IDENTIFICATION OF DROUGHT TOLERANT WHEAT GENOTYPES
BASED ON SEEDLING TRAITS

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ABSTRACT
Drought significantly reduces yield of many crop plants including wheat in the world. Identification of wheat genotypes that can thrive on limited water is vital to boost the wheat production of rainfed areas. Forty wheat genotypes were screened for drought tolerance using 0, 7.5, 15 and 22.5% Polyethylene Ethylene Glycol 6000 solutions at PMAS Arid Agriculture University, Rawalpindi, Pakistan during 2009-10. Data were recorded on various seedling parameters like germination percentage, germination rate index, root length, shoot length, coleoptile length and seedling vigor. The seedling traits showed a decreasing trend in response to increased concentrations of PEG 6000. Wheat genotype Lyalpur-73 was found the best for germination percentage (87.5). The genotypes C-591 had maximum germination rate index (2.4). Wheat genotypes Pashan 90 and WC-18 possessed maximum root length (9.9) and seedling vigor (7.4) respectively. The genotype Auqab-2000 showed maximum shoot length (8.3). Wheat genotypes Pak-81 along with CB 335 had maximum coleoptile length (1.9). Germination percentage and germination rate index showed positive correlation with all other traits. Root length showed positive association with shoot length and coleoptile length. While shoot length had positive correlation with coleoptile length and seedling vigour.

Key Words: Water Stress, Wheat, Seedling Traits, Drought Tolerance, Controlled Conditions

Citation: Ahmad, M., G. Shabbir, N.M. Minhas and M.K.N. Shah 2013. Identification of drought tolerant wheat genotypes based on seedling traits. Sarhad J. Agric. 29(1): 21-27.

INTRODUCTION
Wheat (T. aestivum L.) supplies one-third of the world population with more than half of their calories and nearly half of their protein. The forecasted global demand for wheat in year 2025 may rise up to 750 million tons (Mujeeb-Kazi and Rajaram, 2002). The most threatening problem in wheat production is the shortage of water at the seedling stage, mid season water stress, terminal stress or a combination of any two or three. Various factors affect the yield of a crop like seed germination, seedling vigor, growth rate, and mean emergence time and desiccation tolerance (Crosbie et al., 1980; Noorka et al., 2007).

Selection for drought tolerance at early stage of seedlings is most frequently practiced using poly ethylene glycol (PEG 6000) in the medium (Rauf et al., 2006). PEG 6000 molecules are inert, non ionic and virtually impermeable chains and have frequently been used to induce water stress without causing any significant physiological damage to crop plants (Carpita et al., 1979). PEG can be used to modify the osmotic potential of nutrient solution culture and can induce plant water deficit in a relatively controlled manner, appropriate to experimental protocols (Lagerwerf et al., 1961). Earlier studies focusing on identification of the drought tolerant wheat genotypes using different concentrations of PEG 6000 have showed significant differences for different seedling traits (Rauf et al., 2006; Singh et al., 2008). Significant differences among the wheat genotypes have also been observed for cell membrane stability (CMS), number of tillers and 100-seed weight. A positive correlation was observed between CMS and number of tillers in wheat (Shafeeq et al., 2006). The seedling traits when pooled together could discriminate between drought tolerant and susceptible genotypes (Noorka and Khaliq, 2007).

Identification of wheat genotypes that can tolerate limited water condition is vital to boost the wheat production which can be achieved only by exploring maximum genetic potential from available germplasm of wheat. Knowledge of character association for seedling traits under water deficit conditions is also important for understanding yield limiting factors. The present study was planned to identify wheat genotypes which could tolerate well under water stress conditions.
MATERIALS AND METHODS

This study was performed in the Research Laboratory of the Department of Plant Breeding & Genetics, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan during 2009-2010. The research material comprised of 40 different wheat genotypes of diverse nature i.e. local land races, old and new approved varieties etc. (Table 1). PEG 6000 solutions treatments i.e. 0, 7.5, 15 and 22.5% were used to induce water stress to different wheat genotypes. Seeds of each genotype were placed on moist germination papers and PEG solution treatments were applied on the paper to provide appropriate moisture stress for seed germination. The Petri plates were kept in growth chamber at 25 °C. Mean data were determined for germination percentage, germination rate index, root length, shoot length, coleoptile length and seedling vigour. Simple correlation coefficient between different traits was also computed.

Table 1. List of wheat genotypes used in the study

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Genotypes</th>
<th>Sr. No.</th>
<th>Genotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>WC-11</td>
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<td>Bhakkar-2002</td>
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<td>WC-17</td>
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<tr>
<td>7</td>
<td>LLR-45</td>
<td>27</td>
<td>Rawal-87</td>
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<tr>
<td>8</td>
<td>WC-5</td>
<td>28</td>
<td>C-591</td>
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<tr>
<td>9</td>
<td>Margalla 99</td>
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<td>WC-14</td>
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<td>LLR-23</td>
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<td>Chakwal 86</td>
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<td>WC-2</td>
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<tr>
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<td>CB-93</td>
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<td>Altar-84</td>
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<td>Auqab-2000</td>
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<td>18</td>
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<td>38</td>
<td>Lyalpur-73</td>
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<td>19</td>
<td>Yecora 70</td>
<td>39</td>
<td>Chakwal-50</td>
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RESULTS AND DISCUSSION

Germination Percentage

Results showed that there was decrease in germination percentage at high concentration of PEG i.e. 22.5%. A perusal of Table III depicted that maximum germination (99.38%) was observed under control conditions followed by (90.63 %) in the treatment (T1) where 7.5 % PEG was applied. The minimum germination (15 %) was observed in treatment (T2) where 22.5 % PEG was applied. The genotype Lyalpur-73 showed maximum germination percentage (87.5 %) followed by Rawal-87 that showed 81.3 % germination (Table 2). The genotype LLR-25 showed minimum germination percentage i.e. 40.7 %. The present results are in accordance with findings of Rauf et al. (2006) and Ambawatia et al. (1995).

Germination Rate Index

Mean values regarding the germination rate index are displayed in Table II. The highest value of germination rate index was observed in control i.e. 2.91 which was followed by the treatment T2 i.e. 2.21. The lowest value of GRI (1.34) was produced by treatment (T4). The results are comparable with the findings of Baalbalki et al., 1999 who reported that germination rate index was more sensitive to change in osmotic potential than germination percentage.

The genotype C-591 showed maximum germination rate index (GRI) of 2.4 followed by Chakwal 50 which had 2.2, while the genotype Altar-84 showed minimum germination rate index (0.5). Similar results were reported by Singh et al. (1994) and Akram et al. (1998).
Table 2. Mean values of various seedling traits for different wheat genotypes across four levels of Poly Ethylene Glycol

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Genotypes</th>
<th>Germination Percentage</th>
<th>Germination Rate Index</th>
<th>Root Length (cm)</th>
<th>Shoot Length (cm)</th>
<th>Coleoptile Length (cm)</th>
<th>Seedling Vigour</th>
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<td>6.3</td>
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<td>1.9</td>
<td>1095.0</td>
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</table>

**Root Length**

Mean values regarding root length are given in Table 2. Reduction in root length was observed with an increase in concentration of PEG. The maximum root length (12.09) was recorded in control followed by the treatment T2 (7.79) in which 7.5% PEG was applied. The least root length (0.88) was observed in treatment T4 in which 22.5% PEG was applied. The genotypes Pasban-90 and WC-18 showed maximum root length i.e. 9.9 cm and 9.6 cm respectively. The genotype WC-2 showed minimum root length i.e. 1.2 cm. These results are similar to the findings of Rauf et al. (2006) and Singh et al. (1994).
Shoot Length

Mean values regarding shoot lengths are presented in Table 2. The shoot length decreased significantly by increasing moisture stress irrespective of genotypes. The highest shoot length (8.49 cm) was recorded in control followed by the treatment T2 (6.16 cm). The least shoot length (0.66 cm) was recorded in treatment T4 in which maximum amount of stress was applied. The genotypes Auqab-2000 and Pasban-90 showed highest shoot length i.e. 8.3 cm and 8.1 cm, respectively. The genotype WC-15 showed minimum shoot length of 1.5 cm. These results are in corroboration with the findings of Akram et al. (1998) and Baalbaki et al. (1999).

Coleoptile Length

Mean values regarding coleoptile length (cm) are shown in Table 2. There was reduction in coleoptile length as concentration of PEG increased. Maximum value of coleoptile length (2.10 cm) was observed in control followed by treatment T2 (1.52 cm). Minimum coleoptile length (0.243 cm) was observed in T4 in which 22.5 % PEG was applied (Table 2).

Table 3. Mean values of various treatments of wheat genotypes under different stress levels

<table>
<thead>
<tr>
<th>PEG levels</th>
<th>Germination percentage</th>
<th>Germination rate index</th>
<th>Root length (cm)</th>
<th>Shoot length (cm)</th>
<th>Coleoptile length (cm)</th>
<th>Seedling vigour</th>
</tr>
</thead>
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<tr>
<td>T1 (0)</td>
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<td>12.09</td>
<td>8.49</td>
<td>2.10</td>
<td>2024.</td>
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<tr>
<td>T2 (7.5%)</td>
<td>90.63</td>
<td>2.21</td>
<td>7.97</td>
<td>6.16</td>
<td>1.52</td>
<td>1298</td>
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<td>T3 (15%)</td>
<td>55.00</td>
<td>1.88</td>
<td>4.19</td>
<td>3.57</td>
<td>0.88</td>
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<td>T4 (22.5%)</td>
<td>15.0</td>
<td>1.34</td>
<td>0.88</td>
<td>0.66</td>
<td>0.24</td>
<td>46.46</td>
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</table>

Two genotypes Pak-81 and CB 335 showed maximum coleoptile length of 1.9 cm. The genotype WC-15 showed minimum coleoptile length of 0.5 cm (Table 2). Similar results have already been reported by Boubaker and Hammouda (1997).

Seedling Vigour

The highest value of seedling vigour (2024) was observed in case of control, followed by T2 with mean value of 1298 (Table II). The least value of seedling vigour (46.46) was recorded in case of T4 in which maximum amount of stress was plasticized. The highest value of seedling vigour (1549.2) was shown by genotype Pasban-90, followed by WC-18 with mean value of 1455.5. Lowest value of seedling vigour (336.6) was shown by genotype WC-15.

Results revealed that response of all parameters become decreased by increasing PEG concentrations (Fig. I). Lyalpur-73 showed maximum value of germination percentage. The highest germination rate index was observed for C-591. Root length and shoot length were the highest for wheat genotypes Pasban-90 and Auqab-2000, respectively. Coleoptile length and seedling vigour were maximum in Pak-81 and Pasban-90, respectively. Early vegetative growth is a critical factor in wheat productivity under moisture stress conditions. Seedling germination and seedling vigour may lead to early vegetative growth. A deep and voluminous root system should permit seedlings to extract soil moisture in a greater soil volume. The influence of root architecture on yield and other agronomic traits, especially under stress conditions, has been widely reported in all major crops (Passiouara, 1972; Ludlow and Muchow, 1990; Tuberosa et al., 2002; de Dorlodot et al., 2007). Rapid early development of leaf area and above-ground biomass, denoted as early vigor, contributes to a high yield due to shading of the soil surface, thereby reducing evaporation of water from the soil and leaving more water available for the crop. Greater early vigor can increase the crop’s seasonal water use efficiency by as much as 25% (Siddique et al., 1990), and it is recognized as a trait to select for to improve yield under water stress (Richards, 2000; Botwright et al., 2002; Richards et al., 2002). In more favorable environments, high early vigor may be beneficial by increasing seedling competitiveness against weeds, resulting in less need for herbicide use (Lemerle et al., 2001). The genotypes excelling in various seedling
traits can be further used in hybridization programme for wheat improvement targeted for development of drought tolerant cultivars for rainfed areas of Pakistan.

Fig. 1. Graphs depicting response of studied seedling traits to different stress levels of PEG 6000

**Correlation Studies**

Simple correlation coefficient was calculated among all the characters (Table IV) and described as follows. Germination percentage showed a positive correlation with germination rate index while it shows a very strong positive correlation with root length, shoot length, coleoptile length and seedling vigour. Positive correlation showed that an increase in germination percentage would cause an increase in these parameters. These results are supported by the findings of Khan et al. (2002). Results of correlation analysis showed that germination rate index exhibited a positive association with all other parameters i.e. root length; shoot length, coleoptile length and seedling vigour. It showed that an increase in germination rate index will cause an increase in root length, shoot length, coleoptile length and seedling vigour. These results are in accordance of Singh et al. (1994).

**Table 4. Correlation coefficient among various seedling traits of different wheat genotypes**

<table>
<thead>
<tr>
<th></th>
<th>Germination percentage</th>
<th>Germination rate index</th>
<th>Root length</th>
<th>Shoot length</th>
<th>Coleoptile length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination percentage</td>
<td>0.0523</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root length</td>
<td>0.7992*</td>
<td>0.0582</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoot length</td>
<td>0.8152*</td>
<td>0.0520</td>
<td>0.8407*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coleoptile length</td>
<td>0.8524*</td>
<td>0.0431</td>
<td>0.8540*</td>
<td>0.8646*</td>
<td></td>
</tr>
<tr>
<td>Seedling vigour</td>
<td>0.8508*</td>
<td>0.0620</td>
<td>0.9424*</td>
<td>0.9087*</td>
<td>0.8700*</td>
</tr>
</tbody>
</table>

* Significant at P < 0.05 level
Root length shows a strong correlation with shoot length and coleoptile length. Root length exhibited a very strong correlation with seedling vigour. A positive association indicated that increase in root length will also increase shoot length, root length and seedling vigour. These results are supported by the findings of Khan et al. (2002) and Baalbaki et al. (1999). Shoot length showed a positive and strong correlation with coleoptile length, while it exhibited a very strong correlation with seedling vigour. The findings infer that increase in shoot length will also cause an increase in these parameters. These results are supported by the findings of Khan et al. (1994). A strong and positive correlation was observed between coleoptile length and seedling vigour (Table IV). It showed that increase in seedling vigour will cause an increase in coleoptile length. These results are supported by Singh et al. (1994).

Germination percentage showed a positive correlation with germination rate index while it showed a very strong positive correlation with root length, shoot length, coleoptile length, and seedling vigor. These results are supported by the findings of Khan et al. (2002). Germination rate index exhibited a positive association with all other parameters i.e. root length, shoot length, coleoptile length and seedling vigor. These results are in accordance of Singh et al. (1994). While root length showed a strong correlation with shoot length and coleoptile length. Root length exhibited a very strong correlation with seedling vigour. These results are supported by the findings of Khan et al. (2002) and Baalbaki et al. (1999). On the other hand shoot length showed a positive and strong correlation with coleoptile length, while it exhibited a very strong correlation with seedling vigor. It means that increases in shoot length will also cause an increase in these parameters. These results are supported by Akram et al. (1998). A strong and positive correlation was found between coleoptile length and seedling vigour. These results are supported by Singh et al. (1994).

CONCLUSION AND RECOMMENDATIONS

The present study has helped to identify genotypes that can prove to be useful source for these traits. The genotypes identified include Pasban 90 and WC-18 (root length and seedling vigour), Pak-81 and CB 335 (coleoptile length). Drought tolerant traits like coleoptiles length and root length possessed by these genotypes can be incorporated into other high yielding and well adapted wheat varieties to get maximum plant population and yield under low moisture levels such as rainfed areas of Pakistan. These genotypes can also be utilized to develop mapping populations for seedling traits like root length and coleoptile length.

REFERENCES


