Interactive Effects of Nutrients and Salinity and Drought on Wheat Growth

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Abstract

Spring wheat was grown in nutrient solution to study the interactive effects of macro-nutrients and salinity. Eight salinity levels were established (0, 20, 40, 60, 80, 100, 125, and 150 mM NaCl). The levels of macro-nutrients were 1.0-, 0.2-, and 0.04-strength Hoagland macro-nutrients (× HS). Interactive effects of nitrogen and water supply on the yield of winter wheat grown in sandy soil were investigated in the field. Drought was induced by withholding rainfall for one month during the vegetative growth period. The irrigated treatments received 100 mm of water more than the control treatment, which received only normal rainfall. A consistent decrease in above-ground dry weight with increasing salinity was observed at all levels of macro-nutrients. This decrease was partly counterbalanced in plants provided with high macro-nutrient levels, especially when the nutrients became a limiting factor. Thus, the present data suggest that improved fertilization management can alleviate growth inhibition caused by salinity, only at increased levels of macro-nutrients. Under drought and normal-rainfall conditions, increased application of N fertilizer did not affect grain yield, whereas under irrigated conditions there was significantly increased grain yield with increasing N application. Our studies suggest that increased nutrient supply will not improve plant growth when the nutrient is already present in sufficient amounts in the soil, and when there is severe drought or salt stress.

Keywords: calcium, field experiment, hoagland nutrient solution, N fertilizer, potassium.

Introduction

The increasing frequency of dry periods in many regions of the world, and the problems associated with salinity in irrigated areas frequently result in the consecutive occurrence of drought and salinity on cultivated land. Currently, 50% of all irrigation schemes are affected by salinity (Ghassemi *et al*., 1995;

Hillel, 2000). Nutrient disturbances under both drought and salinity reduce plant growth by affecting the availability, transport and partitioning of nutrients. However, drought and salinity can differentially affect the mineral nutrition of plants (Hu and Schmidhalter, 2005). Salinity may cause nutrient deficiencies or imbalances because of the competition of toxic Na and Cl ions with nutrients such as K, Ca and NO_3. Drought, on the other hand, can affect nutrient uptake and impair acropetal translocation of some nutrients. A better understanding of the role of mineral nutrients in plant resistance to drought and salinity will contribute to improved fertilizer management in arid and semi-arid areas and in regions suffering from temporary drought.

Materials and methods

Salinity versus macro-nutrients

Seven-day-old seedlings of spring wheat (*Triticum aestivum* L. cv. Lona) were transplanted to polyethylene containers filled with 30 l of nutrient solution. The experiment was conducted in growth chambers. Eight salinity levels were established: 0, 20, 40, 60, 80, 100, 125, and 150 mM NaCl. The levels of macro-nutrients were 1.0-, 0.2-, and 0.04-strength Hoagland macro-nutrients (× HS). The above-ground dry weight per plant was measured at final harvest. Dried flag and second leaves from the plant top at final harvest were chosen for analysis of ion (K and Ca) concentrations, which were determined with an ICP model Liberty 200 inductively coupled plasma emission spectrometer (Varian Australia, Mulgrave, Victoria, Australia).

Drought versus N fertilizer application

The interactive effects of nitrogen and water supply on the yield of winter wheat grown in sandy soil in the field were determined. Drought was induced by withholding rainfall for 1 month during the vegetative growth period. The irrigated treatments received 100 mm of water more than the control treatment, which received only normal rainfall. Grain yield was determined at final harvest.

Results and discussion

Above-ground dry weight is defined as the sum of leaf, stem, chaff, and grain dry weights. The results in Fig. 1 demonstrate a consistent decrease in above-ground dry weight with increasing salinity, at all levels of macro-nutrients. This decrease was partly counterbalanced in plants provided with high macro-nutrient levels, especially when the nutrients became limiting factors (e.g., at 0.04 × HS). Thus, the data here suggest that improved fertilization management can alleviate growth inhibition due to salinity only at the increased levels of macro-nutrients.

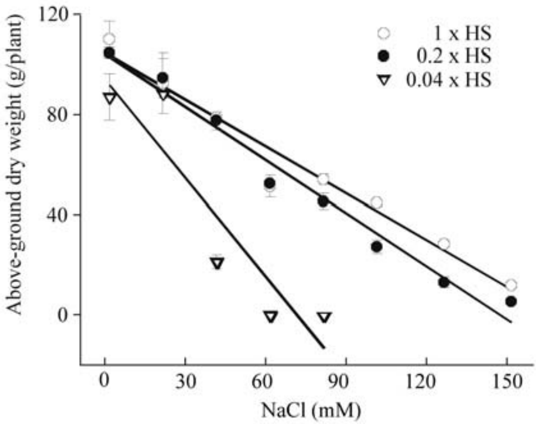

Fig. 1. The interactive effects of salinity and macro-nutrient levels on above-ground dry matter at the final harvest of spring wheat. Error bars represent standard deviations.

Fertilization management alleviated growth inhibition caused by salinity only when the macro-nutrients were increased. The potassium concentration in leaves decreased with increasing salinity (Fig. 2). Raising the macro-nutrient level from 0.04 to 0.2 × HS significantly increased the K concentration in leaves under saline conditions, but raising it further to 1.0 × HS increased the leaf K concentration only slightly. Calcium concentration in leaves decreased with increasing salinity and decreasing macro-nutrient level (Fig. 2). At a given salinity level, however, a change in Ca concentration in leaves as the macro-nutrient level was raised from 0.2 × HS to 1.0 × HS did not enhance their above-ground dry weight.

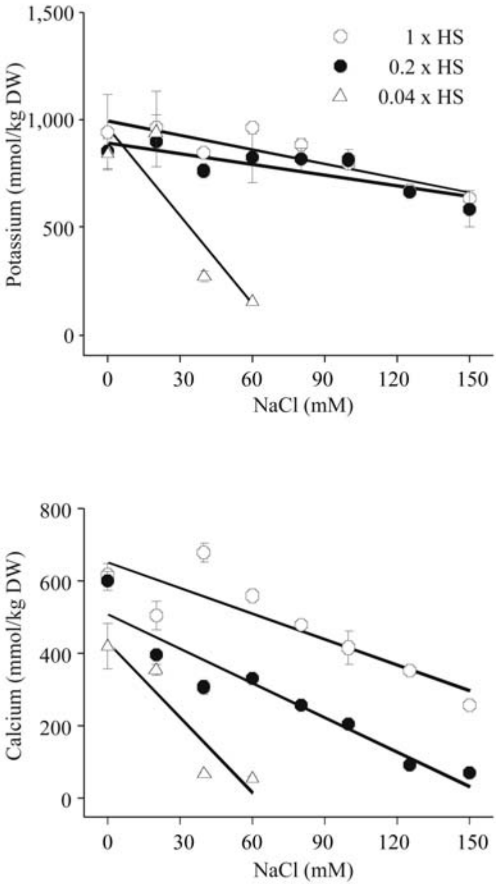

Fig. 2. The interactive effects of salinity and macro-nutrient levels on K and Ca accumulation in wheat leaves at final harvest. Error bars represent standard deviations.

Data in Fig. 3 show that under drought and normal-rainfall conditions, increased application of N fertilizer did not affect grain yield, whereas under irrigated conditions the increased N significantly increased the grain yield. As with the interactive effect of salinity and nutrients, the absence of a change in grain yield with increased N application, under drought conditions (Fig. 3) may indicate that in the present study drought limited the grain yield more severely than the N nutrition. In conclusion, the present results suggest that an increased nutrient supply will not improve plant growth when the nutrient is already present in sufficient amounts in the soil, and when the drought or salt stress is severe.

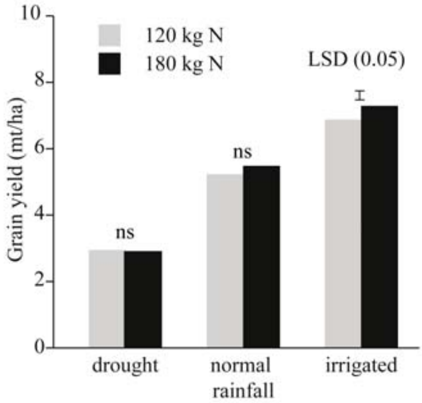

Fig. 3. The interactive effect of nitrogen and water supply on the yield of winter wheat grown in sandy soil. Drought was induced by withholding rainfall for one month during the vegetative growth period. The irrigated treatments received an additional 100 mm of water compared to the control treatment, which received only normal rainfall. Vertical bars and ns indicate LSD values at the 0.05 level and not significant, respectively.

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