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Short Communication

Physiological evaluation of wheat (*Triticum aestivum* L.) genotypes for drought resistance

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Thirty seven percent of the area in the developing countries consists of semi-arid environments in which available moisture constitute a primary constraint on wheat production. Climatic variability in these marginal environments causes large annual fluctuations in yield. Several strategies have been devised to overcome the problem of drought stress. In this connection, a few of the numerous drought screening tests have been identified for their use in breeding programme [1]. Assessment of water loss from excised leaves (ELWL) has shown promise for characterising drought resistance in wheat genotypes [2]. Relative water content (RWC) has also been reported as an important indicator of water stress in leaves, it closely reflect the balance between water supply to the leaf and transpiration rate [3]. This influences the ability of the plant to recover from stress and consequently affects yield and yield stability. Canopy temperature measured under drought stress has also been developed into a rapid field screening method for the maintenance of plant water status under drought stress. Relatively lower canopy temperatures under stress indicate a relatively better plant water status and canopy temperatures were generally found to be negatively correlated with yield under stress. Cell-membrane stability (CMS) is considered to be one of the major selection indices of drought tolerance in cereals [4] it is estimated in leaves subjected to advanced stress, typical to RWC of around 60-70%. The first case of such a study is in rice where QTLs for CMS under drought stress were identified [5]. Genetic variation for yield as well as drought resistance index is limited. However, it can be further exploited by identifications of single or multiple physiological traits for drought resistance. The aim of this study was to establish the extent of genetic variation and to assess the drought tolerance among the wheat genotypes on the basis of drought resistance index and water relation parameters.

A set of 30 contrasting wheat genotypes differing for drought tolerance, morphpo-physiological traits and area of their adaptability was evaluated under drought stress and irrigated conditions during the years 2001-02 under irrigated and rainfed conditions at the CCS Haryana Agricultural University, Hisar (Haryana), India. Half of these lines were drought tolerant varieties including C306, PBW 175, WH533, PBW 396 which are being used as national checks while half were high yielder, susceptible to drought stress and well adapted to the area under study. Plot size for both environments consisted of two lines of three m long with plant to plant spacing of 10 cm. Data for ELWL, RWC,CMS CTD days to heading and maturity, and grain yield under irrigated and rainfed conditions were observed. Drought resistance for individual genotype was computed by the formula as DRI = (YA-YES)/SES. Where YES and YA are the yield estimated by regression and actual yield under stress for the cultivar, respectively, and SES is the standard error of the multiple regression. Positive value of DRI for each genotype denoted drought tolerance, whereas negative values denoted drought susceptibility.

Analysis of variance (Table 1) indicated the presence of substantial amount of genotypic differences for all the characters. Variation due to environment was also significant for all the characters indicating considerable differences over the environments. Significance of genotype × environment interaction for majority of the characters revealed that the genotypes had different response over the environments. The results of variability for majority of the characters were inconsistent over the environments. Under such circumstances where direct chances of improvement in yield and its components are limited, the associations with characters having least reduction under water deficit may offer a good scope of improvement. Genotypes having high DRI also had low excised water loss (–0.40*) high relative water content (0.76**) low injury in plasma membrane (–0.71**) low canopy temperature depression (–0.75**) and high grain yield (Table 2). DRI was positively associated with yield under drought and independent of yield potential and time to flowering and can be considered as a good criterion for assessment of drought resistant traits which would be manipulated as independent genetic characters. Furthermore, this index is also free from the affect of yield potential and days to flowering as this is calculated on the basis of residual variation in grain yield under stress conditions. Significant positive correlation of excised-leaf water loss with CMS, CTD and grain yield

Table 1. Analysis of variance for various morpho-physiological characters among 30 wheat varieties grown under irrigated and rainfed conditions

Source of variation	df	ELWL	RWC	CMS	CTD	DH	DM	GY
Rep	2	175.2*	721.2**	29.3	0.38*	97.5*	127.5*	50.5*
Env. (E)	1	26.1	137.5**	57.3*	0.32**	62.1**	162.1**	27.6**
Genotype (G)	29	761.3**	245.1**	166.2**	0.25**	72.13*	155.1*	96.5**
G × E	29	41.1	35.5*	171.0**	0.17*	75.1**	159.6**	28.4*
Error	118	34.2	28.6	10.7	0.09	18.3	58.3	1.3

*,** Significant at 5% and 1% level of significance, respectively

Table 2. Correlation coefficients between various morpho-physiological and drought related traits among 30 wheat genotypes.

Character	ELWL	RWC	CMS	CTD (Irr)	CTD (Rf)	DH (Irr)	DH (Rf)	GY (Irr)	GY(Rf)
DRI	−0.41*	0.76**	−0.71**	−0.75**	−0.71**	−0.30	−0.04	−0.31	0.83**
ELWL	1.00	−0.31	0.41*	0.36*	0.29	−0.14	−0.08	0.19	−0.36*
RWC		1.00	−0.59**	−0.68**	−0.65**	−0.41*	−0.08	−0.18	0.69**
LMS			1.00	0.61**	0.51**	0.14	−0.13	0.33	−0.51**
CTD (Irr)				1.00	0.87**	0.25	0.09	0.17	−0.71**
CTD (Rf)					1.00	0.31	0.18	0.24	−0.64**
DH (Irr)						1.00	0.65**	−0.32	−0.53**
DH (Rf)							1.00	−0.39*	−0.38*
GY (Irr)								1.00	0.11

*,**Significant at 5% and 1% level of significance, respectively. Where ELWL: Excise leaf water loss, RWC: Relative water content; CMS: Cell membrane stability CTD: Canopy temperature depression, DH: Days to heading, GY: Grain Yield per plant DRI: Drought Response Index.

under rainfed conditions further revealed that ELWL was an important parameter of assessment of drought tolerance of wheat genotypes. Excised-leaf water loss has also been related to drought resistance in wheat [2] and is a rapid method for screening the genotypes under field conditions. Relative water content was better parameter of drought resistance than ELWL as it had significant association with CTD in addition to the relation to other characters and showed more consistent performance with drought related traits [6]. The genotypes having low injury due to drought stress also had lower canopy temperature in addition to higher yields and better water retention. CTD appeared to be the most important indicator of drought resistance because of its consistent relation under both environments as the drought resistance of a genotype may be predicted even in the irrigated conditions. Days to heading under rainfed conditions had significant positive relation with days to heading under irrigated conditions as well as grain yield under both conditions. This revealed that the genotypes had consistent habit of flowering under both environments and have escape mechanism of drought resistance. Grain yield under rainfed conditions was related to the majority of the traits indicating its utility as selection criteria under drought stress conditions. But genetically, grain yield is characterized by low heritability such that non-genetic variations in yield within and between environments are quite large, especially in drought-affected (low-yielding) environments [7]. Yield under drought stress is also influenced by the specific physiological responses to stress, days to heading and the yield potential of the genotype [8]. Thus, yield alone cannot be used as selection criteria. Therefore, the selection based on the characters other than the yield may be advantageous under drought namely, yield components and morpho-physiological traits. Thus, the most conspicuous morpho-physiological characters over the stages that separated drought resistant from drought susceptible genotypes were relative water content, excised-leaf water loss and canopy temperature depression were worthy of interest as it had clear cut differences in correlations under different environments.

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