Investigation of Relationships between Salt Stress, Potassium Application and Macro Element Uptake in Pepper Plant

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Abstract

This study was carried out to determine how plants behave in the uptake of macro nutrients by using different doses of potassium (K^+) together with salt to understand how to recover from stress. Demre Sivri pepper variety was used in the study. The study was carried out in a controlled climate room for 16/8 hours with light / dark photoperiod, 25 ° C and 70% humid climate. Seedlings formed after germination of seeds transformed in pumice were taken to hydroponic culture after having 2 true leaves. Hoagland nutrition solution was used in hydroponic culture. 116, 136, 156 and 176 ppm potassium (K^+) was used in the present Hoagland solution. In addition, 100 mM NaCl salt was applied to the plants. Sampling for measurements and analyzes was performed on day 20 of salt administration. In these samples, total plant weight and potassium (K^+), calcium (Ca^{+2}), magnesium (Mg^{+2}) element contents were determined. At the same time, Na^+ and Cl^- uptake were also investigated because of the salt application. The results showed that K^+ doses of 156 ppm and 176 ppm were effective in ion uptake and reduction of harmful effects of salt.

Keywords: Pepper, Ion accumulation, Potassium doses, Salt stress

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1. Introduction

In plants exposed to salt stress, the decrease in yield is due to the direct toxic effect of sodium (Na) and similar cations in the environment. Reaching high levels of salt stress Na and Cl, K, Ca, N uptake of plants by reducing the ion balance can cause deterioration (Gunes et al. 1994; Inal et al., 1995). There is a positive effect between the amount of K found in the leaf of the plant and the increase of plant resistance under saline conditions and high K^+ / Na^+ ratio is proportional to salt (Sherif et al., 1998). In case of potassium or calcium deficiency, osmoregulation in the plant is disrupted and enzyme activation is inhibited and metabolism is negatively affected. In such a case, an external potassium supplement should be made. In this way, the plant is affected by stress is reduced (Kaya et al., 2006).

Yaşar et al., (2006a) found that under the stress of eggplant, two sensitive and two tolerant varieties used in the study of sensitive genotypes were found to be higher Na and Cl ion accumulation, K and Ca amounts of these genotypes have reported a decrease. Similar results were obtained from the studies of Yaşar et al. (2006b; 2013), Üzal, (2009), Üzal and Yıldız, (2014).

Potassium intake in salty soil conditions also decreases due to water stress and water insufficiency, potassium plays an important role in alternative nutrition (Kemmler and Kraus, 1971). There is a positive

correlation between the amount of potassium present in the plant leaves and the increase in plant resistance under saline conditions and high K^+ / Na^+ ratios are directly proportional to salt resistance (Sherif et al., 1998).
The aim of this study was to determine the relationship between K uptake, macro element uptake and Na, Cl accumulation in stressed plants by applying different doses of K in nutrient medium together with salt stress to Demre peppers.

2. ***Material and Method***

This research was carried out in the climatic room of Van Yuzuncu Yıl University, Faculty of Agriculture, Department of Horticulture, Physiology Laboratory. Demre Sivri Pepper variety was used in the study.
The experiment was carried out in a split air-conditioned climate room with normal atmosphere and water culture. The main objective of the experiment is to ensure that the effects of salt stress occur as normal under normal conditions. In this way, the stress level to which the plants are exposed in the outdoor environment will be measured with the least margin of error and the results obtained as a result of the application of the results obtained will show greater consistency with the study results.

Table 1. Contents of the nutrient solution used (ppm).

Elements	App. 1 Control (ppm)	App. 2 K1+ NaCl (ppm)	App. 3 K2+ NaCl (ppm)	App. 4 K3+NaCl (ppm)	App. 5 K4+ NaCl (ppm)
Nitrogen (N)	186	186	186	186	186
Phosphorus (P)	31	31	31	31	31
Potassium (K)	**136**	**116**	**136**	**156**	**176**
Magnesium (Mg)	49.28	49.28	49.28	49.28	49.28
Calcium (Ca)	200	200	200	200	200
Sulfur (S)	66	66	66	66	66
Iron (Fe)	3.3	3.3	3.3	3.3	3.3
Manganese (Mn)	0.031	0.031	0.031	0.031	0.031
Boron (B)	0.205	0.205	0.205	0.205	0.205
Copper(Cu)	0.015	0.015	0.015	0.015	0.015
Zinc (Zn)	0.023	0.023	0.023	0.023	0.023

The nutrient solution used was prepared according to (Hoagland and Arnon, 1938).

In the study, first of all, pepper seeds were sown in 40x25x5 cm plastic germination cups filled with pumice sieved and then watered with fountain water. The bottom surface of the germination vessels has 9 holes with a diameter of 0.5 cm and the irrigation water is used by the plants. After the pumice was thoroughly wetted and the irrigation water was used by the plants, the germination pots were placed in the climate room with 25±2ºC temperature 70% humidity, covered with A4 paper and the containers were regularly checked and the pumice was continued to be irrigated with tap water. For the better development of the seedlings, the cotyledon leaves coming horizontally and the first true leaves (3-4) began to be seen, irrigation was started with Hoagland nutrient solution. (Hoagland and Arnon, 1938).

2.1. Mineral element analysis

Three leaves from tip to downward were taken and they were kept in deep freezer at –84ºC. About 200 g samples were taken from the deep freezer and samples were supplemented with 10 ml 0.1 N HNO_3 (Nitric acid). They were then kept in plastic boxes at dark and room temperature for a week. The samples were shaken in the shaker for 24 hours and Na^+, K^+, Ca^{+2}, Mg^{+2} contents were determinated in Atomic Absorption Device according to Kacar (1994). Cl^- ion was measured by an automated chloridometer (Buchler – Cotlove chloridometer) which was analyzed by colorimetric amperometric titration with silver ions. At the end of these measurements, the amount of ions in the fresh leaf sample was determined as µg/mg fresh weight (Taleisnik et al., 1997).
All results were the means of three replicates, and each replicate consisted of fifteen plants. Data were analzsed statistically and treatment means were separated by Duncan's Multiple Range Test using SAS (1985) software. Experiments were conducted in complete randomized plots design with 3 replications. Resultant data were subjected to statistical analyses with SAS software (SAS Institute, 1985).

3. Results

At the end of the application of 100 mM NaCl salt stress for 20 days, the data obtained in terms of the amount of Na, K, K/Na, Cl, Ca and Mg ion in the leaf is given in Table 2.

Table 2. Ion deposits in leaf parts after application (µ g / mg F.W.)

Application	Na^+	K^+	K^+/Na^+	Cl^-	Ca^{+2}	Mg^+
Control	0.482 D	26.616 A	17,960 A	0.267 D	5.455 A	25.159 B
K1+Salt	9.544 A	11.009 C	1,153 D	6.420 A	3.049 B	13.782 C
K2+ Salt	4.585 B	17.136 B	3,737 C	4.297 B	2.747 B	14.500 C
K3+ Salt	3.680 C	25.217 A	6,852 B	3.842 B	5.888 A	26.188 B
K4+ Salt	3.625 C	25.174 A	6,945 B	2.215 C	3.350 B	28.927 A

The difference between the means taking the same capital letter in the same column is insignificant according to $P \leq 0.05$. (F.W. Fresh Weight)

Na deposition in the leaves of salt treated plants decreased due to the increase in potassium doses. The highest Na accumulation was observed in K1 + Salt application while the lowest Na accumulation was observed in K4 + Salt application.

The accumulation of K in the leaves of the plants treated with salt increased due to the increase of K doses. Similar to the control, the highest K accumulation was observed in the leaves at K4 + salt dose.

It was observed that there were differences between the doses in terms of K / Na ratio in the leaves of the plants treated with salt. As the potassium dose increased, K / Na ratio in the leaves increased. After the control application, the highest K / Na ratio occurred in K4 + Salt application.

In terms of Cl accumulation in the leaves of the plants treated with salt, the difference between the other treatments except the control was found to be statistically significant. There was an increase in Cl ion accumulation in other applications compared to the control group. Cl accumulation in the leaf organ increased compared to control. The highest increase was seen in K1 + Salt application where the lowest potassium dose was applied, while the lowest Cl accumulation was observed in the application of K4 + Salt where the highest potassium dose was observed. As the K dose increased, the accumulation of Cl in the leaf decreased.

It was seen that there were differences between the applications in terms of Ca accumulation in the leaves in the salt treated plants. Except for K3 + Salt application, Ca deposition decreased in leaves compared to control. K3 + Salt application was in the same statistical value range as the control, while other applications were in the same range.

In the study of salt application, it was found that there are differences in Mg^+ accumulation in leaves. There was a decrease in low doses of potassium before leaf control, there was an increase in high doses.

4. Discussion and Conclusion

On the 20th day of application of different K doses with 100 mM NaCl, pepper plants had the highest decrease in total plant weight compared to the control at the 1st dose of potassium. Yasar et al. (2006a, 2006b, 2008, 2013, 2016) showed that total plant weights were an important parameter in determining the response to salt stress. In addition, salt has had a negative impact on other plant growth parameters. The first dose of potassium did not have the effect of reducing the negative effect of the salt, while the second, third and fourth doses were those which were positively effective, respectively. The results of our study showed that the growth and development of plants are reduced due to the slowing of the respiration of plants in saline environments. Hormonal disorders occur in the plant as a result of the deterioration of the respiratory system, that is, the decrease in stomal mobility, and consequently decrease in the photosynthesis of the plant, thus decrease in the assimilate formation and decrease in the growth and development of all these (Çakırlar and Topçuoğlu, 1985; Yasar, 2003; 2007).

One of the most important reasons for the decrease in the growth of salt stressed pepper plants is the amount of Na they accumulate in their bodies in excess and toxic levels. However, in potassium applications, Na accumulation in leaves decreased as K dose increased. Especially in the K4 dose, the decrease in Na accumulation was more pronounced than the K1 dose. Ion regulation is one of the most prominent features in determining the tolerance of plants to salt. Plants with high NaCl salt concentration receive excessive Na ions. The uptake of K ion, which is very similar to sodium ion due to its ionic diameters and electrical charges, is prevented. In contrast, higher K and Ca uptake during the uptake of low Na and Cl ions in salt conditions of some plant genotypes is a key mechanism of tolerance. Tissues of plants with better tolerance to salt stress are generally capable of producing a higher K / Na ratio. Many studies (eggplant, bean, melon, tomato and pepper) to determine the tolerance to salt stress in

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plants, K / Na and Ca / Na ratios in different plant organs and the determination of Na^+ concentrations in tissues appear as an important parameter (Marschner, 1995; Daşgan et al., 2002; Yaşar, 2003; Zeng et al., 2003; Aktaş et al., 2006; Kuşvuran et al., 2007; Daşgan and Koç, 2009). Due to its very similarity due to its ionic diameters and electrical charges, K and Na ions significantly reduced Na uptake by showing the effect of K doses in saline environment in order to convert the advantage of K and Na ions in favor of K.

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