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Full Length Research Paper

Micronutrients (Fe, Mn, Zn) foliar spray for increasing salinity tolerance in wheat *TRITICUM AESTIVUM* L.

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A pot experiment was carried out to investigate the effect of foliar application of micronutrient compound on improving wheat (var. Gemiza 3) for salt tolerance. Two concentrations (0.10 and 0.15%) of suspension micronutrient compound containing Fe, Mn, Zn in ratios 1:1:1 in concentration 2.8:2.8:2.8% were sprayed. Levels of NaCl (0-1000-2000-5000 ppm) were applied to irrigation water. Results revealed that growth and nutrients uptake were reduced with increasing NaCl concentration ,Na was increased, while K, Ca, P, N as well as K/Na, Mg/Na ratios, Fe, Mn, Zn and Cu also were decreased as salinity levels increased. Foliar spraying with suspension micronutrient induced stimulatory effects on growth parameters and nutrients uptake either before or after the salinization treatments.The results of this study suggest that foliar spray with micronutrient may have a potential role for increasing wheat tolerance to salinity stress.

Key words: salinity stress, foliar spray, Fe, Mn, Zn, salinity tolerance, wheat

INTRODUCTION

Wheat *(Triticum aestivum* L.) is considered as the major cereal crop in the world in respect of the cultivated area and total production. It provides an almost 20% of food energy for people in the world as well as in Egypt. Increasing wheat production is the ultimate goal to reduce the wide gap between production and consumption. Salinity is a major factor limiting the crop productivity in the arid and semi arid areas of the world (Flowers et al., 1997; Khan and Duke, 2001; Tester and Devenport, 2003). Wheat is generally classified to be moderately tolerant to salinity (Abou- Hadid, 2003). The reclamation of salt affected soils or introduction of more tolerant crops by means of traditional breeding programmes, and more recently by biotechnological methods, has been a relatively very expensive and slow process.

One approach is the use of foliar spraying for increasing plant tolerance to salinity by alleviating Na and Cl injury to plants (Alpaslan et al., 1999; El-Fouly and Salama, 1999; El-Fouly et al., 1997, 2002, 2004, 2010). The effect of micronutrient elements on yield and crop performance has been reported by many investigators. Rehm and Albert (2006) reported that, yields were higher for the treatments with micronutrients. In this respect, they reported that, foliar sprays of ferrous sulphate or chelates are found to be more effective and efficient than soil application in correcting Fe-chlorosis in wheat. Micronutrients spraying led to increasing macro and micronutrients uptake as a result of improving root growth which consequently led to greater absorbing surface (Abdalla et al., 1992). The objective of the study was to find out that micronutrient foliar spraying (mixture of Fe, Mn, Zn) can be used as a tool to increase wheat plant tolerance to salinity during early growth stages.

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MATERIALS AND METHODS

The present study was conducted under greenhouse conditions at the National Research Centre, Cairo Egypt. Grains of wheat (var. Gemiza 3) were obtained from Agricultral Research Centre, were sown in Mitcherlich pots filled with 7 Kg soil. 2.0 g triple phosphate (37% P_2O_5), 2.0 g ammonium nitrate (33% 0 N) and 1.0 g

Table 1. Analysis of Soil physico-chemical characteristics.

Soil characteristics							
Sand (%)	**Silt (%)**	**Clay (%)**	**Texture**	**pH**	**EC mmos /cm**	**$CaCO_3$ (%)**	**O.M (%)**
70.8	6.0	23.2	Sandy loamy	8.08	1.44	0.04	1.36

Nutrient concentrations								
Macronutrients (mg/100 g)					**Micronutrients (mg/kg)**			
P	K	Mg	Ca	Na	Fe	Mn	Zn	Cu
4	47	86	371	393	7.4	2.2	1.1	6.3

Figure 1. Effect of foliar application of micronutrients compound before and after salinity treatment on the growth of wheat plant. 1= 5000 ppm NaCl, 2= 5000 ppm NaCl+foliar spray (0.10%) before salinity, 3= 5000 ppm NaCl+foliar spray (0.15%) before salinity, 4= 5000 ppm NaCl+foliar spray (0.10%) after salinity, 5= 5000 ppm NaCl+foliar spray (0.15%) after salinity.

potassium sulfate (48 to 52%) K_2O were mixed with the soil before sowing. Prior to NPK application, soil was sampled and analyzed as shown in (Table 1). 20 days after sowing, plants were irrigated alternatively with saline and tap water. Levels of NaCl used were 0, 1000, 2000 and 5000 ppm. Two levels (0.10 and 0.15%) of suspension micronutrients compound containing of Fe, Mn and Zn in ratio 1:1:1 in concentration 2.8:2.8:2.8% was obtained from the piolet of Fertiliztion Technology Depatment, NRC. It was used to correct the nutrient imbalance caused by salt stress conditions. Micronutrient treatments were applied on 2 plant groups. First before salinity treatments (15 days after sowing) and the second one after salinity treatments (25 days after sowing). At flowering stage samples were taken for plant growth measurements and determine of nutrient contents according to Chapman and Pratt (1978).

RESULTS AND DISCUSSION

Effect of salinity on the dry weight

Data presented in (Figure 1) indicate that a gradual decrease was observed in both shoot and root dry weight in NaCl stressed plants. The decrement was rerelated to the concentration of NaCl. With 1000 ppm NaCl, wheat plants slightly coped with salt stress as shown in Figure 1. At high level of NaCl 5000 ppm both shoot and root dry weight of wheat were reduced from (1.69 to 1.10 g/plant) and from (0.29 to 0.17 g/plant) respectivelly. These findings agree with those obtained by (Din and Flowers, 2002; Al-Ansari, 2003; Morant et al., 2004). Such depressive effect of salinity in wheat growth may be attributed to the adverse effect on enzymatic processes through some interactions of salts and some organic substances of the cell (Oertil, 1996). Moreover, crop reduction due to salinity is generally related to the osmotic potential increase of the root –zone soil solution which leads to certain physiological changes and substantial reduction in productivity (Abou- Hadid, 2003).

Effect of micronutrient foliar spraying on the dry weight under salinity conditions

The dry weight of different organs of control plants increased due to spraying the micronutrients in both concentrations (Figures 1 and 2). The results also shown that spraying micronutrients in both concentrations on

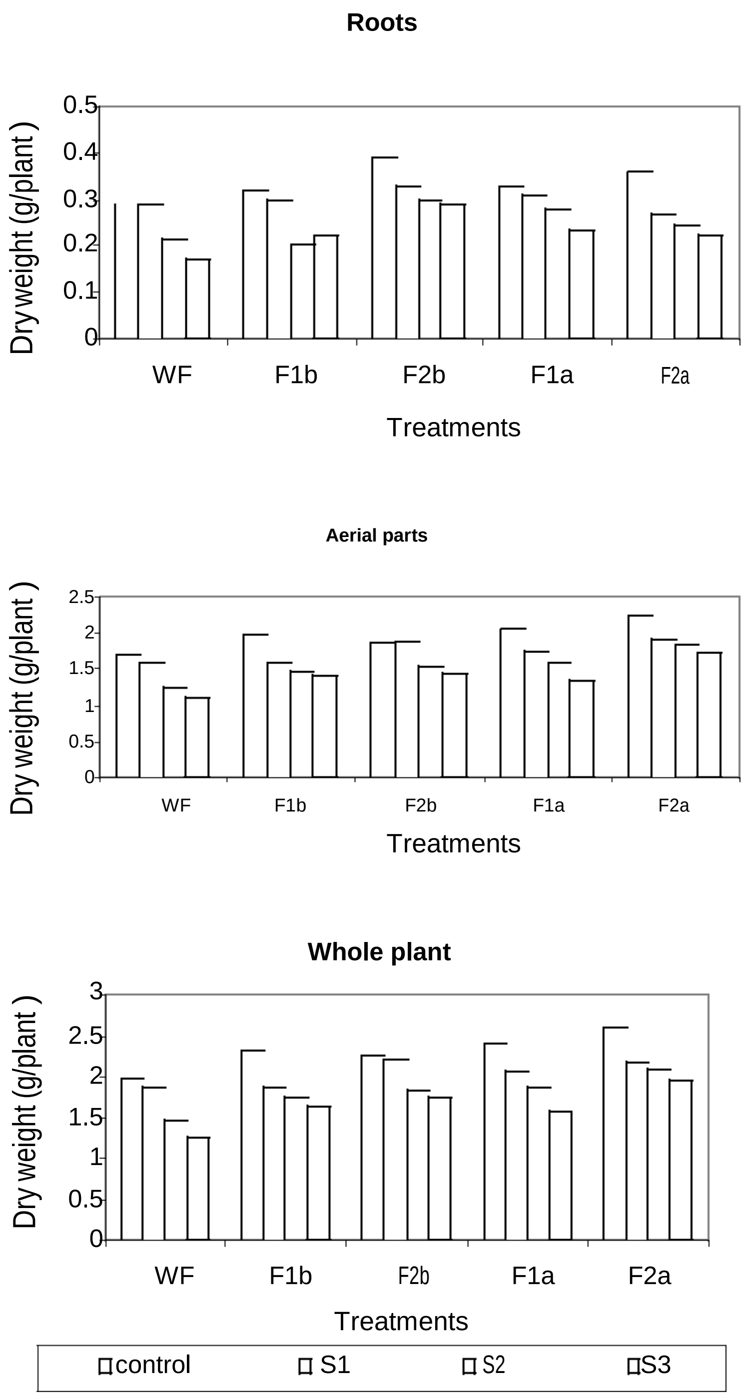

Figure 2. Effect of foliar application of micronutrients compound before and after salinity on dry weight of aerial and roots of wheat plant. W F = without foliar spray, F1b = Foliar spray (0.10%) before salinity, F2b = Foliar spray (0.15%) before salinity, F1a = Foliar spray (0.10%) after salinity, F2a=foliar sprat (0.15%) after salinity. Control= without salinity, S1=1000 ppm NaCl, S2=2000 ppm NaCl, S3=5000 ppm NaCl.

plants grown under salinity conditions increased the dry weight of arial parts and roots at all NaCl levels (Figures 1 and 2). The increment of dry weights of different organs of wheat plants were attributed to spraying micronutrients compound (0.10 and 0.15%). The highest increment was observed at 0.15% with aerial parts from (1.10 to 1.72

g/plant). Regarding, the foliar spraying with micronutrient compound of Fe, Mn or Zn increased shoot and root dry weights as compared with the control treatment.

Fe plays a key role in chlorophyll synthesis. In addition, iron enters in many plant enzymes that play dominant roles in oxidoredox reactions of photosynthesis and respiration (Curie and Briat, 2003). The superiority of Mn treatment resulted from the fact that manganese (Mn), is regarded as an activator of many different enzymatic reactions and takes part in photosynthesis.

Manganese activates decarboxylase and dehydrogenase and is a constituent of complex PSII-protein, SOD and phosphatase. Deficiency of Mn induces inhibition of growth chlorosis and necrosis, early leaf fall and low reutilization (Sajedi et al., 2009).

Effect of salinity on nutrients uptake

Concerning nutrients uptake in different organs of wheat plants, high salt concentration in the growth root medium was found to limit the uptake of all determined nutrients with different degrees. N, P, K, Mg and Ca tended to decrease with NaCl level increase (Figures 3 and 4). Under salt stress nitrogen uptake is limited by an accumalation of Na^+ and Cl^- and its composition with NO (Alam, 1999). A low content of N were due to decreasing synthesis of specific N compounds such as amino acids eq: proline and aspartic acids (glutamine and aspargine) (Mansour, 2000; Ashraf and Harris, 2004). Salinity reduces phosphate uptake and accumulation in different crops grown under salinity stress by reducing phosphate availability. Salinity induced K^+deficiency has been implicated in growth and yield reduction of various crops, spinach (Chow et al., 1990) and maize (Botella et al., 1997). NaCl also reduced Mg and Ca contents in all organs of plants (Figures 3 and 4). The reduction of Ca uptake in roots may be due to that most of Ca migrate to the shoot as an osmoregulation to resist salt determined effects on shoot cells.

Reduction of iron uptake was higher in the aerial parts compared to roots (Figure 5), which suggest that Fe accumulates in the roots because of lack of the processes energize translocation and a pH effect (Mass, 1993; Cravajal et al., 1999). Mn, Zn and Cu content was greatly reduced in the aerial parts with treatment 5000 ppm NaCl, while Zn uptake in the roots of wheat plants slightly increased compared with control plants.

However, in case of shoot Mn uptake, of test crop showed non-significant response. These findings are also in line with results obtained by Achakzai (2007, 2008) in sorghum and maize seedlings subjected to various levels of water stress conditions, as well as Achakzai et al. (2010) in uptake and accumulation of macronutrients by wheat.

Data presented in (Figure 5) showed that there was a decrease in uptake and accumulation of Cu in root and shoot of wheat subjected to different levels of salinity stress. Therefore, present findings in term of Cu uptake are in accordance with the results obtained by Alam (1999).

However, most other researchers indicated that in saline and saline sodic soils, the solubility of Cu is particularly low, and plants grown in such soils often suffer from deficiency of Cu (Rahman et al., 1993). They stated that leaf and stem Cu concentrations were found to decrease in salt-stressed maize grown both in solution cultures and soil. Similar results have also been reported by Tunçturk et al. (2008). Data presented in (Figures 4 and 5) shows a decreament in macro and micronutrients uptake in both shoots and roots of wheat seedlings. The results are in good agreement with those obtained by Murat et al. (2007) who reported that application of NaCl caused a decrease in, N, K, Fe and Cu and Zn concentrations. Such effect may be attributed to the effect of salinity on nutrient absorption. Under saline condition, nutrient absorption is restricted by lack of nutrients by small water potential in the rooting medium (Tabatabaei, 2006). The observed decrease in K might be related to the competition between the uptake of cations Na and K. Such competition might be due to the existence of general carrier for their absorption by the roots (Tattini et al., 1993). The decreases of Fe and Mn concentration in wheat under saline condition may be due to the depressive effect of salinity on root growth and distribution in soil.

Effect of micronutrient foliar sprays on nutrients uptake under salinity conditions

In response for spraying the level of micronutrient (0.10%) the uptake of N, P, K, Mg and Ca was increased (Figures 3 and 4). Wheares Fe and Zn uptake showed increases with 0.15% level (Figure 5) because of micronurients spray improved the performance of root growth and prevented the nutritional disorders and consequently caused increases the uptake of nutrients (El-Fouly et al., 2010). Micronutrients foliar spraying could partially counteract the negative effect of NaCl on nutrients uptake through improving root growth and preventive disorders and consequently caused an increase for the uptake of nutrients by the roots (El-Fouly et al., 2002).

Effect of salinty on nutrients concentration ratios

Concerning, the nutrient concentrations ratio in the plant tissues of wheat plants were affected by NaCl salt stress, the increase of NaCl level induced a decrease in K/Na and Mg/Na ratios in different parts of wheat plants (Figure 6). The decrease is more pronounced in the aerial parts. This decrease can be attributed to the increased

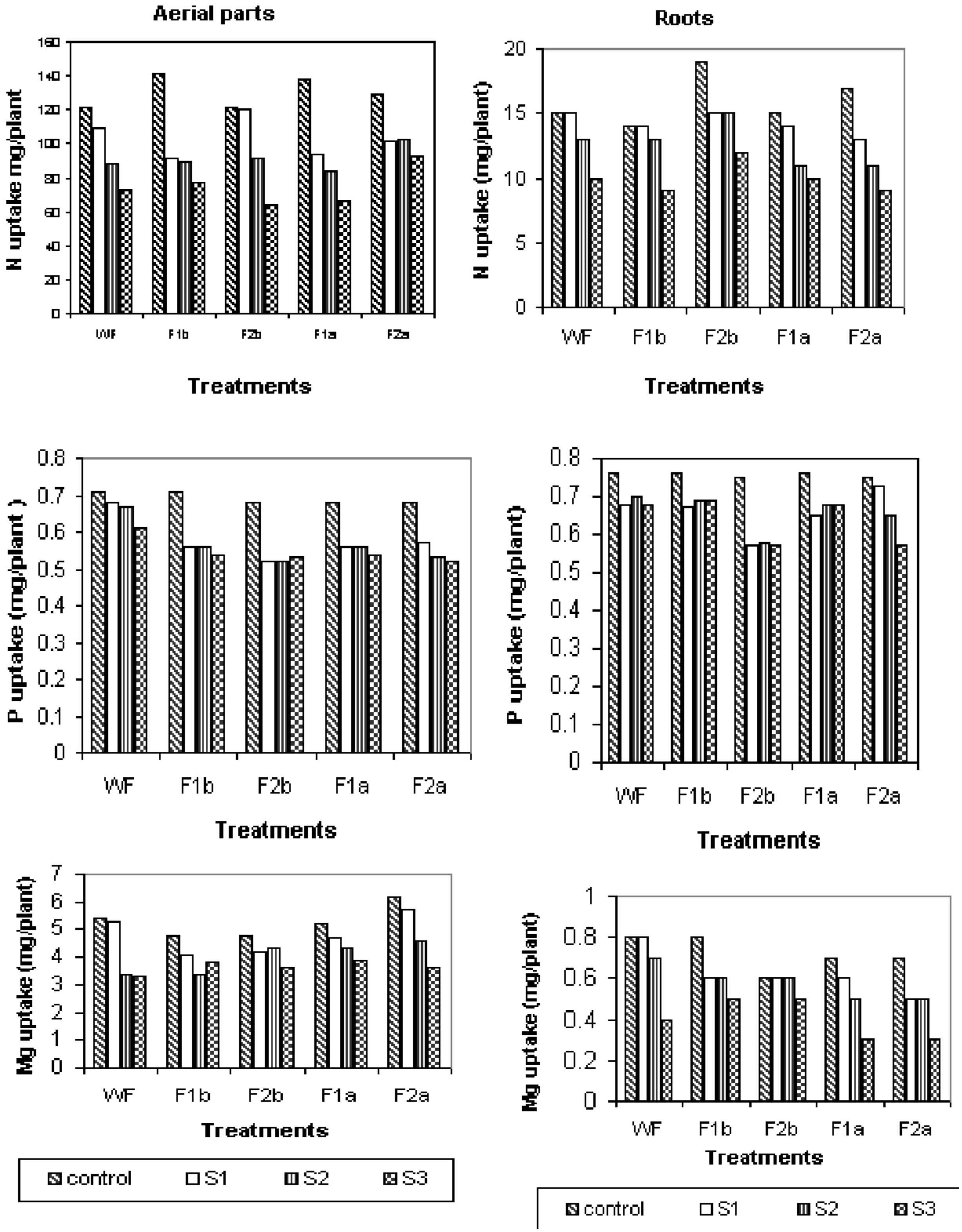

Figure 3. Effect of foliar application of micronutrients compound before and after salinity on N,P and Mg uptake of aerial parts and roots of wheat plant. W F = Without foliar spray, F1b = Foliar spray (0.10%) before salinity, F2b = Foliar spray (0.15%) before salinity, F1a = Foliar spray (0.10%) after salinity, Control= without salinity, S1=1000 ppm NaCl, S2=2000 ppm NaCl, S3=5000 ppm NaCl, W F = Without foliar spray, F1b = Foliar spray (0.10%) before salinity, F2b = Foliar spray (0.15%) before salinity.

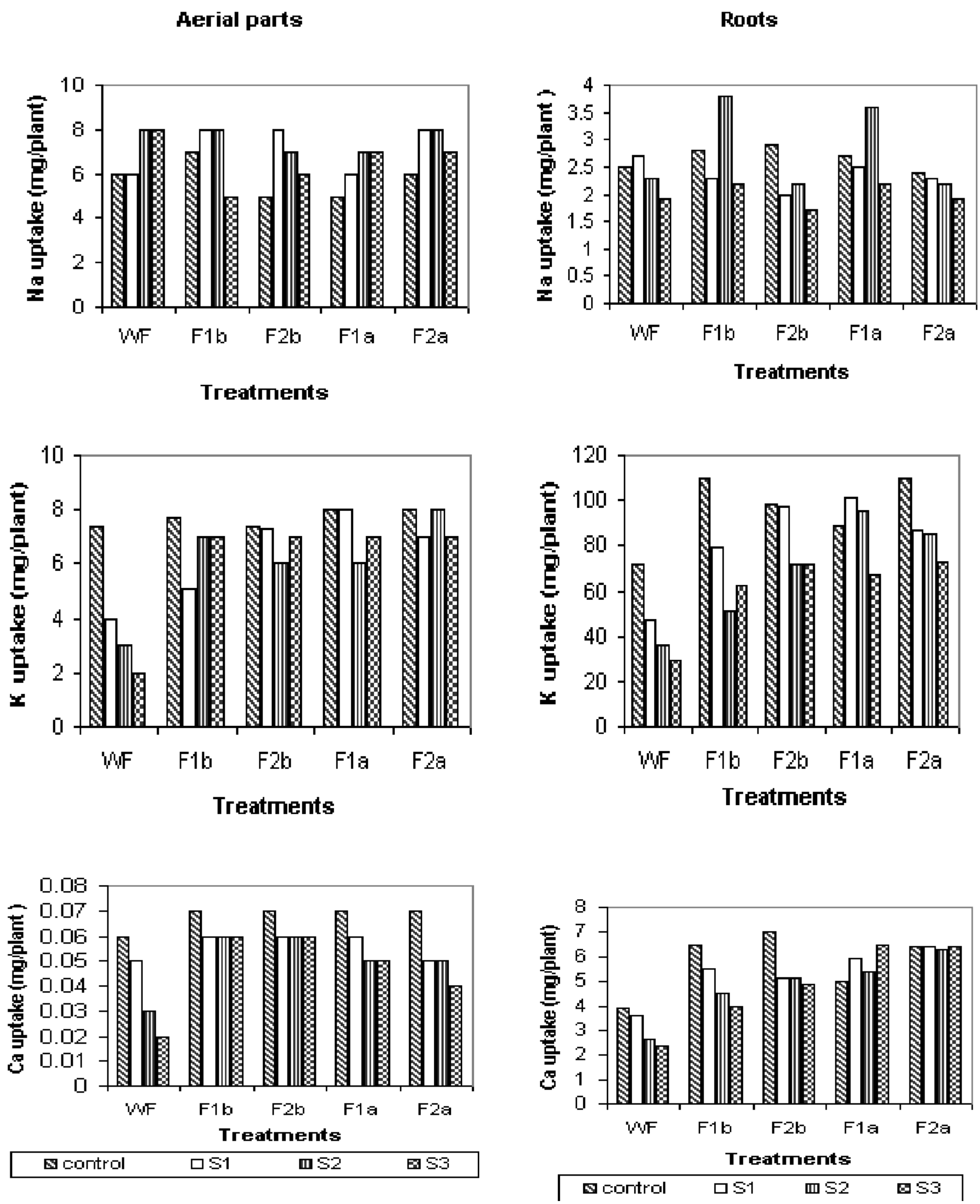

Figure 4. Effect of foliar application of micronutrients compound before and after salinity on Na, K and Ca uptake of aerial parts and roots of wheat plant. F1b = Foliar spray (0.10%) before salinity, F2b = Foliar spray (0.15%) before salinity, F1a = Foliar spray (0.10%) after salinity, F2a = Foliar spray (0.15%) after salinity n, Control = Without salinity, S1 = 1000 ppm NaCl, S2 = 2000 ppm NaCl, S3 = 5000 ppm NaCl.

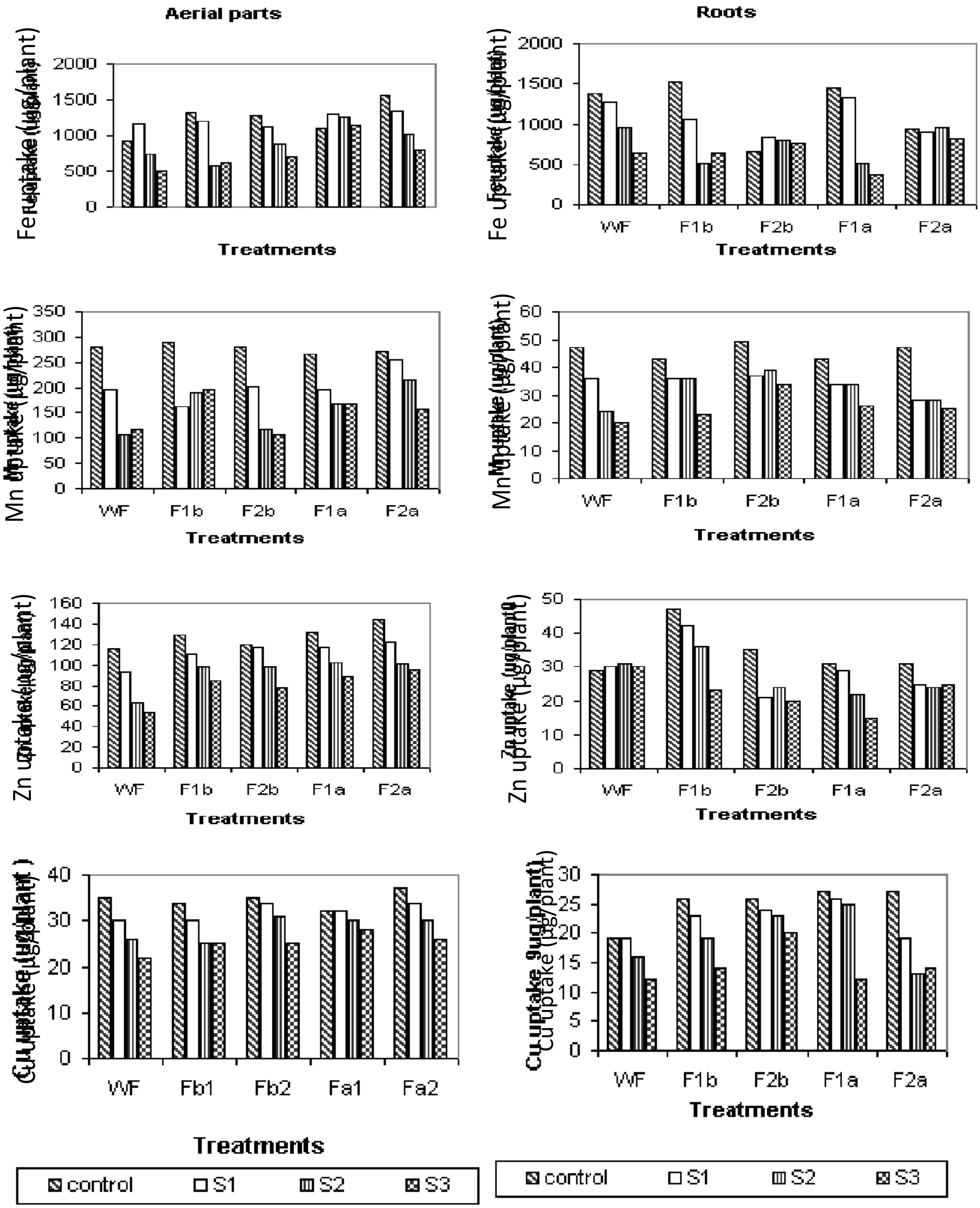

Figure 5. Effect of foliar application of micronutrients compound before and after salinity treatment on Fe, Mn, Zn and Cu uptake (µg/ plant) of aerial parts and roots of wheat plant.W F = Without foliar spray, F1b = Foliar spray (0.10%) before salinity, F2b = Foliar spray (0.15%) before salinity, F1a = Foliar spray (0.10%) after salinity, F2a = Foliar spray (0.15%) after salinity, Control = Without salinity, S1 = 1000 ppm NaCl, S2 = 2000 ppm NaCl, S3 = 5000 ppm NaCl.

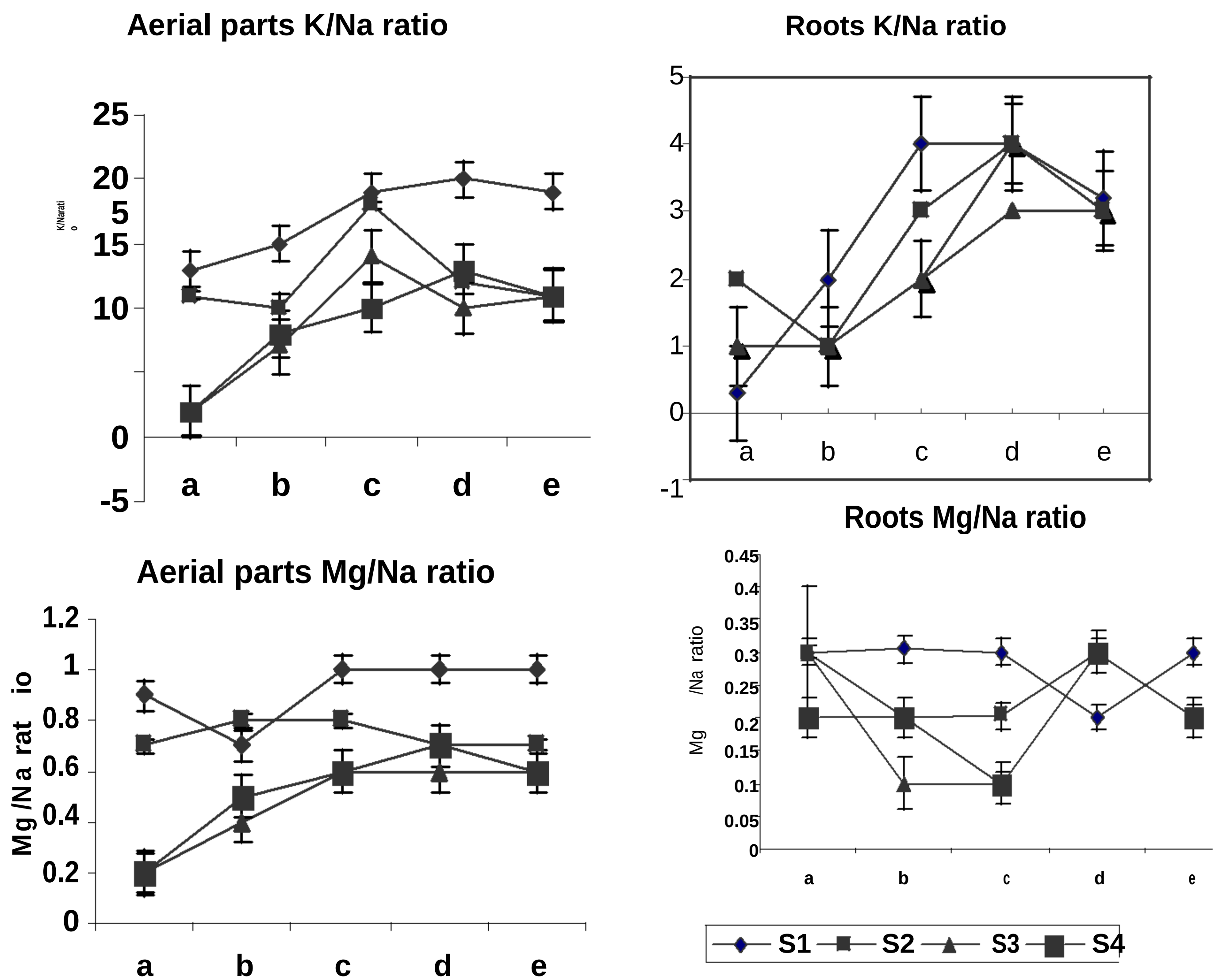

Figure 6. Effect of foliar application of micronutrients compound with different concentrations on K/Na and Mg/Na ratios under different conditions of salinity stress. S1:control, S2:1000 ppm, S3:2000 ppm, S4:5000 ppm, a : control, b : spraying with 0.1% before salinization, c : spraying with 0.1% after salinization, d : spraying with0.15% before salinization, e : spraying with 0.15% after salinization.

Na concentration level which diminished the concentration of both K and Mg concentrations giving low values of both K/Na and Mg/Na (Cuartero and Fernandeze, 1999). In this respect, it was reported that nutrient concentration ratios might be considered as an indicator of crop tolerance to NaCl stress.

Effect of micronutrient foliar spraying on nutrients concentration ratios

Nutrient concentration ratios in plant tissues were found to also affected by foliar spray. Micronutrients spray revealed a pronounce effect with decrease the ions of Na^+ uptake. Consequently, the K/Na and Mg/Na ratios showed high values (Figure 6). This may be attributed to that foliar spray of micronutrients under NaCl stress could increase the capability of root system for selectivity K^+ and Mg^+ ions at high concentration of NaCl, which allows the maintenance of the transport of both ions and the limitation of Na ion uptake in the shoots (Tattini et al.,1993; Carvajal et al., 1999).

Conclusion

Based on the results obtained, it might be concluded that foliar application of micronutrients could be useful for improving the nutrient status, root features and physiological performance of wheat plants. These results are similar to those obtained through foliar application of micronutrients (El-Fouly and Salama, 1999; El-Fouly et al., 2010, suggesting that this type of treatment might be used to induce increases in tolerance to salinity.

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