









Table 3. Mean comparison (LSD test) of yield and yield related attributes of wheat genotypes under irrigated and drought stress conditions.

Traits	Treatment	ANT	DFF	DTM	GPS	FLA	NT	PH	SL	SLPS	TGW	GYP
Genotypes	MARKAZ	93.67 a	85.50 bc	113.33 g	38.67 g	15.78 g	7.00 vcd	95.50 hi	11.0 d	19.33 ab	25.55 efg	7.55 fg
	DILKASH-21	88.00 g	81.50 k	113.50 fg	46.00 cde	20.54 cdef	6.50 cd	99.00 fg	11.0 d	19.83 a	26.30 defg	7.70 fg
	BORLAUG-16	90.17 ef	82.83 j	114.67 de	52.17 ab	16.37 g	7.33 bcd	94.83 i	9.40 i	17.33 cdef	29.00 bc	11.0 bcde
	UJALLA 16	92.50 b	87.33 a	115.00 cd	48.67 abcd	18.16 efg	8.67 ab	98.00 gh	8.50 k	16.17 ef	27.05 cde	11.3 bcd
	ANAJ 17	90.50 de	84.33 fgh	114.00 defg	50.17 abc	22.81 abc	6.00 d	99.50 efg	10.0 h	19.83 a	24.18 gh	8.50 def
	AAS 2002	90.33 def	84.83 cdef	114.33 defg	42.67 efg	18.27 efg	7.00 cd	93.67 i	11.0 d	18.83 abc	29.90 b	8.04 efg
	LASANI 08	90.83 d	84.83 cdef	114.50 def	53.33 a	22.19 abcd	6.33 cd	99.83 efg	9.00 j	15.83 f	35.50 a	11.7 bc
	FSD 2008	89.83 f	83.83 hi	113.67 efg	40.17 fg	21.28 bcde	9.50 a	102.0 e	10.5 f	16.00 f	22.77 h	11.3 bcd
	16104	90.83 d	85.17 cde	114.67 de	49.67 abc	16.99 fg	6.67 cd	100.6 efg	11.0 d	17.50 bcdef	28.40 bcd	9.13 cdef
	NARC 11	93.17 a	87.50 a	116.00 bc	27.67 h	25.05 a	6.33 cd	101.3 ef	9.00 j	18.00 abcde	27.73 bcde	5.27 g
	ZINCOL 16	90.33 def	83.33 ij	114.00 defg	51.67 ab	22.54 abc	6.17 cd	106.5 bcd	10.0 h	19.00 abc	27.52 bcde	9.44 cdef
	FAKHR-E-BAKHAR	90.83 d	83.83 hi	117.00 ab	47.17 bcde	22.65 abc	6.83 cd	105.3 cd	12.0 a	18.67 abcd	26.85 cdef	9.26 cdef
	M.H 12	90.67 de	84.00 ghi	114.67 de	47.00 bcde	17.43 fg	7.00 cd	113.5 a	10.3 g	18.83 abc	25.48 efg	10.3 bcdef
	NARC SUPER	91.67 c	85.00 cdef	115.83 c	42.50 efg	18.88 defg	7.67 bc	99.33 efg	11.3 c	17.33 cdef	28.65 bcd	9.67 bcdef
	AKBAR 19	90.83 d	84.83 cdef	114.67 de	50.33 abc	23.30 abc	7.67 bc	104.8 d	10.7 e	19.33 ab	27.57 bcde	11.0 bcde
	S.A 12	91.67 c	85.33 bcd	113.25 g	49.17 abcd	24.20 ab	6.83 cd	107.7 bc	10.3 g	16.83 def	22.68 h	7.53 fg
	PAK 13	92.50 b	86.00 b	117.25 a	50.67 abc	20.44 cdef	7.50 bcd	105.8 cd	11.3 c	18.83 abc	24.58 fgh	9.96 bcdef
	JOHAR 16	90.50 de	84.50 efgh	114.00 defg	44.33 def	21.65 abcde	6.67 cd	108.8 b	10.3 g	19.50 a	25.63 efg	8.65 cdef
	BLUE SILVERR	90.83 d	84.67 defg	116.00 bc	52.67 a	20.19 cdef	9.83 a	114.3 a	11.8 b	19.67 a	27.00 cdef	15.4 a
	SUBHANI 21	90.50 de	83.83 hi	114.17 defg	51.00 abc	18.74 defg	9.33 a	100.0 efg	11.3 c	16.50 ef	25.50 efg	12.5 ab
Irrigation Levels	1	92.88 a	85.85 a	117.88 a	53.10 a	24.01 a	8.93 a	110.4 a	11.5 a	21.83 a	30.63 a	13.5 a
	2	89.13 b	83.45 b	111.57 b	40.47 b	16.74 b	5.75 b	94.65 b	9.47 b	14.48 b	23.16 b	5.96 b

ANT = Anthesis, DFF = Days to 50% flowering, DTM = Days to maturity, GPS = Grains per spike, FLA = Flag leaf area, NT = Number of tillers, PH = Plant height, SL = Spike length, SLPS = Spikelet per spike, TGW = Thousand grain weight, GYP = Grain yield per plant.







Table 6. Principal component analysis for various traits of bread wheat genotypes under normal conditions.

Variable	PC1	PC2	PC3	PC4
Plant height	0.324	-0.157	0.383	0.102
Anthesis	-0.282	-0.461	0.143	-0.076
Leaf area	-0.212	-0.012	0.459	0.274
Spike length	0.261	0.154	0.424	-0.376
Spikelet per spike	-0.096	0.405	0.354	-0.398
Number of tillers	0.357	-0.444	0.101	0.071
Days to maturity	-0.009	-0.29	0.054	-0.694
Grain per spike	0.420	0.112	-0.035	0.089
Thousand grain weight	0.016	0.121	-0.526	-0.316
Days to 50% flowering	-0.344	-0.451	-0.023	-0.101
Grain yield per plant	0.521	-0.253	-0.160	-0.068
Eigenvalue	2.774	2.327	1.907	1.248
Variability (%)	25.20%	21.20%	17.30%	11.30%
Cumulative variability (%)	25.20%	46.40%	63.70%	75.10%

smaller proportions of the variance (17.3% and 11.3% respectively) but highlighted relationships between traits like spike length, number of tillers, and leaf area. In total, the first four PCs explained 75.0% of the variance in the data. The PCA successfully identified major sources of variation in the agro-morphological traits of bread wheat grown under optimal irrigation. The patterns of trait relationships and variation captured by the PCs provide an overview of the differences among the 20 genotypes when grown under normal conditions.

### Biplot

A PC biplot visually represents variables as vectors or lines, showing their contribution to the overall variance. This allows for more informed decision-making based on the characteristics of each variable. A positive correlation between two variables is indicated by an angle smaller than 90 degrees between their vectors, while a 90-degree angle suggests no correlation. In this analysis, a biplot was used to explore the relationships between multiple attributes in the experimental data presented below. The PC biplot of wheat genotypes for drought stress (50% field capacity) is shown in Fig. 1. The yield per plant exhibited the highest variability, as indicated by the longest vector length compared to other parameters. Among the genotypes, Genotype 20 (BLUE SILVER) has the maximum variability, with its vector length being longer compared to other genotypes. For the parameter of thousand grain weight, Genotypes 6 (AAS 2002), 3 (Borlaug-16), and 14 (NARC Super) demonstrated the maximum variability, with their vectors being longer compared to other genotypes. Regarding the leaf area, anthesis, and days to 50%

flowering parameters under drought stress, Genotype 10 (NARC 11) displayed the highest values among the genotypes. These observations were made through the analysis of the vectors in the PC biplot, which allows for the visualization of relationships and variability among different parameters and genotypes.

The biplot analysis in Fig. 2 visually represented the relationships between the agro-morphological traits and wheat genotypes grown under optimal irrigation. Yield per plant showed the highest variability as it had the longest vector length compared to the other traits. Among the genotypes, Genotype 19 (BLUE SILVER) exhibited the maximum value for yield per plant, number of tillers, and plant height. In contrast, Genotype 12 (Fakhr-e-Bakhar) displayed the highest spike length but had only moderate plant height (110 cm). For thousand grain weight, Genotypes 7 (LASANI 08), 2 (DILKASH-21), and 5 (ANAJ-17) showed the greatest variability, with longer vector lengths than other genotypes. Regarding developmental traits under normal conditions, Genotype 10 (NARC 11), followed by Genotypes 4 (UJALLA-16) and 1 (MARKAZ), had the highest values for anthesis and days to 50% flowering. The biplot visualization enabled the observation of differences among the 20 wheat genotypes for key agro-morphological traits when grown with optimal irrigation.

### Cluster Analysis

The hierarchical cluster analysis is graphically represented by a dendrogram. It depicts the combination of smaller clusters into larger ones until the final clusters are created. The horizontal axis of a dendrogram shows the individual observations or clusters, and the vertical











