Evaluation of Physiological Parameters of Bread Wheat for Identification of Drought Tolerant Germplasm Lines

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Abstract- Different physiological characters were evaluated for identification of best drought resistant germplasm lines. Drought susceptibility index was calculated for different characters for days to 50 per cent flowering, plant height, biomass/plant, grain yield/plant, harvest index and 1000 grain weight over moisture stress and non stress environment for 28 germplasm lines. Drought intensity was negative in case of plant height (0.96), biomass/plant (0.03) and 1000 grain weight (0.49), number of days to 50 per cent flowering (0.81), harvest index (0.99) and had high D-value. Biomass was important character and plant height contributed significantly towards biomass because it had less reduction in D-value (-0.96) under moisture stress condition All the genotypes had drought susceptibility index values (DSI). It was less than unity for number of days to 50 per cent flowering indicating that they flowered earlier under stress condition. For plant height six genotypes HD 2808 were best (-1.57). Genotype C-306 and its mutant C-306 (M) had DSI of 1.18 for plant height. In biomass/plant eleven genotypes had negative DSI values. Highest negative value of-3.60 was for RSP-555 followed by HD-2808 (-2.79) and PBW-396 (-2.33). For harvest index only one genotype HD-2808 had negative DSI value (-0.51). Other genotypes with low DSI values were RSP530 and PBW527. For 1000 grain weight all genotypes except RSP519 had negative DSI values. Highest negative DSI value of 14.06 was for RSP-526 followed by -13.17 for WH-1009 and -12.02 for WH773. Parents having better DSI value for most of the characters included HD-2808, RSP-529, WH-773, RSP-524and RSP-554, RSP-555 and D9-9.

Index Terms- Wheat, Physiological parameters, drought intensity, drought tolerance, drought susceptibility index, relative water content, relative water loss, poly-ethylene glycol

I. INTRODUCTION

Wheat shares about 20 per cent of the total food calories consumed in the world. Being the second major food crop, it occupies premier place among agricultural crops after rice. India is the second largest producer of wheat in the world next to China. The production estimated around 78.4 million tones from an area of about 28.5 m/ha (Anonymous 2008). The. estimates predict that the population of India will be 1.3 billion by the year 2020. To sustain this demand of ever increasing population, the projected annual growth rate requirement is 4.08 per cent (Anonymous 2004). Drought susceptibility index (S) was worked out by Fischer and Maurer (1978) on the basis of grain yield under irrigated and moisture stress conditions. While as Ehdaie *et al.,* (1988) reported no association between stress susceptibility index (S) and yield potential indicating that they may be independently compared and both contributed to stress adoption. Winter *et al.,* (1988) also reported negative correlation of "S" with drought susceptibility index. Rosiella and Hamplin (1981) have defined moisture stress tolerance for grain yield as the difference in yield between non stress and stress environment. Uddin *et al*., (1992) defined it as the yield reduction incurred under drought stress. Hence moisture stress tolerance is the degree to which one genotype is more productive in a given water stress environment than other genotype. The extent of yield reduction owing to moisture stress depends on the stage, severity and duration of the stress as well as the susceptibility of the genotype. Moisture stress at initial stage affects the germination and plant stand.

Seedling survivability has been reported by Tomar and Kumar (2004) as an efficient selection criterion in wheat. They observed that when genotype starts wilting when no irrigation was applied after sowing and studying their recovery response after irrigation based on the days taken for recovery (Seedling survivability) genotypes can be grouped as susceptible (withered early) and drought tolerant (resumed growth). The inheritance was studied by Tomar and Kumar (2004) of this trait and concluded that it is under single dominant gene control. Nagrajan and Rane (2000) has suggested screening of wheat germplasm for drought tolerance using both physiological and agronomical traits as selection criteria Knowledge of different aspects of different aspects of drought tolerance in crop plants has been used to devise strategies to minimize the yield losses due to moisture stress Ashley (1993) and Boyer (1996) gave a simple method of screening germplasm lines using seedling survivability, accurately discriminates between drought tolerance and susceptibility under artificial moisture stress condition. Singh *et al.*, (1999) has adopted it as selection criteria for drought screening. Mai-Kodomi *et al.,* (1999) have reported single dominant gene control for seedling survivability in cowpea. Acevedo *et al*., (1988) showed that yield potential and particular time to flowering explained a substantial fraction of yield under drought of three cereal crops.

II. MATERIAL AND METHODS

Wheat is mainly grown in rainfed areas of the world, in which the available moisture constitutes the primary constraint on wheat production as explained by (Rajaram *et al.,* 1987). About 24 per cent of total wheat area in India remained un-irrigated every year (Paroda, 1992). Loss and Siddique (1994) suggested extending the period of ear development to increase sink capacity of the grain. However Perry and D' Antuono (1989) showed that the improvement in yield with most modern wheat genotypes was largely due to early flowering and matching water use pattern. Turner (1997) summed up it as selection for an early flowering date may not always increase yeld if flowering date coincides with high frost incidence or if the biomass at the anthesis is low (Perry and D.'Antuaono, 1989) has reported that increase in grain yield by cultivar development in Australia (water limited environment) and UK (irrigated condition) has been accomplished with increase in harvest index *viz*. the ratio of grain to above ground biomass. Boyer (1996) and Turner (1997) suggested that improvement in harvest index of modern cultivars grown in water limited environment appears to be due to number of factors. These include a shortening of period from sowing to anthesis and maturity. Perry and D' Antuono (1989) and Siddique *et al.,* (1989) also advocated manipulation in these factors for improving harvest index. Turner and Takeda (1993) suggested an increase in ear development and a pattern of matter production could improve harvest index. Siddique *et al*., (1990) reported that depletion of soil can be taken care of by early ear emergence and increased grain filling in modern cultivars. Turner , Nicholos (1987) and Whan *et al* ., (1991) proposed that rapid and rigorous seedling growth is advantageous on course textured soils in water limited environment, because of more efficient use of water which can be measured as dry matter production at 5 or 6 leaf stage . . The relative drought indexes and index of drought resistance (I.D.R) was studied by Vijay et al., (2001).. The ranking of these genotypes for important drought tolerance traits *viz*. exised leaf water retention (E.L.W.R) and relative water content (R.W. C), under field conditions, while seedling vigour index (S.V.I) and drought stress "S" and" I.D.R" had strong association with these putative drought tolerance traits. Vijay *et al*., (2001) studied 28 wheat hybrids along with 8 diverse parental lines to determine the correlation among grain yield, biological yield and harvest index along with some morphological and physiological characters associated with drought tolerance *viz*. (E.L.W .R) (R.W.C) and (I.D. R) under non stress and stress environment. Various interrelations were studied and it was concluded that an efficient selection index for grain yield under dry conditions would need to be based on yield together with low (E.L.W.R), early flowering and high (I.D.R) and ultimately low drought susceptibility index values. Desalgen *et al*., (2001) tested 18 bread wheat varieties at 5 low moisture stress locations, by including appropriate standard and local checks and observed that there were significant differences among varieties for pedi**gree** dates yield, days to maturity, plant height, 1000 grain weight and test weight. Plant height, 1000 grain weight and test weight showed positive and strong association with grain yield under low moisture condition. Morey *et al*., (1980) collected data on the use of water, the relative water content of the varieties the efficiency in which it was used in eight wheat varieties sown on three dates under rain fed conditions. The results revealed that Bajaga Yellow and N15439 were the most promising drought tolerant varieties because of their yield and their ability to extract water and retain water in their leaves.The trait in plastic boxes and number of seedlings was counted which died before 30 days. Recovery responses of seedling were also studied after applying irrigation when most of genotypes started wilting. Maximum number of ten seedlings dies before 30 days in genotypes RSP-519, PBW-510. The basic requirements for improvement of drought resistance are the availability of rapid and reliable methods for screening large numbers of breeding material for drought resistance (Singh *et al*., 1999) suggested a simple method to screen germplasm lines using seedling survivability, which accurately discriminates between drought tolerance and susceptibility under artificial moisture stress conditions. Minimum number of seedlings died without irrigation upto 30 days in genotypes RSP-529 and HD-2808 followed by RSP-554, PBW-175, C-306, PBW-361, WH-1009. Two genotypes RSP529 and HD-2808 recovered most after initial withering (Tomer and Kumar, 2004) also reported similar results for genotypes C-306. In the Table 2 [published at end of paper] correlation among various drought related traits have been worked and with given yield per plant under stress and non stress conditions. Highest correlation of 0.581 was observed between grain yield under non stress condition. All other drought related traits had correlation of less than 2 with grain yield. Hence in the present study drought susceptibility index was most important trait differentiating between various wheat lines for drought capabilities. All the 28 wheat germplasm lines were also ranked according to drought resistance in Table 3 [published at end of paper]. The genotypes HD-2808 ranked among first seven lines for entire six droughts related traits.

III. Results and Discussion

The drought susceptibility index was calculated for number of days to 50 per cent flowering, plant height, biomass/plant, grain yield/plant, harvest index and 1000 grain weight over moisture stress and non stress environment using formula as suggested by Fischer and Maurer, (1978) and represented in Table 4 [published at end of paper] for 28 germplasm lines. The value of(Drought intensity) were negative in case of plant height (-0.96), biomass/plant (-0.03) and 1000 grain weight (-0.49), Number of days to 50 per cent flowering (0.81) and harvest index (0.99) had high D-values. Biomass was important character and plant height contributed significantly towards biomass because it had less reduction in D-value (-0.96) under moisture stress conditions. All genotypes had drought susceptibility index value (D.S.I) less than unity (0.03-0.79), for number of days to 50 per cent indicating that they flowered earlier under stress condition. For plant height six genotypes had negative D.S.I values. Genotype HD-2808 was best (-1.57) followed by WH773 (0.70), RSP -519 (-0.08), RSP529 (-0.08). Genotype C-306 and its mutant C-306 (M) both had DSI value of 1.18 for plant height. In biomass/plant height eleven genotypes had negative DSI values. Highest negative value of -3.60 was for genotype RSP-555 followed by HD-2808 (-2.79) and PBW-396 (-2.33).

For harvest index only one genotype HD2808 had negative D.S.I value (-0.51), other genotypes with low D.S.I value were RSP-530and PBW-527. For 1000 grain weight all genotypes except RSP- 519 had 519 had negative D.S.I values. Highest negative value of 14.06 was for RSP-526 followed by-13.17 for WH-1009 and -12.02 for WH-773. Parents having better D.S.I value for most of the characters included HD-2808, RSP-529, WH-773, RSP-524 and RSP-554, RSP-555 and D-9-9.

Germination stress index is considered as one of the most suitable criteria for screening drought tolerance genotypes. All the twenty eight germplasm lines were germinated in polyethylene glycol (PEG) and distilled water in Petri dish under controlled condition of seed germinator. After 10 days germination stress index (G.S.I) were estimated. The final germination stress index values are presented in Table 3 [published at end of paper] The highest values of germination stress index was recorded for new rain fed wheat WH-773(99.15) followed by traditional process rain fed wheat C-306 (95.55) and released rain fed PBW-561 (95.29). Other genotypes having higher G.S.I values included RSP-529 (93.94), PBW-396 (90.16), HD-2808 (89.89) and WH-730 (82.83). Genotypes with lowest GSI values were RSP-524 (42.18) and RSP 523 (52.29).

The evaporation of water in leaf provides the major driving force for absorption of water by plants. The plant exercises control over water loss through its stomatal and cuticular resistances. Relative water content of leaves is considered as better indicator of water status than water potential. The relative water content declines with increasing drought stress. Tolerant genotypes possess more relative water content. The relative water content as compared to susceptible type values in percentage for all twenty eight genotypes is presented in Table 2 [published at end of paper] Leaf relative water content was highest in genotype RSP-529 (74 %) and HD-2808 (70 %) followed by (69 %)in genotype PBW-396 and D-9-9. Other genotypes with relatively higher relative water content values include WH-773 (68 %), PBW561 (64 %), C-306 (68 %), C-306 M (65 %), WH-730 (63 %) RSP-528 (65 %). Genotype PBW-527 and RSP-519 had least relative water content values of 42 per cent.

Relative water loss of excised leaves was also suggested as one of the techniques for drought screening. Water deficit occurs whenever water loss exceeds absorption. The mean values of relative water loss of excised leaves are presented in Table 2 [published at end of paper] for all twenty-eight germplasm lines used in present study. Relative water loss values were lowest in magnitude for genotype RSP-529 (0.342) followed by HD-2808 (0.421), C-306 (0.452), D-9-9 (0.453), WH-773 (0.457) and PBW-175 (0.498). Highest value for relative water loss was in genotype RSP-524 (1.361). The range in relative water loss values varies from 0.342 to 1.361.

The proline content was estimated when the plants showed maximum stress. The of proline content increases under stress. The range of proline varied from 2.75 to 10.41 (Table 2 [published at end of paper]). The maximum proline under stress accumulated in genotype WH-730 followed by RSP-554 (9.92), RSP-553 (9.57), WH-1009 (8.74), PBW-396 (8.10), MACS-6198 (8.07) and HD-2808 (8.01). Minimum values proline were exhibited by RSP-526 (2.75), PBW-527 (2.79) and RSP-527 (2.84).

The seedling survivability involves screening germplasm lines which discriminate between drought tolerance and susceptibility under artificial moisture stress conditions. The trait was studied in plastic boxes and number of seedlings was counted which died before 30 days by wilting when no irrigation was applied. Recovery responses of seedling were also studied after applying irrigation when most genotypes started wilting. Maximum number of ten seedlings died before 30 days in genotype RSP-519, PBW-510 followed by seedling in RSP-523, RSP-527 and eight in RSP-528. Minimum number of seedling died were two in genotypes RSP-529 and HD-2808 followed by three each in RSP-554, PBW-175, C-306, C306 M, PBW-561, WH-7733 and WH-1009. Recovery responses of genotypes were studied after irrigating the boxes after 43 days. Genotypes which survived and recovered most were RSP-529 (23), HD-2808 (23) shown in the Table 2 [published at end of paper].

Table 1: Drought susceptibility index of different characters of wheat

Genotypes	Number of days to 50% flowering	Plant height (cm)	Biomass/plant (g)	Grain yield/plant (g)	Harvest index	1000 grain weight (g)
RSP-519	0.06	-0.08	0.52	-0.81	1.43	6.29
RSP-520	0.06	-0.07	0.36	-.0.91	1.05	-7.30
RSP-523	0.08	0.32	0.37	0.06	1.40	-10.24
RSP-524	0.07	-0.05	-0.26	6.15	0.99	-4.52
RSP-525	0.07	0.84	-2.30	0.68	1.43	-7.69
RSP-526	0.05	0.74	0.14	-3.15	1.34	-14.06
RSP-527	0.13	0.88	0.11	-1.47	0.98	-7.51
RSP-528	0.04	0.89	0.32	-0.80	0.84	-5.46
RSP-529	0.06	-0.08	-0.04	-2.95	0.73	-6.50
RSP-530	0.03	0.77	0.47	-0.82	0.45	-7.55
RSP-553	0.08	0.90	0.12	-1.13	1.11	-4.35
RSP-554	0.07	0.99	-1.89	-1.54	1.15	-5.27
RSP-555	0.07	0.97	-3.60	-0.10	1.13	-0.05
PBW-175	0.07	0.83	-1.72	0.37	0.97	-4.31
PBW-396	0.63	1.00	-2.33	0.29	0.54	-0.03
C-306	0.69	1.18	-1.34	0.34	0.82	-4.20
C-306M	0.79	1.18	-0.30	0.21	0.77	-4.37
HD2808	0.09	-1.57	-2.79	-2.85	-0.51	-5.17
D9-9	0.07	1.03	-2.10	-3.50	0.54	-9.10
PBW-510	0.08	1.06	0.23	-1.48	0.85	-7.15
WH-730	0.08	1.00	0.54	-2.51	1.45	-7.15
PBW-561	0.66	0.97	0.41	-0.32	0.96	-8.06
KO-343	0.05	1.09	0.14	-1.19	1.12	-9.21
MACS-6198	0.05	1.09	0.48	-0.31	1.24	-7.99
PBW-527	0.07	1.10	0.48	-1.19	0.45	-11.03
WH-773	0.08	-0.70	0.40	-4.53	1.22	-12.02
WH-1009	0.08	0.93	0.43	-1.13	1.06	-13.17
HUW-576	0.66	0.96	0.43	-1.08	0.60	-4.35
D-Value	0.81	-0.96	-0.03	0.19	0.99	-0.49

Table 2: Mean values of six drought related parameters in Germplasm lines of wheat

S. No.	Genotype	Drought susceptibility index for yield	Germination stress index	Relative water content (%)	Relative water loss	Proline content	Seedling survivability	
							Died before 30 days	Revived after irrigation
1	RSP-519	-0.81	60.82	42	1.276	4.82	10	15
2	RSP-520	-0.91	86.64	54	0.529	6.14	5	20
3	RSP-523	0.06	52.29	50	0.585	5.11	9	16
4	RSP-524	6.15	42.18	48	1.361	6.74	4	21
5	RSP-525	0.68	83.95	50	1.212	3.62	5	20
6	RSP-526	-3.15	66.57	52	0.897	2.75	4	21
7	RSP-527	-1.47	68.52	59	0.585	2.84	9	16
8	RSP-528	-0.80	62.42	65	1.186	6.35	8	17
9	RSP-529	-2.95	93.94	74	0.342	4.96	2	23
10	RSP-530	-0.82	60.67	44	0.983	4.58	6	19
11	RSP-553	-1.13	74.11	58	0.978	9.57	4	21
12	RSP-554	-1.54	71.47	59	0.737	9.92	3	22
13	RSP-555	-0.10	63.53	43	0.826	2.90	5	20
14	PBW-175	0.37	93.51	64	0.498	7.90	3	22
15	PBW-396	0.29	90.16	69	0.529	8.10	4	21
16	C-306	0.34	95.55	68	0.452	7.90	3	22
17	C-306-M	0.21	66.40	65	0.519	6.70	3	22
18	HD-2808	-2.85	89.89	70	0.421	8.01	2	23
19	D9-9	-3.50	85.13	69	0.453	5.80	4	21
20	PBW-510	-1.48	65.13	43	0.837	6.30	10	15
21	WH-731	-2.51	82.83	63	0.509	10.41	5	20
22	PBW-561	-0.32	95.29	64	0.501	7.63	3	22
23	KO-343	-1.19	79.01	55	0.531	5.70	6	19
24	MACS-6198	-0.31	63.86	45	0.693	8.07	6	99
25	PBW-527	-1.19	70.65	42	0.972	2.79	5	20
26	WH-773	-4.53	99.15	68	0.457	6.36	3	22
27	WH-1009	-1.13	72.27	54	0.795	8.74	3	22
28	HUW-576	-1.08	70.96	58	0.694	4.82	4	21
	Range	-4.53-6.15	42.18-99.15	42-74	0.342-1.361	2.75-1042	2-10	15.23

Table 3: Correlation between grain yield and various drought related traits

Character	Correlation
Drought susceptibility Index Vs Yield(S)	0.5809**
Drought susceptibility Index Vs Yield(NS)	0.3727**
Germination Stress Index Vs Yield(S)	0.1132**
Germination Stress Index Vs Yield(NS)	0.0525*
Relative water content Vs Yield(S)	0.1806*
Relative water content Vs Yield(NS)	0.114*
Relative Water Loss Vs Yield(S)	-0.1759**
Relative Water Loss Vs Yield(NS)	-0.1020**
Proline Vs Yield(S)	-0.0280*
Proline Vs Yield(NS)	0.082*
Seed Died Vs Yield(S)	0.1182**
Seed Died Vs Yield(NS)	-0.153**

**,* Significant at 5 and 1 percent level, respectively

Table 4: Ranking of top ten wheat Germplasm lines for various drought related traits

S. No	Genotypes	Drought susceptibility index for yield	Germination stress index	Relative water content %	Relative water loss	Proline content	Seedling survivability	Frequency among six traits
1.	RSP-519	-	-	-	-	-	-	-
2.	RSP-520	-	VIII	-	X	-	-	2/6
3.	RSP-523	-	-	-	-	-	-	-
4.	RSP-524	-	-	-	-	-	X	1/6
5.	RSP-525	-	X	-	-	-	-	1/6
6.	RSP-526	III	-	-		-	X	2/6
7.	RSP-527	IX	-	--	-	-	-	-
8.	RSP-528	-	-	VII	-	-	-	1/6
9.	RSP-529	IV	IV	I	I	-	I	5/6
10.	RSP-530	-	-	-	-	-	-	-
11.	RSP-553	-	-	-	-	III	X	2/6
12.	RSP-554	VII	-	-	-	II	II	3/6
13.	RSP-555	-	-	-	-	-	-	-
14.	PBW-175	-	V	X	VI	IX	II	5/6
15.	PBW-396	-	VI	III	X	V	X	5/6
16.	C-306	-	II	V	III	IX	II	5/6
17.	C-306M	-	-	VII	IX	-	-	-
18	HD2808	V	VII	II	II	VII	I	6/6
19.	D9-9	II	IX	III	IV	-	X	5/6
20	PBW-510	VIII	-	-	-	-	-	1/6
21.	WH-730	VI	XI	-	VIII	I	-	4/6
22.	PBW-561		III	X	VII	XI	II	5/6
23.	KO-343	X	-	-	-	-	-	1/6
24.	MACS-6198	-	-	-	-	VI	-	1/6
25.	PBW-527	X	-	-	-	-	-	1/6
26.	WH-773	I	I	V	V		II	5/6
27.	WH-1009	-	-	--	--	IV	II	2/6
28.	HUW-576	-	-	-	-	-	X	1/6

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