

Alleviation of Adverse Effects of Salt Stress by Presowing Treatments of Glycinebetaine in Maize (*Zea mays* L.)

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Abstract: The effect of pre-sowing seed treatment with glycinebetaine (GB) on maize (*Zea mays* L.) germination and seedling biomass under normal (0 dS m⁻¹) and saline (100 dS m⁻¹) conditions was studied to determine their usefulness in increasing relative salt-tolerance. Two maize cultivars i.e., i.e., Haricon -11 & Agati-2002 were used for germination test. Three levels of GB (0, 50 and 100 mM) were applied as pre-sowing seed treatment. Salinity stress caused reduction in fresh and dry biomass of root and coleoptile. However, exogenous application of GB as pre-sowing treatment ameliorated the inhibitory effects of salt stress.

Key words: Glycinebetaine • Salt stress • Maize • Germination • Seedling • Growth

INTRODUCTION

An environmental factor that limits crop productivity or destroys biomass is referred to as a stress or disturbance [1]. Salinity is currently the major factor which reduces crop yields. World-wide about 33% of the irrigated land is affected by salinity and more land is not being irrigated because of salinity [2]. Salinity adversely affects physiological and metabolic processes and finally diminishes plant growth and yield. Shoot growth and dry matter are reduced by salinity, root: shoot ratio is increased [3-4]. Salinity stress induces osmotic stress and physiological drought which typically reduces growth and photosynthesis in plants. It also affects seed germination, growth and survival of agricultural field crops, grasses, pasture range plants and trees to varied degree of extent [3]. Salt stress can affect germination of seeds either by creating osmotic potential which prevent water uptake, or by toxic effects of ions on embryo viability [5]. Seed germination is very important phase in plant life cycle [6]. It limits the establishment of plants in saline environment [7, 8]. It is significantly influenced by salinity [8-10]. Lower levels of salinity delay germination, whereas higher levels not only reduce the final percentage of germinated seeds [11], but also can inhibit the seed germination. Salinity stress causes reduction in plant growth because plant may suffer four types of stresses such as low osmotic potential of soil solution

(water stress), nutritional imbalance, specific ion effect (salt stress) or a combination of these factors [12].

Numbers of methods have been used for improving salinity tolerance of different crops [13, 14]. Pre-sowing treatment of seeds with different osmolytes is a common strategy for inducing salt tolerance in different crops. In this treatment seeds are held at water potential that allows imbibition but prevents radicle emergence [15]. The purpose of priming is increasing germination percent, decreasing mean of germination time and improving growth and vigour of seedling at very wide favor and unfavored environmental conditions [16]. There are many reports demonstrating positive effects of exogenous application of GB on plant growth and final crop yield under salt stress in tobacco, wheat, maize, barley, sorghum, soybean and common beans [17].

Glycinebetaine, a quaternary ammonium compound, occurs in substantial amount in a wide variety of plants, animals and microorganisms [18]. It is an amino acid derivative, which is dipolar in nature, but electrically neutral molecule at physiological pH. It is highly soluble in water but includes a non-polar hydrocarbon moiety that consists of three methyl groups [19]. Objective of the present study was to assess the effectiveness of exogenously applied GB as a pre-sowing seed treatment on maize plants in terms of improvement in germination percentage and biomass production, parameters in maize plants under salt-stress.

MATERIALS AND METHODS

The experiment was conducted in growth chamber of Botany Department at University of Gujrat, Gujrat. The seeds of maize cultivars were obtained from Department of Botany, University of Agriculture Faisalabad. There were two maize cultivars i.e. Haricon-11 and Agati-2002, three pre-soaking levels of glycinebetaine i.e., water soaked, 50 mM and 100 mM of GB and two salinity treatments i.e., control and salt stressed (100 dS m⁻¹ of NaCl). The experiment was laid out in a completely randomized design with three replicates. Seeds of two maize cultivars were washed with distill water, dipped in 0.1% mercuric chloride for 5 min and then washed thoroughly with sterilized water. The washed seeds were primed in distill water, 50mM GB and 100mM GB for 24 hours. After 24 hours seeds were placed in 10 cm petri-dishes and added 10 ml of NaCl to salt stressed petri-dishes, whereas 10ml of distill water was added to control.

Germinated seeds were counted regularly after every 24 hours. Germination test was ended when the number of germinated seeds was equal in three sequential counting. Germination % was calculated by dividing of germinated seeds with total seeds. Root and coleoptiles lengths (cm) were measured with the help of scale meter. Root and coleoptiles fresh weights (g) were noted by electric balance.

RESULTS

Salt stress caused a significant reduction in germination and growth parameters such as coleoptiles length, root length, coleoptile fresh weight and root fresh weight of the two maize cultivars, Haricon-11(V1) and Agati- 2002 (V2) when exposed to salt stress (10 dS m⁻¹).

Germination Percentage: Salt stress caused a significant reduction in germination of both maize cultivars (Fig.1). However, glycinebetaine (GB) applied as pre-sowing treatment promoted seed germination, at 100 mM NaCl in both maize cultivars (Fig 1). Both levels of glycinebetaine (50 and 100 mM) enhanced the germination percentage of the salt-stressed plants in both cultivars. Germination of both maize cultivars was more significantly improved by 100 mM GB than 50mM under normal and saline conditions. For example, under normal conditions, it caused 17.8% increase, whereas, under saline conditions, the increase was 35.6% over 0 mM GB in Haricon-11. Cultivar Agati-2002 had more germination

percentage as compared to Haricon-11 under both normal and saline conditions.

Root Length (cm): As with root length of both cultivars was significantly reduced due to salt stress and the cultivars also differed significantly in this growth attribute cv. Agati-2002 being higher than cv. Haricon-11 (Fig. 2). Exogenously applied GB significantly ameliorated the adverse effects of salt stress on both cultivars in terms of root length. Under saline conditions maximum root length (4.5cm) and (5.7cm) was found when 50mM GB was applied in Haricon-11 and Agati-2002 respectively. So in contrast to germination percentage 100mM was less effective in this case particularly under saline conditions.

Coleoptile Length (gm): Data regarding this parameter is presented in (Fig. 3). Coleoptile length in both cultivars was markedly reduced due to saline conditions of the growth medium. Both cultivars differed with respect to this attribute under saline and normal conditions. Under saline conditions, maximum length (3.63cm) was found in Agati-2002, when 50mM GB was applied as pre-sowing treatment.

However, 100mM GB was unable to improve the coleoptiles length in Haricon-11 under saline conditions.

Root Fresh Weight (g): Root fresh weight (g) was lower in salinized plants of both cultivars than that in non-salinized plants (Fig. 4). Cultivar Agati-2002 was 16.66% and 12.72% higher in root fresh weight as compared to cv. Haricon-11 under normal and saline conditions respectively. Application of GB increased this growth attribute in both cultivars. In cv. Haricon-11, pre-sowing application of 100 mM GB was more effective in increasing root fresh weight under normal and saline conditions. However, in cv. Agati-2002, 50mM GB was more effective in non-salinized plants and same pattern of improvement was observed as in Haricon-11 under saline conditions.

Coleoptile Fresh Weight (g): Excessive amounts of salt in the growth medium caused reduction in coleoptile fresh weight of both maize cultivars (Fig. 5). Both cultivars performed differently with respect to this growth parameter under normal and saline conditions. Under normal conditions 50mM GB was more effective than 100mM GB in both cultivars but under saline conditions both cultivars showed different response to different levels of exogenous GB. For example, in case of V1, 50mM GB was more effective in ameliorating the adverse effects of salt stress than 100mM GB.

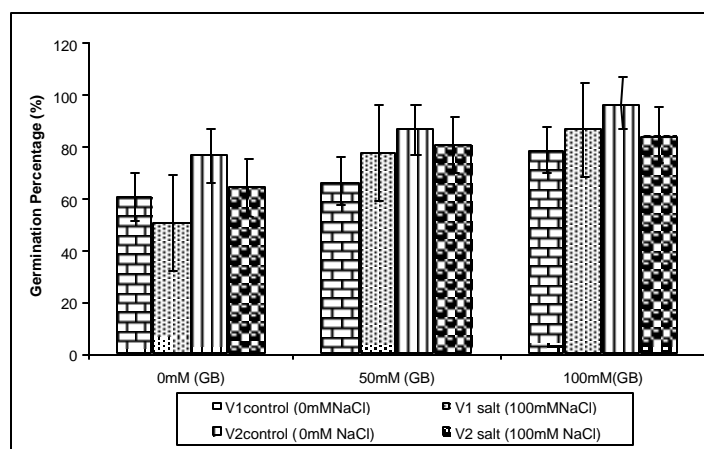


Fig. 1: Effect of exogenous GB as presowing treatment on germination % of maize under saline cinditions

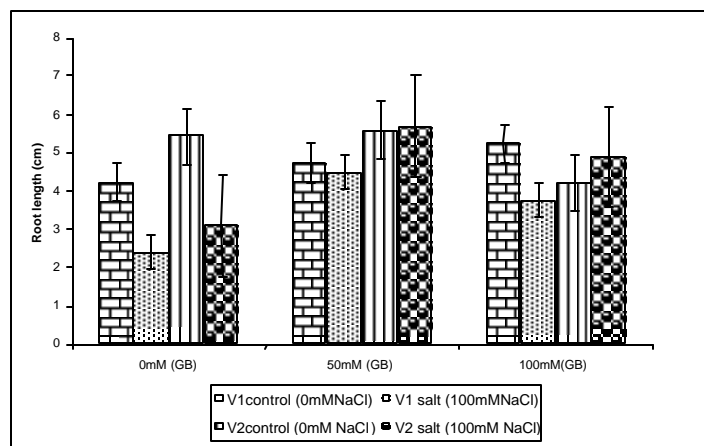


Fig. 2: Effect of exogenous GB as presowing treatment on root length (cm) of maize at seedling stage under saline conditions

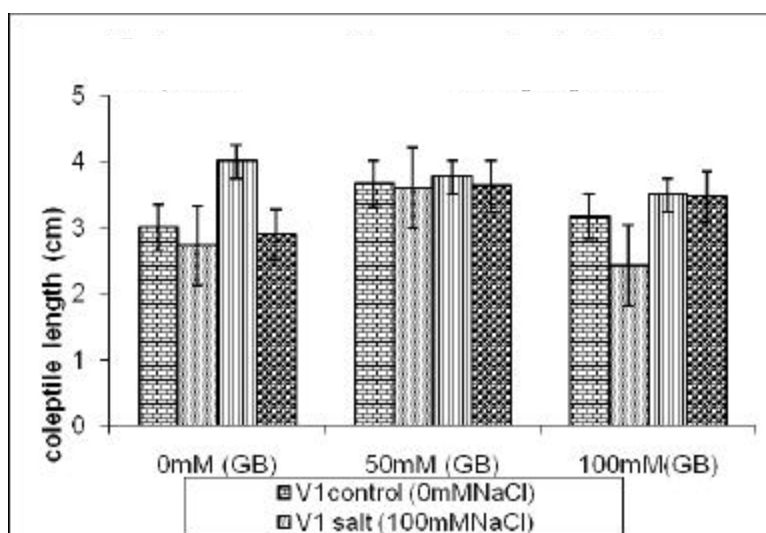


Fig. 2: Effect of exogenous GB as presowing treatment on coleoptilength (cm) of maize at seedling stage under saline conditions

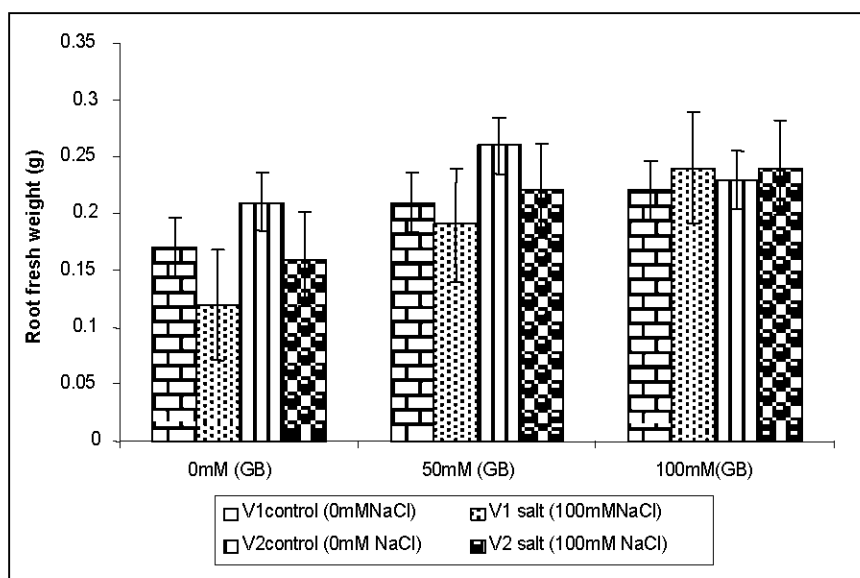


Fig. 4: Effect of exogenous GB as presowing treatment on root fresh weight (g) of maize at seedling stage under saline conditions

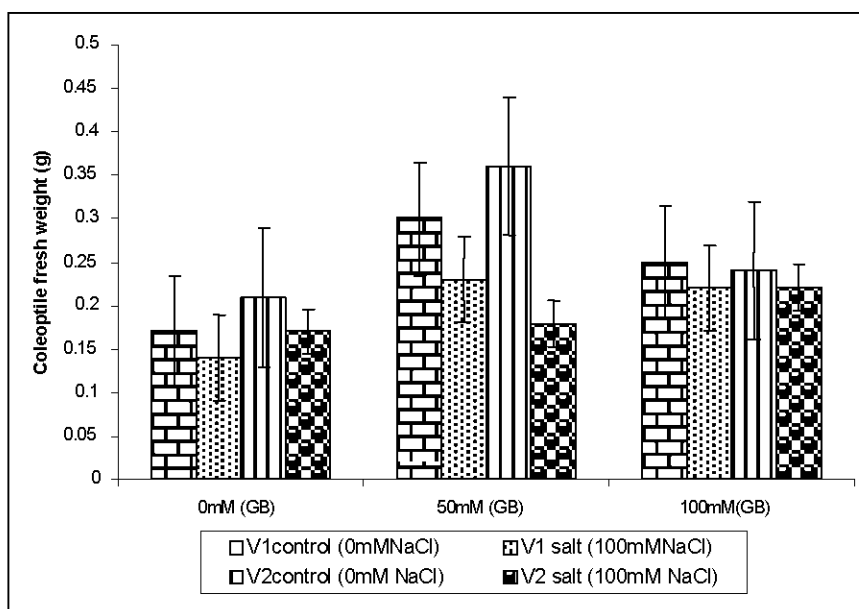


Fig. 5: Effect of exogenous GB as presowing treatment on coleoptile fresh weight (g) of maize at seedling stage under saline conditions

DISCUSSION

Germination percentage and some growth parameters in two maize cultivars were reduced due to salt stress; however, exogenous application of GB as pre-sowing treatment ameliorated the inhibitory effects. Germination and seedling stages are very sensitive to different stresses during the life cycle of plant species. It has been

observed that better germination and better growth at early stages induce resistance at later stages under salt stress and will show better crop growth and ultimately the yield [20-22]. Excess of salt in growth medium decreases the fresh weight of plumule due to decreasing in remobilization of reservoirs from cotyledons to embryo axis. The factors that affect the growth rate of embryo axis, also are affecting the mobility of reservoirs and its

remobilization from cotyledons to embryo axis [23, 24]. Increase in salt concentration results in reduction of plumule length in different crops such as wheat, barley, pea and cabbage [25]. They pointed out that decreasing the growth of young seedlings by increasing salinity, was because of the most decreasing of water absorption by radicle and subsequently by accumulation of soluble salts in cells, water potential of root cells decreases and biological processes occur in roots even in low water potentials. In view of the results of the present study that exogenous application of GB as pre-sowing treatment improved the seed germination of both maize cultivars under saline conditions, it is likely that GB might have been absorbed by the developing seedlings though not measured here, where they might have maintained a better water status by increasing water influx and reducing efflux of water under salt-induced water limited conditions [22,26-28], they might have protected the membranes against ion toxicity and salt-induced oxidative stress in germinating seeds [28,29,30], increased the cellular growth [22,31,32] and thus increased the seedling growth of maize.

CONCLUSION

The results of experiment showed that priming with GB improves germination and seedling growth of two maize cultivars under salt stress. Cultivar Agati-2002 showed better response in terms of germination percentage and growth under normal and saline conditions than cv. Haricon-11. These results can be useful for improving crop yield in saline soils.

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