EVALUATION OF SCREENING TECHNIQUES FOR DROUGHT TOLERANCE IN WHEAT (TRITICUM AESTIVUM L.)

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SUMMARY

Several laboratory and field screening techniques were evaluated for their ability to differentiate drought tolerant genotypes in nine cultivars and their F_1 hybrids. The plant height stress index was observed to be unsuitable because it could not differentiate between tolerant and susceptible types. Percent thermoinstability was also unsuitable because of its limited association with other parameters. Percent reduction in RWC and germination percentage in PEG were most effective among the laboratory techniques. High yield under stress was associated with percent reduction in RWC and germination under PEG. Among the field screening techniques (at maturity), drought susceptibility index and dry matter stress possessed low drought susceptibility index and high dry matter stress index.

Keywords: Screening techniques, drought tolerance, wheat.

INTRODUCTION

Improving drought tolerance of wheat has long been a major objective of most breeding programmes because water deficit during some part of the growing period are common to most regions of the world where wheat is produced. Plant breeders have measured selected physiological parameters like leaf water potential, relative water content and diffusion resistance for the purpose of identifying selection criterion which would be used to screen germplasm for drought tolerance (Blum, 1989, Jaradat and Konzak, 1983, Matin et al., 1989, Turner, 1986). A major limitation in selection of genotypes for drought tolerance has been the lack of technique that is repeatable and can be used in segregating population.

Techniques suggested for drought screening includes germination in PEG (Singh and Afzal, 1998, Saldivar, 1988, Ambawatia et al., 1995) per cent reduction in RWC (Ritchie et al., 1990, Deshmukh et al., 1991) per cent thermoinstability, plant height stress index, dry matter stress index (Bauslama and Scapaugh, 1984) and drought susceptibility index (Fischer and Maurer, 1978). In the present investigation screening of nine parents and their thirty six F_1 hybrids were used for drought tolerance to determine suitability of these parameters for the selection of drought tolerant genotypes.

MATERIALS AND METHODS

Nine spring wheat cultivars of which five (K-8027, PBW-175, NI-5439, Pissi Local and Hybrid-65) are recommended for rainfed and four HD-2329, HD-2009, WH-542 and Sonalika) for irrigated condition were crossed in a diallel mating system without reciprocals to produce 36 F_1's. The F_1 and parent seeds were tested for germination percentage at -8.0 bar PEG (Polyethylene glycol 6000) in three replications following Michael and Kaufmann (1973). All the material was grown in the same field under two different conditions i.e. E_1 (with three irrigations) and E_2 (Without irrigation/rainfed) with three replications following Michael and Kaufmann (1973). All the material was grown in the same field under two different conditions i.e. E_1 (with three irrigations) and E_2 (Without irrigation/rainfed) with three replications in a randomized block design. Each plot consisted to one row of 1.5 m length with 30 cm and 10 cm inter and intra...
row spacing, respectively. Observations on grain yield, biological yield and plant height were recorded at maturity on five plants from each plot.

RWC was measured following Barrs and Weatherley (1962) for all the replications under both the conditions at anthesis stage. Per cent reduction was calculated using the RWC value for E1 and E2 conditions. Ion leakage was measured following the method of Onwueme (1979). Per cent thermoinstability (PTI), PHS1 and DMSI was calculated using the conductivity ratio data from both the conditions for each genotype following Bausloma and Schapaugh (1984).

$$\text{PTI} = 1 - \frac{1-(T_1/T_2)}{(C_1/C_2)} \times 100$$

$$T_1/T_2 = \text{Conductivity ratio under rainfed condition.}$$

$$T_2/T_1 = \text{Conductivity ratio under irrigated condition.}$$

Plant height stress index (PHSI) was calculated as

$$\text{PHSI} = \frac{\text{Plant height under } E_2}{\text{Plant height under } E_1 } \times 100$$

Dry matter stress index (DMSI) was calculated for each genotype using the data of biological yield.

$$\text{DMSI} = \frac{\text{Total dry matter produced under } E_2}{\text{Total dry matter produced under } E_1 } \times 100$$

Drought susceptibility index (S) was calculated for grain yield using the formula as presented by Fischer and Maurer (1978).

$$S = 1 - \frac{Y_d}{Y_p} / D$$

Where,

$Y_d$ and $Y_p$ are the mean yield of the genotype under $E_1$ and $E_2$ conditions, respectively and $D$ is the drought intensity.

$$D = 1 - \frac{\text{Mean } Y_d \text{ of all the genotypes under } E_2}{\text{Mean } Y_p \text{ of all the genotypes under } E_1} \times 100$$

Yield Stability ratio (YS) was calculated by taking the ratio of grain yield under $E_1$ and $E_2$ as suggested by Lewis (1954).

$$\text{YS} = \frac{\text{Grain yield under } E_2}{\text{Grain yield under } E_1} \times 100$$

RESULTS AND DISCUSSION

As our parental materials were tolerant as well as susceptible to drought, YS values showed clear distinction between tolerant and susceptible parents (Table I). The tolerant parents had higher values of YS (>50.0%) than the susceptible parents. Using the same procedure we also indentified the most susceptible and tolerant F1 crosses. On the basis of germination percentage under PEG, clear differences could be seen between tolerant and susceptible genotypes. Similarly per cent reduction in RWC and PTI also differentated the tolerant and susceptible genotypes (parents + F1s). Among the field screening techniques, estimated at maturity, DMSI values were higher (>50.0%) for all the tolerant genotypes. Drought susceptibility index (S) was less than one for all the tolerant genotypes as also suggested by Fischer and Maurer (1978) and Clarke et al. (1984). However, PHSI failed to differentiate between tolerant and susceptible genotypes.

Correlation coefficients among all the parameters studied alongwith grain yield under $E_2$ (Table II) were found to be significant except PHSI and PTI. Per cent reduction in RWC showed significant positive correlation with (S) and highly significant negative correlation with grain yield under $E_1$ condition. Germination percentage under PEG, YS and DMSI showed significant negative correlation with (S) and positive with grain yield under $E_2$ condition. So, it is obvious to say that genotypes with higher germination percentage under PEG and high YS and DMSI with less percent reduction in RWC are high yielder and less susceptible under drought condition. Though PTI showed significant negative correlation with

### Table 1. Drought susceptibility and different estimated parameters for parents and most tolerant and susceptible F₁ crosses.

<table>
<thead>
<tr>
<th>Parents</th>
<th>Germination reduction (%PEG)</th>
<th>Reduction in RWC (%RWC)</th>
<th>Thermon-in-stability</th>
<th>YS</th>
<th>DMSI</th>
<th>PHSI</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolerant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-8027</td>
<td>58.87</td>
<td>10.66</td>
<td>1.22</td>
<td>51.16</td>
<td>49.19</td>
<td>79.35</td>
<td>0.98</td>
</tr>
<tr>
<td>PBW-175</td>
<td>72.33</td>
<td>12.07</td>
<td>2.47</td>
<td>52.91</td>
<td>53.18</td>
<td>82.20</td>
<td>0.95</td>
</tr>
<tr>
<td>NI-5439</td>
<td>71.33</td>
<td>15.52</td>
<td>1.16</td>
<td>50.66</td>
<td>50.36</td>
<td>75.21</td>
<td>0.99</td>
</tr>
<tr>
<td>Pissi Local</td>
<td>76.33</td>
<td>8.24</td>
<td>1.16</td>
<td>65.66</td>
<td>59.88</td>
<td>74.93</td>
<td>0.69</td>
</tr>
<tr>
<td>Hybrid-65</td>
<td>57.33</td>
<td>8.95</td>
<td>1.26</td>
<td>59.68</td>
<td>61.58</td>
<td>76.62</td>
<td>0.81</td>
</tr>
<tr>
<td>Susceptible</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>HD-2329</td>
<td>38.00</td>
<td>18.71</td>
<td>7.14</td>
<td>33.97</td>
<td>34.73</td>
<td>79.31</td>
<td>1.33</td>
</tr>
<tr>
<td>HD-2009</td>
<td>56.00</td>
<td>17.22</td>
<td>9.33</td>
<td>33.03</td>
<td>35.98</td>
<td>84.41</td>
<td>1.35</td>
</tr>
<tr>
<td>WH-542</td>
<td>33.33</td>
<td>15.93</td>
<td>7.69</td>
<td>44.57</td>
<td>43.55</td>
<td>74.49</td>
<td>1.12</td>
</tr>
<tr>
<td>Sonalika</td>
<td>44.33</td>
<td>20.62</td>
<td>10.63</td>
<td>39.41</td>
<td>41.91</td>
<td>80.95</td>
<td>1.22</td>
</tr>
<tr>
<td>Crosses</td>
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<tr>
<td>Tolerant</td>
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<td></td>
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</tr>
<tr>
<td>PBW 175×Pissi Local</td>
<td>78.00</td>
<td>4.72</td>
<td>1.17</td>
<td>75.48</td>
<td>74.77</td>
<td>75.64</td>
<td>0.49</td>
</tr>
<tr>
<td>PBW 175×NI 5439</td>
<td>75.67</td>
<td>4.38</td>
<td>1.17</td>
<td>85.87</td>
<td>66.92</td>
<td>84.85</td>
<td>0.28</td>
</tr>
<tr>
<td>NI 5439×Hybrid-65</td>
<td>64.33</td>
<td>6.84</td>
<td>2.41</td>
<td>68.64</td>
<td>78.52</td>
<td>74.69</td>
<td>0.63</td>
</tr>
<tr>
<td>NI 5439×Pissi Local</td>
<td>82.33</td>
<td>2.69</td>
<td>1.15</td>
<td>59.00</td>
<td>56.08</td>
<td>78.62</td>
<td>0.83</td>
</tr>
<tr>
<td>K-8027×Pissi Local</td>
<td>73.00</td>
<td>10.55</td>
<td>1.21</td>
<td>64.51</td>
<td>61.54</td>
<td>72.93</td>
<td>0.71</td>
</tr>
<tr>
<td>Susceptible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HD 2329×HD 2009</td>
<td>23.67</td>
<td>14.47</td>
<td>8.45</td>
<td>36.69</td>
<td>34.04</td>
<td>83.99</td>
<td>1.28</td>
</tr>
<tr>
<td>HD 2329×Sonalika</td>
<td>55.33</td>
<td>16.12</td>
<td>15.21</td>
<td>26.09</td>
<td>20.06</td>
<td>75.06</td>
<td>1.49</td>
</tr>
<tr>
<td>K 8027×HD 2009</td>
<td>45.00</td>
<td>15.26</td>
<td>8.69</td>
<td>40.88</td>
<td>33.60</td>
<td>76.83</td>
<td>1.19</td>
</tr>
<tr>
<td>K 8027×WH-542</td>
<td>23.67</td>
<td>19.02</td>
<td>9.09</td>
<td>43.38</td>
<td>41.61</td>
<td>72.83</td>
<td>1.14</td>
</tr>
<tr>
<td>Hybrid 65×HD 2329</td>
<td>55.33</td>
<td>15.21</td>
<td>9.86</td>
<td>33.82</td>
<td>35.51</td>
<td>78.54</td>
<td>1.34</td>
</tr>
<tr>
<td>CD(P=0.05)</td>
<td>8.23</td>
<td>2.39</td>
<td>2.01</td>
<td>6.31</td>
<td>3.67</td>
<td>1.72</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Germination in PEG and grain yield under E, but did not show any correlation with S, YS or DMSI. So, PTI and PHSI are not strong parameters for screening wheat genotypes for drought tolerance. Similar conclusions have also been made by Blum and Ebercon (1981). On the other hand, Bauslama and Schapaugh (1984) suggested the use of these two parameters for screening soybean genotypes for drought tolerance.

Based on their ability to differentiate the genotypes into tolerant and susceptible and from their correlation study for different parameters measured at maturity, S and DMSI were found to be most effective for screening wheat genotypes for drought tolerance. Among laboratory screening techniques, germination percentage under PEG is quickest and relatively low cost for evaluation of drought tolerance in a large number of wheat cultivars. (Singh and Afria, 1988, Saldivar, 1988, Ambawati et al., 1995). Percent reduction in RWC is also relatively simple and rapid and could be used for screening of large number of genotypes and is more amenable for selection in drought stressed environment than other parameters before maturity (Schofield et al., 1988, Deshmukh et al., 1991).
Table II. Correlation coefficient among grain yield under E, and all other different parameters studied.

<table>
<thead>
<tr>
<th>PEG</th>
<th>YS Reduction (%)</th>
<th>PTI</th>
<th>DMSI</th>
<th>PHSI</th>
<th>S</th>
<th>Grain yield (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination (%) PEG</td>
<td>0.327*</td>
<td>-0.502**</td>
<td>-0.301*</td>
<td>0.339*</td>
<td>-0.008</td>
<td>-0.331*</td>
</tr>
<tr>
<td>YS Reduction (%)</td>
<td>-0.430**</td>
<td>-0.286</td>
<td>-0.921**</td>
<td>-0.211</td>
<td>-0.999**</td>
<td>0.634**</td>
</tr>
<tr>
<td>RWC</td>
<td>0.621**</td>
<td>-0.434**</td>
<td>0.098</td>
<td>0.429**</td>
<td>-0.749**</td>
<td></td>
</tr>
<tr>
<td>PTI</td>
<td>-0.245</td>
<td>0.156</td>
<td>0.283</td>
<td>0.433**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMSI</td>
<td>0.170</td>
<td>-0.922**</td>
<td>0.667**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHSI</td>
<td>-0.210</td>
<td>-0.169</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>-0.634**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* **, Significant at 5% and 2% levels, respectively.

REFERENCES


