**In vitro saline sodic status of Camelina sativa cv. Blaine creek**

**Abstract**

The capability of *Camelina sativa* to survive salinity and sodicity stress *in vitro* by developing saline sodic soils (<4 dSm⁻¹, 12.9 (mmolL⁻¹)², 4.5 dSm⁻¹+20 (mmolL⁻¹))², 9.0 dSm⁻¹+20 (mmolL⁻¹)², 13.5 dSm⁻¹+20 (mmolL⁻¹)², 4.5 dSm⁻¹+30 (mmolL⁻¹)², 9.0 dSm⁻¹+30 (mmolL⁻¹)², 13.5 dSm⁻¹+30 (mmolL⁻¹)², 4.5 dSm⁻¹+40 (mmolL⁻¹)², 9.0 dSm⁻¹+40 (mmolL⁻¹)²) and 13.5 dSm⁻¹+40 (mmolL⁻¹)² at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan was conducted during, 2016. Saline sodic status of the plants was deliberated with various growth and yield parameters at maturity. Completely randomized design was applied with three repeats. % decrease over control in plant height showed positive behaviour with increased saline sodic conditions. 57% decrease over control in plant height was gained by the highest saline sodic treatment. However, the highest % increase over control in # of branches plant⁻¹ of this plant was found with the highest saline sodic treatment. Reduction in number of branches plant⁻¹ was increased as well as saline sodic level increased. Further, % decrease over control in grain yield was increased by increasing the intensiveness of salinity and sodicity.

**Keywords:** camelina seedlings, electrical conductivity, sodium absorption ratio, salt tolerance

**Introduction**

Salinity causes the disruption of the homeostatic balance of water potential and ion distribution in plants resulting in decreased availability of water to root cells and the plants tend to accumulate high concentrations of Na⁺ and Cl⁻ in their vacuoles to protect their cytoplasmic water potential and metabolic imbalances. These metabolic imbalances cause oxidative stress¹ and increased production of reactive oxygen species (ROS) – hydrogen peroxide (H₂O₂), hydroxyl radical (OH), and superoxide ions.² Scavenging of ROS in plant cells occurs by an endogenous protective mechanism involving antioxidant molecules and enzymes.³,⁴ On the other hand, it is well known that current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100, according to a new United Nations report being launched today.⁵ The world economy grew by 2.6 percent a year to almost double in size between 1990 and 2014. During that period, global economic growth was driven mainly by low-income and middle-income countries, whose gross domestic product (GDP) grew by some 5.1 percent annually. China’s GDP grew at double that rate, by more than 10 percent year, and in 2014 the country accounted for 9 percent of global GDP, compared to just 2 percent in 1990.⁶ Salinity is one of the most severe environmental factors limiting the productivity of agricultural crops, because most crops are sensitive to salinity induced by high concentrations of salts in the soil. This brief presentation of data suggests that salt tolerant plants should be taken into consideration, since they could play an important role in biosaline agriculture.⁷ It also reduces photosynthetic activity by destruction of green pigments, lowering leaf area or by decreasing the activity of photosynthetic enzymes. Further, salinity affects the cell membranes and causes lipid peroxidation leading to higher accumulation of malondialdehyde (MDA).⁸ Soil salinity presents a notable challenge to agriculture, which may be a consequence of human activities, such as irrigation, or alterations in rainfall patterns that reduce leaching of salts and minerals from soils. Lands that were once highly fertile have become less productive due to increased salt levels.⁹ Furthermore, increasing pressure to use marginal lands for farming often means that growers struggle with naturally-occurring high levels of salt.¹⁰ The effect of salt on plant growth and productivity is dependent on salt type, concentration, sensitivity of the crop, and the capacity of the plants to tolerate or mitigate the effects of salts alone or in combination.¹¹ For example, exposure to salt alters differentiation of the Casparian strip causing it to be unusually close to the root meristem¹² which changes root architecture¹³ and the root gravitropic response, halotropism.¹⁴ In addition, cell cycle inhibition as a result of salt stress causes cells in the meristem to stop dividing; cells elongate at the root tip, but do not divide¹⁵ and root size is reduced.¹⁶ The interest in the study of halophytes is still argued by theoretical reasons, and especially by the current context of human condition, regarded as a well-defined part of surrounding environment. Salinity has affected agriculture from millennia, having a deeply negative impact in agriculture and most likely, being involved in the fall of some ancient flourishing civilizations.⁸ Of the cultivated lands, about 340 million ha (23%) are saline (salt affected) and another 560 million ha (37%) are sodic (sodium-affected).¹⁸ Here are many different projections, suggesting that human population will increase over 8 billion by the year 2020 that will worsen the current scenario about food insecurity.¹⁹ There are often not sufficient reservoirs of freshwater available and most of the agronomical used irrigation systems are leading to a permanent increase in soil-salinity and slowly to growth conditions unacceptable for most of the common crops.²⁰ Moreover, salinity causes an increase in the concentration of some leaf osmotiles such as proline, betaine and free and bound polyamines.²¹ A previous study carried out by our group²² on a high oleic sunflower hybrid showed the oleic acid content to increase and the linoleic acid content to decrease with salinity increase.
Camelina sativa (canepelina, false flax or gold of pleasure) is a close relative of the model plant Arabidopsis thaliana (Arabidopsis) and the oilseed Brassica crops. Camelina was cultivated in Europe as an oilseed crop for food and fuel before being displaced by higher-yielding crops, such as oilseed rape/canola (Brassica napus) and wheat. The C. sativa genome was suggested to have arisen from a genome triplication event,23 a supposition supported by genome sequencing.24 However, the evolutionary origin of the ancestral genomes and the polyploidization and post-polyploidization events that led to diploidization are not fully understood.24 There is little evidence of fractionation bias in the C. sativa genome and the highly undifferentiated polyploid genome presents significant challenges for breeding and genetic manipulation.24-26 Efforts to diversify annual crop rotation portfolios renewed interest in this ancient crop as it can be grown on marginal lands that are not well-suited for food crops and has the potential to be a low cost, high value oil and meal bio-feedstock.27-29 It has enhanced drought, some degree of salinity and cold tolerance, displays early maturation, and requires fewer inputs compared to other oilseeds.30-32 It is also naturally resistant to diseases that afflict canola, such as blackspot,33 blackleg,34 and stem rot,35 as well as insect pests, such as the flea beetle and diamondback moth.36-38 Keeping in view the above facts an invitro experiment was planned to investigate the salt tolerance of camelina sativa plants under different concentrations of salinity and sodicity.

Materials and methods

A pot study was conducted to evaluate the growth and yield of camelina sativa under different artificial developed saline- sodic soils at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan during, 2016. The soil used for the pot experiment was analysed and having the lowest ECe and SAR. Lowest plant height (25.1cm) was produced in T10, % decrease over control in plant height showed positive behavior with increased saline sodic conditions. 57% decrease over control in plant height was gained by T10. # of branches plant-1 is the important growth parameter under saline sodic environment. Statistically significant results were produced in # of branches plant-1 as mentioned in Table 1. T10 produced the maximum number of branches plant-1(10.8) while the lowest figure (3.6) was attained in the highest saline sodic severity as depicted by T5. % decrease over control in # of branches plant-1 varied from 17 to 67 in different treatments. However, the highest% decrease over control in # of branches plant-1(67) of this plant was found with T5. Reduction in number of branches plant-1 was increased as well as saline sodic level increased. Many physiological processes of plants like seed germination, seedling growth, flowering, and fruit set are adversely affected by high salt concentrations. In particular, salinity delays germination, reduces the shoot growth as expressed by reduced leaf area, and affects many physiological processes like electrical conductivity (EC) and relative water content (RWC).39-41 Sunflower plants grown under saline stress show worsening leaf water status.42 This means that salinity disturbs the plant growth affecting important physiological processes in plants. Yield is the final product of every plant or crop. The performance of better growth under saline sodic environment hopes for the survival of this plant to provide some yield to utilize such soils for the betterment of salt- affected communities. Data of grain yield presented in Table 1 showed significant differences among treatments. Decreasing trend in yield was observed as well as the salinity and sodicity increased. Further, % decrease over control in grain yield was increased by increasing the intensiveness of salinity and sodicity. However, the differences among treatments was huge i.e. 25 to76%. This variation in percentage decrease in yield was understood the worse influence of saline sodic environment. Similar behaviour was also depicted in straw yield as indicated in Table 1.

Each unit increase in ECe above 4.8dSm-1 was found to reduce yield by 5 by 4.5% according to Flagella et al.22 Yield reduction was attributed mainly to a decrease in achenes per head and in the 1000 achenes weight.22 Katerji et al.,23 also classified sunflower as a tolerant crop based on the estimation of the crop water stress index. Salinity inhibits plant growth and development by reducing water availability, similar to drought, and via ion toxicity.43 Salt stress affects many cellular processes, including gene expression, protein synthesis, carbohydrate and lipid metabolism, osmotic and pH homeostasis44 and limits plant growth by impairing photosynthesis, metabolic processes and nutrient acquisition.45-47 While species and even genotypes may respond differently to stress, many stresses share the same set of general responses.48 Since camelina is somewhat resistant to drought, some degree of salinity resistance is to be expected. Indeed, the ability to avoid drought by developing deep root systems or making metabolic adjustments49 is a common feature of both drought and salt tolerance. Typically, salt affects root elongation Potters et al.,50 Bernstein et al.,51 and root architecture by reducing cell size and cell division and altering differentiation patterns. Pre and post harvest soil analysis i.e. pH, ECe and SAR presented in Table 2. Minute differences were found among treatments. Soil ECe reduction showed the salt tolerance of camelina sativa plant. Better salt tolerance in case of ECe was depicted in T4, 4.5dSm-1, T9, 9.0dSm-1 and T13, 13.5dSm-1 due to utilization of more salts than other treatments. Regarding SAR, treatments T2 [20 (mmolL-1)2], T3 [30 (mmolL-1)2] and T5 [40 (mmolL-1)2] showed better salt tolerance than other treatments.
Table 1 Effect of different combinations of salinity/sodicity on growth and yield per pot of Camelina sativa

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>% decrease over control</th>
<th># of branches plant⁻¹</th>
<th>% decrease over control</th>
<th>Grain yield (g)</th>
<th>% decrease over control</th>
<th>Straw yield (g)</th>
<th>% decrease over control</th>
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<tr>
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<td>---</td>
<td>10.8a</td>
<td>-----</td>
<td>4.12a</td>
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<td>6.30a</td>
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<td>55.8 a</td>
<td>5</td>
<td>9.0b</td>
<td>17</td>
<td>3.08ab</td>
<td>25</td>
<td>5.45b</td>
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<tr>
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<td>15</td>
<td>8.4bc</td>
<td>22</td>
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<td>4.44bc</td>
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<td>23</td>
<td>8.1 bc</td>
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<td>4.25cd</td>
<td>33</td>
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<td>27</td>
<td>7.8bc</td>
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<td>32</td>
<td>7.2 cd</td>
<td>33</td>
<td>2.06e</td>
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<td>6.3 de</td>
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<td>46</td>
<td>5.4 ef</td>
<td>50</td>
<td>1.30f</td>
<td>68</td>
<td>2.20fg</td>
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<td>4.5 fg</td>
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<td>72</td>
<td>1.93g</td>
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<td>3.6 g</td>
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<td>1.2</td>
<td>-----</td>
<td>0.41</td>
<td>-----</td>
<td>0.53</td>
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Table 2 Pre and post-harvest of soil analysis of pots of Camelina sativa plants

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pHs Pre-Harvest</th>
<th>pHs Post-Harvest</th>
<th>Soil ECe (dSm⁻¹) Pre-Harvest</th>
<th>Soil ECe (dSm⁻¹) Post-Harvest</th>
<th>Soil SAR (mmol L⁻¹)¹/² Pre-Harvest</th>
<th>Soil SAR (mmol L⁻¹)¹/² Post-Harvest</th>
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<tr>
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<td>8.03</td>
<td>&lt;4 dSm⁻¹</td>
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<td>8.13</td>
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<td>18</td>
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<td>8.22</td>
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<tr>
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<td>8.41</td>
<td>13.5</td>
<td>11.28</td>
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<td>28.92</td>
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<tr>
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<td>8.01</td>
<td>8.49</td>
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<td>3.8</td>
<td>40</td>
<td>38.25</td>
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<tr>
<td>T₉</td>
<td>8.01</td>
<td>8.56</td>
<td>13.5</td>
<td>11.66</td>
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<td>37.58</td>
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<tr>
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<td>8.56</td>
<td>13.5</td>
<td>11.66</td>
<td>40</td>
<td>37.86</td>
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</table>

Tₑₑ <4 dSm⁻¹+12.9 (mmol L⁻¹)¹/², Tₑₑ 4.5 dSm⁻¹+20 (mmol L⁻¹)¹/², Tₑₑ 9.0 dSm⁺⁺20 (mmol L⁻¹)¹/², Tₑₑ 13.5 dSm⁺⁺20 (mmol L⁻¹)¹/², Tₑₑ 13.5 dSm⁺⁺30 (mmol L⁻¹)¹/², Tₑₑ 13.5 dSm⁺⁺30 (mmol L⁻¹)¹/², Tₑₑ 4.5 dSm⁺⁺40 (mmol L⁻¹)¹/², Tₑₑ 9.0 dSm⁺⁺40 (mmol L⁻¹)¹/² and Tₑₑ 13.5 dSm⁺⁺40 (mmol L⁻¹)¹/²

Conclusion

Camelina sativa plant can withstand with saline sodic soil having 13.5 dSm⁺⁺40 (mmol L⁻¹)¹/² at 76% decreases over control in yield. Survival of camelina plant is the gift for the psychoanalysis of salt-affected lands.

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Conflict of interest

Author declares that there is no conflict of interest.

References


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