) encaged in a net-house at Nuclear Institute for Agriculture and Biology (NIAB) in February, 2006 when flag leaf emerges on most of the wheat varieties

Results and Discussion

Increasing salinity levels (10, 15 and 20 dSm^{-1}) did not affect the F_v/F_m values of most of the plants containing introgression from chromosomes ID of *Ae. tauschii* except in plants Nos. 2, 6 and 7 where EC 20 dS m^{-1} significantly reduced F_v/F_m ratio (Fig. 1) below 0.8: a normal value reported for most the plants (Zarco-Tejada *et al*., 2000). F_v/F_m value of 0.8 shows the health and vigor of the plant (Bjorkman & Demmig-Adams, 1995) while value below 0.8 indicates that plants are experiencing stress conditions (Schreiber *et al*., 1995). These results indicated that plants 2, 6 and 7 may contain segments of chromosomes ID that are sensitive to high salinity.

Imposition of salt stress did not reduce F_v/F_m values of almost all wheat genotypes containing introgression from chromosome 3D, except in wheat genotypes 2 and 11 where values of F_v/F_m were reduced with increasing level of salt stress. However, these values were either equal or still higher than 0.8 which indicated that these plants contained segment (s) of chromosomes that induced protection against salt-induced oxidative damage. Similarly, wheat genotypes containing introgression from chromosome 5D also showed higher than 0.8 values for F_v/F_m under saline conditions, except in wheat genotype No. 9, where F_v/F_m ratio was reduced to 0.3 which indicated that this plant contained a segment of chromosomes that are highly sensitive to salinity. These results can be related to some earlier findings in which it has been observed that salt stress has no effect on PSII photochemical activity, e.g., in wheat (Raza *et al*., 2006).

Grain yield is the most important determinant in appraising crop productivity under stressful environments. However, decline in productivity in many plant species subjected to stressful environment is often associated with a reduction in photosynthetic capacity (Ashraf, 2004; Raza *et al*., 2006; Arfan *et al*., 2007). Since, photosystem II (PSII) plays a key role in the response of leaf photosynthesis to environmental perturbation (Athar & Ashraf, 2005), it is highly likely that higher PSII photochemical activity calculated as F_v/F_m contributed more in grain yield of wheat genotypes under saline condition. However, if we draw the relationship between F_v/F_m and grain yield of all wheat genotypes, it is clear that grain yield was not related with changes in F_v/F_m ratio (Table 1, 2, and 3). Thus, F_v/F_m can not be referred as a selection criterion for salt tolerance in wheat genotypes examined in the present study.

Table 1. The effect of salinity stress on the grain yield (g plant^{-1}) in different wheat genotypes containing introgression from chromosome ID.

Wheat Introgression Lines (WILs)	Grain yield ((g plant^{-1}) at different electrical conductivities (dS m^{-1})			
	1.0 (Control)	**10**	**15**	**20**
WIL 1	27.1	21.3	17.4	17.2
WIL 2	23.9	22.2	15.0	13.0
WIL 3	25.9	21.5	16.1	10.6
WIL 4	20.4	15.4	13.8	10.4
WIL 5	21.0	14.5	12.4	10.7
WIL 6	26.8	18.4	16.4	5.7
WIL 7	20.2	18.6	16.6	9.4
WIL 8	18.6	13.3	12.7	8.2
WIL 9	23.4	12.9	9.8	5.7
WIL 10	14.7	11.6	6.9	4.9

Table 2. The effect of salinity stress on the grain yield (g plant^{-1}) in different wheat genotypes containing introgression from chromosome 3D.

Wheat genotypes	Grain yield ((g plant^{-1}) at different electrical conductivities (dS m^{-1})			
	Control (1.0)	**10**	**15**	**20**
WIL 1	14.1	14.0	11.8	11.2
WIL 2	22.5	15.3	8.1	2.0
WIL 3	16.2	13.2	12.0	9.8
WIL 4	14.9	14.3	13.9	10.0
WIL 5	13.3	13.0	12.2	11.7
WIL 6	17.1	13.7	13.3	13.0
WIL 7	18.7	15.2	13.9	10.7
WIL 8	14.6	14.5	12.7	9.5
WIL 9	19.9	13.0	10.6	8.5
WIL 10	16.2	13.0	12.7	11.4
WIL 11	16.0	13.1	12.6	8.7
WIL 12	14.7	11.6	6.9	4.9

Table 3. The effect of salinity stress on the grain yield (g plant^{-1}) in different wheat genotypes containing introgression from chromosome 5D.

Wheat genotypes	Grain yield ((g plant^{-1}) at different electrical conductivities (dS m^{-1})			
	Control (1.0)	**10**	**15**	**20**
WIL 1	11.3	10.0	7.7	7.6
WIL 2	14.4	8.7	4.7	3.7
WIL 3	21.3	17.7	17.0	11.4
WIL 4	11.3	11.3	9.3	8.2
WIL 5	5.1	4.9	4.0	3.6
WIL 6	13.4	12.1	12.0	4.4
WIL 7	8.0	6.7	6.5	4.9
WIL 8	12.2	9.4	8.3	2.9
WIL 9	18.6	18.5	18.0	14.6
WIL 10	14.8	13.0	10.8	8.3
WIL 11	10.0	8.8	7.3	6.6
WIL 12	14.7	11.6	6.9	4.9

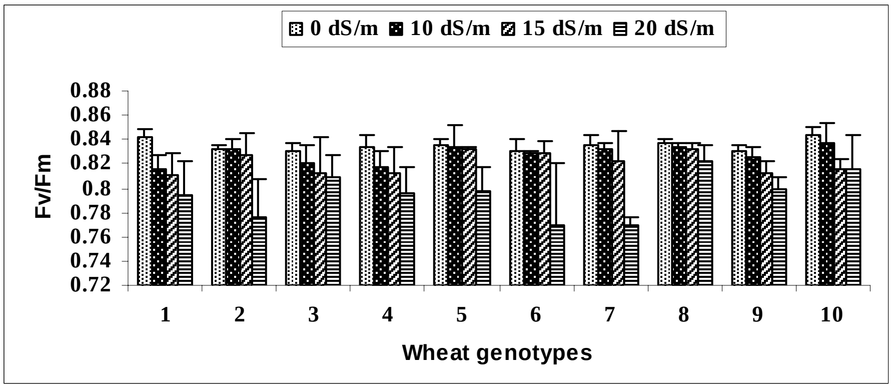

Fig. 1. The effect of different salinity levels (0, 10, 15 and 20 dS m^{-1}) on PS-II efficiency (F_v/F_m) in different wheat genotypes containing introgression from chromosome ID of *Ae. tauschii.*

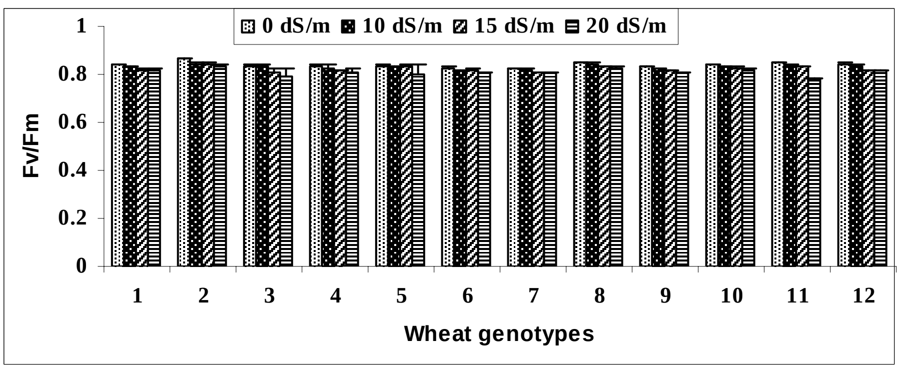

Fig. 2. The effect of different salinity levels (0, 10, 15 and 20 dS m^{-1}) on efficiency of PS-II (F_v/F_m) in different wheat genotypes containing introgression from chromosome 3D of *Ae. tauschii.*

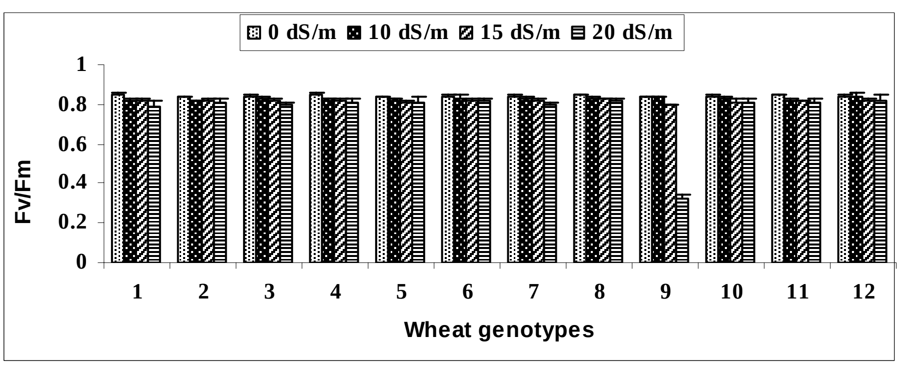

Fig. 3. The effect of different salinity levels (0, 10, 15 and 20 dS m^{-1}) on efficiency of PS-II (F_v/F_m) in different wheat genotypes containing introgression from chromosome 5D of *Ae. tauschii.*

Wide variation in F_v/F_m ratio indicated that *Ae. tauschii* contains genes that can either enhance or reduce absorption of light used by individual plants for photosynthesis, which in combination with other factors may affect grain yield under salinity stress. However, further work is required to get meaningful results.

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