Indian J. Genet., **54** (4): 351–356 (1994)

STABILITY ANALYSIS IN WHEAT (*TRITICUM AESTIVUM*) FOR SEEDLING EMERGENCE AND ESTABLISHMENT CHARACTERS AT DIFFERENT SALINITY LEVELS

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(Received: October 14, 1991; accepted: September 24, 1993)

ABSTRACT

Twenty one genotypes of wheat (*Triticum aestivum* L.) were evaluated at four salinity levels for seedling emergence and establishment characters. The genotypes exhibited significant differences for all the traits studied. Results of joint regression analysis suggested that both predictable and unpredictable components contributed significantly to the observed difference in the stability of genotypes for various characters. It was inferred that genotypes HD 2385, KRL 5, WH 157, WH 291 and VW 120 were found to be ideal under conditions of salinity for all the characters. On the other hand, the genotypes HD 2009, HUW 300, Kharchia 65 and Raj 1482 were found suitable only for nonsaline conditions. Raj 3214 was found to be stable for shoot length and osmolarity.

Key words: *Triticum aestivum*, salinity, stability, osmolarity, electrolyte leakage.

In many areas, production of wheat is limited because of soil salinity. However, considerable variation exists among wheat genotypes to tolerate saline conditions which opens an avenue for selection of salt tolerant genotypes [1]. Salinity primarily sensitizes early stages of crops growth, namely, seed germination and seedling growth [2]. These two parameters have been used to screen large number of genotypes [1–3]. However, the stability of genotypes thus screened for salt tolerance under varying salinity conditions is questionable. As information on this important aspect is lacking, we have made an attempt to determine the nature of stability of different wheat genotypes for seed germination and various morpho-physiological characteristics of seedlings affected by salinity under simulated saline environments.

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MATERIALS AND METHODS

Twenty one promising genotypes of wheat (including Kharchia 65 which grows well in salt affected areas) were evaluated with three replications under different levels of salinity, viz. 0.0, 0.5, 1.0, 1.5 and 2.0% salt concentration. The experiment was conducted under hydroponic conditions with Hoagland's solution [4] of different salinity levels created by adding 0.0, 5, 10, 15 and 20 g the mixture of NaCl, $CaCl_2$ and Na_2SO_4 (in the ratio of 7:2:1) per litre. The corresponding electric conductivity (EC) values of the saline solutions were 1.8, 5.4, 11.0, 20.0 and 31.0 dSm^{-1} and pH levels 6.9, 7.2, 8.45, 8.65 and 8.8.

25 surface sterilized seeds of each genotype (C 306, GW 141, HD 2009, HD 2285, HD 2385, HUW 300, Kharchia 65, KRL 5, KRL 6, Lok 1, PBW 65, Raj 1482, Raj 1972, Raj 3077, Raj 3214, Sonalika, VW 120, WH 157, WH 283, WH 291 and WSF 885) were sown in sterilized Petri dishes containing Whatman No. 1 filter paper. Each Petri dish was irrigated with 5 ml sterilized test solution each day up to 5th day and thereafter with 10 ml test solution until 10th day. Before irrigating with fresh test solution each day, the Petri dishes were drained of the remaining solution from the previous day in order to maintain stable balance at each salinity level. The Petri dishes were incubated under dim light for the first 3 days and subsequently under artificial light in a culture room at $20^{\circ} \pm 1.5^{\circ}C$.

Germination was recorded on the 3rd, 5th and 7th day after sowing. Data on coleoptile length, shoot length, fresh and dry weight of roots and shoots, electrolyte leakage (percent injury) and osmolarity were recorded on the 10th day after sowing.

The electrolyte leakage was estimated according to the Sullivan's technique [5], and injury percentage calculated using the formula:

$$\text{Percent injury} = 1- \left[\frac{1-\frac{T_1}{T_2}}{1-\frac{C_1}{C_2}} \right] \times 100$$

where T_1—EC value in the treatment before boiling, T_2—EC value in the treatment after boiling, C_1—EC value in the control before boiling, and C_2—EC value in the control after boiling.

The osmolarity of each genotype at each level of salinity was recorded using Vapour Pressure Osmometer (Wescor 5500).

At 2% salt concentration, none of the genotype germinated till the 10th day. Therefore, this salinity level was excluded from the experiment. Angular transformed values of germination percentage on 3rd, 5th and 7th days were used for further analysis. Mean values of three replications were used for statistical analysis [6].

RESULTS AND DISCUSSION

Analysis of variance at various salinity levels revealed significant differences among genotypes at each salinity level for all the characters studied. The pooled analysis also revealed significant differences among genotypes for all the characters studied, indicating that genotypes used in this investigation were adequately diverse (Table 1). The effect of different environments, i.e. levels of salinity, were also highly significant for all the traits suggesting influence of the environment on the performance of these genotypes. Also highly

Table 1. Joint regression analysis for seedling characters of wheat genotypes tested against four salinity levels

Source	d.f.	Germination	Shoot length	Electrolyte leakage (% injury)	Osmolarity
Genotypes	20	156.9*	2.7**	304.4**	178587.4**
Salinity levels	3	2987.9**	552.3**	2016.0**	5583959.0**
Genotype x salinity levels	60	18.5**	4.6**	80.1**	24854.7**
Salinity + (genotype x salinity levels)	63	160.7**	30.5**	171.8**	289574.0**
Salinity level (linear)	1	8363.6**	1656.9**	4032.0**	16751877.1**
Genotype x salinity levels (linear)	20	91.4**	5.9**	141.9**	22490.3**
Pooled error	168	9.3	0.1	2.2	49.9

*,**Significant at P = 0.05 and 0.01, respectively.

significant genotype x environment (salinity) interaction was obtained for all the traits. The joint regression analysis revealed that the components of G x E interaction were highly significant for all the characters, indicating that the genotypes had divergent linear response to environmental changes, while significant pooled deviation suggested that deviation from linear regression also contributes substantially to the differences in the stability of genotypes. Thus, it can be concluded that both predictable (linear) and unpredictable (nonlinear) components contributed significantly to the differences in the stability of genotypes.

Better germination is essential for good plant stand under conditions for salts stress [7]. In the present investigation, most of the genotypes had significant S^2d estimates for germination percentages on the 3rd and 5th days while for 7th day only one genotype

(C 306) showed significant S^2d value, indicating its stability of this variety under salt stress. Comparison on the basis of regression coefficient (b) and mean ($\bar{x}$) estimates revealed that genotypes WSF 885, WH 291, WH 283, VW 120 and KRL 5 have above average stability (better suited to high salinity). However, the genotype VW 120 showed stability for this character (Table 2).

Table 2. Mean performance and estimates of stability parameters for seedling characters of various genotypes of wheat grown under salinity

Genotype	Germination (%)			Shoot length (cm)			Electrolyte leakage (% injury)			Osmolarity (mmol kg-1 water)		
	mean	b	S^2_d	mean	b	S^2_d	mean	b	S^2_d	mean	b	S^2_d
C 306	78.4	0.3*	25.7*	6.5	1.1**	0.7**	29.5	0.6	19.5**	1309.6	0.9**	67092.6**
GW 141	75.4	0.9**	6.0	6.4	1.1**	0.5**	22.5	0.0	36.8**	922.1	0.9**	448.8**
HD 2009	73.9	1.1**	8.6	5.6	1.1**	3.0**	38.5	1.2**	11.5*	1219.1	1.2**	5866.6**
HD 2285	70.7	1.2**	4.1	5.8	1.0**	2.1**	32.3	0.7*	2.8	1200.8	1.2**	11483.7**
HD 2385	67.5	1.4**	2.0	5.2	0.7**	1.2**	21.0	0.8	– 2.1	894.5	0.9**	7164.4**
HUW 300	61.7	1.0**	– 6.3	5.3	0.8**	4.5**	34.8	2.1**	8.7	894.7	1.2**	26162.4**
Kharchia 65	68.2	1.4**	– 7.4	7.9	1.8**	7.1**	25.6	1.9**	9.3	1373.4	1.1**	89347.9**
KRL 5	66.5	1.0**	– 2.4	6.0	0.7**	1.8**	6.7	0.4	1.1	781.3	0.8**	5588.9**
KRL 6	69.8	1.3**	– 5.9	6.1	1.2**	1.9**	15.4	1.2**	57.4**	1132.2	1.2**	2608.9**
Lok 1	61.5	1.0**	– 1.6	6.9	0.8**	3.4**	29.6	1.34**	49.1**	900.6	0.9**	2311.3**
PBW 65	70.6	1.2**	– 4.4	6.7	0.8**	11.4**	25.4	0.6	– 1.9	975.2	1.3**	48005.9**
Raj 1482	64.6	1.5**	6.4	5.3	1.2**	4.3**	36.0	2.2**	16.2*	1289.6	1.3**	17898.7**
Raj 1972	78.5	0.9**	– 4.5	7.1	1.2**	0.8**	24.7	1.7**	21.1**	940.2	0.9**	2306.5**
Raj 3077	63.8	1.1**	0.4	7.1	0.8**	8.8**	34.4	1.6**	0.6	735.7	0.9**	61458.5**
Raj 3214	75.4	0.9**	– 6.2	5.1	1.1**	3.0**	47.5	0.9**	31.4**	1070.9	1.0**	21070.7*
Sonalika	66.3	1.1**	– 9.1	5.6	1.4**	3.6**	41.2	0.2	1.7	1080.7	1.1**	14901.5**
VW 120	72.1	1.0**	– 4.9	5.2	0.7**	0.2**	18.1	0.1	– 2.1	1107.8	0.9**	11411.9**
WH 157	64.1	1.2**	– 7.4	6.7	0.8**	5.1**	31.3	0.4	2.2	78v.2	0.9**	30150.6**
WH 283	81.7	0.5**	7.9	6.2	1.2**	1.6**	22.9	0.7*	34.3**	1233.7	0.9**	9271.3**
WH 291	77.8	0.5**	– 5.3	7.8	0.6**	9.6**	11.2	0,8*	1.5	589.9	0.7**	4029.8**
WSF 885	80.7	0.6**	14.0	7.2	1.2**	1.2**	34.5	2.9**	– 1.9	1179.4	0.9**	44393.9**

*,**Significant at 5% and 1%, respectively.

For shoot length, S^2d estimates of all genotypes were highly significant, indicating their instability. However, based on mean and regression coefficient, Raj 3214 exhibited stability; genotypes WH 291, Raj 3077, Lok 1, HUW 300, PBW 65, WH 157 and KRL 5 exhibited above average stability indicating their suitability under saline environment. On the other hand, genotypes C 306, Wh 283, WSF 885, Raj 1972, GW 141, KRL 6 and Kharchia 65 showed better shoot growth under salinity free condition and had poor development under saline conditions.

The cell wall integrity is one of the most important traits for differentiating genotypes for the purpose of adaptability to salinity. Percent injury is taken as an indirect measure of cell wall integrity (electrolyte leakage) and should be minimum in the ideal genotypes. None of the genotypes tested showed stability for this character. The genotype KRL 5, WH 291, HD 2385, VW 120, PBW 65, WH 157 and Sonalika gave above average stability estimates with nonsignificant S^2d values.

Low osmolarity status of a genotype is another important index for selection of the salinity tolerant genotype. The S^2d estimates were highly significant for osmolarity. The genotype Raj 3214 was found to be the most stable genotype having regression coefficient very close to unity and the mean slightly higher than the general mean. Genotypes C 306, Raj 3077, WH 157, WH 291, WH 283, WSF 885 and VW 120 (having regression coefficient less than unity) are, therefore, well adapted to higher levels of salinity. On the other hand, HD 2009, HD 2285, HUW 300, Kharchia 65, KRL 6, PBW 65, Raj 1482 and Sonalika with regression coefficient higher than one are suited only for saline free conditions.

Salinity tolerance is a complex phenomenon [9] and the tolerance of a genotype varies according to growth stage. Therefore, several parameters have been proposed which may help to screen the germplasm [7]. When a plant is exposed to high level of salinity extra metabolic energy is consumed in the process of osmotic adjustment and to maintain cell wall integrity. This diversion of energy could reduce the total amount of energy available to the cell which eventually influences productivity [8]. Thus, an ideal plant type having salinity tolerance should have both low osmolarity value and reduced electrolyte leakage (percent injury). On the basis of osmolarity and electrolyte leakage, genotypes WH 291, KRL 5 and VW 120 can be considered as salinity tolerant genotypes.

From the present study it may be concluded that Raj 3214 is the most stable genotype. HD 2009, Kharchia 65, Raj 1482 and HUW 300 are suited for salinity free conditions and HD 2385, KRL 5, WH 157, WH 291 and VW 120 are suited for higher salinity levels. Kharchia 65, which is generally considered to be highly saline tolerant variety has shown below average stability for all the characters. This is in contrast to the reports [1]. This may be because of the type of salinity used for evaluation in the present investigation.

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