Effect of Priming with Gibberellic Acid (GA$_3$) on Germination and Growth of Corn (Zea mays L.) under Saline Conditions

Vahid Ghodrat$^1$, Mohammad J. Rousta$^2$

1. Islamic Azad University, Arsanjan branch, Arsanjan, Fars, Iran  
2. National Salinity Research Center, Yazd, Iran

Corresponding author email: vahid.ghodrat@gmail.com

ABSTRACT: In order to study the effect of priming with Gibberellic acid (GA$_3$) on germination and growth of corn under saline conditions, an experiment was conducted as factorial with completely randomized design with three replications. The factors of the experiment are different levels of Gibberellic acid concentration (0, 1.5, 2.5 and 5 mgL$^{-1}$) and salinity (0, 5, 10, 12 and 15 ds$m^{-1}$). The results showed that increasing salinity would decrease the components of germination including germination percentage, germination rate, root and shoot length and fresh and dry weight of seedling. Priming with GA$_3$ had no effect on seed germination however in some concentrations GA$_3$ increased shoot length, root length, dry weight, fresh weight and tissue water content.

Key words: priming, GA$_3$, corn, germination, salt stress

INTRODUCTION

The overarching goal of crop establishment is to achieve rapid and uniform germination, followed by rapid and uniform seedling emergence plus autotrophy (Covell et al., 1986). Nearly 20% of the world’s cultivated area and nearly half of the world’s irrigated lands are affected by salinity (Zhu, 2001). The effect of salinity at seedling stage of wheat range from reduction in germination percentage, fresh and dry weight of shoots and roots to the uptake of various nutrient ions. The use of cultivars with high salt tolerance may also offer an alternative (Wannamaker and Pike, 1987). Per-sowing seed treatments have been shown to enhance stand establishment in non saline areas (Khan, 1992) and have potential in saline areas as well (Ashraf and Rauf, 2001; Basra et al., 2005). Presoaking seeds with optimal concentration of phytohormones has been shown to be beneficial to growth and yield of some crop species growth under saline conditions by increasing nutrient reserves through increased physiological activities and root proliferation (Singh and Dara, 1971). Prior to selecting these alternatives, it seems necessary to examine seed vigor enhancement techniques leading to better and synchronized stand establishment under stress conditions which have been intensively investigated in the past two decades (Bradford, 1986). Incorporation of plant growth regulators during per-soaking, priming and other per sowing treatments in many vegetables crops have improved seed performance. Typical responses to priming are faster and closer spread of times to emergence over all seedbed environments and wider temperature range of emergence, leading to better crop stands, and hence improved yield and harvest quality, especially under suboptimal and stress condition growing conditions in field (Halmer, 2004). Plant growth regulators are organic compounds, which are produced in very small amount in plants and play an important role in growth, development and yield of crops and are becoming quite popular in the field of agriculture. Gibberellic Acid (GA$_3$) is the most important growth regulator, which breaks seed dormancy, promotes germination, intermodal length, hypocotyls growth and cell division in cambial zone and increases the size of leaves. GA stimulates hydrolytic enzymes that are needed for the degradation of the cells surrounding the radicle and thus speeds germination by promoting seedling elongation growth of cereal seeds (Rood et al., 1990). Therefore, an understanding of the physiological basis of seed germination under saline conditions is important since research is in progress to ameliorate the adverse effects of salinity on germination by employing certain chemical and biochemical agents. The present study is conceived to investigate the effects of presoaking of corn seeds in different concentration of hormones upon their germination and subsequent growth under saline conditions.
MATERIALS AND METHODS

SEED MATERIALS

Seeds of corn (*Zea mays* L.) were obtained from agricultural and natural resource research center of Zarghan. Before the experiment, seeds were surface sterilized in 1% sodium hypochlorite solution for 3 min, then rinsed with sterilized water and air dried.

SEED SOAKING WITH PLANT GROWTH REGULATOR

Hormone solutions of 0, 1.5, 2.5 and 5 mg L\(^{-1}\) of GA\(_3\) were prepared separately. 250 g of seeds were soaked in 500 ml of this hormonal solution for 12 h and redried to original weight with forced air under shade (Sundstrom et al., 1987).

SEEDLING VIGOR EVALUATION

An experiment was conducted as factorial with completely randomized design with three replications. The factors of the experiment are different levels of Gibberellic Acid concentration (0, 1.5, 2.5 and 5 mg L\(^{-1}\)) and salinity (0, 5, 10, 12 and 15 dsm\(^{-1}\)). Control and treated seeds were put in Petri dish, covered completely with paper and placed in growth chamber at temperature 25 °C. Emergence was recorded daily and the experiment was preceded for 10 days.

In this study, germination percentage (GP) was calculated according to the International Seed Testing Association (ISTA) method

\[
GP = \frac{\text{number of normally germinated seeds}}{\text{total number of seeds}} \times 100
\]

Also, the germination rate (GR) was calculated according to ISTA method

\[
GR = \sum_{i=1}^{j} \frac{n_i}{D_i}
\]

Where \(n\) is the number of seeds emerged on \(i^{th}\) day and \(D_i\) is the number of days counted from the beginning of the experiment. \(j\) is set to 10 days in this experiment.

The tissue water content (TWC) was calculated by the following formula (Black and Pritchard, 2002):

\[
\text{TWC} = \frac{\text{fresh weight} - \text{dry weight}}{\text{fresh weight}} \times 100
\]

At the end of the experiment Shoot and root lengths, fresh weight and root shoot ratio were measured. The data analysis of variance is done by SAS statistical program. The treatment means were compared using the Duncan test at 0.05 probability level.

RESULT

Soaking of seed with plant growth regulator had subtractive effect on germination percentage, germination rate and tissue water content under both normal and saline conditions (Table 1). Germination percentage (GP) in seed soaked with Gibberellic acid (GA\(_3\)) decreased compared to the control. As analysis showed the Germination rate (GR) in seeds soaked with GA\(_3\) in levels of 0, 5, 10 and 12 dsm\(^{-1}\) were decreased. In the level of 15 dsm\(^{-1}\) GR of seeds soaked with 1.5 mg L\(^{-1}\) GA\(_3\) was increased compared to the control. Total water content (TWC) of the seeds was unaffected by hormonal treatment except of the seed soaked with 1.5 mg L\(^{-1}\) GA\(_3\) in the level of 5 dsm\(^{-1}\) that showed an increase (Table 1).

Table 1. Effect of different pre-sowing seed treatments on emergence percentage, emergence rate and tissue water content of corn growing under normal and saline conditions during emergence test.

<table>
<thead>
<tr>
<th>EC</th>
<th>GP (%)</th>
<th>GR (%)</th>
<th>TWC</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>0</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>mgL(^{-1})</td>
<td>mgL(^{-1})</td>
<td>mgL(^{-1})</td>
<td>mgL(^{-1})</td>
</tr>
<tr>
<td>Control</td>
<td>100(^a)</td>
<td>86.7(^g)</td>
<td>70(^d)</td>
</tr>
<tr>
<td>5</td>
<td>100(^a)</td>
<td>68.3(^d)</td>
<td>61.7(^c)</td>
</tr>
<tr>
<td>10</td>
<td>80(^g)</td>
<td>60(^d)</td>
<td>50(^c)</td>
</tr>
<tr>
<td>12</td>
<td>60(^d)</td>
<td>51.7(^c)</td>
<td>50(^c)</td>
</tr>
<tr>
<td>15</td>
<td>50(^c)</td>
<td>43.3(^d)</td>
<td>30(^c)</td>
</tr>
</tbody>
</table>
The treatments had different results on shoot and root lengths and root shoot ratio under both normal and saline conditions (Table 2; Fig 1). The highest shoot length in level of 5ds⁻¹ was obtained for seeds soaked with 1.5 mg L⁻¹ GA₃ with 33 percent increase compared to the control. According to the results, the best shoot length in levels of control, 10 and 15 ds⁻¹ was related to seeds soaked with 5 mg L⁻¹ GA₃ respectively with 0.7, 33 and 210 percent increase compared to the control. The best shoot root ratio in levels of control and 5 ds⁻¹ was related to seeds soaked with 2.5 mg L⁻¹ GA₃ with 23 and 10 percent increase compared to the control. Shoot root ratio in level of 10 ds⁻¹ increased for seeds soaked with 1.5 mg L⁻¹ GA₃ (Table 2). The highest root length in level of 5ds⁻¹ was related to seeds soaked with 2.5mg L⁻¹ GA₃ with 36 percent increase compared to the control. Root length of seeds soaked with 1.5mg L⁻¹ GA₃ in level of 10 ds⁻¹ increased by 125 percent compared to the control (Table 2).

Table 2. Effect of different pre-sowing seed treatments on shoot length, root length and root shoot ratio of corn growing under normal and saline condition during emergence test

<table>
<thead>
<tr>
<th>EC mgL⁻¹</th>
<th>Control</th>
<th>5dsm⁻¹</th>
<th>10dsm⁻¹</th>
<th>15dsm⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot length (cm)</td>
<td>Root shoot ratio</td>
<td>Root length (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1.5</td>
<td>2.5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>0 mg L⁻¹</td>
<td>14.6⁴</td>
<td>10.9⁵</td>
<td>11.9⁵</td>
<td>14.7⁴</td>
</tr>
<tr>
<td>5 mg L⁻¹</td>
<td>6</td>
<td>8</td>
<td>7.5</td>
<td>5.8</td>
</tr>
<tr>
<td>10 mg L⁻¹</td>
<td>5.3⁴</td>
<td>7.1⁵</td>
<td>5.6⁴</td>
<td>7.1⁴</td>
</tr>
<tr>
<td>15 mg L⁻¹</td>
<td>8.2⁴</td>
<td>6.3⁴</td>
<td>4.1⁴</td>
<td>4.1⁴</td>
</tr>
</tbody>
</table>

Figure 1. Seeds germination per-sowed with GA₃ in (a) control, (b) 1.5 mg L⁻¹, (c) 2.5 mg L⁻¹, and (d) 5 mg L⁻¹. In each figure, samples from right to left are show salinity levels of 0, 5, 10, 12 and 15 ds⁻¹.

Seeds soaked with plant growth regulator affected total fresh weight and dry weight under both normal and saline conditions (Table 3). In level of 5ds⁻¹, the highest total dry weight obtained for seeds soaked with 2.5mgL⁻¹ GA₃. In levels of 10, 12 and 15ds⁻¹ the highest total dry weight was related to seeds soaked with 1.5mgL⁻¹ GA₃. The best total fresh weight in levels of 10, 12 and 15 ds⁻¹ was recorded for seeds soaked with 1.5mgL⁻¹ GA₃ with 20, 28 and 40 percent increase compared to the control (Table 3).

Table 3. Effect of different pre-sowing seed treatments on total dry weight, total fresh weight of corn growing under normal and saline conditions during emergence test

<table>
<thead>
<tr>
<th>Total dry weight (mg)</th>
<th>Total fresh weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC mgL⁻¹</td>
<td>0mg L⁻¹</td>
</tr>
<tr>
<td>control</td>
<td>0.32⁴</td>
</tr>
<tr>
<td>5</td>
<td>0.3³</td>
</tr>
<tr>
<td>10</td>
<td>0.18³</td>
</tr>
<tr>
<td>12</td>
<td>0.13³</td>
</tr>
<tr>
<td>15</td>
<td>0.09³</td>
</tr>
</tbody>
</table>
DISCUSSION

Much research has been done considering the effect of priming with plant growth regulator GA3 on germination and growth of cereal. Most of these researches show that GA3 increases germination and growth of cereal. Under saline condition, GA3 increases seedling (Naeem and Muhammad, 2006; Afzal et al., 2002; Afzal et al., 2005). In most experiments high concentrations of GA3 were used while the interspaces between consequent concentrations are large (Angrish et al., 2001; Afzal et al., 2005). In this experiment, we have used lower concentrations of GA3 and the interspaces are chosen to be smaller. Also, we studied the maximum level of salinity (15dsm–1) in which corn has its lowest germination. It is known that salt stressed seeds are desiccation sensitive, which cause physiological injuries in seeds and thus lead to the reduction of seed germination (Wiebe and Tiessen, 1979). Our results showed that germination percentage and germination rate of corn seeds would decrease by increasing salinity. We observed that priming with low concentrations of GA3 had no effect on seed germination; however in some concentrations GA3 could increase shoot and root lengths, dry weight, fresh weight and tissue water content. Similarly, Khan et al. (1990) found that 1mM GA3 during celery priming had no effect on emergence parameters, but did increase shoot fresh weight. The root and shoot length are the most important parameters for salt stress because roots are in direct contact with soil and absorb water from soil and shoot supply it to the rest of plant. For this reason, root and shoot length provides an important clue to the response of plants to salt stress (Jamal and Rha, 2004). Priming with appropriate concentration of GA3 plays an important role in the induction of tolerance to salinity and overcome limitations created by the environmental stress such as osmotic effects, ion toxicity and nutritional imbalance (Jamal and Rha, 2007). In this experiment we saw that priming with low concentrations of GA3 had no effect on germination rate and germination percent but it could increase shoot length, root length, dry weight, fresh weight and tissue water content. On the other hand priming with higher concentrations of GA3 had good effect on germination and growth of cereal (Naeem and Muhammad, 2006; Singh and Dara 1971). This study helps to find concentrations of GA3 which has the highest effect on the components of growth which are also economic enough to be suggested to the farmers.

REFERENCES