Effect Of Potassium Stress On Seed Germination And Growth Of Popcorn (K.Sc.6o4 P.C)

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ABSTRACT: Environmental factors may influence popcorn germination rates and seedling establishment before seeds are even produced. Evaporation and transpiration remove pure water from the soil. This water loss concentrates solutes in the soil. When irrigation water contains a high concentration of solutes, Potassium can reach rapidly injurious levels vis-à-vis salt-sensitive species. One factor limiting Popcorn plant (Zea mays everta Sturt(K.sc.6o4 p.c.)) domestication in the central areas of Iran is the damage caused by salt effect since irrigation enhances salinity in plantation soils. The objectives of this study were to define the effect of various KNO3 concentration levels on plant growth and seed germination. The tolerance to salinity of Popcorn seed and seedlings was assessed at KNO3 concentrations of 0, 1.2, 2.4, 3.6, 4.8, and 6 g l$^{-1}$ and the experiment was undertaken in the laboratory under greenhouse conditions. Results obtained show that more than half of the seeds germinated in the presence of 4.8 g/l of KNO3; whereas 4.8 g/l of KNO3 inhibited completely the emergence of plumes. Concerning Popcorn seedlings, 3.6 g/l of KNO3 marked the start of negative affect on the growth.

Keywords: seedling, Potassium, Popcorn, salinity.

Introduction

Environmental stresses are among the most limiting factors to crop plant productivity. Salinity is one of the most detrimental ones (Flowers et al., 1997, Boyer, 1982). The progressive salinisation of irrigated land produces vast amounts of uncultivated soils (Ashraf, 1994). The deleterious consequences of high salt concentrations in the external solution of plant cells are hyperosmotic shock and ionic imbalance (Niu et al., 2000). Plant survival and growth are dependent on adaptation and tolerance that re-establish ionic homeostasis, thereby minimizing the duration of cellular exposure to disequilibria of ions by maintaining the osmotic balance and thus widening cultivated areas (Marshner, 1986). Plants tolerance toward salts is a complex phenomenon which affects several aspects of the plant. The germination rate and early growth under salty soils indicate clearly that the plant is tolerant to environmental stresses (Tal, 1985). Poor germination and seedling establishment adversely affect growth and development of crop plants and results into low yields of crop plants. The success of seedling vigour depends on formation of radicle and plumule. Seedling vigour in the form of root length and shoot length of crop plants are positively affected by humic acid application (trfan et al., 2005, Ulukan 2008). Halophyte germination is affected in two ways when seeds are exposed to saline conditions. Firstly, the high osmotic potential of the medium prevents the embryo from taking up water, and secondly, the toxic effect of some ions leads to embryo poisoning (Pollack & Waisel, 1972). It is difficult to
decipher the exact share that is caused by an excess of ions or that is due to water deficiency. Glycophyte species are generally affected by an excess of ions in spread mature leaves and by hydrous deficit in the young expanding ones (Greenway & Munnus, 1980). Among studies looking at the factors affecting popping characteristics (especially expansion volume) of popcorn, many have focused on physical properties of the popcorn kernels. These physical properties include kernel size (Willier and Brunson 1927; Lyerly 1942; Haugh et al. 1976; Lin and Ananthawaran 1988; Pordesimo et al. 1990; Song et al. 1991), length, width, and thickness or kernel sphericity (Willier and Brunson 1927; Lyerly 1942; Haugh et al. 1976; Pordesimo et al. 1990), and kernel density (Lyerly 1942; Haugh et al. 1976; Chang 1988). Due to differing moisture contents, varieties, methods of popping, term definitions, measurements, and experimental conditions in previous studies, results have been contradictory and inconclusive at best. Willier and Brunson (1927) explained that small kernels were much more likely than large kernels to have a large proportion of hard endosperm, which is why the expansion volume was highest in the lightest kernels. Lyerly (1942) conducted the experiments by oil popping and obtained results in agreement with Willier and Brunson (1927). In contrast, Lin and Ananthawaran (1988) reported that large kernels had higher expansion volumes than small kernels when microwave popping methods were used. Pordesimo et al. (1990) indicated that expansion volume increased from kernels retained on standard sieves 13 to 15, then decreased from kernels retained on sieves 15 to 17 when popped by a microwave popping method. Song et al. (1991) also concluded the middle-sized (retained on sieves 13 and 14) popcorn kernels had the highest expansion volume by oil popping. Willier and Brunson (1927) showed that length, breadth, and thickness of kernels were correlated negatively with expansion of popcorn. Among these three dimensions, length had the greatest negative correlation with expansion and thickness had the least. Lyerly (1942) used the oil popping method and reported that length and width of kernels had negative correlations with popping expansion but thickness of kernels had a positive correlation. Haugh et al. (1976) did not mention the relationship between sphericity and expansion volume directly, although they did notice that kernels at the butt location of the ear had the greatest value for sphericity, and popcorn with greater test weights had greater expansion volumes. Pordesimo et al. (1990) popped five varieties of popcorn in a microwave oven and expansion volumes were positively correlated with sphericity ($r = 0.87$). They concluded that smaller, shorter, and broader kernels with higher sphericities had higher expansion volumes. Lyerly (1942) showed that density of kernels had a weak positive correlation with expansion ($r = 0.26$). Haugh et al. (1976) investigated 12 varieties of popcorn and used a specific gravity gradient tube to measure kernel densities. No statistically significant differences in specific gravities were found at 15.5% moisture content for 12 varieties of popcorn, but hybrids with higher specific gravities had higher expansion volumes. Pordesimo et al. (1990) measured the specific gravity of popcorn in three solutions with different known specific gravities. They found that the mean specific gravities of four out of five varieties were not significantly different from each other, but expansion volume significantly increased as specific gravity of kernels increased within one variety investigated. Chang (1988) measured density of grain kernels using a gas pycnometer. Popcorn has deep root systems and grows in both arid and saline conditions (Brown et al., 1996; Jensen & Salisburry, 988). Most of the oriental Iran land surface is arid or semiarid. Unfortunately these areas can only be made more productive by irrigation. A strong link with salinisation (Ghassemi et al., 1995), throws an immediate question over the sustainability of using irrigation to increase food production. Furthermore, given the amount by which jobs creation will have to be increased, it seems reasonable to introduce salt tolerant and drought resistant plants with economic values to this area to improve the sustainability of rural activities and thus tackle rural emigration. We have undertaken the introduction of Popcorn (K.sc.604 p.c) in the semiarid area of the central part of Iran (Markazi province) for the first time in 2004. In order to improve the domestication, it is necessary to study its resistance under non-biotic stresses. In the present study, we examine the effect of various levels of KNO3 concentration on the germination and the growth of Popcorn seedlings.

**Material and Methods**

**Seed priming:** To accomplish the priming study, self pollinated seed of “Sancerre” were used. For early seed germination priming was done with different concentrations of potassium nitrate (KNO3) as mentioned in Table 1. The effect of these treatments on seed germination and vigor was also determined. The percent solutions were prepared by dissolving 1, 2, 3, 4, 5 and 0 g KNO3 per 100 ml distilled water correspondingly. Seeds were dipped in different concentrations (1 to 5%) of KNO3 solution and in distilled water i.e., T6 in a
beaker for duration of 48 hours. For each treatment, 40 seeds were kept on filter paper treated with fungicide solution of Topsin M @ 2g/L and placed in the growth chamber at a temperature of 20 ± 2ºC for germination. The optimum moisture was maintained by application of distilled water with two days interval. The data for germination percentage (%), number of days required to attain 50% of the final germination, mean germination time (MGT) was recorded during the course of study from 20 seeds, randomly selected from each treatment. After seed germination, observation were taken for seedling length, bulb weight and bulb diameter.

Table 1. Different priming treatments to enhance seed germination popcorn.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>KNO3</th>
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<tbody>
<tr>
<td>T1</td>
<td>1 % Solution</td>
</tr>
<tr>
<td>T2</td>
<td>2 % Solution</td>
</tr>
<tr>
<td>T3</td>
<td>3 % Solution</td>
</tr>
<tr>
<td>T4</td>
<td>4 % Solution</td>
</tr>
<tr>
<td>T5</td>
<td>5 % Solution</td>
</tr>
<tr>
<td>T6</td>
<td>Distilled water (0 %)</td>
</tr>
<tr>
<td>T7</td>
<td>No treatment (control)</td>
</tr>
</tbody>
</table>

Statistical analyses
The statistical analysis was carried out by the test of comparison of means in order to detect the effect of salt on germination and growth parameters. In the same way, the correlation analysis was given between each one of these parameters and the KNO3 concentrations.

Results and Discussion
The germination of Popcorn seeds was affected negatively by KNO3 starting from the concentration of 3.6 g/l, whereas the concentration of 1.2g/l stimulated this germination (fig. 1). Comparison of the mean germination rates vis-à-vis various KNO3 concentrations shows that the salt effect was raised when KNO3 concentrations ranged from 4.5 to 6 g/l. These results revealed the depressive effect of strong salt concentrations and are in agreement with those observed in the case of the Argania spinosa plant (Reda Tazi et al. 2001). In the case of Hordeum vulgare and Atriplex halimus, the effect of KNO3 was observed in situ starting from 10g/l (Sibi and Fakiri 2000; Ben Naceur et al. 2001) and 13 g/l (Belkhodja et al. 2004; Choukr-Allah et al.1997) respectively. It is also noted that a concentration of 2g/l of KNO3 stimulated the rate of germination of Atriplex halimus.

Figure1: Effect of KNO3 concentrations on the rate of plumule emergence
As salinity reached 3.6 g/l of KNO3, the rate of the plumule emergence of Popcorn seeds decreased by 50% and it was completely inhibited by KNO3 concentration of 4.5 g/l. In the meantime, the rate of germination decreased slightly to 73% compared to the control sample (fig. 1) at 4.5 g/l of KNO3. These results are in agreement with earlier reports on argan (Reda Tazi et al., 2001) and cereals (Malek-Maalej et al., 1998; Ben Naceur et al, 2001). Statistical analysis of results obtained for samples under salt stress showed significant control differences. The monitoring of electrical conductivity at the start and end of the salinity treatment showed a considerable increase in this parameter for all media except for the control one where the final conductivity was slightly lower than the initial one (Table 1). This strong final electric conductivity can be explained by the cumulative effect of various solutions used for irrigation, which blocked the opening of the plumule. The incubation of samples with 6g/l KNO3 solution resulted in salt accumulation at the soil surface and produced a salinity medium with concentration of 16g/l of KNO3.

Table 1. Initial and final electric conductivity in different Petri dishes

<table>
<thead>
<tr>
<th></th>
<th>Initial electrical conductivity $^a$ (mmhos/cm)</th>
<th>Finale electrical conductivity $^a$ (mmhos/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>0.45</td>
<td>0.26</td>
</tr>
<tr>
<td>T1</td>
<td>1.73</td>
<td>3.01</td>
</tr>
<tr>
<td>T2</td>
<td>6.1</td>
<td>6.73</td>
</tr>
<tr>
<td>T3</td>
<td>8.12</td>
<td>15.12</td>
</tr>
<tr>
<td>T4</td>
<td>12.20</td>
<td>24.25</td>
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<tr>
<td>T5</td>
<td>13.12</td>
<td>25.01</td>
</tr>
<tr>
<td>T6</td>
<td>14.01</td>
<td>28.12</td>
</tr>
<tr>
<td>T7</td>
<td>15.02</td>
<td>26.01</td>
</tr>
</tbody>
</table>

$^a$ Average values reported with R.S.D.< 5%

The effects of salt on the shoot system growth were highly perceptible. Indeed, significant statistical differences were observed in the case of samples treated with salt concentration of 3.6, 4.8 and 6 g/l over the control one. Results indicated that length reduction over control of the stem was 25 and 69% for samples watered by KNO3 solutions of 3.6 and 6 g/l respectively (fig. 2). It appeared clearly that the growth in length of the Popcorn seedlings was very affected by strong KNO3 concentrations. These results are in agreement with those reported by Benzioni et al., (1992) where Popcorn responded to soil salinity by reducing its shoot system. The growth reduction of the stem was also observed in the case of argan seedlings starting from the concentration of 3.6g/l (Reda Tazi et al., 2001).

![Figure 2: Effects of salt concentration on the mean shoot length](image)
The effect of salinity on length of seedlings produced a reduction in the number of leaves and internodes. Statistical analysis showed that there was a salt effect on the number of leaves and internodes on KNO3 treated plants over the control sample (fig. 3 and 4). According to Botti et al (1998) Popcorn plants grown under high salt levels did not show much difference from those grown under non-saline conditions for most of the morphological and anatomical parameters such as number and size of stomata, density of trichomes, leaf size, branching characteristics and stem diameter. Only leaf and cuticle thickness showed a high tendency to increase under saline conditions.

It is important to note that saline stress during the drought period had no affect on ramification of young Popcorn plants. In contrast, Botti et al., (1998) reported that saline stress depressed the ramification and diameter of adult stems of seedlings. In addition, the green colour of leaves was attenuated by high KNO3 concentrations; this could be explained by a reduction of chlorophyll pigments. It is worth noting that the growth reduction along with an increase in the damage of the foliar percentage could be explained by reduction in the hydrous potential which resulted from an increase in KNO3 concentration in the cultural medium. Indeed, the toxicity of sodium and chloride ions was the principal cause of the inhibition of growth of several species, though the salt concentration was weak (Marshner, 1986). The resistance of the crop plants to saline stress depends in part on their capacity to control the access of sodium in the leaves. The non halophytes accumulate much more sodium and/or chloride ions in foliar tissue even in the presence of weak salt concentrations (Downtown, 1978; Greenway & Munns, 1980). For several species of Eucalyptus, when the seedlings were exposed to strong KNO3 concentrations, roots accumulated much more sodium than the leaves (Fathi and Part, 1989; Van der Moezel et al. 1988). The correlations between the parameters which were studied on the one hand and the various KNO3 concentrations on the other were high (0.946< r<0.973), thus confirming the depressive effect of the saline stress on germination, growth and development of the Popcorn plant. These results are in agreement with those obtained on other species such as argan (Reda Tazi et al., 2001), acacia (Hatimi,1999) and cereals (Driouich & Rachidai, 1996; Sibi & Fakiri, 2000; Ben Naceur et al., 2001).
Figure 4: Effects of KNO3 concentration on the number of internodes

Conclusion

The in vitro study of the germination of seed and the growth of the Popcorn plant under potassium stress enabled us to conclude that KNO3 1.2 g/l stimulated the seeds germination. More than half of the Popcorn seed germinated in medium with KNO3 concentration up to 6 g/l, whereas 4.8 g/l of KNO3 marks the start of the complete inhibition of the emergence of plums. The salt seemed to affect the opening of the plumule rather than germination. The evolution of the growth and the development of the young seedlings are strongly affected by strong KNO3 concentrations.

References

Pollack G, Waisel Y (1972) Salt secretion inA.Litoralis (Gramineae). *Physiol Plantarum.*, 47. 177-184