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Dissecting Bread Wheat Heritability For Yield And Yield Related Physiological Components For Drought Tolerance

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1. ABSTRACT
Drought is a periodic natural phenomenon that develops while there is a critical shortage of precipitation. Drought is a major hazard that is known to inflict substantial damage. Crops adapt to drought stress in several different ways by alteration in morphological, physiological, metabolic, and molecular responses. Water deficiency has a detrimental effect on the vegetative and reproductive phases of plants. In a field trial, twenty-five different bread wheat genotypes were used for the assessment of physiological traits that most effectively mitigate the effects of drought stress. Higher levels of were observed in moisture deficient conditions. In drought stress treatment The longest number of days till heading were recorded for the line Zarlashta-99 , the tester NARC-11 (103.7). The cultivars with the longest time taken for maturity reports were Zarghoon-79 and Pirsabak-15 (125.9), as well as the testers Aas-11 and Raskoh-05. Under drought stress, the 1000 grain weight was highest for the lines Zarghoon-79 and Sariab-92, the tester Dharabi had better weight than other lines. The relationship between grain production and physiological traits is positive.

1.1 Keywords: Drought tolerance, Bread Wheat, Heritability, Physiological, Yield

2. INTRODUCTION
Wheat grows differently depending on the soil and climate. This low-cost energy source provides 8–15% of the protein in a typical diet and 70–75% of the calories (Day, 2013). Pakistan needs wheat. The Pakistan Economic Survey for 2022-23 recorded a GDP value of 8.9% at 1.6%. The Pakistan Economic Survey for 2022-23 recorded 2,519,000 tons from 8.74 million hectares. The top wheat producers are defying the drought. Understanding hybrids and genotypes may aid in the survival of wheat during a drought. Line analyzers measure gene activity and combinability. This method separates segregating genotypes from hybrid-performing ones (Sprague and Tatum, 1942).
Individual lines in each cross contribute to the performance of SCA, while hybrid combination performance is determined by desirable or undesirable features. In contrast to growing SCA values, increasing GCA values suggest additive gene activity. The major effect is GCA, and the interaction is SCA (Fasahat, Rajabi, Rad, & Derera, 2016).
Physical maturity and heading determine the vegetative phase. In 30 F1 hybrids, Tsenov and Tsenova (2011) measured gene activity, GCA, and SCA. GCA calculations collectively altered these properties more than SCA.
Researchers use genetic variation estimations and plant trait heritability to separate genetic from phenotypic variation and determine selectivity efficiency. Due to limited sense heritability, wheat pedigree selection may enhance drought tolerance ($h2(n.s)$).
Population and environment affect the genetic improvement and heritability of wheat (Naveed et al., 2016). According to Fellahi et al. (2013), days till heading and grain weight per thousand grains are heritable. Khalil and Saeed (2017) reported a significant inheritance of wheat maturity days.

3. MATERIALS AND METHODS
3.1 PLANT MATERIAL AND GROWTH ENVIRONMENT
During the final week of October, 25 distinct wheat genotypes stipulated from AZRI Quetta were grown in 5-meter rows at

ARI, Sariab Quetta, utilizing a randomized complete bock design.

3.2 DATA HARVESTING

3.2.1 DAYS TO HEADING (DTH)

The number of days till heading was calculated by subtracting the number of days between sowing and 50% heading from the total number of days using the Zadoks scale 55 (Zadoks, Chang, & Konzak, 1974).

3.2.2 DAYS TO ANTHESIS (DTA)

We counted the days till anthesis from the day the seeds were sown until 50% of the central florae on the main spike underwent anthesis (Zadoks scale 64) (Zadoks, Chang, & Konzak, 1974).

3.2.3 DAYS TO MATURITY (DTM)

The number of days was computed until harvest by calculating the day when the plant reached 50% of its potential physiological maturity (Zadoks scale 88) (Zadoks, Chang, & Konzak, 1974).
At crop maturity (Zadoks scale 90), we recorded morphological traits (Zadoks, Chang, & Konzak, 1974).

3.2.4 THOUSAND GRAIN WEIGHT (g)

Thousands of grains linked to each genotype were counted and weighed using an automated balance.

3.2.5 GRAIN YIELD PER PLANT (g)

We calculated the spike yield using an electronic balance and performed the threshing by hand. We then calculated the mean.

3.2.6 STATISTICAL ANALYSIS

Kempthorne (1957) proposed utilizing combining ability analysis to estimate GCA and SCA as well as determine the kind of gene activity. Kwon and Torrie (1964) carried out the calculations required to calculate heredity in its limited meaning (h2(n.s)).

4. RESULTS AND DISCUSSION

Finding the best combiner might lead to the identification of drought-resistant wheat genotypes. Breeding techniques aimed at increasing drought resilience via genetics must choose genotypes with both wide and narrow combining potential as well as gene activity.

4.1 DAYS TO HEADING (DTH)

The line Zarlashta-99 (109.4), the tester NARC-11 (103.7), and the crossings Zarlashta-99 x NARC-11 (107.9) recorded the longest number of days until heading when exposed to drought stress. The line Sariab-92 (87.9%), the tester Dharabi (89.3%), and the cross Sariab-92 x Dharabi (89.0%) all obtained the greatest possible relative performance. According to the results reported by Laghari et al. (2012), postponing planting resulted in an increase in heading performance ranging from 83% to 86%. When compared to genotypes that were vulnerable to the effects of drought, drought-resistant genotypes were better able to sustain their number of days until heading. As a result, they were able to better protect themselves against the negative impacts of the drought's stress.
Under normal circumstances, heritability measured in the limited sense (h2(n.s)) reached its maximum at 56%, while under drought conditions, it dropped to its lowest point at 54%. Drought has a cumulative effect on a plant's genetic composition, according to Irshad et al. (2012b) and Yadav et al. (2017). However, participants exposed to drought stress showed evidence of non-additive effects on genetics, as discovered by Yadav et al. (2017). Different genotypes and environmental conditions occurring at different periods of the crop's life cycle may explain this observation. Ram et al. (2014) identified cumulative effects related to increased h2(n.s.) in all circumstances. Because of the presence of additive gene activity as well as a high h2 (n.s.), the heading was picked early in the process of segregating generations.

4.2 DAYS TO ANTHESIS (DTA)

The lines Raskoh-05 (128.2), Zarghoon-79 (115.9), NARC-11 (125.1), and Aas-11 (112.3), as well as the crossings Raskoh-05 x NARC-11 (131.2) and Zarlashta-99 x Chakwal-92 (113.8), successfully traversed each of the hypothetical conditions. The Line Raskoh-05 strain performed best (91.9%), followed by the tester Aas-11 strain (93.1%) and Chakwal-92 x NARC-11 (98.1%).

Table 4.1: Mean, and GCA for days to heading and days to anthesis.

	NORMAL		DROUGHT STRESS	
LINES	GCA (DTA)	GCA (DTH)	GCA (DTA)	GCA (DTH)
Zarghoon-79	1.753	-1.681*	0.841	-0.712
Zardana-89	-6.753*	0.041	-0.259	-0.679
Zarlashta-99	-1.642	-1.092	-0.659	-0.012
Raskoh-05	-2.314	0.152	0.005	1.449*
Inqalab-91	-0.916	0.352	0.803	-0.729
Dharabi-11	-1.386	0.236	-0.876	-0.590
Sariab-92	1.753	-1.198*		-1.223*

Testers			0.111	
Chakwal 50	0.723	-0.898*	0.129	-0.005
Aas-11	-1.866*	0.402	-0.134	0.646
Zarghoon-79	-0.05	0.299	-0.376	-0.671
NARC-2011	1.314	-0.476	-0.013	-0.005
Chakwal-92	-0.05	0.672*	0.841	0.843
Gene action				
Additive	19.35	2.72	0.95	3.16
Dominance	4.51	1.43	0.19	2.50
Environment	6.75	0.69	3.11	0.18
h^2 (n.s)	63%	56%	39%	54%

Both circumstances indicated that the GCA of days to anthesis had a maximum value smaller than zero. This was true for the Aas-11 (-1.686) and Inqalab-91 (-0.376) tests, as well as the lines Sariab-92 (-6.753) and NARC-11 (-0.876). The crossings Chakwal-92 x Zarghoon-79 (-7.586) and Sariab-92 x Dharabi (-1.188) showed the highest negative SCA values under both normal and drought stress. The D values were substantially higher than the H values, indicating that the drought stress had little influence on the activity of the additive genes. It was discovered that narrow sense heredity was high (63%) under normal circumstances but low (39%) when exposed to drought stress. It advised conducting selection methods on the population's younger generations. According to Irshad et al. (2014b), both factors had additive effects with a high heritability for the number of days required to attain anthesis.

4.3 DAYS TO MATURITY (DTM)

Zarghoon-79 (146.2) and Pirsabak-15 (125.9) had the longest time for maturity reports, as did the testers Aas-11 (145.9) and Raskoh-05 (127.1), as well as the croses Zarghoon-79 x Inqalab-91 (147.1) and Zarghoon-79 x Dharabi (126.9). Under drought stress, the lines Zarlashta-99 (89.7%), tester Raskoh-05 (89.0%), and cross Pirsabak-15 Raskoh-05 (92.4%) all performed adequately. Inamullah et al. (2007) observed in similar research that the maximum time for carbohydrate absorption and translocation under drought stress situations ranged from 91–96% relative performance for the number of days to biological maturity. The researchers arrived at this result after determining that the maximal period for carbohydrate absorption and translocation under drought-stress conditions was three days.

When circumstances were usual, the lines Zarghoon-79 (3.769) and Pirsabak-15 (0.636) had the most exact GCA maturity assessments. Participants maintained high GCA estimations of Aas-11 (0.708) and Raskoh-05 (0.717) across both rounds of the test. According to SCA crossing estimates, the most activity occurred at Pirsabak-15 Dharabi (2.056), followed by Zarlashta-99 Zarghoon-79 (1.756) (Tables 4.19 and 4.20). This was true in both instances. A conglomeration of genetic components governed the maturation process in each case.

Under normal circumstances, the heritability of the plant was high at 79%, but exposure to drought stress caused it to drop to a relatively low level of 56%. Due to the high h2(n.s.) additive effects, it was determined that the single seed descent technique would be utilized to develop this characteristic over generations exposed to drought. It was established that this method would be implemented, demonstrating its effectiveness. Yadav et al. (2017) found that genetic variables interacting with each other may influence the age at which organisms achieve full maturity. Breeding initiatives aimed at increasing drought tolerance in wheat may involve altered genotypes that have been transformed by genetic variables. This is conceivable because of the large range of genetic possibilities in wheat.

Table 4.4: Mean, relative performance and GCA for physiological maturity.

	NORMAL		**DROUGHT STRESS**	
LINES	**MEAN**	**GCA**	**MEAN**	**GCA**
Zarghoon-79	139.1 e	-0.437	124.8 ab	0.208
Zardana-89	140.8 d	0.069	124.3 ab	-0.319
Zarlashta-99	140.8 d	0.408	123.9 ab	-0.242
Raskoh-05	142.3 c	0.758	124.4 ab	-0.036
Inqalab-91	142.1 c	0.624	124.5 ab	0.019
Dharabi-11	143.7 b	1.252	123.2 b	0.397
Testers				
Chakwal 50	144.4 bc	0.177	126.4 ab	0.297
Aas-11	145.9 b	0.708	122.8 b	-1.439*
Zarghoon-79	144.8 d	0.792	215.6 ab	0.017
NARC-2011	143.8 a	-0.711	217.6 ab	0.408
Chakwal-92	142.8 c	-0.604*	211.7 a	0.717*
Gene action				
Additive	6.79		2.15	

Dominance	2.45	0.24
Environment	0.69	0.73
h^2 (n.s)	79%	56%

Table 4.5: Mean, relative performance and SCA for physiological maturity

CROSSES	MEAN (NS)	SCA	MEAN (DS)	SCA
Zarlashta-99 × Dharabi	142.4 cdefghi	0.181	124.1 efghijklm	0.350
Zarlashta-99 × Aas-11	140.6 ijklmn	-1.038	124.3 defghijklm	-1.136
Zarlashta-99 × Zarghoon-79	141.2 ghijklmn	-0.574	126.9 a	1.756*
Zarghoon-79 × Dharabi	141.7 efghijk	0.284	125.8 abcdef	0.253
Zarghoon-79 × Aas-11	141.6 fghijk	1.148	124.7 bcdefghijklm	-1.222*
Zarghoon-79 × Zarghoon-79	141.4 fghijkl	-0.766	124.4 defghijklm	-0.497
Zarghoon-79 × NARC-11	143.3 cdef	0.537	122.8 lm	-0.428
Zarghoon-79 × Chakwal-92	142.2 cdefghij	-0.080	125.4 abcdefghij	0.756
Zardana-89 × Dharabi	141.6 efghijk	-0.249	126.5 abcd	1.447*
Zardana-89 × Aas-11	141.5 fghijkl	0.559	124.1 efghijklm	-1.278*
Zardana-89 × Zarghoon-79	142.7 cdefg	0.173	125.7 abcdefgh	0.647
Zardana-89 × NARC-11	142.8 cdefg	-0.302	123.2 jklm	-0.117
Zardana-89 × Chakwal-92	142.8 cdefg	0.164	124.5 cdefghijklm	-0.239
Zarlashta-99× Dharabi	141.7 efghijk	-0.505	125.0 abcdefghijkl	-0.103
Zarlashta-99× Aas-11	141.8 efghijk	0.470	125.3 abcdefghijk	-0.189
Zarlashta-99× Zarghoon-79	142.2 defghij	-0.705	125.6 abcdefghi	0.358
Zarlashta-99× NARC-11	143.7 bcd	0.292	122.4 m	-1.072
Zarlashta-99 × Chakwal-92	143.1 cdefg	0.064	124.5 cdefghijklm	-0.444
Raskoh-05× Dharabi	142.7 cdefg	0.089	125.7 abcdefg	0.386
Raskoh-05× Aas-11	141.9 defghijk	0.259	126.4 abcd	0.772
Raskoh-05 × Zarghoon-79	143.6 bcde	0.817	124.7 bcdefghijklm	-0.614
Raskoh-05 × NARC-11	143.3 cdef	0.009	123.3 jklm	-0.294
Raskoh-05× Chakwal-92	140.1 bc	2.153	123.5 abcdefghij	0.444
Inqalab-91 × Dharabi	130.5 ijklmn	-1.972*	125.7 abcdefgh	0.275
Inqalab-91 × Aas-11	141.4 fghijklm	-0.108	126.0 abcdef	0.300
Inqalab-91 × Zarghoon-79	143.7 bcd	0.328	124.9 abcdefghijkl	-0.742
Inqalab-91 × NARC-11	143.8 bcd	-0.119	123.9 fghijklm	-0.033
Inqalab-91 × Chakwal-92	142.6 cdefgh	0.514	126.3 abcde	0.172
Dharabi-11 × Raskoh-05	142.6 cdefgh	0.514	126.3 abcde	0.172
Dharabi-11 × Aas-11	142.6 cdefgh	0.514	126.3 abcde	0.172

4.4 THOUSAND GRAIN WEIGHT (g)

The 1000 grain weight was greatest under drought stress for the lines Zarghoon-79 (44.7 g) and Sariab-92 (39.8 g), testers Dharabi (28.3 g, 27.5 g), and crossings Zardana-89 x Zarghoon-79 (35.1 g), and Dharabi-11 x Raskoh-05 (28.9 g). The line Zarghoon-79-79 (with a relative performance of 99.0%), the tester Aas-11 (with a relative performance of 97.4%), and the cross Chakwal-92 Raskoh-05 (95.0%) had the best degree of success when compared to the default settings.

Table 4.6: Mean, relative performance and GCA for 1000-grain weight.

	NORMAL		DROUGHT STRESS	
LINES	MEAN	GCA	MEAN	GCA
Zarghoon-79	26.6 de	-1.295	24.5c	-1.564*
Zardana-89	26.4 e	-1.710*	25.7bc	-0.821
Zarlashta-99	30.1 bc	0.352	28.7ab	0.191
Raskoh-05	26.5 de	-0.753	24.8c	-0.936
Inqalab-91	29.3 bc	0.053	26.7bc	-0.569
Sariab-92	30.3 bc	0.603	28.9a	1.427*
Testers				
Dharabi	28.5 b	0.140	27.4ab	0.740*
Aas-11	26.5 b	-0.790	25.8b	-0.680
Zarghoon-79	33.8 a	2.371*	29.8a	0.590*
NARC-2011	26.2 b	-1.196	25.1b	-0.885*
Chakwal-92	27.4 b	-0.525	26.2ab	0.235
Gene action				
Additive	5.40		2.55	
Dominance	0.44		0.32	

Environment	1.83	1.14
h^2 (n.s)	75%	69%

Table 4.7: Mean, relative performance and SCA for 1000-grain weight

CROSSES	MEAN (NS)	SCA	MEAN (DS)	SCA
Zarghoon-79 × Dharabi	30.5 cdefghijkl	0.924	24.7 ghijk	-0.592
Zarghoon-79 × Aas-11	22.4 abc	0.366	19.3 abcde	-0.094
Zarghoon-79 × Zarghoon-79	31.8 abcdefghij	0.020	25.2 efghijk	-0.233
Zarghoon-79 × NARC-11	28.5 ijkl	0.275	24.0 ijk	0.204
Zarghoon-79 × Chakwal-92	28.3 jkl	-0.579	24.7 fghijk	-0.165
Zardana-89 × Dharabi	29.1 ghijkl	-0.067	26.9 abcdefghi	0.938
Zardana-89 × Aas-11	28.5 ijkl	0.243	24.1 hijk	-0.608
Zardana-89 × Zarghoon-79	31.6 abcdefghijk	0.218	26.1 abcdefghijk	-0.103
Zardana-89 × NARC-11	28.1 jkl	0.277	23.6 jk	-0.977
Zardana-89 × Chakwal-92	27.8 kl	-0.671	26.4 abcdefghij	0.752
Zarlashta-99× Dharabi	31.2 bcdefghijk	-0.028	25.9 bcdefghijk	-1.102
Zarlashta-99× Aas-11	31.2 bcdefghijk	-0.028	25.9 bcdefghijk	-1.102
Zarlashta-99× Zarghoon-79	33.6 abcd	0.089	27.1 abcdefg	-0.040
Zarlashta-99× NARC-11	30.0bcdef	0.052	26.7 abcdefghi	1.196
Zarlashta-99 × Chakwal-92	30.7 bcdefghijk	0.089	25.4 efghijk	-1.216*
Raskoh-05× Dharabi	30.5 cdefghijkl	0.374	26.4 abcdefghij	0.534
Raskoh-05× Aas-11	31.2 bcdefghijk	-0.028	25.9 bcdefghijk	-1.102
Raskoh-05 × Zarghoon-79	31.4 abcdefghijk	-0.966	26.4 abcdefghij	0.342
Raskoh-05 × NARC-11	30.3 defghijkl	1.490	24.5 ghijk	0.091
Raskoh-05× Chakwal-92	29.2 fghijkl	-0.290	25.9 bcdefghijk	0.331
Inqalab-91 × Dharabi	30.7 bcdefghijk	-0.257	25.7 defghijk	-0.538
Inqalab-91 × Aas-11	30.0 defghijkl	-0.014	25.7 cdefghijk	0.752
Inqalab-91 × Zarghoon-79	33.1 abcde	-0.043	25.7 cdefghijk	-0.659
Inqalab-91 × NARC-11	29.7 efghijkl	0.106	25.7 cdefghijk	0.961
Inqalab-91 × Chakwal-92	30.5 cdefghijkl	0.208	25.4 efghijk	-0.515
Dharabi-11 × Raskoh-05	30.4 cdefghijkl	-1.118	28.8 ab	0.513
Dharabi-11 × Aas-11	30.7 bcdefghijk	0.108	26.4 abcdefghij	-0.547
Dharabi-11 × Zarghoon-79	34.3 ab	0.629	28.7 abc	0.323
Dharabi-11 × NARC-11	30.4 cdefghijkl	0.218	25.4 efghijk	-1.339*
Dharabi-11 × Chakwal-92	31.0 bcdefghijk	0.163	28.9 a	1.049
Zarghoon-79 × Dharabi	32.2 abcdefghi	-0.059	27.4 abcdefg	-0.523
Zarghoon-79 × Aas-11	31.1 bcdefghijk	-0.241	28.1 abcde	1.410*
Zarghoon-79 × Zarghoon-79	34.1 abc	-0.381	27.3 abcdefg	-0.800
Zarghoon-79 × NARC-11	30.1 defghijkl	-0.858	27.5 abcdefg	0.982
Zarghoon-79 × Chakwal-92	33.1 abcde	1.540*	26.5 abcdefghij	-1.068
Zardana-89 × Dharabi	32.9 abcdef	1.587*	27.0 abcdefgh	0.532
Zardana-89 × Aas-11	31.5 abcdefghijk	1.100	24.1 hijk	-1.074
Zardana-89 × Zarghoon-79	35.1 a	1.562*	27.3 abcdefg	0.661
Zardana-89 × NARC-11	26.8 l	-3.235*	23.7 jk	-1.271*
Zardana-89 × Chakwal-92	29.7 efghijkl	-1.014	27.3 abcdefg	1.153
Zarlashta-99× Dharabi	31.4 abcdefghijk	-0.797	26.9 abcdefghi	-1.004
Zarlashta-99× Aas-11	31.6 abcdefghijk	0.368	27.2 abcdefg	0.643
Zarlashta-99× Zarghoon-79	33.3 abcde	-1.071	27.4 abcdefg	-0.618
Zarlashta-99× NARC-11	31.4 abcdefghijk	0.604	27.7 abcdef	1.314*
Zarlashta-99 × Chakwal-92	32.4 abcdefgh	0.896	27.2 abcdefg	-0.336
Raskoh-05× Dharabi	30.0 defghijkl	-0.560	28.5 abcd	1.243*
Raskoh-05× Aas-11	29.5 efghijkl	-0.113	24.8 fghijk	-1.225*
Raskoh-05 × Zarghoon-79	32.7 abcdefg	-0.057	28.6 abcd	1.127
Raskoh-05 × NARC-11	30.3 defghijkl	1.072	24.7 ghijk	-1.160
Raskoh-05× Chakwal-92	30.7 efghijkl	-0.343	25.9 abcdefghi	0.015

Table 4.8: Mean, relative performance and GCA for grain yield per plant

	NORMAL		DROUGHT STRESS	
LINES	MEAN	GCA	MEAN	GCA
Zarghoon-79	6.2 d	-0.670*	4.6 f	-0.4644*
Zardana-89	6.4 cd	-0.478	5.3 e	-0.3100
Zarlashta-99	8.8 a	0.323	5.9 bc	0.0336
Raskoh-05	6.9 bcd	-0.252	6.0 bc	0.0279

Inqalab-91	6.4 cd	-0.379	5.7 cde	-0.1939
Sariab-92	8.7 a	0.414	6.5 a	0.5752*
Testers				
Dharabi	8.7 ab	0.401*	6.4 a	0.0091
Aas-11	7.9 bc	-0.119	6.4 a	0.1186*
Zarghoon-79	8.9 a	-0.011	6.1 b	-0.0305
NARC-2011	7.9 bc	-0.154	6.1 b	-0.0282
Chakwal-92	7.8 c	-0.116	6.3 ab	-0.0690
Gene action				
Additive	0.39		0.17	
Dominance	0.07		0.11	
Environment	0.26		0.26	
h^2 (n.s)	60%		40%	

Table 4.9: Mean, relative performance and SCA for grain yield per plant

CROSSES	MEAN (NS)	GCA	MEAN (DS)	GCA
Zarghoon-79 × Dharabi	7.3 cdefghi	-0.160	5.6 cde	0.036
Zarghoon-79 × Aas-11	6.9 ghi	-0.090	5.2 de	-0.111
Zarghoon-79 × Zarghoon-79	7.7 abcdefghi	0.639*	6.2 abcde	0.205
Zarghoon-79 × NARC-11	6.8 hi	-0.132	6.0 abcde	-0.077
Zarghoon-79 × Chakwal-92	6.7 i	-0.257	6.1 abcde	-0.054
Zardana-89 × Dharabi	7.6 abcdefghi	-0.043	6.3 abcde	0.364*
Zardana-89 × Aas-11	7.1 fghi	-0.073	6.5 abcd	-0.164
Zardana-89 × Zarghoon-79	7.2 defghi	-0.028	6.3 abcd	0.019
Zardana-89 × NARC-11	7.1 efghi	-0.010	4.6 e	0.085
Zardana-89 × Chakwal-92	7.3 cdefghi	0.154	6.4 abcd	-0.303
Zarlashta-99× Dharabi	7.8 abcdefghi	-0.650*	7.0 abcd	-0.031
Zarlashta-99× Aas-11	7.9 abcdefghi	-0.062	6.7 abcde	0.052
Zarlashta-99× Zarghoon-79	8.9 a	0.894*	7.0 abcd	-0.010
Zarlashta-99× NARC-11	8.0 abcdefghi	0.141	5.9 abcde	-0.050
Zarlashta-99 × Chakwal-92	7.6 abcdefghi	-0.324	6.6 abcd	0.038
Raskoh-05× Dharabi	8.2 abcdefgh	0.89	6.3 abcde	-0.267
Raskoh-05× Aas-11	7.2 defghi	-0.150	6.3 abcd	0.122
Raskoh-05 × Zarghoon-79	6.7 i	-0.781*	5.8 bcde	-0.343*
Raskoh-05 × NARC-11	7.6 abcdefghi	0.243	6.8 abcd	0.249
Raskoh-05× Chakwal-92	7.7 abcdefghi	0.351	6.7 abcde	0.239
Inqalab-91 × Dharabi	7.3 cdefghi	-0.452	5.9 abcde	-0.296
Inqalab-91 × Aas-11	7.7 abcdefghi	0.433	6.6 abcde	0.371*
Inqalab-91 × Zarghoon-79	7.5 bcdefghi	0.134	6.8 abcd	0.075
Inqalab-91 × NARC-11	7.0 fghi	-0.163	6.2 abcd	0.079
Inqalab-91 × Chakwal-92	7.3 cdefghi	0.049	5.9 abcde	-0.229
Dharabi-11 × Raskoh-05	8.8 ab	0.261	6.9 abcd	0.025
Dharabi-11 × Aas-11	7.9 abcdefghi	-0.164	7.6 a	-0.137
Dharabi-11 × Zarghoon-79	8.3 abcdefg	0.128	7.3 ab	0.029
Dharabi-11 × NARC-11	8.0 abcdefghi	0.048	6.6 abcde	0.033
Dharabi-11 × Chakwal-92	7.8 abcdefghi	-0.272	6.9 abcd	0.050
Zarghoon-79 × Dharabi	8.7 abc	0.217	6.8 abcd	0.302
Zarghoon-79 × Aas-11	8.3 abcdefg	0.344	7.1 abcd	0.139
Zarghoon-79 × Zarghoon-79	7.9 abcdefghi	-0.184	5.7 bcde	-0.059
Zarghoon-79 × NARC-11	7.3 cdefghi	-0.631	6.3 abcde	-0.358*
Zarghoon-79 × Chakwal-92	8.2 abcdefgh	0.256	6.7 abcd	-0.025
Zardana-89 × Dharabi	7.1 fghi	-0.698*	6.5 abc	0.079
Zardana-89 × Aas-11	7.8 abcdefghi	0.124	6.7 abcde	-0.105
Zardana-89 × Zarghoon-79	7.1 fghi	-0.698*	6.5 abc	0.079
Zardana-89 × NARC-11	7.8 abcdefghi	0.124	6.7 abcde	-0.105
Zardana-89 × Chakwal-92	8.0 abcdefghi	0.335	7.0 abc	-0.020
Zarlashta-99× Dharabi	7.1 fghi	-0.698*	6.5 abc	0.079
Zarlashta-99× Aas-11	7.8 abcdefghi	0.124	6.7 abcde	-0.105
Zarlashta-99× Zarghoon-79	7.5 bcdefghi	-0.326	6.7 abcde	-0.032
Zarlashta-99× NARC-11	7.7 abcdefghi	0.111	6.3 abcde	0.215
Zarlashta-99 × Chakwal-92	7.5 bcdefghi	-0.206	6.2 abcde	0.NARC-11
Raskoh-05× Dharabi	7.1 fghi	-0.698*	6.5 abc	0.079
Raskoh-05× Aas-11	7.8 abcdefghi	0.124	6.7 abcde	-0.105

Raskoh-05 × Zarghoon-79	8.6 abcd	0.223	7.2 abcd	0.037
Raskoh-05 × NARC-11	8.5 abcdef	0.269	7.2 abcd	-0.071
Raskoh-05× Chakwal-92	8.1 abcdefgh	-0.084	6.8 abcd	-0.017

The Zarghoon-79 (1.362), Dharabi-11 (1.427), and testers Aas-11 (2.371) and Dharabi (0.740) had the highest general combining ability estimates. This held true for both test circumstances. Tables 4.35 and 4.36 show the SCA for crossings between Zardana-89 Dharabi (1.587) and Zardana-89 Dharabi (1.410), which had the highest values. It was discovered that additive genetic effects with high h2 (n.s.) (75%), and drought circumstances (69%), under normal environmental conditions. Irshad et al. (2014b) found that additive genetic effects were highly heritable, independent of the context in which they were studied. The researchers arrived at this conclusion. Yadav et al. (2017), on the other hand, observed inconsistent non-additive effects. They attributed their results to the fact that they examined a wide range of environmental conditions. Cumulative genetic effects, on the other hand, showed that earlier selection in separated generations might be beneficial.

4.5 GRAIN YIELD PER PLANT (g)

When plants were stressed by drought, the best grain came from the lines Sariab-92 (9.92 g) and Dharabi (7.84 g), the testers Zarghoon-79 (9.83 g) and NARC-11 (7.36 g), and the crosses Raskoh-05 x Dharabi (9.72 g) and Zarghoon-79 x Dharabi (8.61 g). Under drought circumstances, the lines Sariab-92 (90%), Dharabi (89.0%), and Zardana-89 x Zarghoon-79 (91.5%) all maintained the maximum grain yield. Relative performance indicated that these lines maintained the maximum grain yield.

Under both conditions, estimates of GCA were most optimistic for the lines Sariab-92 (0.715), testers Dharabi (0.613), and NARC-11 (5.010), while estimates of SCA were most optimistic for the crosses Raskoh-05 x Dharabi (0.984) and Inqalab-91x Aas-11 (0.298) (Tables 4.39 and 4.40). Additive genetic variables regulated the quantity of grain produced, and these effects were independent of the conditions of the surrounding environment. Under normal conditions, the grain yield had a high h2 (n.s.) of 60%, but under drought stress, the grain yield only had a moderately high h2 (n.s.) of 40%. Under normal circumstances, h2 (n.s.) was 60%. Irshad et al. (2012a) reached a similar finding about cumulative impacts when drought was present in the ecosystem. Farooq et al. (2011) observed cumulative effects in both sets of experimental conditions with relatively substantial amounts of h2(n.s.) exposure. Under normal conditions, Irshad et al. (2014a) found that additive gene activity-controlled grain yield, but it remained unaffected by the drought stress the plants were exposed to. One of their investigations' results was exactly this one. Irshad et al. (2014b) investigated two unique scenarios and observed that high levels of h2(n.s.) were associated with additive gene activation in both. Therefore, it is strongly recommended to perform selection early in the process of segregating generations to achieve the highest potential grain yield.

5. REFERNCES

6. Day, L. (2013). Proteins from land plants potential resources for human nutrition and food security. *Trends in Food Science and Technology, 32*(1), 25-42.
7. Economic survey of Pakistan. (2022-23). Government of Pakistan, ministry of finance, economic advisor's wing, Islamabad.
8. Farooq, M., Bramley, H., Palta, J. A., & Siddique, K. H. (2011). Drought stress in wheat during reproductive and grain-filling phases. *Critical Reviews in Plant Science, 30*(6), 491-507.
9. Fasahat, P., Rajabi, A., Rad, J. M., & Derera, J. (2016). Principles and utilization of combining ability in plant breeding. *Biometrics and Biostatistics International Journal, 4*(1), 00085.
10. Fellahi, Z. E. A., Hannachi, A., Bouzerzour, H., & Boutekrabt, A. (2013). Line × tester mating design analysis for grain yield and yield related traits in bread wheat (*Triticum aestivum* L.). *International Journal of Agronomy, 1*, 1-9.
11. Inamullah, N., Shah, Z. H., & FU, K. (2007). An analysis of the planting dates effect on yield and yield attributes of spring wheat. *Sarhad Journal of Agriculture, 23*(2), 269-275.
12. Irshad, M., Ghaffar, A., Khaliq, I., Aslam, M., Hussain, N., Iqbal, J., & Din, N. (2014a). Genetic control of thermo-tolerance in spring wheat as measured by canopy temperature depression and cell membrane thermostability. *Internatoinal Journal of Scientific Research, 3*(10), 1877-1884.
13. Irshad, M., Khaliq, I., Iqbal, J., Hussain, N., Aslam, M., Hussain, K., & Din, N. (2014b). Genetics of some polygenic traits in hexaploid bread wheat in high temperature stress. *Journal of Animal and Plant Science, 24*(4), 1212-1219.
14. Irshad, M., Khaliq, I., Khan, A. S., & Ali, A. (2012a). Genetic studies for some agronomic traits in spring wheat under drought stress. *Pakistan Journal of Agricultural Sciences, 49*(1), 11-20.
15. Kempthorne, O. (1957). An introduction to genetic statistics. John Wiley and Sons, Inc., New York.
16. Kwon, S. H., & Torrie, J. H. (1964). Heritability and interrelationship among traits of two soybean population. *Crop Science, 4*, 196-198.
17. Laghari, K. A., Sial, M. A., & Arain, M. A. (2012). Effect of high temperature stress on grain yield and yield components of wheat (*Triticum aestivum* L.). *Journal of Science, Technology and Development, 31*, 83-90.
18. Naveed, M., Ahsan, M., Akram, H. M., Aslam, M., & Ahmed, N. (2016). Genetic effects conferring heat tolerance in a cross of tolerant × susceptible maize (*Zea mays* L.) genotypes. *Frontier in Plant Sciences, 7*, 729-736.
19. Ram, M., Singh, R., & Agrawal, R. (2014). Genetic analysis for terminal drought stress in bread wheat (*Triticum aestivum* L. em Thell). *Bioscan, 9*(2), 771-776.
20. Saeed, M., & Khalil, I. (2017). Combining ability and narrow-sense heritability in wheat (*Triticum aestivum* L.) under rainfed environment. *Sarhad Journal of Agriculture, 33*(1), 22-29.
21. Sprague, G. F., & Tatum, L. A. (1942). General vs specific combining ability in single crosses of corn. *Agronomy Journal, 34*(10), 923-932.

22. Yadav, J., Sharma, S., & Jakhar, M. (2017). Combining ability analysis for yield and its components in bread wheat (*Triticum aestivum* L. em. Thell.) over environments. *International Journal of Plant Sciences, 12*(2), 95-101.
23. Zadoks, J. C., Chang, T. T., & Konzak, C. F. (1974). A decimal code for the growth stages of cereals. *Weed Research, 14*(6), 415-421.