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Full Length Research Paper

Variability for drought tolerance in cotton (*Gossypium Hirsutum* L.) for growth and productivity traits using selection index

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The presence of genetically based difference in drought stress tolerance is a key for breeding cultivars with enhanced tolerance to water stress by selection and breeding. In order to achieve such evidence in *Gossypium hirsutum,* 90 genotypes were evaluated for growth and productivity traits in randomized complete block design (RCBD) with three replications. The genotypes were evaluated under well watered (W1) and water stressed conditions (W2). From the variance analysis, significant differences were detected among varieties for seed cotton yield, boll number, boll weight, number nodes and plant height. The data indicates that the numbers of formed bolls in water stressed were less than that in non-stress conditions, and significantly correlated with seed cotton yield. High heritability and high genetic advance was also found for certain traits. Some genotypes were ranked top on the basis of plant height and number of nodes, while others ranked well on the basis of seed cotton yield. Hence, to become clear of this difficulty, selection index was performed by giving an equal weight to all the growth and productivity traits studied. Index ranked all 90 genotypes from top to low and revealed that MNH-6070, MNH-552, SLS-1, MNH-812, MNH-806, MNH-636, FH-113, 4 F, MS-40, CIM-1100, 1021(Kivi), L.S.S, MNH-807, FH-682, 841/52 were the top 15 genotypes more tolerant and stable at drought stress condition.

Key words: Cotton, drought, selection index.

INTRODUCTION

Currently, agriculture is facing a great threat from the risk of climate change. The productivity of the agriculture is also being seriously affected as a significance of key changes in the pattern of temperature and rainfall. It is expected that such changes will affect water availability to plants, especially for those native to the arid and semi-arid tropics (Giorgi, 2005). The genus *Gossypium* L. has long been the focus of genetic and breeding research. Cotton is one of the first species to which the Mendelian philosophies were applied and has a long history of progress through breeding with continual long-term yield gains. *Gossypium* contains at least 45 diploid and five allotetraploid species. The upland cotton (*Gossypium hirsutum* L., 2n = 52), one of four cultivated *Gossypium* species, is the world’s important fiber crop, providing natural fiber for the textile manufacturing (Endrizzi et al., 1985). Cotton is grown commercially in the tropical and subtropical zones of more than 50 countries worldwide (NAAS USDA, 2009).

Plant breeding programs develop populations for variety development from crosses within locally adjusted germplasm. For understanding genetic diversity, population structures are of great significance in breeding programs for the additional utilization of cotton genetic

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diversity in the development of superior cultivars that combine the positive qualities conditioned by this diverse germplasm. Most of the cultivars from current cotton plants have been developed under irrigated conditions and have experienced intensive selection to increase the yield and value of the fiber produced, as well as screening to obtain the most adequate genotypes for mechanized harvesting and processing, which are often improved under irrigation conditions (Rosenow et al., 1983). A cotton crop needs an adequate amount of water for its normal development. Due to the shortage of good quality irrigation water, the crop experiences severe water deficiency, thereby resulting in reduction of crop yield. This can be more critical due to excessive with drawal of ground water and reducing irrigation water resources in the future (Ullah et al., 2008).

Currently, water availability for use in agriculture is gradually becoming limited and costly; creating apriority impetus for research projects that can find genotypes with more effective and/or tolerance to water-stress circumstances. Thus, identifying morphological traits that can be assessed easily can characterize accessions in germplasm banks and may support cotton breeding programs in finding cultivars that are more tolerant to water stress or that may be used in the preliminary stages of a breeding program (Ullah et al., 2008). Pakistan is mainly an agricultural country, as agriculture is vital to the country's economy, accounting for a share of 23% in the gross domestic product (GDP) and employing 44% of the labor force. Presently, Pakistan is facing a severe problem in national food security because of the loss of valuable arable land caused by drought, water logging and salinity. In addition, it is estimated that every day, about 500 acres of farm land are taken out of agriculture due to expansion of roads, factories and urbanization according to Qureshi and Barrett-Lennard (1998).

Drought tolerance and susceptible cotton genotypes were studied under field environments. Burke (2007) identified varietal differences in cotton responses to available soil water under field and greenhouse conditions. It was found that varieties differed in their response to the physiological traits under both watered and water-stress conditions. Studies on evaluating the responses of five hybrid varieties of cotton to moisture stress in the field for their relative tolerance to drought revealed that moisture deficit adversely affected the chlorophyll stability index and nitrate reductase activity (Kar et al., 2005). Water stress causes the most critical effects at the flowering stage rather than vegetative and ripening stages (Kar et al., 2005). Therefore, improving regular screening of available genotypes is essential. This screening of germ plasm for drought tolerance needs some selection criteria, which can clearly differentiate tolerant and susceptible genotypes.

Thus, the objectives of this study were to: (i) determine genotypic differences among cotton genotypes for growth and productivity traits in response to water stress and (ii) select the tolerance genotypes for further conventional and molecular breeding. The information obtained from this study will support the existing record obtained from other productivity and physiological traits in cotton which will be helpful in selecting drought-tolerant genotypes.

MATERIALS AND METHODS

Cotton seeds of 90 different genotypes of *G. hirsutum* were collected from the Central Cotton Research Institute (CCRI) Multan, Pakistan, and Cotton Research Station Multan, Pakistan. These 90 cotton accessions *of G. hirsutum* were evaluated for their drought tolerance in field condition. The genotypic responses to well watered (W1) and water stressed (W2) conditions were assessed at the CEMB Punjab University field. The experimental land was prepared during the month of February 2011 by giving two cross-wise plowing, followed by cold crushing and leveling. The land was saturated with irrigation water when it became ready for sowing; the land was plowed twice with a disc harrow and with cultivator, followed by planking with patio and leveled properly for fine seed bed preparation.

Experimental design

Planting of all 90 accessions was completed during the 14th day of March 2011 in three replications, following randomized complete block design (RCBD). Seeds were planted in rows 75 cm apart, each with plants spaced 25 cm within the rows and there were 10 plants in each row. The two water regimes were: (a) Plants under well watered conditions (W1) kept at field capacity, applied sowing irrigation once and 5 subsequent irrigations as necessary for usual crop growth and development; the total water applied including rainfall was (826 mm). (b) For water stressed (W2), sowing irrigation was applied once at planting and one supplemental irrigation 40 days after planting (DAS) was applied; the total water applied including rainfall was (632 mm). Chemical fertilizer was applied at the rate of 100-50-50 kg NP_2O_5- K_2O ha^{-1} at the time of seedbed preparation. Appropriate control measures were used as needed for insect pests and weed control.

Measurement of growth and productivity traits

Plant height (cm) from the cotyledonary node to the apical bud was recorded with measuring tape and the average plant height from 5 plants was calculated for each replication. For numbers of nodes, five consecutive plants from each variety in each replication were taken for recording the number of nodes, starting with the node above the cotyledons as node one; the number of main stem nodes was counted. The harvest of seed cotton yield per plant (g) was completed in three picks from 5 plants for each replication of each genotype of water regime levels and weighed by electronic balance. Next, the average yield per plant was calculated. To determine the number of bolls per plant, mature bolls picked from 5 plants were counted and averaged. Individual boll weight (g) was calculated by dividing total weight of seed cotton picked over total number of bolls picked.

Statistical analysis

Analysis of variance for the RCBD experiment, was performed with Statistical Analysis System SAS (SAS Institute, ver. 9.2 2008). The GLM procedure to evaluate the effects of drought application and genotypes on growth and productivity traits.

Statistical significance was assumed at 5 and 1% levels of probability. Broad-sense heritability was calculated with the formula of Lush (1940). The correlation analysis was performed in Statistix® 8.1 statistical software. Selection index (Smith, 1936) based on the equal weight of all seedling traits was calculated and the genetic similarities within the tolerant and susceptible genotypes selected on the basis of selection index determined by GGE Biplot analysis software.

RESULTS

Analysis of variance for growth and productivity traits

The analysis of variance of means of growth and productivity traits revealed highly significant variations ($P \leq 0.01$) with respect to water levels and genotypes. The interaction between water levels and genotypes was also highly significant for boll weights and significant ($P < 0.05$) for plant height, indicating differential responses of cultivars over irrigation treatments, but non-significant for the number of nodes, number of bolls and seed cotton yield, thus indicating that cultivars were fairly stable over irrigation regimes for these traits (Table 1). The mean data of all 90 genotypes indicated significant reductions in all growth and productivity traits of plants (data not shown).

Correlation coefficients

Correlation coefficients between means in the stressed and non-stressed conditions were positive and highly significant ($P < 0.01$) for most of the traits (Table 2). Boll number was positively correlated with plant height and number of nodes, while boll weights were negatively correlated with plant height and number of nodes. There were highly significant correlations between the seed cotton yield with number of bolls and boll weights (Table 2).

Components of variance, heritability and genetic advance estimates

Higher values of heritability indicated that the trait can be improved by selection and breeding, while selection on the basis of low heritability may be misleading due to more influence of environment on the genetic make-up (Singh, 2004; Nadarajan and Gunasekaran, 2005). The components of variance, heritability and genetic advance estimates for growth and productivity traits were obtained. For plant height, the genotypic and phenotypic variances were higher than environmental variances, indicating that plant height was genetically controlled and selection may be successful due to presence of high genetic variation (Table 3). For Individual boll weight (g), the environmental coefficient of variance occupied the lowest category at all levels, which indicated low environmental influences on the expression of this trait (Table 5). Also, genotypic and phenotypic variances were higher than environmental variances; indicating that selection will be effective in Individual boll weight (Table 6). The seed cotton yields environmental coefficient of variance occupied lower category than the phenotypic coefficient of variance and higher than the genotypic coefficient of variance, which indicated moderate environmental influences on the expression of seed cotton yield per plant (Table 7). Regarding the numbers of nodes, the environmental influences were observed due to the wide gap between genotypic and phenotypic variance. Moreover, heritability and genetic advance values were low, which suggested that number of nodes is largely influenced by environmental factors (Table 4).

Selection index

Different genotypes occupy variable rank for all traits with respect to different water levels. Thus, making selection on this material is very difficult and complicated. To simplify this, a selection index was arranged giving an equal weight to all the growth and yield traits studied. Thus, the genotypes which collectively achieved highest or lowest performance on the basis of all traits were selected. Selection index was performed by operating the well-watered, water-stressed and relative means of all traits. Single trait and multi-trait selection using GGE biplot were performed. The data were scaled by trait maxima for selection index (SI) calculation. Independent selection has the first priority. The overall cutting rate of 80% was selected of the entries, and the remaining 20% were promoted as the best performance for water limited condition (Table 8).

Data indicates that MNH-6070 and MS-40 occupied the top rank when well watered; MNH-6070 and MNH-552 under water-limited conditions, while MNH-807 and MNH-6070 showed overall best performance at relative means value. Among the high-yielding genotypes, MNH-6070 maintained high yield under both the well-watered and the water-limited regimes. Similarly, the top 15 varieties that performed best under water limited conditions are as follows: MNH-6070, MNH-552, SLS-1, MNH-812, MNH-806, MNH-636, FH-113, 4 F, MS-40, CIM-1100, 1021(Kivi), L.S.S, MNH-807, FH-682 and 841/52, and the top 15 varieties according to their relative means of all traits were MNH-807, MNH-6070, CRSM-83, 841/52, Bt-1573, MNH-806, CIM-1100, GR-156, FH-113, MNH-147, MNH-636, CRSM-38, BH-118, CIM-109 and MNH-552. These varieties can be selected as drought-tolerant for further investigation. CIM-446, NIAB-824, M-944-00-0243, Australia-407721, FH-1000 are the drought susceptible genotypes. Thus, these traits may be useful as a selection criterion in breeding programs with the objective of improving drought tolerance in cotton under water-limited environments (Table 8).

Table 1. Analysis of variance for growth and productivity traits of 90 cotton genotypes under two water regimes.

Source of variation	Mean square				
	Plant height	**No. of nodes**	**No. of bolls**	**Boll weight**	**Seed cotton yield**
Block	6656.4	10.34	61.67	14.24	39606.0
Water levels (WL)	179917.51**	3127.00**	62752.80**	17.96**	802588.9**
Error	730.90	15.33	400.42	0.005	3532.71
Genotypes (G)	3337.20**	41.04**	877.29**	0.62**	8262.4**
WL×G	710.67*	11.95^{ns}	346.08^{ns}	0.12**	3216.6^{ns}

*,**Significance; n.s, non-significant.

Table 2. Correlation coefficients of growth and productivity traits for well watered and water stressed conditions.

Parameter	NNW1	NNW2	NBW1	NBW2	PHW1	PHW2	BWW1	BWW2	SCYW1
NNW2	0.5123**								
NBW1	0.3581**	0.2824**							
NBW2	0.2612**	0.3298**	0.4344**						
PHW1	0.4985**	0.4448**	0.3047**	0.3423**					
PHW2	0.3196**	0.6704**	0.2400**	0.3592**	0.6703**				
BWW1	0.2379*	0.1286^{NS}	-0.027.^{NS}	0.1387^{NS}	-0.007^{NS}	0.0737^{NS}			
BWW2	0.1818^{NS}	0.0606^{NS}	-0.123^{NS}	0.1412^{NS}	-0.0220^{NS}	0.002^{NS}	0.6737**		
SCYW1	0.4188**	0.3089**	0.8919**	0.4739**	0.2813**	0.2656**	0.4110**	0.166^{NS}	
SCYW2	0.2844**	0.2893**	0.3368**	0.9169**	0.2986**	0.3179**	0.3461**	0.4925**	0.4716**

NN, Number of nodes; NB, number of bolls; PH, plant height; BW, boll weight; SCY, seed cotton yield; W1, well watered; W2, water stressed. *,**significance; n.s, non-significant.

Table 3. Components of variance, heritability and genetic advance estimates of 90 cotton genotypes for plant height under water stress.

Source of variation	Plant height well watered	Plant height water stressed	Relative plant height
Grand mean of trait	215.72	170.99	79.40
Minimum	120.00	80.00	45.17
Maximum	270.00	240.83	96.73
Variance	946.30	1129.00	134.88
CV (%)	14.26	19.65	14.63
Environmental variance	581.29	634.85	73.11
Genotypic variance	655.66	889.6	113.01
Phenotypic variance	1236.95	1524.54	186.11
Environmental coefficient of variance (%)	11.18	17.44	13.39
Genotypic coefficient of variance (%)	11.87	14.74	10.77
Phenotypic coefficient of variance	16.30	22.83	17.18
Heritability (%) (broad-sense)	53.01	41.64	39.28
Genetic advance (i = 10% = 1.76)	32.81	28.62	9.43
Genetic advance as percent of mean	15.21	16.74	11.88

DISCUSSION

Drought stress is one of the most important abiotic stresses manipulating performance of crop plants. Thus, the screening for identification or development of tolerant genotypes is of high importance for improving cotton production. In order to achieve such evidence in *G. hirsutum*, 90 genotypes were evaluated for growth and productivity traits under drought and well-watered conditions. This method distinguished drought-tolerant

Table 4. Components of variance, heritability and genetic advance estimates of 90 cotton genotypes for number of nodes under water stress.

Source of variation	No. of nodes well watered	No. of nodes water stressed	Relative no. of nodes
Grand mean of trait	26.04	20.12	78.26
Minimum	18.00	10.33	42.99
Maximum	35.67	27.50	94.75
Variance	15.57	11.49	117.00
CV (%)	15.16	16.85	13.82
Environmental variance	14.94	16.16	218.80
Genotypic variance	8.11	2.58	0.26
Phenotypic variance	23.04	18.74	219.06
Environmental coefficient of variance (%)	14.84	19.98	18.90
Genotypic coefficient of variance (%)	10.93	7.98	0.65
Phenotypic coefficient of variance	18.44	21.52	18.91
Heritability (%) (broad-sense)	35.18	13.77	0.12
Genetic advance (i = 10% = 1.76)	2.97	1.05	0.03
Genetic advance as percent of mean	11.41	5.21	0.04

Table 5. Components of variance, heritability and genetic advance estimates of 90 cotton genotypes for number of bolls under water stress.

Source of variation	No. of bolls well watered	No. of bolls water stressed	Relative no. of bolls
Grand mean of trait	58.48	32.10	59.26
Minimum	11.67	3.33	7.28
Maximum	140.00	90.00	97.81
Variance	445.91	165.86	339.74
CV (%)	36.11	40.12	31.11
Environmental variance	596.84	206.30	615.91
Genotypic variance	147.50	62.27	29.14
Phenotypic variance	744.33	268.57	645.05
Environmental coefficient of variance (%)	41.77	44.75	41.88
Genotypic coefficient of variance (%)	20.77	24.58	9.11
Phenotypic coefficient of variance	46.65	51.06	42.86
Heritability (%) (broad-sense)	19.82	23.18	4.52
Genetic advance (i = 10% = 1.76)	9.52	6.69	2.02
Genetic advance as percent of mean	16.27	20.83	3.41

and non-tolerant genotypes. Assessment of genotypic responses to water stress was carried out using selection indices for water stress tolerance. Different scientists studied the plant growth at different stages of plant and development. Seed cotton yield per plant is determined by two basic traits, namely the boll number and boll weight. When water-shortage stress occurs during the flowering stage, seed cotton yield decreases due to square and young boll shedding (Cook and El-Zik, 1992). Yield in cotton depends upon the interaction of several yield components like bolls per plant, boll weight under a set of particular environmental conditions. The significant correlation of seed cotton yield with number of bolls per plant and decline in boll number with drought in this study confirmed this association. This correlation results also supports the hypothesis that genotypic advantages selected under near-optimum growing conditions may be obtained under less favorable growing environments (Quisenberry et al., 1980). Water stress circumstances reduced the boll weight; bolls per plant and eventually seed cotton yield were seriously affected under water stress as compared to normal irrigation conditions. Maurer (1991) also observed reduced bolls per plant in stress conditions. Plant height also regulates the yield in the sense that as plant height rises, both the number of fruiting branches and number of bolls also increases, accordingly yield also increases.

In the present study, the varieties revealed significant diversity for growth and productivity traits in relation to water regimes. The performance of cotton genotypes

Table 6. Components of variance, heritability and genetic advance estimates of 90 cotton genotypes for boll weight under water stress.

Source of variation	Boll weight well watered	Boll weight water stressed	Relative boll weight
Grand mean of trait	3.05	2.60	85.47
Minimum	2.06	1.65	50.60
Maximum	3.88	3.65	98.83
Variance	0.17	0.20	109.38
CV (%)	13.43	17.33	12.24
Environmental variance	0.01	0.01	0.99
Genotypic variance	0.16	0.19	102.54
Phenotypic variance	0.17	0.20	103.53
Environmental coefficient of variance (%)	2.33	2.73	1.17
Genotypic coefficient of variance (%)	13.33	16.96	11.85
Phenotypic coefficient of variance	13.53	17.17	11.90
Heritability (%) (broad-sense)	97.03	97.47	99.04
Genetic advance (i = 10% = 1.76)	0.70	0.77	17.74
Genetic advance as percent of mean	23.10	29.46	20.75

Table 7. Components of variance, heritability and genetic advance estimates of 90 cotton genotypes for seed cotton yield under water stress.

Source of variation	SCY well watered	SCY water stressed	Relative seed cotton yield
Grand mean of trait	177.85	83.43	50.60
Minimum	41.09	8.83	5.65
Maximum	399.00	220.50	90.12
Variance	4396.98	1342.92	278.54
CV (%)	37.28	43.93	32.98
Environmental variance	5478.33	1597.30	470.69
Genotypic variance	1657.81	541.65	42.43
Phenotypic variance	7136.14	2138.94	513.12
Environmental coefficient of variance (%)	41.62	47.90	42.88
Genotypic coefficient of variance (%)	22.89	27.90	12.87
Phenotypic coefficient of variance	47.50	55.44	44.77
Heritability (%) (broad-sense)	23.23	25.32	8.27
Genetic advance (i = 10% = 1.76)	34.54	20.61	3.30
Genetic advance as percent of mean	19.42	24.71	6.51

SCY, Seed cotton yield.

under water stress condition revealed that different genotypes occupied variable rank for all traits at water stress. For example, MNH670 and MNH552 had maximum seed cotton yield and plant heights, but MNH807 had the highest boll number, thus, making selection on these genotypes difficult and resulting in many complications. However, in this study, selection criteria were based on five traits studied and those genotypes were selected, which performed well on the basis of all traits. The cultivar MNH670 and MNH807 showed high water stress tolerance as compared to other cultivars. Ullah et al. (2008) observed that seed cotton yield and growth were clearly affected in all cultivars, except few genotypes which showed their advantage over others in water stress tolerance.

Conclusion

According to the selection index, the top 15 genotypes (MNH-6070, MNH-552, SLS-1, MNH-812, MNH-806, MNH-636, FH-113, 4 F, MS-40, CIM-1100, 1021(Kivi), L.S.S, MNH-807, FH-682 and 841/52) promoted as top performance for water limited conditions can be used as a female parent (line) in further study. However, the lowest five genotypes (CIM-446, NIAB-824, M-944-00-0243, Australia-407721 and FH-1000) which showed low performance were selected as drought susceptible, and

Table 8. Ranking of 90 cotton accessions on the basis of selection index.

S/N	Well watered (W1)		Water stressed (W2)		Relative value	
	Genotype	**Index**	**Genotype**	**Index**	**Genotype**	**Index**
1	MNH-6070	0.895	MNH-6070	0.946	MNH-807	0.953
2	MS-40	0.863	MNH-552	0.805	MNH-6070	0.889
3	TH-35/99	0.842	SLS-1	0.748	CRSM-83	0.878
4	FH-1000	0.836	MNH-812	0.742	841/52	0.871
5	MNH-552	0.82	MNH-806	0.725	Bt-1573	0.87
6	S-14	0.814	MNH-636	0.715	MNH-806	0.864
7	SLS-1	0.81	FH-113	0.713	CIM-1100	0.86
8	S-12	0.802	4 F	0.71	GR-156	0.854
9	1021(Kivi)	0.788	MS-40	0.704	FH-113	0.849
10	FH-682	0.775	CIM-1100	0.703	MNH-147	0.848
11	STAMP-82	0.773	1021(Kivi)	0.701	MNH-636	0.836
12	3996	0.768	L.S.S	0.696	CRSM-38	0.826
13	299F	0.765	MNH-807	0.688	BH-118	0.824
14	U-276	0.763	FH-682	0.685	CIM-109	0.819
15	4 F	0.753	841/52	0.685	MNH-552	0.815
16	CIM-448	0.743	CRSM-38	0.682	NIBGE-4	0.811
17	MG-66	0.738	Bt-1573	0.678	CIM-534	0.801
18	NIAB-78	0.736	MNH-638	0.665	CIM-4/99	0.801
19	CHINA	0.729	Xing Tai-68-71	0.659	298-F	0.801
20	298-F	0.726	MNH-802	0.653	AYT-85073	0.8
21	FH-125	0.724	BH-118	0.648	CRS-2007	0.798
22	MNH-802	0.724	China	0.647	Xing Tai-68-71	0.796
23	IS-7F1	0.722	CIM-109	0.647	U-4(5143)	0.794
24	Stone Villa	0.721	GR-156	0.642	SLS-1	0.791
25	MNH-806	0.72	CRS-2007	0.637	Xiao-Vemian	0.785
26	BT-3701	0.72	Stoneville--825	0.637	MNH-814	0.785
27	MNH-636	0.719	S-14	0.636	MNH-812	0.777
28	U-4	0.717	AYT-85094	0.634	MNH-638	0.766
29	FH-113	0.709	MNH-147	0.629	IMRA-1480	0.76
30	814	0.709	CIM-496	0.625	AYT-85094	0.755
31	UA-7-25/46	0.706	FH-901	0.623	Stoneville--825	0.751
32	MS-39	0.703	B-557	0.617	Bt-2009	0.744
33	MNH-638	0.702	U-4(5143)	0.616	FH-901	0.742
34	B-557	0.702	LA-208	0.613	CIM-496	0.741
35	CRSM-38	0.701	CRSM-83	0.612	LA-208	0.74
36	M-944-00-0030	0.699	299F	0.61	1021(Kivi)	0.736
37	Stoneville--825	0.693	Rehmani	0.609	Rehmani	0.735
38	Rehmani	0.688	NIBGE-4	0.607	Stoneville-213	0.735
39	MNH-770	0.687	FH-900	0.602	S-11	0.733
40	1021	0.683	MNH-814	0.601	CIM-506	0.728
41	CIM-109	0.679	MNH-770	0.599	4 F	0.727
42	AYT-85094	0.677	Bt-2009	0.595	MNH-802	0.727
43	UA-73	0.677	U-276	0.584	VH-148	0.725
44	CIM-496	0.676	MS-39	0.582	China	0.724
45	MNH-720	0.67	CIM-4/99	0.579	MNH-770	0.722
46	FH-901	0.67	UA-73	0.579	362	0.719
47	CIM-446	0.669	S-12	0.575	FH-682	0.717
48	6040	0.668	S-11	0.574	BS-1	0.717
49	CIM-482	0.665	Stoneville-213	0.568	L.S.S	0.717
50	CRS-2007	0.663	IS-7F1	0.564	B-557	0.715

Table 8. Contd.

51	LA-208	0.662	814	0.563	814	0.706
52	65090	0.662	UA-7-25/46	0.562	UA-13-102	0.7
53	BH-118	0.661	298-F	0.559	CIM-473	0.696
54	BT-2009	0.655	AYT-85073	0.556	TH-35/99	0.693
55	Kl-85/343	0.655	N-karshong	0.551	268 F	0.681
56	N-karshong	0.655	VH-148	0.55	MS-39	0.678
57	CIM-1100	0.651	Kl-85/343	0.549	Ms-40	0.674
58	841/52	0.651	65090	0.547	SLH-284	0.663
59	Xing Tai-68-71	0.65	FH-125	0.545	UA-7-25/46	0.662
60	Xu-2hou-142	0.65	UA-13-102	0.542	299F	0.662
61	LSS	0.649	CIM-448	0.539	KL-85/343	0.661
62	Bt-1573	0.645	Xiao-Vemian	0.538	6040	0.656
63	VH-148	0.639	6040	0.538	UA-73	0.651
64	Stoneville-213	0.636	268 F	0.538	U-276	0.65
65	U-4(5143)	0.636	362	0.532	65090	0.647
66	NIBGE-4	0.625	CIM-534	0.531	N-karshong	0.646
67	268 F	0.622	Bt-3701	0.521	FH-900	0.644
68	MNH-814	0.621	Stone Villa	0.52	2616	0.638
69	S-11	0.616	NIAB-78	0.514	S-14	0.632
70	Gr-156	0.615	Xu-2hou-142	0.508	MNH-554	0.63
71	MHH-147	0.614	U-4	0.506	CIM-482	0.629
72	UA-13-102	0.602	CIM-473	0.504	Xu-2hou-142	0.621
73	CIM-4/99	0.6	MG-66	0.499	FH-125	0.62
74	CIM-473	0.598	CIM-482	0.497	IS-7F1	0.616
75	362	0.595	IRMA-1480	0.495	NIAB-824	0.615
76	MNH-807	0.589	CIM-506	0.49	S-12	0.613
77	FH-900	0.58	2616	0.486	Australia-407721	0.606
78	2616	0.576	M-944-00-0030	0.483	Stone Villa	0.599
79	CRSM-83	0.575	MNH-720	0.472	Bt-3701	0.598
80	IMRA-1480	0.571	SLH-284	0.471	CIM-448	0.594
81	Xiao-Vemian	0.569	STAMP-82	0.469	FH-1000	0.577
82	SLH-284	0.561	TH-35/99	0.468	NIAB-78	0.575
83	CIM-534	0.56	3996	0.451	MNH-720	0.552
84	Ayt-85073	0.556	BS-1	0.436	U-4	0.549
85	CIM-506	0.552	1021	0.43	1021	0.547
86	NIAB-824	0.546	CIM-446	0.429	M-944-00-0030	0.545
87	MNH-554	0.513	NIAB-824	0.423	MG-66	0.523
88	M-944-00-0243	0.489	M-944-00-0243	0.42	M-944-00-0243	0.521
89	BS-1	0.479	Australia-407721	0.411	STAMP-82	0.488
90	Australia-407721	0.447	FH-1000	0.347	CIM-446	0.479

can be used as male parent (tester) for hybridization with the above nominated drought tolerant lines for further investigations.

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