EFFECTS OF SALICYLIC ACID PRIMING FOR SALT STRESS TOLERANCE IN WHEAT

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Abstract: The present research experiment was conducted in the greenhouse of the Institute of Molecular Biology and Biotechnology, The University of Lahore for determining the possible involvement of salicylic acid (SA) in seed priming and affects on the seedling growth and development under NaCl treatments in wheat variety ANAJ-2017, Shafq-2006 and Galaxy-2013. The data was collected for various seedling traits and statistically analyzed, which revealed the significance of results for treatments, salt applications, genotypes and the interactions between salt treatments and genotypes. The lower coefficient of variation was recorded for all studied traits which revealed that there was consistency among the results for salicylic acid applications and salt or NaCl treatments. It was concluded from our study that the application of salicylic acid (SA) under salt (NaCl) stress conditions helps wheat seedlings to withstand and compete with stressful conditions. The study revealed that the seed priming with salicylic acid helps to improve root length, shoot length, seedling moisture percentage and fresh seedling weights. The application of NaCl caused to increase the root length, number of roots and shoot length of wheat while salicylic acid (SA) was applied in foliar spray. The use of water priming shows medium effects for the seedling growth of wheat under salt stress environmental conditions. The wheat variety Galaxy-2013 has shown good performance for most of the studied traits of seedlings under salt stress conditions. It was suggested from our study that the variety Galaxy-2013 may be used under salt stress conditions or salt affected soils to improve grain yield of wheat.

Keywords: wheat, salicylic acid, priming, salt stress, NaCl, root length, shoot length

Introduction
The bread wheat (Triticum aestivum L.); is as an important cash crop among the food crops throughout the world farming which occupies a significant position among all of the cultivated cereal crops. The cultivation of wheat has been remained the symbolic of the green revolution which has played a pivotal role in making the nations a food spare nation. The bread wheat is one of the member of the poaceae family with chromosomes 2n = 42 and is highly self-pollinated crop among cereals (Dixon et al., 2009; Sears, 1954; Shewry, 2009). Wheat ranks first among the world food and grain crops, in the terms of cultivated area which is about 223,813 m ha or production about 733,144 m tonnes and along with the productivity of about 3280 kg ha⁻¹ (Asseng et al., 2015). Wheat may be grown from the below of sea level up to 5000 meter altitude and in the areas where the rainfall ranges between 300-1130 mm per annum. Wheat contributes higher calories up to 20% and higher protein to the growing population of the world's more than any of the other food crops. The demands of wheat has been increased from about 79 g capita⁻¹ day⁻¹ to higher as much as 185 g capita⁻¹ day⁻¹ regardless of the doubling of the world population since from 1961 (Bhardwaj et al., 2010; Sarker et al., 2015). In Pakistan, the bread wheat is the second foremost important cereal crops next only to the rice and also a key crop in the green and post green revolution eras. India stands the second among world wheat producing countries while China stands first. The wheat production in Pakistan was 28.9 million tones and was grown over an area of about 31.18 m ha (Govt, 2018). The wheat production in Pakistan is lower as compared with other wheat growing countries in the world due to various factors including the quality seed availability, irrigation water, fertilizers, farm mechanization and biotic and abiotic stress conditions. Among abiotic stress conditions, drought, heat, salt, clod and heavy metal played an important role in decreasing the yield, production and over productivity of wheat in Pakistan (Charles et al., 2006; Fisher and Byerlee, 1990; Kirkegaard et al., 2008; Raza et al., 2006). Under abiotic stress conditions the wheat is highly affected which caused reduction in the yield and productivity. The salt stress caused cell membrane damage, production of toxic chemicals and accumulation of reactive oxygen species in the plant body. We have conducted our research while keeping few research objectives in mind as given below: To evaluate the effects of salicylic acid wheat seedling growth and
development. To find out the stress resistant wheat variety from selected varieties for research work and to find out the seed priming effects on wheat seedling growth with water and salicylic acid (SA).

Materials and Methods
The present research experiment was conducted in the greenhouse of the Institute of Molecular Biology and Biotechnology, University of Lahore for determining the possible involvement of salicylic acid (SA) in seed priming and affects on the seedling growth and development under NaCl treatments in wheat variety ANAJ-2017, Shafaq-2006 and Galaxy-2013. The seed of selected genotype was sown in 18 pots which were filled with 2kg of sand and soil. 500mg/kg of NaCl was added in the soil filled in the pots along with the control pots. The 120 wheat seeds were primed out through water while 120 wheat seeds were primed out by using 100mg/g of salicylic acid solution for overnight. In the next morning the primed wheat seeds which were washed out by distilled water (H₂O dist.) and 20 primed seeds were sown in each pot. The following sets of SA and NaCl treatments were kept for study: T₀ (Control), T₁ (Water priming), T₂ (SA priming), T₃ (Only NaCl), T₄ (Water priming + NaCl) and T₅ (SA priming + NaCl). The data was collected for various seedling morphological traits, viz., leaf area (LA), number of roots/plant (NR), root length (RL), shoot length (SL), shoot/root dry weight ratio (SRDWR) and shoot/root fresh weight ratio (SRFWR). The data was statistically analyzed through analysis of variance techniques by using SPSS23.1 software.

Results and Discussions
Leaf area or LA (cm²)
The results given in table 1 described significant differences among the genotypes, treatments and interactions between the treatments × genotypes. It was found from results that the average leaf area under all applied treatments was recorded as 6.0043±0.0213 cm². The lower value of coefficient of variation (0.24%) for leaf area indicated that there was consistency among the results which also cleared that the results were reliable for leaf area of wheat seedling under different treatments of salicylic acid and NaCl or salt. The results form table 2 indicated that the higher leaf area (97.3033 cm²) under T₃ (NaCl application) treatment, T₄ or water priming + NaCl (6.3967 cm²) was found while lowest was for control (5.190 cm²) and treatment T₅ or salicylic acid + NaCl (4.6556 cm²). The mean performance of genotypes under all treatments of NaCl and salicylic acid priming indicated that the genotypes/variety Galaxy-2013 (6.1933 cm²) showed higher leaf area while Shafaq-2006 (5.9933 cm²) and ANAJ-2017 (1.58261 cm²) average leaf area under all treatments (Table 3). The higher leaf area of wheat seedlings under NaCl treatment indicated that the genotypes with higher leaf area showed tolerance against salt stress without any application of growth regulator. The higher leaf area also revealed that the photosynthetic rate under salt stress may be higher which helped the seedlings to withstand under stressful environmental conditions (Agarwal et al., 2005a; Agarwal et al., 2005b; Shakirova et al., 2003). The results from figure 1 indicated that the ANAJ-2017 wheat variety or genotype showed higher leaf area (6.1 cm²) under water priming + NaCl treatment followed by NaCl (6.11 cm²) and salicylic acid priming + NaCl (6.01 cm²) while lowest leaf area under control (5.01 cm²) and salicylic acid priming (5.0 cm²). The Galaxy-2013 wheat variety or genotype showed higher leaf area (6.27 cm²) under water priming + NaCl treatment followed by NaCl (6.28 cm²) and salicylic acid priming + NaCl (6.26 cm²) while lowest leaf area under control (5.18 cm²) and salicylic acid priming (5.17 cm²). The Shafaq-2006 wheat variety or genotype showed higher leaf area (6.47 cm²) under water priming + NaCl treatment followed by NaCl (6.48 cm²) and salicylic acid priming + NaCl (6.46 cm²) while lowest leaf area under control (5.38 cm²) and salicylic acid priming (5.37 cm²). It was found from results that the seed priming with the application of salicylic acid for better growth and development plays an important role while depending upon the genetic potential of the crop plants. The genotype Galaxy-2013 showed good performance for leaf area under salt stress conditions and also good response for applications of salicylic acid. It was suggested that the genotype or variety Galaxy-2013 may be used for improved plant growth, development and higher grain yield variety under salt stress and salt affected soils (Amin et al., 2008; Catinot et al., 2008; Hayat et al., 2005; Singh and Usha, 2003).

Table 1: Pooled analysis of variance for different traits of wheat genotypes

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Shoot length</th>
<th>Root length</th>
<th>Roots per plant</th>
<th>Fresh root/shoot weight ratio</th>
<th>dry root/shoot weight ratio</th>
<th>Leaf Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>0.1666</td>
<td>0.0881</td>
<td>0.03185</td>
<td>0.01494</td>
<td>0.00607</td>
<td>0.00075</td>
</tr>
<tr>
<td>Treatment</td>
<td>5</td>
<td>26.3633*</td>
<td>64.0019*</td>
<td>1.61575*</td>
<td>0.28158*</td>
<td>0.08995*</td>
<td>7.9883*</td>
</tr>
</tbody>
</table>

Table 2: Tukey HSD for all-pairwise comparisons test for different stress treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Leaf area</th>
<th>Shoot length</th>
<th>Root length</th>
<th>Roots per plant</th>
<th>Fresh root/shoot weight ratio</th>
<th>Dry root/shoot weight ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>5.1900</td>
<td>18.867 D</td>
<td>19.040 D</td>
<td>7.0500</td>
<td>B</td>
<td>0.7466 BC</td>
</tr>
<tr>
<td>Water priming</td>
<td>6.2800</td>
<td>C</td>
<td>21.740 B</td>
<td>9.6833</td>
<td>C</td>
<td>0.7709 BC</td>
</tr>
<tr>
<td>Salicylic acid priming</td>
<td>6.2000</td>
<td>D</td>
<td>20.697 C</td>
<td>8.0833</td>
<td>A</td>
<td>0.7521 BC</td>
</tr>
<tr>
<td>NaCl</td>
<td>7.3033</td>
<td>A</td>
<td>22.800 A</td>
<td>7.0833</td>
<td>C</td>
<td>0.6553 C</td>
</tr>
<tr>
<td>Water priming + NaCl</td>
<td>6.3967</td>
<td>B</td>
<td>18.900</td>
<td>7.0833</td>
<td>A</td>
<td>0.8251 B</td>
</tr>
<tr>
<td>Salicylic acid + NaCl</td>
<td>4.6566</td>
<td>F</td>
<td>24.387 A</td>
<td>7.0467</td>
<td>B</td>
<td>1.1619 A</td>
</tr>
</tbody>
</table>

Table 3: Tukey HSD all-pairwise comparisons test of different traits for varieties/genotypes

<table>
<thead>
<tr>
<th>DF</th>
<th>Leaf area</th>
<th>Shoot length</th>
<th>Root length</th>
<th>Roots per plant</th>
<th>Fresh root/shoot weight ratio</th>
<th>Dry root/shoot weight ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANAJ-2017</td>
<td>5.8261</td>
<td>C</td>
<td>19.617 C</td>
<td>20.077 C</td>
<td>7.1056 B</td>
<td>0.8788 A</td>
</tr>
<tr>
<td>Shafaq-2006</td>
<td>5.9933</td>
<td>B</td>
<td>20.401 B</td>
<td>20.253 B</td>
<td>7.1539 B</td>
<td>0.8576 A</td>
</tr>
<tr>
<td>Galaxy-2013</td>
<td>6.1933</td>
<td>A</td>
<td>20.901 A</td>
<td>20.477 A</td>
<td>7.4056 A</td>
<td>0.7195 B</td>
</tr>
</tbody>
</table>

Fig. 1: Leaf area (cm$^2$) of wheat varieties under different treatments

Shoot length or SL (cm)

The results given in table 1 suggested that significant differences were found among genotypes and treatments while non-significant for interactions between treatments × genotypes. It was found from results that the average shoot length under all applied treatments was recorded as 20.306±0.0643 cm. The lower value of coefficient of variation (9.1%) for shoot length indicated that there was consistency among the results which also cleared that the results were reliable for shoot length of wheat seedling under different treatments of salicylic acid (SA) and NaCl. The results form table 2 revealed that there was higher shoot length (20.800 cm) under T3 (NaCl application) treatment, T1 or water priming (21.740 cm) while lowest was for control (18.867 cm) and treatment T5 or salicylic acid + NaCl (18.833 cm). The mean performance of genotypes under all treatments of NaCl and salicylic acid priming indicated that the genotypes/variety Galaxy-
2013 (20.904cm) showed higher shoot length while Shafaq-2006 (20.401cm) and ANAJ-2017 (19.617cm) average shoot length under all treatments (Table 3). The higher shoot length of wheat seedlings under NaCl treatment indicated that the genotypes with higher shoot length showed tolerance against salt stress without any application of growth regulator. The higher shoot length also revealed that the accumulation of organic compounds under salt stress may be higher which helped the seedlings to withstand under stressful environmental conditions (Afzal et al., 2006a; ASHRAF, 2006; Kovács et al., 2014; Misra and Saxena, 2009). The results from figure 2 indicated that the ANAJ-2017 wheat variety or genotype showed higher shoot length (21.12 cm) under water priming + NaCl treatment followed by NaCl (21 cm) and salicylic acid priming + NaCl (21 cm) while lowest shoot length under water priming (18 cm) and salicylic acid priming (18 cm). The Galaxy-2013 wheat variety or genotype showed higher shoot length (22.42 cm) under water priming + NaCl treatment followed by NaCl (22.30 cm) and salicylic acid priming + NaCl (22.12 cm) while lowest shoot length under water priming (18.8 cm) and salicylic acid priming (18.8 cm). It was found from results that the seed priming with application of salicylic acid for better growth and development plays an important role while depending upon the genetic potential of the crop plants. The genotype Galaxy-2013 showed good performance for shoot length under salt stress conditions and also good response for applications of salicylic acid. It was suggested that the genotype or variety Galaxy-2013 may be used for improved plant growth, development and higher grain yield variety under salt stress and salt affected soils (Afzal et al., 2006b; Gautam and Singh, 2009; Rafique et al., 2011; Turkyilmaz, 2012).

![Fig. 2: Shoot length (cm) of wheat varieties under different treatments](image_url)

**Fig. 2: Shoot length (cm) of wheat varieties under different treatments**

**Root length or RL (cm)**

The results as given in table 1 suggested that significant differences were found among genotypes and the applications of treatments while non-significant for interactions between treatments x genotypes. It was found from results that the average root length under all applied treatments was recorded as 20.269±0.0479cm. The lower value of coefficient of variation (0.69%) for root length indicated that there was consistency among the results which also cleared that the results were reliable for root length of wheat seedling under different treatment applications of salicylic acid (SA) and NaCl. The results form table 2 revealed that there was lower root length (18.393cm) under T4 (water priming+ NaCl application) treatment, T2 or salicylic acid priming (17.406cm) while higher was for NaCl application (22.592cm) and treatment T5 or salicylic acid + NaCl (24.387cm). The mean performance of genotypes under all treatments of NaCl and salicylic acid priming indicated that the genotypes/variety Galaxy-2013 (20.477cm) showed higher root length while Shafaq-2006 (20.253cm) and ANAJ-2017 (20.077cm) average root length under all treatments (Table 3). The higher root length of wheat seedlings under NaCl treatment indicated that the genotypes with higher root length showed tolerance against salt stress without any application of growth regulator which can absorb water mineral salts from deeper soil. The higher root length also revealed that the

accumulation of organic compounds under salt stress may be higher which helped the seedlings to withstand under stressful environmental conditions (Agami, 2013; Hussein et al., 2007; Idrees et al., 2010; Kang et al., 2012; Wang and Zhang, 2017). The results from figure 3 indicated that the ANAJ-2017 wheat variety or genotype showed higher root length (19.34 cm) under water priming + NaCl treatment followed by NaCl (19.60 cm) and salicylic acid priming + NaCl (19.17 cm) while lowest root length under water priming (18.54 cm) and salicylic acid priming (19 cm). The Galaxy-2013 wheat variety or genotype showed higher root length (19.74 cm) under water priming + NaCl treatment followed by NaCl (20 cm) and salicylic acid priming + NaCl (20.10 cm) while lowest root length under water priming (18.94 cm) and salicylic acid priming (19.4 cm). The Shafaq-2006 wheat variety or genotype showed higher root length (19.52 cm) under water priming + NaCl treatment followed by NaCl (19.78 cm) and salicylic acid priming + NaCl (19.88 cm) while lowest root length under water priming (18.72 cm) and salicylic acid priming (18.18 cm). It was found from results that the seed priming with application of salicylic acid for better growth and development plays an important role while depending upon the genetic potential of the crop plants. The genotype Galaxy-2013 showed good performance for root length under salt stress conditions and also good response for applications of salicylic acid. It was suggested that the genotype or variety Galaxy-2013 may be used for improved plant growth, development and higher grain yield variety under salt stress and salt affected soils (Amin, 2011; Deef, 2007; Liting et al., 2015).

![Fig. 3: Root length (cm) of wheat varieties under different treatments](image)

**Number of roots per plant or RPP**

The results given in table 1 suggested that significant differences were found among genotypes and treatments while non-significant for interactions between treatments × genotypes. It was found from results that the average roots/plant under all applied treatments was recorded as 7.2217±0.0432. The lower value of coefficient of variation (1.31%) for number of roots per plant indicated that there was consistency among the results which also cleared that the results were reliable for number of roots per plant of wheat seedling under different treatments of salicylic acid and NaCl or salt application. The results from table 2 suggested that there was higher number of roots per plant (7.0833) under T4 (water priming + NaCl application) treatment, T2 or salicylic acid priming (8.0833) while lower was for water priming (6.9833) and treatment T5 or salicylic acid + NaCl (7.0467). The mean performance of genotypes under all treatments of NaCl and salicylic acid priming indicated that the genotypes/variety Galaxy-2013 (7.4056) showed higher number of roots per plant while Shafaq-2006 (7.1539) and ANAJ-2017 (7.1056) average number of roots per plant under all treatments (Table 3). The higher number of roots per plant of wheat seedlings under NaCl treatment persuaded that the genotypes with higher roots/plant showed tolerance against salt stress without any application of growth regulator which can produce large amount of organic compounds through photosynthesis (Iqbal and Ashraf, 2006; Kim et al., 2006; Loutfy et al., 2012; Mohase and van der Westhuizen, 2002). The results from figure 4 indicated that the ANAJ-2017 wheat variety or genotype showed lower number of roots per plant (6.7) under water priming + NaCl treatment followed by water priming (6.8) and salicylic acid priming + NaCl (6.9) while higher number of roots per plant

under control (7), NaCl (7) and salicylic acid priming (7). The Galaxy-2013 wheat variety or genotype showed lower number of roots per plant (7) under water priming + NaCl treatment followed by water priming (7.1) and salicylic acid priming + NaCl (7.2) while higher number of roots per plant under control (7.3) and salicylic acid priming (7.3). The Shafaq-2006 wheat variety or genotype showed lower number of roots per plant (6.75) under water priming + NaCl treatment followed by water priming (6.85) and salicylic acid priming + NaCl (6.95) while higher number of roots per plant under control (7.05) and salicylic acid priming (7.05). It was found from results that seed priming with the application of salicylic acid for better growth and development plays an important role while depending upon the genetic potential of the crop plants. The genotype Galaxy-2013 showed good performance for number of roots per plant under salt stress conditions and also good response for applications of salicylic acid. It was suggested that the genotype or variety Galaxy-2013 may be used for improved plant growth, development and higher grain yield variety under salt stress and salt affected soils (Ashraf et al., 2004; Renard-Merlier et al., 2007; Seckin et al., 2009; Yordanova and Popova, 2007).

**Table 1**

<table>
<thead>
<tr>
<th>Treatments/wheat varieties or genotypes</th>
<th>ANAJ-2017</th>
<th>Shafaq-2006</th>
<th>Galaxy-2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (T0)</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Water priming (T1)</td>
<td>6.8</td>
<td>6.7</td>
<td>7.3</td>
</tr>
<tr>
<td>Salicylic acid priming (T2)</td>
<td>7</td>
<td>6.7</td>
<td>7</td>
</tr>
<tr>
<td>Water priming + NaCl (T4)</td>
<td>6.9</td>
<td>6.95</td>
<td>7.3</td>
</tr>
<tr>
<td>Salicylic acid priming + NaCl (T5)</td>
<td>7.05</td>
<td>7</td>
<td>7.2</td>
</tr>
<tr>
<td>Water priming + NaCl treatment (T0)</td>
<td>6.85</td>
<td>6.75</td>
<td>7.05</td>
</tr>
</tbody>
</table>

**Fig. 4:** Number of roots per plant of wheat varieties under different treatments

**Fresh root/shoot weight ratio or FRSWR**

The results given in table 1 suggested that significant differences were reported among treatments, genotypes and for interactions between treatments × genotypes. It was found from results that the average FRSWR under all applied treatments were recorded as 0.8186±0.0023. The lower value of coefficient of variation (10.02%) for FRSWR indicated that there was consistency among the results which also cleared that the results were reliable for FRSWR of wheat seedling under different applications of salicylic acid (SA) and NaCl. The results form table 2 revealed that there was higher FRSWR (0.7709) under T1 (water priming) treatment, T4 water priming + NaCl (0.8251%) and T5 SA priming + NaCl application showed 1.1619 while lower was for T3 or NaCl (0.6553) and treatment T0 or control (0.7466). The mean performance of genotypes under all treatments of NaCl and salicylic acid priming indicated that the genotypes/variety Shafaq-2006 (0.8576) followed by Galaxy-2013 (0.7195) and ANAJ-2017 (0.8788) average FRSWR under all treatments (Table 3). The results from figure 5 indicated that the ANAJ-2017 wheat variety or genotype showed lower FRSWR (0.750) under water priming + NaCl treatment followed by NaCl (0.76) and salicylic acid priming + NaCl (0.73) while higher FRSWR under water priming (0.82), control (0.79) and salicylic acid priming (0.84). The Galaxy-2013 wheat variety or genotype showed higher FRSWR (0.80) under water priming + NaCl treatment followed by NaCl (0.82) and salicylic acid priming (0.78) while lower FRSWR under water priming (0.58), control (0.58) and salicylic acid priming + NaCl (0.58). The Shafaq-2006 wheat variety or genotype showed lower FRSWR (0.77) under water priming + NaCl treatment followed by NaCl (0.78) and salicylic acid priming + NaCl (0.75) while higher FRSWR under water priming (0.84), control (0.82) and salicylic acid priming (0.86). The higher FRSWR of wheat seedlings under NaCl treatment indicated that the genotypes with higher fresh root-to-shoot weight ratio showed tolerance against salt stress and it may help the seedlings to withstand under stressful environmental conditions. It was found from results that seed priming with the application of salicylic acid for better growth and development plays an important role while depending upon the genetic

potential of the crop plants. The genotypes shafaq-2006 and Anaj-2017 showed good performance for FRSWR under salt stress conditions and also good response for applications of salicylic acid (El-Shintinawy, 2000; Hampson and Simpson, 1990; Jafar et al., 2012; Salam et al., 1999; Zheng et al., 2009).

Fig. 5: Fresh root-to-shoot weight ratio of wheat varieties under different treatments

Dry root/shoot weight ratio or DRSWR

The results given in table 1 persuaded that significant differences were reported among treatments, genotypes and for interactions between treatments × genotypes. It was found from results that the average DRSWR under all applied treatments were recorded as 1.0082±0.0011. The lower value of coefficient of variation (10.71%) for DRSWR indicated that there was consistency among the results which also cleared that the results were reliable for DRSWR of wheat seedling under different applications of salicylic acid and NaCl. The results form table 2 revealed that there was lower DRSWR (0.8910) under T1 (water priming) treatment, T4 water priming + NaCl (0.9404) and T2 SA priming application showed 0.9450 while higher was for T5 or SA priming + NaCl (1.1581) and treatment T0 or control (1.0706). The mean performance of genotypes under all treatments of NaCl and salicylic acid priming indicated that the genotypes/variety Shafaq-2006 (0.9508) followed by Galaxy-2013 (1.1859) and ANAJ-2017 (0.8878) average DRSWR under all treatments (Table 3). The results from figure 6 indicated that the ANAJ-2017 wheat variety or genotype showed lower DRSWR (0.80) under water priming + NaCl treatment followed by NaCl (0.67) and salicylic acid priming + NaCl (0.65) while higher DRSWR under water priming (1.02), control (0.90) and salicylic acid priming (1.04). The Galaxy-2013 wheat variety or genotype showed lower DRSWR (1.11) under water priming + NaCl treatment followed by NaCl (1.00) and salicylic acid priming (1.22) while higher DRSWR under water priming (1.33), control (1.20) and salicylic acid priming + NaCl (1.15). The Shafaq-2006 wheat variety or genotype showed lower DRSWR (0.91) under water priming + NaCl treatment followed by NaCl (0.83) and salicylic acid priming + NaCl (0.83) while higher DRSWR under water priming (1.01), control (0.95) and salicylic acid priming (1.02). The higher DRSWR of wheat seedlings under NaCl treatment indicated that the genotypes with higher DRSWR showed tolerance against salt stress and it may help the seedlings to withstand under stressful environment conditions. It was found from results that seed priming with the application of salicylic acid (SA) for better growth and development plays an important role while depending upon the genetic potential of the crop plants. The genotype Glaxy-2013 showed good performance for dry root-to-shoot weight ratio under salt stress conditions and also good response for applications of salicylic acid (Alpaslan et al., 1998; Basra et al., 2005; Li et al., 2011; Ma et al., 2007; Nagy and Galiba, 1995).
It was concluded from our study that the application of salicylic acid under salt stress conditions helps wheat seedlings to withstand and compete with stressful conditions. The study revealed that the seed priming with salicylic acid helps to improve shoot length, root length, seedling moisture percentage and fresh seedling weight. The application of NaCl caused to increase the root length, number of roots and shoot length of wheat while salicylic acid (SA) was applied in foliar spray applications. The use of water priming shows medium effects for the growth of wheat seedlings under salt stressed conditions. The wheat variety Galaxy-2013 revealed good performance for most of the seedlings studied traits of wheat under salt stress conditions.

Conflict of interest
The authors have declared absence of any type of conflict of interest.

References


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