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FULL LENGTH ARTICLE

Effect of silicon and selenium on enzymatic changes and productivity of dill in saline condition

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KEYWORDS

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Abstract *Anethum graveolens* is an annual herb in the celery family Apiaceae. The experiment was carried out in a factorial design with two factors include salinity, which was applied to the root medium as NaCl (0 and 10 ds/m) and nutrition as sodium silicate (0 and 1.5 mM), and selenate (0, 5 μM). Supplementary Si or Se ameliorated the negative effects of salinity on plant dry matter and chlorophyll content. Application of Si or Se decreased Na^+ concentration and increased K^+ concentration in roots and shoots of dill plants. Salinity imposed oxidative stress and leaded to increase malondialdehyde (MDA) concentration. Under saline condition, addition of Si/Se significantly increased the activities of superoxide dismutase (SOD) and catalase (CAT) in salt-stressed plant when compared with plant subjected to salinity alone. Our results revealed that improvement in growth of salt stressed plants under the influence of Si and Se may be due to the improved ion balance, antioxidant enzymes activities and osmotic adjustment. These trace elements had negative effect on growth under non-saline conditions. Therefore, application of these trace elements (especially Silicon) under saline condition could be a better strategy for maintaining the crop productivity in these regions.

1. Introduction

Soil salinity is one of the most serious environmental problems limiting crop production mainly in arid and semiarid areas. About one-third of the world's irrigated lands are affected by salt (Flowers and Colmer, 2008). Salinity can be hazardous to plant growth and productivity especially in arid and semiarid areas, where irrigation of crops with saline water could accumulate salts in soil. The response of plants to salinity is multifaceted and involves changes in plant's morphology, physiology and metabolism (Hilal et al., 1998), resulted in diminishing growth and yield (Ashraf and Harris, 2004). Ahmad et al. (2012) reported that >65% yield losses in wheat occur due to salinity. Accumulation of salts in soil solution exerts an osmotic pressure and reduces the soil water potential making water unavailable to plants as reported by Munns et al. (2006). Ionic imbalance and specific ion toxicity due to excessive buildup of Na^+ and Cl^- is other factor that affects the uptake of other mineral nutrients (Grattan and Grieve, 1999; Chinnusamy et al., 2005), resulted in growth reduction.

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Salt stress not only imposes the osmotic stress and ion toxicity, but is also marked as an oxidative stress (Gueta-Dahan et al., 1997) which can elevate membrane permeability (Tabaei-Aghdaei et al., 2000) and show reduction in chlorophyll contents (Hashemi et al., 2010).

Recently, various chemical, physical and biological strategies are adapted for stable productivity of crops in saline soils. Of all these strategies, exogenous application of nutrients has gained a considerable ground as an effective approach to ameliorate the adverse effects of salt stress (Grattan and Grieve, 1999). Silicon (Si) is the second most abundant mineral element in the soil after oxygen (Epstein, 1999; Liang et al., 2007), and also is a major structural component of the cell walls in some monocotyledonous species (Inanaga and Okasaka, 1996). Although Si is a major constituent of plants, to date its essentiality has not been completely established, but various studies have demonstrated that Si application significantly increased plant growth under stress condition including biotic and abiotic stresses as salt stress (Rodrigues et al., 2003; Ma, 2004). The exogenous application of Si has been shown to ameliorate the adverse effects of salinity in several plants, including *Oryza sativa* (Lekklar and Chaidee, 2011), *Triticum aestivum* (Tuna et al., 2008; Tahir et al., 2012), *Zea mays* (Moussa, 2006), *Brassica napus* (Hashemi et al., 2010) and *Lycopersicon esculentum* (Romero-Aranda et al., 2006). Hashemi et al. (2010) found that exogenous Si ameliorated the deleterious effects of salinity on the growth through lowering tissue Na^+ content, maintaining the membrane integrity and increased ROS scavenging capacity.

Selenium (Se) is considered to be an essential trace element for human, animals, and some species of microorganisms. Although, Se is not confirmed to be required by higher plants, several studies demonstrate that at low concentrations it plays an important role in antioxidative reactions and hormone balance in plant cells such as enhancing the activity of glutathione peroxidase (GPX) (Djanaguiraman et al., 2005; Cartes et al., 2010; Filek et al., 2008). Some studies show plants supplemented with Se have shown enhanced resistance to certain abiotic stresses including salinity (Djanaguiraman et al., 2005; Filek et al., 2008; Cartes et al., 2010; Chu et al., 2010; Djanaguiraman et al., 2010; Hasanuzzaman et al., 2011). For instance, Hawrylak-Nowak (2009) reported that low level of exogenous Se (5 and 10 μM) generally stimulates growth as well as photosynthetic pigments accumulation in NaCl-treated cucumber seedlings. Literatures have emerged that the protective role of Se ions in salt-stressed plants is not well-known and can be related to inhibited lipid peroxidation process, enhanced accumulation of free proline, and/or decrease in content of chloride ions in shoot issues (Hawrylak-Nowak, 2009; Hasanuzzaman and Fujita, 2011; Hasanuzzaman et al., 2011).

Dill (*Anethum graveolens* L.) is an annual aromatic and medicinal plant belonging to the Apiaceae (Umbilliferae) family. It contains a wide ranges of essential oils, Carvone, limonene, fatty oil, moisture (8.39%), proteins (15.68%), carbohydrates (36%), fiber (14.80%), ash (9.8%) and mineral elements such as calcium, potassium, magnesium, phosphorous, sodium, vitamin A and niacin (Kaur and Arora, 2010). The leaves of dill are used for prevention and treatment of diseases and disorders of the gastrointestinal tract, kidney and urinary tract, for spasms and sleep disorders. An aqueous dill extract, also is used for lowering blood pressure, dilates blood vessels, stimulates respiration and slows heart rate in animals (Khare, 2007).

Our previous research showed that dill is relatively sensitive to saline water at levels around the 10 ds/m; therefore, in the present research we investigated the ameliorative effect of silicon and/or selenium nutrition on growth and essential oils content of dill plants exposed to salinity.

2. Material and methods

The experiments were conducted during 2014 in a greenhouse at the University of Maragheh. Seeds of Dill (*A. graveolens*). The seeds were incubated in a moistened paper towel and germinated in the dark at 25 ± 5 °C for 48 h. Seedlings were initially hydro-cultured in the aerated water and were grown inside the growth chamber under light condition in ratio of 16:8 light and darkness, 25 °C, 65% relative humidity and light intensity of 6000 Lux. The experiment was carried out in a factorial completely randomized design. Factor one was salinity, which was applied to the root medium as NaCl (0 and 10 ds/m), and factor two was silicon nutrition, which was supplied as sodium silicate (0 and 1.5 mM), and selenium nutrition (0, 5 μM) which was applied as (Na_2SeO_4). Treatments were started 2 weeks after transplanting the seedlings to hydroponic culture. The pH of the nutrient solution was measured by a pH meter and adjusted to 5.5 through adding 1 N sulfuric acid (H_2SO_4). Plants were harvested 25 days after starting the treatments and used to assess growth parameters and for chemical analyses. Samples from the above ground organs and roots were weighed, oven-dried for 3 days at 70 °C, re-weighed and ground to determine the mineral contents. Fresh samples or deep-frozen samples were used for the biochemical assays.

2.1. Analysis of growth and essential oil content

The shoots and roots of seedlings from each jar were harvested separately and washed with distillated water, and then samples were weighted for their fresh weight determination. The samples were dried in an oven at 105 °C for 24 h and then the DW of both shoots and roots was measured for the different treatments. Aboveground organ samples were mixed with 300 ml of distilled water and the essential oil content was determined by hydro-distillation for 3 h, using a modified Clevenger apparatus.

2.2. Chlorophyll concentration

Chlorophyll a and b was determined according to Dere et al. (1998). One-hundred mg of fresh leaf material was taken from the aboveground organs and extracted with 99% methanol and read absorption recorded using spectrophotometer (Jenway Model 6305) at 653 and 666 nm wavelengths, for chlorophyll a and b, respectively. Chlorophyll concentrations were calculated by using the below equations (Dere et al., 1998):

Ch a = 15.65 A666 – 7.340 A653.
Ch b = 27.05 A653 – 11.21 A666.

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