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Yield Potential and Stability of Nine Wheat Varieties under Water Stress Conditions

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ABSTRACT

Selection for drought tolerance typically involves evaluating genotypes for either high yield potential or stable performance under varying degrees of water stress. A field study was conducted on sandy loam soil, in the Research Area, Department of Crop Physiology, University of Agriculture, Faisalabad during 1999-2000 to evaluate genotypes for combined high yield potential and stability under water stress conditions. Nine wheat (*Triticum aestivum* L.) varieties were grown under well-watered and stressed condition. Water stress was imposed at anthesis stages by withholding irrigation supply. Drought susceptibility index (DSI) and relative yield (RY) values were used to describe yield stability and yield potential. There were high variations in drought susceptibility index and relative yield values within genotypes. The DSI values ranged from 0.62 to 1.26 and the mean RY values were 0.81 for well-watered plots and 0.83 for water stressed plots. The varieties Parwaz-94, Pasban-90 and Punjab-96 showed high yield potential and stability (i.e. DSI < 1; and RY > mean RY) so, these varieties could be further tested for their drought confirming characteristics.

Key Words: Wheat; Water stress; Yield potential

INTRODUCTION

The ability of a cultivar to produce high and satisfactory yield over a wide range of stress and non-stress environments is very important. Finlay (1968) believed that stability over environments and yield potential are more or less independent of each other. Blum (1979) suggested that one method of breeding for increased performance under water stressed conditions might be to breed for superior yield under optimum conditions on the assumption that the best lines would also perform well under sub optimum conditions. Sojka *et al.* (1981), however, pointed out that a high yield baseline that allows a cultivar to do well over a range of environments does not imply drought resistance. They defined drought resistance as the ability to minimize yield loss in the absence of soil water availability. The ideal situation would be to have a highly stable genotype with high yield potential (Finlay & Wilkinson, 1963; Smith, 1982).

The most widely used criteria for selecting high yield performance are mean yield, mean productivity (average yield performance under stress and non stress conditions) and relative yield performance in drought-stressed and more favourable environments. Relative yield (yield of an individual genotype under drought relative to that of the highest yielding genotupe in the population) could be used to assess the yield poential of a genotype under water-stressed conditions. Higher relative yield shows that the genotype performed relatively well under drought. Pinter *et al.* (1990) and Ahmad *et al.* (1999) found relative grain yield to be a useful criterion for assessing drought response of wheat genotypes. Stability in grain yield for each genotype is estimated by the drought susceptibility index, derived from the yield difference between stress and non stress environments (Blum *et al.*, 1989). Fisher and Maurer (1978) and Langer *et al.* (1979) involved the use of drought susceptibility index (DSI), which characterizes the yield stability between two environments. There are many reports in literature on the use of DSI for identifying genotypes with yield stability in moisture limited environments (Fisher & Maurer, 1978, Clarke *et al.*, 1984; Bruckner & Frohberg, 1987; Edhaie *et al.*, 1988; Bansal & Sinha, 1991).

The combination of high yield stability and high relative yield under drought, has been proposed as useful selection criterion for charactering genotypic performance under varying degree of water stress (Pinter *et al.*, 1990). Ahmad *et al.* (1999) found combination of drought susceptibility index (measure of yield stability) vs. relative yield useful in identifying genotypes with yield potential and relatively stable yield performance under different moisture environments. The objectives of this study, therefore, were to screen wheat varieties with high yield potential and stability under water stress conditions.

MATERIALS AND METHODS

The experiment was conducted in the research area, Department of Crop Physiology, University of Agriculture, Faisalabad during 1999-2000. Nine wheat varieties (Chakwal-86, Pasban-90, Inqilab-91, Parwaz-94, Shahkar-95, Punjab-96, Durum-97, Kohistan-97, MH-97) were used for this study.

The experiment was laid out in a split block design, with three replications, keeping irrigation levels in main plots and varieties in sub-plots. Wheat was planted on December 14, 1999 on a sandy-loam soil in lines with the help of a single row hand drill. Row to row distance measured 22 cm, with each genotype consisting of 5 rows, 1.14 m wide and 6.096 m long. Net plot size measured 6.97 m^2. Nitrogen was applied @ 100 kg ha^{-1} as urea, while phosphorus was applied @ 100 kg ha^{-1} as P_2O_5 using DAP. Half of nitrogen and whole phoshorus were applied at the planting time and the rest of the nitrogen was applied with the first irrigation, after days to sowing. Water stress was imposed by with holding irrigation at anthesis stage and continued till maturity. One set of treatments with normal irrigations from planting to maturity served as control.

Grain yield per plant was recorded after harvesting the crop at maturity. The measures of yield stability (DSI) and yield potential (RY) were calculated from mean grain yield. The DSI (Fischer & Maurer, 1978) was as

$$DSI = (1-Yd/Yw)/D$$

Where Yd = mean yield under drought, Yw = mean yield under well-watered conditions, and D = environmental stress intensity = 1-(mean yield of all genotypes under drought/mean yield of all genotypes under well-watered conditions). The relative yield under drought was calculated as the yield of a specific genotype under drought divided by that of the highest yielding genotype in the population.

RESULTS AND DISCUSSION

Drought susceptibility index values (Table I) ranged from 0.62 to 1.26. The varieties Perwaz-94, Punjab-96 and Pasban-90 were relatively drought resistant (DSI values < 1), while the varieties Kohistan-97, Durum-97, MH-97 and Shahkar-95 were relatively drought susceptible (DSI > 1).

Drought susceptibility index is a measure of yield stability. However, timing of water stress in relation to the development of different genotypes (Clarke *et al.*, 1984) or lack of adaptation to favourable environments (Baker, 1987) could be other possible causes of variation in DSI. The result of this study are in good agreement with the early findings of Clarke *et al.* (1984), Bruckner and Frohberg (1987) and Clarke *et al.* (1992), when they reported considerable variation in DSI values of certain genotypes of both across and within years.

Genotypes with low DSI values (less than I) can be considered to be drought resistant (Bruckner & Frohberg, 1987), because they exhibited smaller yield reductions under water stress compared with well-watered conditions than the mean of all genotypes. However, the low DSI values may not necessarily give a good indication of drought resistance of a genotype. Low DSI values of a variety could be due to lack of yield production under well-watered conditions rather than an indication of its ability to tolerate water stress.

The DSI has sometime been represented as providing a measure of genotypic yield potential under water stress conditions (Brukner & Frohberg, 1987). However, DSI does not account for differences in yield potential among genotypes (Clarke *et al.*, 1992). DSI actually provide a measure of yield stability based on minimization of yield loss under stressed compared to non stressed conditions rather than on yield level under dry conditions per se (Clarke *et al.*, 1984). Therefore, a stress tolerant genotype as defined by DSI, need necessarily not to have a high yield potential.

The mean relative grain yields values under imposed water stress and well-watered treatments were 0.81 and 0.83, respectively (Table I). Mean relative yield in case of water stress was less than that of control. Varieties Punjab-96, Inqilab-91, MH-97, Pasban-90 and Perwaz-94 were relatively high yielding under water stress (RY > mean RY), while Durum-97, Chakwal-87, Kohistan-97 and Shahkar-95 were relatively low yielding (RY < mean RY) in this treatment.

It is concluded from the results of this study that water stress imposed at anthesis stage reduced wheat yield in all varieties. The differential response of varieties to imposed water stress condition indicate the drought tolerance ability of wheat varieties. Varieties Parwaz-94, Pasban-90 and

Table I. Effect of moisture stress on drought susceptibility index values and relative yield in nine wheat varieties

Variety	Yield (t ha^{-1}) well-watered	Yield (t ha^{-1}) Water stressed	DSI	RY_W	RY_S
Parwaz-94	2.17	1.63	0.82	0.80	0.89
Shahkar-95	2.03	1.31	1.15	0.75	0.71
Durum-97	1.60	1.00	1.21	0.59	0.55
Punjab-96	2.24	1.81	0.62	0.53	1.00
Chakwal-86	2.27	1.43	1.20	0.84	0.79
Kohistan-97	2.31	1.43	1.26	0.76	0.79
Pasban-90	2.12	1.69	0.66	0.79	0.93
Inqilab-91	2.31	1.74	0.82	0.88	0.96
MH-97	2.70	1.69	1.21	1.00	0.94
Mean	2.19	1.53	-	0.81	0.83

RY_W = Relative yield under control; RY_S = Relative yield under water stress condition

Punjab-96 showed high yield potential and stability, so these varieties could be further tested for their other drought conferring characteristics.

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