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Growth Analysis of Wheat (*Triticum aestivum* L.) Cultivars under Saline Conditions

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ABSTRACT

Growth of eight wheat cultivars was assessed under saline conditions (EC_e 7.5 dS m^{-1}). The wheat cultivars differed significantly for emergence, leaf area index, relative growth rate and net assimilation rate. At emergence stage the least affected cultivar was BWP-2000, whereas other cultivars Drawar-97, Manthar-3, BWP-97, Iqbal-2000 and SARC-1 were severely affected by salinity. The cultivar Panjnad-1 was moderately sensitive at this stage under saline conditions. Although the emergence of two cultivars Drawar-97 and Manthar-3 was severely affected under saline conditions but these cultivars showed highest relative growth rates at 50, 57 and 64 DAS, respectively. The lowest relative growth rates were observed in cultivars SARC-1, BWP-97 and BWP-2000 at 50, 57 and 64 DAS, respectively. The changed salt sensitivity behaviors were also observed in leaf area index and net assimilation rate. The lowest leaf area indices were found in the cultivar Panjnad-1 at all growth stages. The leaf area index of cultivar BWP-97 was also at par with Panjnad-1 at 50 and 57 DAS. The cultivars BWP-97 and Panjnad-1 showed the highest net assimilation rates at 50, 64 and 57 DAS, respectively. The net assimilation rates were the lowest in Manthar-3 at 50 and in Darawar-97 at 57 and 64 DAS, respectively.

Key Words: *Triticum aestivum* L.; Saline conditions; Genotypic variation; Growth; Selection traits

INTRODUCTION

Growth is a vital function of plants and indicates the gradual increase in number and size of cells. The processes of growth and development are considered to begin with germination, followed by large complex series of morphological and physiological events (Ting, 1982). Along with other favorable environmental conditions, adequate availability of essential elements increases the growth. The presence of salts in the irrigated systems of arid and semi-arid regions is among the important factors affecting the availability of water and essential elements to plants by osmotic stress. Salinity checks the availability of nutrients to plants and reduces growth (Zalba & Peinemann, 1998).

Growth parameters such as germination, leaf area index, relative growth rate and net assimilation rate are very important to assess the growth and are affected by salinity. Significant reduction in vegetative growth of wheat genotypes has been observed under saline conditions (Naseem *et al.*, 2000). The reduced growth may be due to slow rate of cell division, elongation and differentiation that will result reduced number of cells of small size. Even prolonged lower salt levels can influence the growth of crops and cause significant reduction in seedling growth (Zeng & Shannon, 2000). Hendawy *et al*. (2005) reported that growth of salt tolerant wheat genotypes affected by salinity was primarily due to decline in photosynthetic capacity rather than a reduction in leaf area, whereas net assimilation rate was more important factor in determining relative growth rate of moderately tolerant and salt sensitive genotypes.

The genetic diversity for growth between and within crop species gives economic stability and enables to choose the crops and their cultivars that are adapted for a region or for the specific field conditions. The cultivars having balanced vegetative growth under stress leads to better economic returns. Salt accumulation is increasing in irrigated agricultural systems and salt-tolerant cultivars showing adequate vegetative growth would provide a solution to the continuation of agriculture under conditions of increasing salinity (Loomis & Connor, 1992). Large seedling leaves and high growth rate of wheat, barley and triticale genotypes indicate an absolute salt tolerance and are desire able parameters for screening purposes (Rawson *et al*., 1988). The present study was initiated to analyze the growth of wheat cultivars under saline conditions.

MATERIALS AND METHODS

The eight wheat cultivars were evaluated for their growth pattern under saline conditions at the University College of Agriculture Research Farm, Bahauddin Zakariya University, Multan, Pakistan. The soil had pH 8.3, EC_e 7.5 dS m^{-1} and exchangeable sodium percentage (ESP) 16. The concentrations of nitrogen, phosphorus and exchangeable potassium in the soil were found 0.03%, 9.0 ppm and 110.0 ppm, respectively. The treatments under study were wheat cultivars. The wheat cultivars were Manthar-3, Panjnad-1, BWP-2000, Inqalab-91, Iqbal-2000, SARC-1, BWP-97 and Darawar-97. The experiment was laid out in randomized complete block design with four replications. The wheat cultivars were sown in rows with a hand drill at seed rate of 70 kg ha^{-1}.

After completion of emergence, data on seedling emergence was taken. The data were taken with the help of a meter quadrate. The quadrate was thrown randomly into the net plot area at two places. The number of plants enclosed by the quadrate in each treatment was counted and average was computed to record data on emergence count m^{-2}. Leaf area measurements were started at 50 days after sowing. The time interval between two consecutive measurements was 07 days. From each plot, 10 plants were selected randomly. Leaf area was measured with the help of a leaf area meter. To record relative growth rate and net assimilation rate, the same plants were cleaned and oven dried at 70°C for 48 h. Following formulae proposed by Gardener *et al.* (1985) were used to calculate relative growth rate, leaf area index and net assimilation rate.

$$RGR = \frac{\ln W_2 - \ln W_1}{T_2 - T_1}$$

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

$$NAR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{\ln LAI_2 - \ln LAI_1}{LAI_2 - LAI_1}$$

Where:
W_1 = Dry weight of first harvest.
W_2 = Dry weight of second harvest.
ln = Natural logarithm.
LAI_1= Leaf area index at first harvest.
LAI_2 = Leaf area index at second harvest and
T_2-T_1 =Time interval between two harvests

The data obtained were subjected to analysis of variance and least significant differences (LSD) test was used to compare the means of treatments. The statistical program Minitab version 13.1 was used to analyze the data.

RESULTS AND DISCUSSION

Significant differences for emergence, leaf area index, relative growth rate and net assimilation rate were observed among the wheat cultivars grown in soil having EC_e 7.5 dS m^{-1} (Tables I, II). Maximum emergence was obtained in cultivar BWP-2000 (136.0 m^{-2}) followed by Panjnad-1 (119.7 m^{-2}), whereas other cultivars showed minimum emergence. The results showed a great magnitude of the genetic variations to salinity at emergence stage. Aquila and Spada (1993) and Shirazi (2001) reported that there was a gradual decrease in germination of the wheat varieties with the increased salt concentrations. This necessitates the need of great care at the time of sowing.

Leaf area index ranged between 0.17 to 2.80, 0.28 to 0.51, 0.42 to 1.13 and 0.67 to 2.17 at 50, 57, 64 and 71 days after sowing (DAS), respectively (Table I). It was also evident from the results that leaf area index increased linearly from one growth phase to another. The highest leaf area indices were observed in cultivar Inqlab-91 (1.13 & 2.17) and the lowest in Panjnad-1 (0.415 and 0.670) at 64 and 71 DAS, respectively. The cultivar Panjnad-1 was the most salt sensitive with respect to leaf area index. The low leaf area index in salinity sensitive cultivars may be due to senescence of leaves enhanced by salinity. The fallen leaves reduced the number of intact green leaves hence leaf area index was decreased. Salinity reduces number of total and green leaves in wheat cultivars (Pervaiz *et al*., 2002). Wilting of leaves was also observed in salinity sensitive cultivars and temporary wilted leaves contributed to lower leaf area index values. The genotypic variations to retain leaf relative water contents might be another reason for differences in leaf area index among the wheat cultivars.

The relative growth rate ranged between 61.38 to 105.5, 52.66 to 188.20 and 61.73 to 127.20 g kg^{-1} day^{-1} at 50, 57 and 64 DAS, respectively (Table II). The cultivars Drawar-97 (155.0 g kg^{-1} day^{-1}) and Manthar-3 (188.2 g kg^{-1} day^{-1}) showed highest relative growth rates at 50 and 57 DAS, respectively. The lowest relative growth rates were observed in cultivars SARC-1 (61.38 g kg^{-1} day^{-1}), BWP-97 (52.66 g kg^{-1} day^{-1}) and BWP-2000 (61.73 g kg^{-1} day^{-1}) at 50, 57 and 64 DAS, respectively. Earlier Rivelli *et al.* (2003) reported that relative growth rate of wheat was decreased with salinity. Probably salty condition influenced the availability of certain nutrients to plant roots. The altered and/or reduced supply of certain plant nutrients might be the cause of low relative growth rate in the cultivars showing less relative growth rate. As described earlier, salinity enhances wilting and senescence of leaves. The less leaf area resulted in less interception of light. Less interception of light caused a decrease in photosynthetic efficiency and hence decreased relative growth rates (Datta, 1994).

The cultivars BWP-97 (899.1 & 918.8 g cm^{-2} day^{-1}) and Panjnad-1 (1168.0 g cm^{-2} day^{-1}) showed the highest net assimilation rates at 50 & 64 and 57 DAS, respectively, whereas at 64 DAS, the lowest net assimilation rate was recorded in Darawar-97 (474.0 g cm^{-2} day^{-1}) and Inqalab-91 (349.2 g cm^{-2} day^{-1}). Salinity had significant effect on net assimilation rate (Parveen *et al*., 1990). The low net assimilation rate might be due to restricted availability of essential nutrients and decreased photosynthetic efficiency (Datta, 1994). Another reason might be more drain on photosynthates in the salinity sensitive cultivars to continue their life cycle, which resulted less biomass production hence less net assimilation rate.

CONCLUSIONS

The wheat cultivars showed changed salt sensitivity behavior for emergence, leaf area index, relative growth rate and net assimilation rate under salt stress. Leaf area index,

Table I. Emergence and leaf area index of wheat cultivars under saline conditions

Cultivars	Emergence (m^{-1})	LAI at 50 DAS	LAI at 57 DAS	LAI at 64 DAS	LAI at 71 DAS
Manthar-3	106.3 d *	0.240 b	0.380 d	0.540 d	0.700 e
Panjnad-1	119.7 bc	0.180 g	0.286 g	0.415 h	0.670 e
BWP-2000	136.0 a	0.190 e	0.390 c	0.560 c	0.756 d
Inqlab-91	109.7 cd	0.226 c	0.500 b	1.130 a	2.170 a
Iqbal-2000	129.7 d	0.280 a	0.366 e	0.536 e	0.830 c
SARC-1	109.7 bcd	0.186 f	0.300 f	0.490 g	0.786 cd
BWP-97	106.0 d	0.190 f	0.280 h	0.496 f	0.836 c
Darawar-97	101.7 d	0.190 f	0.510 a	0.960 b	1.550 b
LSD (0.05)	12.32	0.001	0.001	0.001	0.055

* Means not sharing a common letter in a column differ significantly at 0.05% level of probability

Table II. Net assimilation rate and relative growth rate of wheat cultivars under saline conditions

Cultivars	RGR at 50 DAS g kg^{-1} day^{-1}	RGR at 57 DAS g $kg^{-1}day^{-1}$	RGR at 64 DAS g $kg^{-1}day^{-1}$	NAR at 50 DAS g $cm^{-2}day^{-1}$	NAR at 57 DAS g $cm^{-2}day^{-1}$	NAR at 64 DAS g $cm^{-2}day^{-1}$
Manthar-3	63.16 d	188.20 a	127.20 a	213.0 e	901.18	866.3 c
Panjnad-1	90.56 b	122.60 c	87.89 c	459.8 cd	1168.0	889.6 b
BWP-2000	83.78 c	90.81 d	61.73 e	695.2 b	847.0	673.5 f
Inqlab-91	92.29 b	92.29 b	81.44 d	500.4 cd	589.4	349.2 h
Iqbal-2000	88.93 b	94.58 d	85.80 c	561.0 bc	548.4	750.9 d
SARC-1	61.38 d	138.40 b	95.07 b	385.0 cde	740.2	699.9 e
BWP-97	80.44 c	52.66 f	83.70 c	899.1 a	592.5	918.8 a
Darawar-97	105.5 a	84.48 e	88.78 c	367.9 de	403.6	474.0 g
LSD (0.05)	5.11	4.86	4.06	188.1	4.30	4.36

* Means not sharing a common letter in a column differ significantly at 0.05% level of probability

relative growth rate and net assimilation rate were reliable indicators to differentiate wheat cultivars for salt tolerance. Wheat cultivars showing low emergence in the field compensated the loss by an increase in subsequent growth during later growth stages.

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