Salt tolerance of coriander (Coriandum sativum) as medicinal plant under integrated salinity and sodicity conditions

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ABSTRACT

Salinity confines the growth, circulation and production of plants growth of coriander (Coriandum sativum). This experiment was conducted to determine the impacts of (4 dSm⁻¹ + 13.5 (mmol L⁻¹)¹/₂, 5 dSm⁻¹ + 25 (mmol L⁻¹)¹/₂, 5 dSm⁻¹ + 30 (mmol L⁻¹)¹/₂, 10 dSm⁻¹ + 25(mmol L⁻¹)¹/₂ and 10 dSm⁻¹ + 30 (mmol L⁻¹)¹/₂) on biomass yield of coriander to screen against salinity tolerance collecting biomass yield factor. Maximum biomass yield (32.57 gpot⁻¹) was produced by 4 dSm⁻¹+ 13.5 (mmol L⁻¹)¹/₂ treatment. Biomass produce was reduced with the increase of the salts toxicity. Minimum biomass yield (24.41 gpot⁻¹) was gained at 10 dSm⁻¹+ 30 (mmol L⁻¹)¹/₂. 5 dSm⁻¹ + 25 (mmol L⁻¹)¹/₂ treatment showed improved outcome, that is, the least diminution % over the control (10.19). Salinity- sodicity showed staid effect on the growth reduction from 10.19 to 25.05%. This reduction fissure was impacted by the harmful effect of salinity and sodicity on coriander growth. Salinity- sodicity had toxic impact on growth reduction from 10.19 to 25.05%. Based on the findings of this study, coriander (C. sativum) was able to grow better at 4 dSm⁻¹+ 13.5 (mmol L⁻¹)¹/₂ treatment.

Key words: Coriandum sativum, Saline- sodic, Medicinal value and biomass yield

INTRODUCTION

Salinity is the most effective problem for crop production. Approximately 6% world’s land surface area suffers from salinity (FAO, 2010). Furthermore, saline soils are major problems for cultivated lands in the semi arid and arid areas. About 23% of the worlds (1.5 x 109 ha of cultivated) land is saline and 37% is sodic (Khan and Duke, 2001). Depending on the increasing world population, it has become necessary to develop crops that can adapt to saline conditions. Some of the plants show significant tolerance or sensibility to the salinity.

Abiotic stresses, such as salinity, always limit the growth, distribution and production of plants. According to a recent estimate, 1128 million ha of global land is affected by salinity and sodicity (Chen et al., 2016; Akhtar et al., 2015). Due to high evapotranspiration and low rainfall, the majority of the areas in Iran have been classified as arid and semi-arid. According to statistics released by the Ministry of Agriculture, total area of saline soils of Iran is estimated to be about 44 million hectares which is about 30% of plains and more than 50% of the country's irrigated lands. Considering that salinity is a stable stress, plants will be permanently exposed to it during their growth period. Seed germination “as the most important stage of plant growth” is also affected by salinity. Increased Na⁺ uptake in plants under salinity disturbs those metabolic processes that require low Na⁺ and high K⁺, Ca²⁺ or both for normal functioning (Akhtar et al., 2015). Coriander grows in sandy loam, fertile and humus rich soil in between October to May month. It performs well at a temperature range of 20-25°C and soil pH of 6.0-6.7.

Medicinal and aromatic plants are cultivated because of their active constituents that are used for different purposes (Aghaei and Kamatsu, 2013). Coriander which is an annual plant belonging to the family Umbelliferae and used as an aromatic and medicinal plant is cultivated mainly for its fruits and seeds. The medicinal plant is used...
as carminative, stimulant, diuretic, dyspeptic, antipyretic and antioxidant (Sahib et al., 2012). Coriander is believed to be a native plant of Egypt, Turkey, and East Mediterranean region. The major producers are India, Morocco, Canada, Pakistan, Romania and the former Soviet Union, while Iran, Turkey, Egypt, Israel, China, Burma and Thailand are minor producers (Sharma et al., 2014).

Coriander’s fruits are also used for food ingredients (preparation of sausages, alcoholic beverages), cosmetics and parfumery (Ahl and Omer, 2014). The seeds are rich in polyphenols and essential oil (Bhat et al., 2014).

The fresh green leaves of coriander, commonly known as cilantro, possess an unique aroma quite different from that of the fruit and, with a distinctive pungent, fatty, and aldehydey aroma, also have wide culinary uses such as flavoring foods or masking unpleasant odors of certain foods (Gil et al., 2002). Coriander extracts and its essential oil are also reported to exhibit anti diabetic (Gallagher et al., 2003), antioxidant (Guerra et al., 2005), antibacterial (Burt, 2004), anti cancerous and anti mutagenic activities (Chithra and Leelamma, 2000). There are considerable variations in the reported oil composition, which could be due to differences in genetics, ontogeny and analytical methods (Eyres et al., 2005). Coriander seeds and leaves are used as common food flavoring agents both sweet and savory dishes, especially in Europe and India. It helps to remove toxic mineral residue, such as mercury and lead and excretes them in the urine or faeces (Leena et al., 2012). Both leaves and seeds of the plant are used for medicinal purpose. Oil of coriander is used in medicine and in flavoring beverage, such as gin, whisky and various liqueurs.

Coriander (Coriandrum sativum), which belongs to family Apiaceae (Umbelliferae), is a fast growing annual herb that possesses nutritional and medicinal properties, besides, it is one of the most commonly used spices. The first medicinal uses of the plant were reported by the ancient Egyptians. Coriander is also used in detox diet. It helps to remove toxic mineral residue, such as mercury and lead and excretes them in the urine or faces (Leena et al., 2012).

All cultures, from ancient time to the present, have used plants as a source of medicine. According to the World Health Organization (WHO), most of the world’s population depends upon plants as an important element in primary health care system (Tomlinson, 2015; Khan, 2011). Natural products are a source for novel antibiotics. In the area of cancer, from around the 1940s to date, 47% of the antibiotics used have been actually either natural products or directly derived there from. In other areas, the influence of natural product structures is quite marked, with the anti-infective area being dependent on natural products and their structures (Newman and Cragg, 2007).

Salinity is one of the significant factors affecting the productivity of plants. Considerable attention is paid to the study of salt stress effects on the physiological symptoms in various types of plants (Munns and Gillham 2015; Negrão et al., 2017). Salinity causes both water stress and osmotic stress in plants and the accumulated salt ions have a toxic effect on plants. Water deficit causes a leaf turgor decrease, further causing stomata closure and decreases stomatal conductance (gs); one of the factors limiting photosynthesis rates (Chaves et al., 2009). There is also an ion imbalance due to the excessive collection of Na⁺ and Cl⁻ along with decreased absorption of other ions such as K⁺, Ca²⁺ and Mn²⁺ (Flowers and Colmer, 2008). Studies have shown that salinity has a negative effect on germination characteristics of some herbs (Seghatoleslami, 2011). In the past, efforts aimed at the utilization of saline waters were mainly concerned with enhancing the production of annual crops. In recent years, however, worldwide attention has been paid to accommodating salt tolerant species of industrial importance in highly degraded saline areas and irrigating them with saline waters of high salinity (Dagar, 2003; Jaradat, 2003). It is now believed that many salt-tolerant species have potential agricultural value and could be grown successfully in the degraded saline areas and irrigated with saline waters. Utilizing the saline ground waters, Tomar et al. (2003a, b) showed that salt-tolerant tree plantations and forage grasses might provide for an economic use of abandoned arid and semiarid lands. There is a large amount of information available about the tolerance of plant species to salinity (Dagar et al., 2001; Tomar et al., 2003a, b), but knowledge about the soil salinity tolerated by under-explored woody and herbaceous crops of high economic value is limited (Dagar, 2003; Tomar and Minhas, 2004a, b). In deep-rooted woody perennials, the additional salts going into the soil/root-zone, through enhanced frequency of irrigations during their establishment, may hinder the growth of the saplings. Therefore, irrigation with saline waters should aim to create favourable niches for the better establishment of saplings, while at the same time also eliminating the excess salinity build up. This could be achieved by irrigating only the limited area under furrows planted with tree saplings (Tomar et al., 2003b). The same technique was adopted in the present studies for planting the woody species.

Salinity is one of the major abiotic factors reducing global crop yield; it affects nearly 20% of the cultivated lands around the world and about 50% of all irrigated lands (Zhao et al., 2015; Zhu, 2001). In China, there are about 34.6 million hectares of salinized lands. Among the major and vital groups of crops, the medicinal plants, which exert an important role in human disease prevention and treatment (Aghaei and Komatsu, 2013), are also being threatened by this constraint. It is well established that secondary metabolites in medicinal plants are involved in the treatment of human diseases and health disorders (Wink, 2015). However, their accumulation is strongly dependent on growing conditions (Selmar and Kleinvachter, 2013). Among the secondary metabolites, polyphenolic compounds with strong antioxidant activities are abundant in the Lamiaceae plants (Taārīt et al., 2012). Under salinity...
and other biotic/abiotic stresses, their synthesis and accumulation are generally vitalized (Ksouri et al., 2007). Salinity is of the most dangerous environmental factors limiting plant growth and productivity. Salt stress changes the morphological, physiological and biochemical responses of plant (Amirjani, 2010). The adverse effects of salt stress appear on the entire plant at almost every stage of growth including germination, seedling development, vegetative and reproductive stages. Salinity in a given land depends upon the various factors such as amount of evaporation (leading to increase in salt concentration), or the amount of precipitation (leading to decrease in salt concentration). Salinity affects plant physiology through changes of water status in cells. Salinity stress may curtail or promote nutrient uptake by plant species affecting the mobility of a nutrient within the plant or by increasing the nutrient requirement by plants in the cells. About 23% of the world’s cultivated lands is saline and 37% is sodic (Khan and Duke, 2001).

Salinity is associated mainly with two types of stresses: osmotic stress and/or ion toxicity (Eisa et al., 2012). Osmotic effect of salts on plants is a result of lowering of the soil water potential due to increasing solute concentration in the root zone. Osmotic effect contributes to reduction of growth rates, change in leaf colour, and development of characteristics such as root/shoot ratio and maturity rate.

High ion-concentration may disturb membrane integrity and function. The high Na+ concentration in saline water potential in the rooting zone decreases water permeability in to plant tissue (Koyro et al., 2011). Ion toxicity occurs when salt accumulates to toxic concentration in leaves. Sodium chloride (NaCl) reduced all the parameters, including seed germination, number of leaves per plant plant length, roots number, root length and percentage of survivals, with significant differences among all treatments. So, increasing NaCl concentration leads to more reduction in seed germination percentage and plant growth rate as well. It leads to decrease in the percentage of survivals, while the shoot tip necrosis is increased by increasing concentration.

Na exclusion ability is significantly correlated with salinity resistance in plants (Ferdose et al., 2009). Photosynthesis is the most significant physiological process and, in all its phases, is affected by stress factors. Ashraf and Harris (2013) state that the mechanism of photosynthesis involves various components, including photosynthetic pigments and photosystems, the electron transport system, and CO2 reduction pathways. Any damage at any level caused by a stress factor, that is, salts may reduce the overall photosynthetic capacity of a green plant. Seed germination is the first critical and the most sensitive stage in the life cycles of plants (Ahmed, 2009). Under saline condition, germination and plumule length of oat decreased with increasing salinity levels (Tiwari et al., 2000). Excessive salinity reduces productivity of many crops including most vegetables (Pena and Hughes, 2007). According to Begum et al. (2010), germination of seeds depends on the utilization of reserved food material of the seed. According to Navaz et al. (2010), salt stress reduced the ability of plants to absorb water which leads to reduction in growth. Salinity results in delayed germination, high rate of seedling mortality, stunted growth and reduced yield (Muhammad and Hussain, 2010). Sarker et al. (2014) reported that salinity stress significantly decreased germination and growth parameters of seedlings of four vegetable crops (radish, cabbage, mustard and water spinach).

The growing use of medicinal plants has led to the increase of their cultivation area. Thus, the study of its salt tolerance to salinity of soil/sodicity is necessary because it leads to a greater level use of lands that are somewhat faced with problems caused by salinity.

**MATERIALS AND METHODS**

A pot study was conducted to evaluate the salt tolerance of coriander (C. sativum) as medicinal plant under different saline and sodic concentrations at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan in 2017. The soil used for the pot experiment was analysed and having 7.4 pH, 1.7 ECe (dSm−1), 4.4 SAR (mmol L−1)1/2, 20.9 Saturation Percentage (%), 0.39 O.M. (%), 6.9 Available P (mg Kg−1) and 96.7 Extractable K (mg Kg−1). Considering the pre-sowing soil analysis, the ECe (Electrical conductivity) and SAR (Sodium Absorption Ratio) were artificially developed with salts of NaCl, Na2SO4, CaCl2 and MgSO4 using Quadratic Equation. 10 Kg soil was used to fill each pot. 10 seeds of coriander (C. sativum) as medicinal plant were sown in each pot. Fertilizer was applied @50-45-40 NPK Kg ha−1. Treatments were 4 dSm−1 + 13.5 (mmol L−1)1/2, 5 dSm−1 + 25 (mmol L−1)1/2, 5 dSm−1 + 30 (mmol L−1)1/2, 10dSm−1 + 25 (mmol L−1)1/2, 10dSm−1 + 30 (mmol L−1)1/2 and 10 dSm−1 + 30 (mmol L−1)1/2. Completely randomized design was applied with three repeats. Data on biomass yield were collected. The collected data were statistically analysed and means were compared by LSD at 5% (Montgomery, 2001).

**RESULTS AND DISCUSSION**

Extreme salinity decreases efficiency of many crops including most vegetables by causing various irregular morphological, physiological and biochemical alterations that cause late germination, high seedling transience, poor plant population, diminutive growth and lower yields. Biosaline agriculture (utilization of these salt-affected lands without disturbing present condition) is an economical way to reclaim the salt-affected soils and bring this area under cultivation. Therefore, a pot study was
carried out to assess the salt tolerance of coriander (C. sativum) under different salt concentrations. Significant divergence was initiated with treatments on biomass yield (Table 1). Highest biomass yield (32.57 gpot⁻¹) was gained by 4 dSm⁻¹ + 13.5 (mmol L⁻¹)⁻¹/² treatment. Biomass yield was decreased and also, the toxicity of salts was increased. Minimum biomass yield (24.41 gpot⁻¹) was produced at 10 dSm⁻¹ + 30 (mmol L⁻¹)⁻¹/², Sharma et al., 2013 investigated that coriander plants are moderately tolerant to salinity. Coriander can also be grown in the soils up to 6 EC (dSm⁻¹) and 10 ESP (exchangeable sodium percentage). Coriander is known as moderately tolerant to salinity, the effect appears mainly during germination and plant growth (Elouaer and Hannachi, 2013).

Table 1 also demonstrates the % decrease in biomass yield over control. 5 dSm⁻¹ + 25 (mmol L⁻¹)⁻¹/² treatment performed better results, that is, the least reduction % over the control (10.19). Salinity-sodicity showed serious effect on the growth reduction from 20.25 to 39.05%. This huge fissure was impacted by the negative effect of salinity and sodicity on coriander (C. sativum) growth. Also, they showed staid effect on the growth reduction from 10.19 to 25.05%. This reduction fissure was impacted by the harmful effect of salinity and sodicity on coriander growth. Salinity-sodicity showed toxic impact on the growth reduction from 10.19 to 25.05%. High salt concentrations decrease the osmotic potential of soil, which decreases the availability of water and disrupts the transport of water and nutrients to plant roots (Munns 2002; Tester and Davenport 2003). Salinity stress inhibits the growth of plants at early seedling and developed seedling stage (Ferdose et al., 2009). Salinity is a constraint to the sustainable agricultural production. Increasing salinity was found to inhibit growth, height, and total leaf area of rice from vegetative to generative stages (Hariadi et al., 2015).

CONCLUSION

Based on the findings, coriander (C sativum) was able to show more salt tolerance at 4 dSm⁻¹+ 13.5 (mmol L⁻¹)⁻¹/² treatment. Therefore, this plant is suggested to be cultivated in farmlands having salinity and sodicity of about 4 dSm⁻¹+ 13.5 (mmol L⁻¹)⁻¹/².

REFERENCES


