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DIFFERENCES IN AGRONOMIC AND PHYSIOLOGICAL PERFORMANCE OF VARIOUS WHEAT GENOTYPES GROWN UNDER SALINE CONDITIONS

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Abstract

Nine wheat genotypes having introgression from chromosome 1D of *Aegilops tauschii* were studied under control (non-stress) and salt stress conditions. The objective was to detect variation in wheat genotypes against salt stress using physiological parameters such as transpiration rate, stomatal conductance, net CO_2 assimilation rate, grain yield plant^{-1} and green biomass production and CO_2 fixation. Wheat Introgression Line (WIL) 1 and 2 showed highly significant correlation between stomatal conductance and transpiration rate as compared to all other genotypes in control and salinity. Genotype 2 and 4 showed significant correlation between transpiration rate and net photosynthesis in plants growing under controlled condition. Similarly yield and biomass production are strongly correlated in control and treated conditions in WILs 5, 6, 7. It is inferred that the tested genotypes had significant differences regarding the above mentioned parameters. It appeared that stomatal conductance, net photosynthesis and transpiration are directly and indirectly correlated with grain yield and biomass. The introgression lines tested in the present study showed plants with different segments of ID chromosome that promote these parameters differentially under saline conditions and can help identify chromosomal segments that can be used for improvement of wheat plants particularly for these parameters.

Keywords: photosynthesis, introgression lines, CO_2 assimilation, transpiration rate

Introduction

Soil salinity is a major environmental stress that drastically affects crop productivity (Ashraf, 2004). Salts may also reduce plant growth by significantly reducing the water potential (Ashraf, 2004; Farooq *et al.,* 2005), because it is intricately meshed with water and nutrient uptake in plants. It can also disrupt nutrient availability by interfering with their uptake (Feddes *et al.,* 2001). Salt stress affects many aspects of plant metabolism, which ultimately result into growth reduction. Excess of salts in soil affect the physiology of plant growth either through osmotic inhibition, by specific ion effects or by a combination of both (Ashraf, 1994; 2004). Wheat (*Triticum aestivum* L.) is especially known to have reduced relative water contents and high NaCl uptake if cultivated under saline conditions (Farooq & Azam, 2006). However, certain derivatives of wheat hybrids with introgression from D genome wild relatives (*Aegilops cylindrica* or *Ae. tauschii*) can tolerate both saline and water deficient conditions (Farooq & Azam, 2001). Here we report for the first time, the results of salt tolerance in wheat cultivar Chinese Spring and its lines containing introgression from chromosome 1D of *Ae. tau*schii when tested for certain physiological parameters after growing it under varying salinity levels. The

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objective was to assess variation in various WILs against salt stress using morpho-physiological parameters such as biomass production, grain yield and photosynthetic capacity.

Materials and Methods

Eight wheat genotypes having introgression from chromosome 1D of *A. tauchii* (hereafter known as wheat introgression lines: WILs) and wheat parent Chinese Spring were used in this study. This material was very kindly provided by the Department of Gene Bank, IPK, Gaterslaben, Germany, and was grown under four field blocks (20 x 15 feet) maintained inside the net house using electrical conductivity of (EC) of 1.5 (control) and 15 dS m^{-1} created artificially by mixing NaCl with water. The experiment was conducted using a randomized complete block design with 9 replications, genotypes being as main block and salinity as sub-block. Saline water was applied for irrigation throughout the growth period. Data with respect to plant growth, plant weight (fresh and dry) at the booting stage, number of tillers, number of leaves, spike length, grains/spike, 100 grain weight, grain yield $plant^{-1}$ and green biomass was recorded at maturity. Physiological parameters included CO_2 assimilation (fixed CO_2), stomatal conductance, transpiration rate, and net photosynthesis was measured on a fully expanded flag leaf at 11:00 a.m. under full sunshine. All the physiological parameters were measured with hand held portable photosynthetic instrument CI 340. Data was statistically analyzed using analysis of variance test as described by (Steel & Torrie, 1980)

Results and Discussion

A significant genetic variation exists among nine wheat genotypes for all morpho-physiological parameters. Among the 8 WILs growing under non-saline conditions, transpiration rate was the highest in WIL-2 and WIL-6 (Fig 1) and was even higher than that of the parent Chinese Spring, which indicates that segment of chromosome 1D in this plant promotes transpiration rate. Salinity of EC 15 dS m^{-1} reduced transpiration rate significantly, however this salt induced in transpiration was less in WIL-7 (Fig.1), which indicates that this line contains segment (s) of chromosome 1D possessing genes that are different than those present in WIL-2 and 6. WILs 2 and 6 also showed higher stomatal conductance but it is equally higher in WIL 5 and the highest in WIL-7 under control conditions, but under saline condition it is drastically reduced (Fig 2) which again showed difference in the genetic makeup of the plants in terms of chromosome segment (s) transferred from *Ae. tauschii.*

Net photosynthesis was the highest in WIL2 and-6. Contrary to this, in WILs 1 and 4, net photosynthesis was significantly lower than that in WILs 2 and 6. Salinity induced reduction in photosynthesis has already been reported in wheat (Raza *et al*., 2006; Arfan *et al*., 2007), however, less photosynthesis in WILs 1 and 4 is apparently not due to salinity as it is equal to the net photosynthesis of parent Chinese Spring (Fig 3), which indicated that this line may contain the introgression of genes similar to that of parent, while WIL 4 may contain genes that are not affected by salinity (Fig 3). Under control conditions, net photosynthesis was negatively correlated ($p<0.01$and 0.05) with transpiration (-786**) and positively with stomatal conductance (0.746*), and green biomass (0.741*). From these results it is suggested that changes in biomass production

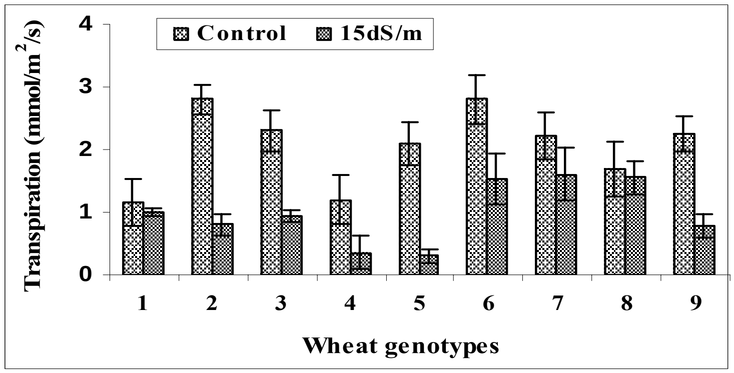

Fig. 1. The effect of different salinity levels (1.5 and 15 dS m^{-1}) on transpiration rate (E) of various introgression lines of wheat (1-8) and parent Chinese Spring (9).

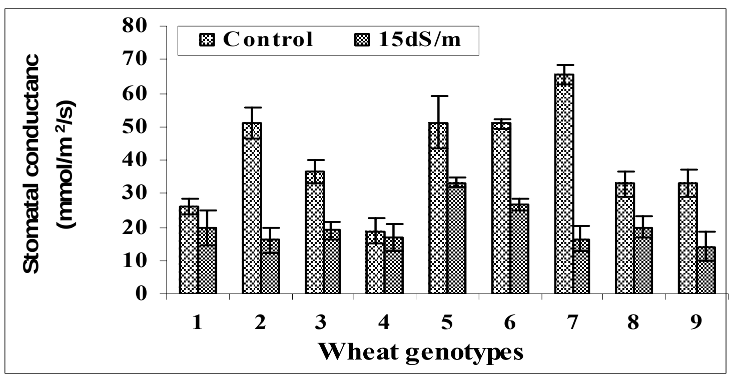

Fig. 2. Effect of different salinity levels (1.5 and 15 dS m^{-1}) on stomatal (c) conductance of wheat introgression lines.

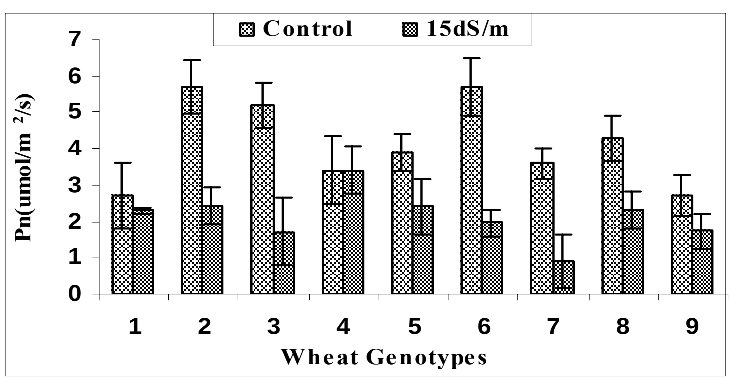

Fig. 3. Effect of different salinity levels (1.5 and 15 dS m^{-1}) on CO_2 assimilation rate of various introgression line of wheat.

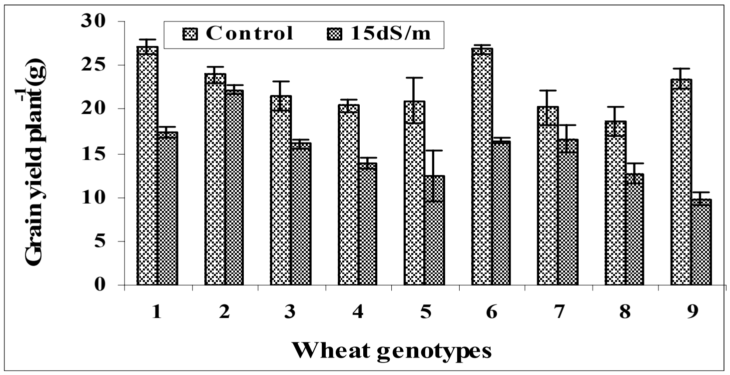

Fig. 4. Effect of different salinity levels (1.5 and 15 dS m^{-1}) on grain yield (g $plant^{-1}$) of wheat genotypes.

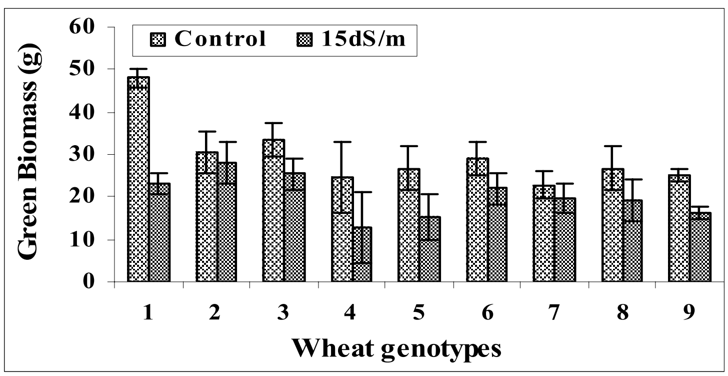

Fig. 5. Effect of different salt levels (1.5 and 15 dS m^{-1}) on green biomass (g) of wheat introgression lines of wheat.

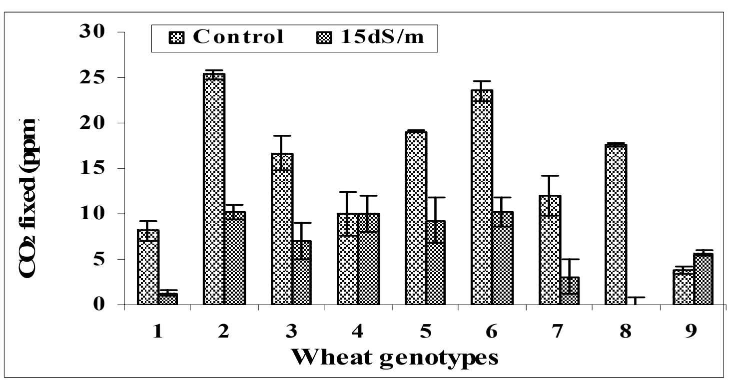

Fig. 6. The effect of different salt levels (1.5 and 15 dS m^{-1}) on ΔC (the difference between C_{an} [ambient CO_2] and C_i [internal CO_2]) of various introgression lines of wheat.

Table 1. Coefficient of correlation observed between different parameters of different wheat genotypes growing under saline (S) and non saline control (C) conditions.

	Pn		E		gs		ΔC		G		GB	
	C	**S**	**C**	**S**	**C**	**S**	**C**	**S**	**C**	**S**	**C**	**S**
Pn	-	-	-.786**	-.488	0.746*	0.231	0.751*	0.645*	0.741*	-.108	0.428	-.154
E			-	-	-.792**	-.421	-.403	-.724*	-.773**	-.055	-.597*	-.121
g_s					-	-	0.512	0.461	0.789**	0.235	0.648*	0.069
ΔC							-	-	0.465	0.136	0.524	0.254
G									-	-	0.750*	0.633*
GB											-	-

S: Saline; C: Control

* Significant at 5% (p=0.5) level of significance; ** Significant at 1% (p=0.1) level of significance

in all genotypes was associated with their photosynthetic capacity as earlier has been observed in maize (Ashraf & Rehman, 1999), wheat (Raza *et al*., 2006; Arfan *et al*., 2007). Secondly, this higher photosynthetic rate in these introgression lines might have been transferred from their parents that resulted in higher growth.

Grain yield was the highest in WIL-1 and 6 (Figure 4) while in the remaining lines grain yield was equal to or lower than that of parent Chinese Spring. WIL 6 also showed the highest net photosynthesis and transpiration which could be one of the reasons of highest grain yield in this line. However, a significant correlation of grain yield (Table 1) was not found with net photosynthesis (-0.428, 0.154) but with stomatal conductance, the correlation is significant (0.648*) under control conditions only. Perhaps the gene transferred in these lines that enhanced grain yield significantly are independent of the effect of net photosynthesis on these lines.

Grain yield, however, showed a positive and highly significant (0.750 and 0.633*) correlation with green biomass both under saline and non-saline conditions, respectively which was the highest in WIL 1 (Fig 5; Table-1). In the remaining lines, green biomass is significantly less than WIL-1 (Figure-5). Salinity reduced it further but in WILs 2 and 7 salinity induced reduction was not significant which indicates that these lines contain genes for biomass production that are not affected by salinity.

Considerable variation was observed in CO_2 fixation that was the lowest in parent Chinese spring and about 5 times higher in WIL 2 and 6 plants growing under non-saline conditions (Figure 6). Reduction in CO_2 fixation due to salinity was also the highest in WILs2 and 6 growing under saline condition. CO_2 fixation was significantly and positively correlated with net photosynthesis (0.751*, 0.645*) under control and saline conditions and less significantly with stomatal conductance (0.512) under control conditions only (Table-1).

Green biomass was significantly and positively correlated (0.802**) with CO_2 fixation which was lower in WIL-1 after the lowest in the parent Chinese Spring (Figure-6) which indicates that fixed CO_2 is not the only factor that enhances green biomass in WIL-1. Contrary to this, WILs 2 and 6 showed the highest fixed CO_2 and also the grain yield which in not significantly different than that observed in WIL-1 which indicated that fixed CO_2 does have some role in enhancing green biomass and ultimately the grain yield. Green biomass is significantly and positively correlated (0.741*, 0.773** and 0.789**) with net photosynthesis, transpiration and stomatal conductance (Table-1), respectively under non-saline control conditions but not with grain yield. Both stomatal and non-stomatal factors contributing in reduced photosynthetic capacity under stress conditions including salt stress or water stress. However, stress induced reduction in photosynthetic capacity was mainly due to stomatal limitations in different crops (Athar & Ashraf, 2005; Dubey, 2005). Similar results have also been observed in wheat (Raza *et al*., 2006; Arfan *et al*., 2007).

It appeared that stomatal conductance, net photosynthesis and transpiration are directly and indirectly correlated with grain yield and biomass. The introgression lines tested in the present study showed plants with different segments of ID chromosome that promote these parameters differentially under saline conditions. They can help to identify chromosomal segments that can be used for improvement of wheat plants for these parameters and ultimately the grain yield under salinity stress.

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