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ORIGINAL ARTICLE

# A comparison study on the effect of some growth regulators on the nutrients content of maize plant under salinity conditions

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**KEYWORDS**

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**Abstract** A comparison study between the foliar application effects of the gibberellic acid (GA3), salicylic acid (SA) and silicon on the nutritional content of the maize plant leaves (*Zea mays* L. CV.) has been carried out through a pot experiment using an irrigation saline water. Chlorophyll, macro- and micro-nutrients contents of the plant leaves were estimated for the untreated and the treated plants by a 100 mg $L^{-1}$ solution of GA3, SA or Si. GA3 was found to be the most effective for resisting the severe salinity effects on the leaves' chlorophyll followed by the Si then the SA. In almost the same order, the Fe, Zn and Si toxicity due to the salinity effects on the leaves could be reduced. Cu and Mn deficiency might be controlled but to a limited extent by SA then by GA3. Silicon ions may compete for the $Na^+$ ions and hence reduce their absorption by the maize plants.

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## Introduction

Crops grown in the arid and semi-arid regions are often exposed to adverse environmental factors such as high soil salinity. The reduction in the plant growth in the saline environments may be due to either water relations or the toxic effects of $Na^+$ and $Cl^-$ ions on the metabolism. $Na^+$ influx into the root cells elevates the cytoplasm $Na^+$ concentration and causes toxicity symptoms.

When plants are subjected to stress conditions, highly reactive oxygen species ROS (cytotoxic species) are produced. In the absence of any protective mechanism, excessive amounts of ROS can seriously disrupt the normal metabolism through oxidative damage to lipids, protein and nucleic acids. They can enhance membrane lipid per-oxidation, electrolyte leakage, damage chloroplast; inhibit photochemical reactions, decrease photosynthesis and loss of cell membrane integrity. The balance between ROS generation and scavenging may be disrupted by salt stress and high light or UV exposure. Plants have a number of antioxidant enzymes protecting themselves that used as indicators for the salinity stress (Chen et al., 2011).

In the field, the solid phase of the soil system, the concentration and composition of the solutes in the soil solution and its pH control the concentrations and activity of the

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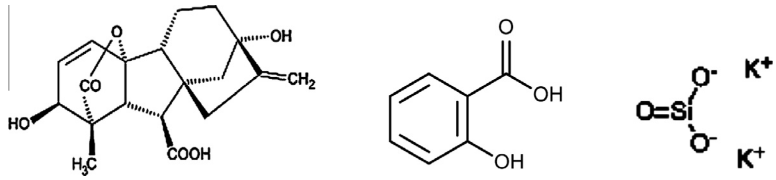

**Fig. 1** Chemical structure of GA3, SA and K-silicates used in the study.

nutrient ion, particularly P, K and the micronutrients. The speciation, transformations (e.g. nitrification: ammonium to nitrate) and thus availability of certain nutrients is affected by salinity, soil moisture, texture and its nutritional status (Grattan and Grieve, 1999; Jia-minl et al., 2008). The relations between salinity and mineral nutrition of horticultural crops are extremely complex affecting the nutrient availability, competitive uptake, and transport or partitioning within the plant. The plant becomes susceptible to osmotic and specific ion injury as well as to nutritional disorders that may result in reduced yield or quality. This depends upon the salinity level, the composition of salts, the crop species, the nutrient in question and a number of environmental factors. Salt stress (S) was found to reduce the chlorophyll content and increase some enzyme activities and electrolyte leakage. It also reduced some macro and micronutrient concentrations and induces membrane permeability (Ananieva et al., 2002; Dong et al., 2006; Tuna et al., 2008a,b; Janda et al., 2012; Saidi et al., 2013). Salinity reduces N and P uptake and accumulation in crops. High levels of external $Na^+$ interfere with $K^+$ acquisition by the roots, disrupt the integrity of root membranes and alter their selectivity. Salinity may increase, decrease, or have no effect on the micronutrients (e.g. Cu, Fe, Mn, Mo and Zn) concentration in the plant shoots (Grattan and Grieve, 1999).

The effects of salinity can be minimized by improved irrigation and drainage techniques but the cost is very high which emphasizes the need for an alternative strategy. Exogenous application (Foliar application) of plant growth regulators (PGRs) such as gibberellic (GA3) and salicylic (SA) acids could overcome; to variable extents, the adverse effects of NaCl stress on the salt-affected physiological parameters. GA3 of potential economic interest could be obtained by processing of some wastes (Berry and Sachar, 1981; Slakeski and Fincher, 1992; Pastrana et al., 1995; Tuna et al., 2008a,b).

Depending on the plant species, PGRs like GA3 can improve the plant growth, ion uptake and transport, and the nutrient utilization under salt stress. They are responsible for seed germination, stem elongation, leaf expansion and flowering, and prevent chlorophyll breakdown and decreases ROS levels that lead to cell death. They stabilize microtubules in plant organs against de-polymerization (Maya-Ampudia and Bernal-Lugo, 2006; Rosenvasser et al., 2006; Tsavkelova et al., 2008; Wen et al., 2010; Janda et al., 2012; Bose et al., 2013).

Salicylic acid (SA), a naturally occurring plant phenolic is considered as a hormone like endogenous regulator. It could ameliorate the oxidative stress damaging effects of heavy metals like Cd in rice. SA strongly inhibited $Na^+$ and $Cl^-$ accumulation, stimulated N, Mg, Fe, Mn and Cu concentrations of salt stressed maize plants. One of the pathways of SA biosynthesis is located in the chloroplasts in processes catalyzed by some enzymes so, it affects leaf photosynthesis (Misra and Saxena, 2009; Szepesia et al., 2009; Torre-Hernandez et al., 2010; Nazar et al., 2011; Radwan, 2012).

But the majority of results obtained with the exogenous application of PGRs cannot be generalized, since the effect may vary not only with the plant species, but also may depend on the method of administration (for example spraying, pre-soaking, addition to the growth medium, etc.), as well as on the time scale of the experiments. Many of the described effects in the treated plants are probably not directly due to PGRs, but may be secondary ones induced by the treatment at the site of application (Hao et al., 2012).

Additionally, the use of PGRs must be under strict control because they can provoke several diseases. Studies indicated that they may produce organ damages, including the brain, alarming toxicity to the breast, lung, kidney, liver and neurotoxicity of experiment mice. A combination of GA3 with a high concentration of EDTA causes severe soil and ground water pollution (Young et al., 1997; Hadi et al., 2010; Troudi et al., 2012).

Silicon (Si) may be beneficial for the plant growth and photosynthetic activity. According to the literature and under the salt stress conditions, Si enhanced the $K^+$:$Na^+$ ratio against the toxic effects of $Na^+$. Sodium ($Na^+$) transportation into roots and shoots as well as shoot $K^+$ and $Ca^{+2}$ concentrations was reduced by added silicate. Si application reversed the chlorosis, protected the chloroplast from disorganization, and significantly increased the pigments contents. It increases the resistance of some plant species to toxic metals such as Cd by decreasing their uptake and accumulation which damage chloroplast and root-to-shoot transport (Tuna et al., 2008a; Feng et al., 2010).

The interaction between salinity and different nutrients like nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu) and silicon (Si) is complex. The interaction is highly dependent upon the plant species (or cultivar), plant developmental age, the composition and level of salinity and the concentration of nutritional element in the substrate. Therefore, depending upon plants selected and conditions of the experiment, different results can be obtained. The present study is a greenhouse pot experiment to compare the salt stress counteraction effects of gibberellic acid (GA3), salicylic acid and silicon application on some nutrients content of maize plant (*Zea mays* L. CV.).

## Materials and methods

### *Materials*

The materials used were Gibberellic acid GA3 ($C_{19}H_{22}O_6$ – Berelex, VALENT Bio-Science co.), Salicylic acid SA

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