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What role does tillering play in wheat tolerance to salinity?

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Abstract

Under saline conditions, the reduction in wheat yield is highly dependent upon the number of tillers. The objective of this study was to identify the role of tillering in salt tolerance of different wheat genotypes. Thirteen wheat cultivars were grown in saline soil in a greenhouse. The results demonstrated that there was a close correlation between tiller number and salt tolerance of 13 wheat cultivars. This may suggest that tiller number is one important trait of salt tolerance of wheat, which may also be associated with early vigour of wheat growth under saline conditions because tiller formation in wheat occurs during its early growth stages. Analysis of yield components of wheat showed that yield of the main spike is much less reduced as compared with that in other spikes by salinity, indicating that the mainstem tiller in wheat is probably more tolerant to salinity. To better understand the mechanism of salt distribution in maintem tillers and subtillers, the partitioning/retranslocation of salt in tillers should be studied to verify whether maintem tillers may play a role in the exclusion of salt to subtillers as a strategy for increasing their salt tolerance.

Introduction

Salinity affects about 7% of the world's total land area (Flowers, 2004). Most importantly, about 20% of irrigated land has suffered from secondary salinization and 50% of irrigation schemes are affected. Grain yield of wheat is highly dependent upon the number of spike-bearing tillers produced by each plant (Power and Alessi, 1978). The tillering ability enables a plant to adjust to its environment and to compensate when stand establishment is poor (Kirby and Faris, 1970). Although effects of salinity on the grain yield also occur during the periods of spike emergence to anthesis and maturity of grain under high level of salinity, the reduction in grain yield by salinity is mainly due to a decrease in the tiller number at the early growth stages (Maas and Grieve, 1990; Hu *et al*, 1997). However, little is known about the relation of tillering with salt tolerance in different wheat genotypes and the possible mechanisms of the inhibition of tillering in wheat.

The objective of this study was to investigate the relations between tiller or spike number and grain yield of 13 genotypes of wheat under saline conditions. The distribution of toxic ions among the maintem tiller and subtillers will be discussed in our companion paper.

Materials and methods

Plant materials

Thirteen varieties of spring wheat (*Triticum aestivum* L.) from different countries were used in this study. Eight varieties (Sakha 8, Sakha 93, Sakha 61, Sakha 69, Giza 168, Sids 1, Sahel 1 and Gemmeza 7) were obtained from the Agricultural Research Centre, Giza, Egypt. Sakha 8 and Sakha 93 are usually cultivated in saline areas in Egypt. Additionally, Thasos and Triso were obtained from Germany, Westonia and Drysdale from Australia, and Kharchia was from India. Kharchia is the most salt-tolerant of all wheat genotypes, and is used as a standard for salt-tolerance tests of wheat worldwide.

Growth conditions

This study was carried out in the greenhouse. The air temperature ranged from 23 to 28 ℃ in the daytime and 15 to 18 ℃ at night during the whole period of plant growth. Relative humidity fluctuated between 45% and 85% between day and night. Loamy soil was air-dried, ground, passed through a 5-mm mesh screen, and thoroughly mixed.

Four salt levels (control (no added NaCl), 50, 100 and 150 mM NaCl) in the soil were applied. The final water content (25% on dry soil basis) was achieved by adding tap water or salt solution (50, 100 and 150 mM NaCl) to each layer. To avoid an osmotic shock for seedling emergence, however, the topmost soil layer was not salinized until 10 days after sowing. There were 20 plants per pot. During the experiment, the pots were weighed daily and the water loss was replaced by adding tap water as needed. All treatments were replicated four times. After tillering, the total number of tillers was recorded. When the grain was mature, plants were harvested, and then the spike number, the grain yield per plant and the yield components of the main spike were measured.

Results

Tiller number at vegetative stage decreased with increasing salinity (Fig. 1). At 50, 100 and 150 mM NaCl, for example, tiller number was reduced by 22%, 28% and 37.5%, respectively, as compared with the control treatment. Similarly, the spike number was greatly reduced by salinity regardless of the genotypes. Spike number was highly correlated with tiller number which is in agreement with earlier reports by Maas and Grieve (1990) and Hu *et al.* (1997). Genotypic variation in tiller and spike number per plant at a given salinity level was observed (Fig. 1). At 150 mM NaCl, the highest tiller and spike number was found for Kharchia, while the lowest was recorded for Westonia, Sakha 61, Gemmeza 7 and Sids 1.

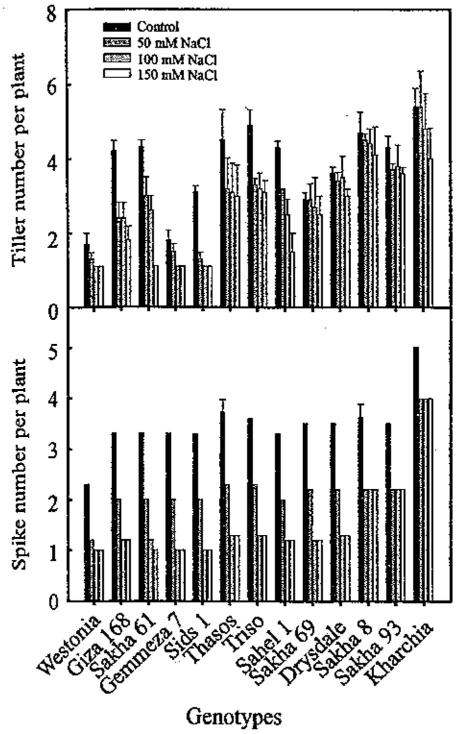

Figure 1. Effect of salinity on the tiller number at day 45 after sowing and on the spike number at final harvest for 13 wheat genotypes.

Fig. 2 shows that salinity markedly reduced grain yield per plant for all genotypes. The results also show a wide variation among genotypes. According to the grain yield per plant at 150 mM NaCl, for instance, Sakha 8, Sakha 93 and Kharchia were the most salt tolerant, whereas Sakha 61, Giza 168, Sids 1, Sahel 1, Gemmeza 7, Thasos, Triso and Westonia were the most salt sensitive (Fig. 2).

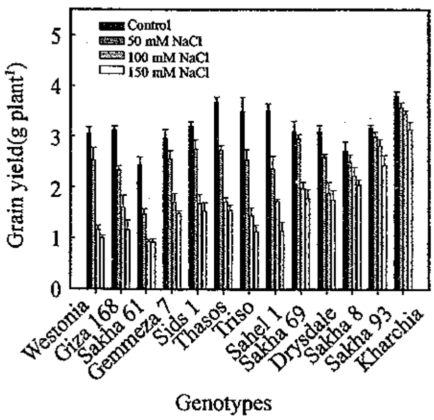

Figure 2. Effect of salinity on the grain yield of 13 wheat genotypes at final harvest.

Interestingly, the most salt-tolerant genotypes of wheat demonstrated a higher productivity of tillers or spikes and grain yield per plant (Fig. 3), suggesting that an increase in tillering can be a strategy for increasing wheat salt tolerance, and that tiller number per plant can be used as one important trait for screening of wheat cultivars to salinity.

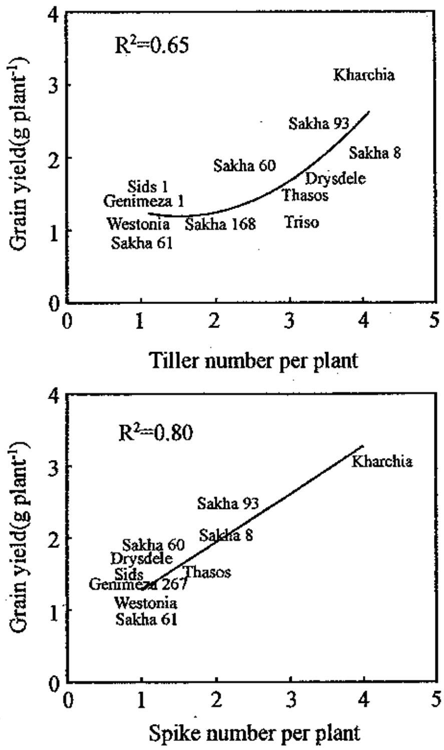

Figure 3. Correlation between tiller or spike number and grain yield per plant of 13 wheat genotypes at 150 mM NaCl.

Analysis of yield components of the main spike in wheat showed that yield was much less reduced as compared with that in other spikes by salinity, indicating that the maintem tiller in wheat is probably more tolerant to salinity.

Conclusions

Our study shows that salinity-decreased grain yield of wheat genotypes was related to a reduced number in tillers and spikes. The genotypic variation in salt tolerance associated with tiller or spike number suggests that an increase in tillering can be a strategy for increasing wheat salt tolerance, and that tiller number per plant can be used as one important trait for screening of wheat cultivars to salinity. However, mechanisms of the inhibition of tillering in wheat plants should be further studied.

Acknowledgments

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