



Response of Different Bread Wheat Genotypes under Water Deficit Conditions

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Abstract: Wheat is a crop that is considered to be essential since it is utilized in the production of a wide range of various meals. This investigation was conducted out at the Nuclear Institute of Agriculture (NIA), located in Tandojam, during the years 2021-22. The results of an ANOVA performed on wheat showed significant differences between treatments, genotypes and the interaction (genotype x treatment) for plant height, productive tillers plant⁻¹, spike length in



centimeters, spikelet number per plant, grain yield plant⁻¹, biological yield plant⁻¹, and harvest index in percentage. These variables were measured in terms of wheat. In terms of physiological characteristics, such as relative water content (%), chlorophyll content (%), and leaf area (cm²), there was also a significant association between genotypes, treatments, and the interaction. This relationship was significant at the P0.01 level. Despite this, there were a few small characters who you may engage with. Benazir and Khirman plants grown under circumstances of control and drought had, on average, lower plant heights and more tillers than those grown under conditions of drought alone. Longer rises were recorded in TD-1 and NIA-Sunehri. It was observed that NIA-Sunehri and Khirman were producing an increasing number of spikelets. Khirman often has a higher seed index than the other cities. In spite of the drought, the grain harvests in Benazir and Khirman were much greater. Kiran-95 and NIA-Sunehri cultivars produced the highest levels of biological output. At the NIA-Saarang location, the harvest index reached its highest point. The TD-1 and NIA-Sunehri strains both have bigger leaf areas. According to the findings of the researchers, individuals with the Kiran-95 and TD-1 genotypes often had greater levels of RWC. Under both normal and dry conditions, the NIA-Saarang and NIA-Sunehri genotypes exhibited significantly greater chlorophyll content percentages. As a result, the Benazir, Khirman and NIA-Sunehri genotypes have the potential to be used in the near or far future as drought-resistant breeding stock.

Keywords: Wheat, water deficit, physiological parameters, ANOVA, Correlation

Introduction

Wheat, also known as (*Triticum aestivum* L.) is widely recognized as one of the most significant and beneficial agricultural crops in the world. According to Gupta et al. (2008), present technologies for the production of food are capable of feeding over forty percent of the world's population assuming that protein accounts for twenty percent of the total calories in food. Wheat is a kind of grass that is a member of the poaceae family and is indigenous to the highlands of Ethiopia and the Near East. Wheat is now cultivated in many parts of the globe. Wheat is Pakistan's most valuable crop for food production. In the 2017–18 crop years, wheat was planted on an area that totaled 8,734,000 hectares, which is a 2.6% decrease from the 8,000,000 hectares that were cultivated in the previous crop year. The overall amount of wheat harvested in 2017 was 25.492 million metric tonnes, which is 4.4% less than the amount of wheat harvested in 2016, which was 26.674 million metric tonnes. Wheat contributed 9.1% to gross domestic product (GDP) and 7.1% the growth rate of agriculture in Pakistan (GoP 2018).

Wheat, which is scientifically known as (*Triticum aestivum* L.) is one of the most significant crops on the planet in terms of its calorie content. According to Ullah et al.'s research from 2020, the majority of the wheat-growing regions throughout the globe are negatively impacted by high temperature occurrences that are over the ideal level. Heat stress during wheat's essential development stages causes serious disruptions to the reproductive physiology of the plant, which ultimately leads to major output losses. Several empirical and model-based studies (Bergkamp et al., 2018) have shown that a one degree Celsius increase in temperature results in a drop in wheat production that ranges from 6.4%-27%. Due to the

fact that it is a source of both energy and protein, it will likely continue to play a significant role in people's diets. Wheat has been harvested from the world's 222, 16 million hectares (or 222,16 million acres) of wheat fields at an average annual rate of 752 million metric tonnes. Around 10,000 years ago, tetraploid wheat and Genus hybridised to produce the *Triticum aestivum* L. species of wheat, which is the most wide spread species of wheat used in agriculture (it has a diploid, DD genome) Dubcovsky, J., et al 2017. Wheat is an excellent primary source for the vitamins B1, B2, B3 and E, as well as for the minerals and nutrients selenium, manganese, phosphorus, and copper. Not only may it be used for the production of food (such as flour and cookies), but it can also be used as animal feed. Additionally, it is possible to make alcoholic drinks, starch, and candies by using it as a raw material in the manufacturing process. This cereal grain is prepared and eaten in a variety of ways all across the globe, such as couscous, pasta, flatbread, and bulgur. The results were reported in a publication in the year 2020 (Ouaja et al. (2020)). It has been determined which wheat germplasm is present in disease seedlings, a resistance gene has been introduced from a wild species, and disease-resistant mutant wheat has been developed in wheat. The introduction of mutations into wheat genomes by the use of chemicals or radiation is one technique for the introduction of unique genetic variants. According to Hussain et al. (2018), conventional mutation-based techniques may not be effective since it might be challenging to assess the phenotypic differences that result from mutagenesis.

It is recommended to sow seeds towards the end of October or at the beginning of November. However, there are a number of challenges that farmers face that prohibit them from planting wheat at the appropriate time (Subhani et al., 2014). These challenges include delays in rain fall, a shortage of irrigation water and equipment at the appropriate time, growing wheat adjacent to sugarcane and rice crop, and a number of other factors. According to FAOSTAT 2020, wheat took up over 30 percent of the total area that was planted to cereals in 2018, making it the most widely cultivated crop in the United States. Wheat, also known as *Triticum aestivum* L., is a crop that is grown in Pakistan. Wheat is a staple food for around one-third of the world's population. Wheat is planted in Pakistan over a total area of 8,825,000 ha, which results in a total annual production of 24, 946, 000 t/y and an average annual yield of 2,827 metric tonnes per hectare. (Hussain et al., 2018) is a good example.

Materials and Methods

The experiment was conducted at the wheat field of Nuclear Institute of Agriculture (NIA), Tandojam during, 2021-22. This trial was carried out with three replications. The details are as below:

Design of experiment: Split Block Design (RCBD)

Net plot size: $6 \times 5 = m^2$

Row to Row Distance: 45cm

Replications: (03) Three

Treatments

1. Irrigation
2. Drought (Only soaking dose)

Genotypes: 06

Varieties: 06

V₁ = Kiran- 95

V₂ = TD-1

V₃ = Benazir

V₄ = NIA-Saararag

V₅ = NIA-Sunahri

V₆ = Khirman (check variety)

Parameters studied

Ten plants from each plot were randomly selected and following growth and yield Parameters were recorded.

Plant height (cm)

Numbers of tillers Plant⁻¹

Spike length (cm)

Number of spikelet's spike⁻¹

Seed index (1000 grain weight)

Grain yield plant⁻¹ (g)

Biological yield plant⁻¹ (g)

Harvest index (%)

Relative water content (%)

Chlorophyll content (RG)

Leaf area (cm²)

Statistical analysis

The statistical investigation will be carried out by using a technique known as analysis of variance (ANOVA), which was established by Gomes and Gomes (1984). We will use statistical approaches to conduct an analysis of the data that we collect. At the 5% probability level, we will compare the means of genotypes for all characteristics using a statistical method called the least significant difference, or L.S.D. Snedecor and Cochran will discover and propose a correlation analysis in the year 1980.

Results

The stress of drought is a significant abiotic factor that impedes both growth and harvesting. As a result, the objective of this study was to investigate the capacity of different genotypes to endure drought conditions when they were subjected to water restriction. This experiment was conducted at the Nuclear Institute of Agriculture (NIA), which is situated in Tandojam. Six different genotypes were subjected to three different drought-stress treatments during the course of the years 2021 and 2022.

4.1 Analysis of variance (ANOVA)

A number of morphological characteristics, such as plant height, productive tillers per plant, spike length in centimetres, spikelet density, grain yield per plant, biological yield per plant, and harvest index in percentage, were subjected to an analysis of variance, which revealed that there were significant differences between treatments, genotypes, and the interaction (genotype x treatment) for all of these characteristics. In terms of physiological characteristics, such as relative water content (%), chlorophyll content (%) and leaf area (cm²), there was also a significant association between genotypes, treatments, and the interaction. This relationship was significant at the P<0.01 level.

Table 4.1 Mean squares from analysis of variance for various physiological and morphological traits of wheat genotypes grown under field conditions

Source of variation	DF	Plant height (cm)	Number of tillers plant ⁻¹	Spike length (cm)	Spikelet's spike ⁻¹	1000 grain weight	Grain yield plant ⁻¹	Biological yield plant ⁻¹	Harvest index (%)	Leaf area	RWC	Chlorophyll content
Replication	2	12.25	2.5833	0.8679	2.5833	15.739	176.765	5.14	0.8679	37.98	27.33	0.016
Treatments	1	1736.11**	56.25**	56.0252**	56.25**	701.279**	7.618**	47.83**	56.25**	622.08**	2942.7**	0.169**
Genotype	5	640.27**	18.45**	20.0494**	18.45**	44.849**	139.315**	61.388**	72.733**	50.65**	385.05**	0.460**
Genotype x Treatment	5	65.18**	0.45**	0.4875**	0.45**	5.703**	109.394**	0.4875**	33.62**	19.28**	156.86**	0.0239**
Error	20	13.76	1.6333	0.8765	1.6333	13.127	119.399	8.39	5.703	7.34	105.05	0.0061

**Significant P<0.01 probability level

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Table 4.2 Mean performance of various morphological character in wheat genotypes

Genotypes	Plant height (cm)			Tillers plant ⁻¹			Spike length (cm)		
	Control	Drought	R.D%	Control	Drought	R.D%	Control	Drought	R.D%
Kiran-95	103.43	94.25	-9.25	12	8	-4.46	10.82	7.27	-3.81
TD-1	109.25	91.35	-17.9	10	7	-3.12	14.75	12.69	-2.97
Benazir	96.68	84.66	-12.43	14	12	-2.19	13.67	11.59	-2.58
NIA-Saarang	107.21	94.39	-11.96	13	11	-2.33	12.79	10.67	-2.58
NIA-Sunehri	103.35	87.22	-15.61	13	11	-2.38	14.29	12.44	-2.95
Khirman	94.37	82.69	-12.38	14	12	-2.29	12.89	10.79	-2.29
Mean	102.38	81.26	-20.26	12.67	10.17	-2.45	13.20	10.91	-3.97
LSD 5%	T=1.81	G=4.72	TxG=7.79	T=0.88	G=2.29	TxG=3.78	T=0.46	G=1.21	TxG=2.0

Table 4.3 Mean performance of various morphological characters in wheat genotypes

Genotypes	Spikelet's spike			Seed index (1000 grain weight) g			Grain yield plant ⁻¹		
	Control	Drought	R.D%	Control	Drought	R.D%	Control	Drought	R.D%
Kiran-95	18.64	12.18	-6.66	38.21	21.61	-17.44	32.11	21.56	-11.86
TD-1	17.55	13.12	-4.24	37.39	29.88	-8.09	25.00	21.00	-4.00
Benazir	15.41	9.18	-6.43	38.36	30.52	-8.44	23.89	22.67	-1.11
NIA-Saarang	17.42	10.22	-7.33	36.27	29.21	-7.47	22.89	20.22	-2.66
NIA-Sunehri	19.78	16.51	-3.53	37.42	30.73	-7.88	22.89	21.89	-2.37
Khirman	22.53	18.40	-4.33	40.26	32.58	-12.08	21.56	20.12	-1.68
Mean	18.56	13.27	-6.42	37.99	29.09	-23.40	24.72	21.24	-12.78
LSD 5%	T=0.63	G=1.64	TxG=2.71	T=1.32	G=3.44	TxG=5.68	T=1.78	G=2.18	TxG=4.33

Table 4.4 Mean performance of various morphological and physiological characters in wheat genotypes

Genotypes	Biological yield plant ⁻¹			Harvest index (%)			Leaf area (cm ²)		
	Control	Drought	R.D%	Control	Drought	R.D%	Control	Drought	R.D%
Kiran-95	30.66	21.27	-9.80	45.00	44.12	-1.96	10.82	7.27	-3.81
TD-1	28.18	20.58	-8.97	45.00	43.20	-2.00	14.75	12.69	-2.97
Benazir	27.98	14.27	-13.00	45.11	44.11	-1.22	13.67	11.59	-2.22
NIA-Saarang	32.09	18.75	-14.57	48.42	45.22	-3.61	12.79	10.67	-2.58
NIA-Sunehri	26.94	22.45	-4.67	45.00	43.25	-2.89	14.29	12.44	-2.95
Khirman	21.66	17.59	-4.79	45.22	42.01	-3.10	12.89	10.79	-2.29
Mean	27.92	19.15	-8.80	45.63	43.65	-2.30	13.20	10.91	-13.97
LSD 5%	T=1.82	G=2.85	Tx G=4.47	T=1.66	G=4.19	Tx G=4.07	T=3.57	G=3.26	Tx G=4.61

Table 4.5 Mean performance of various physiological characters in wheat genotypes

Genotypes	Relative water content (%)			Chlorophyll content (%)		
	Control	Drought	R.D%	Control	Drought	R.D%
Kiran-95	72.96	61.81	-11.28	70.50	69.82	-1.96
TD-1	67.06	58.48	-9.79	70.17	69.25	-1.31
Benazir	59.95	51.51	-8.08	70.20	68.87	-2.89
NIA-Saarang	64.00	54.43	-10.95	70.97	70.35	-0.87
NIA-Sunehri	60.65	54.14	-6.73	71.00	70.17	-1.17
Khirman	60.85	53.42	-7.21	71.02	69.45	-2.21
Mean	64.25	55.63	-9.34	70.64	69.65	-1.40
LSD 5%	T=12.40	G=12.34	T x G=12.34	T=10.84	G=15.86	TxG=12.12

4.2 Mean performance

4.2. Plant height (cm)

Plant height observed to have short stature height in Benazir and Khirman (96.68cm and 94.37cm) under control condition. However, under drought stress most of the genotypes showed short stature height of plant (Table 4.2). The relative decline was found in almost all the genotypes depicting that due to drought stress the height decreased eventually.

4.2. Number of tillers plant⁻¹

Greater tillers plant⁻¹ was found in the genotype Benazir and Khirman (14), under control conditions. Similarly, under drought stress both the genotypes Benazir and Khirman showed maximum tillers plant⁻¹ as 12, respectively. The relative decrease found maximum in Kiran-95 as -2.33%, however almost all the genotypes were affected due to drought stress (Table 4.2).

4.2. Spike length (cm)

The spike length showed that the genotypes TD-1 and NIA-Sunehri possessed larger spike length as 12.69 and 12.44cm, respectively under normal condition. However, under drought stress both these genotypes showed maximum spike length as 12.69 and 12.44cm, respectively. The relative decrease was found greater in the genotype Kiran-95 as -3.81%. Almost all the genotypes were affected due to drought stress for this character (Table 2).

4.2. Spikelets spike⁻¹

This character showed that NIA-Sunehri and Khirman produced maximum number of spikelet's spike as compare to other genotypes under control condition. Whereas, under drought stress Khirman showed more number of grains spike⁻¹ as compare to other genotypes. However, the decline was greater in the genotypes Benazir and NIA-Saarang as -6.43 and -7.33%, respectively.

4.2. Seed index (1000-grain weight, g)

This character showed that Khirman possessed maximum seed index under control condition and under drought stress Khirman again showed greater seed index (40.26 and 32.58 g), respectively. The relative decrease was greater in Kiran-95 AS -17.44%.

4.2. Grain yield plant⁻¹

Maximum grain yield was reported in Kiran-95 as 32.11 g. However, under control condition the other genotypes also showed greater yield. Similarly, under drought stress the genotype Benazir showed maximum yield as 22.67g as compare to other genotypes, However, the decline was found greater in Kiran-95 as -12.78%.

4.2. Biological yield plant⁻¹

The biological yield depicted greater yield in the genotype Kiran-95 and NIA-Sarang (30.66 and 32.09), respectively under control conditions. Whereas, under drought condition Kiran-95 and Sunehri showed maximum biological yield plant⁻¹ (21.27 and 22.45), respectively. The relative decrease was greater in Benazir as -13.00.

4.2. Harvest index (%)

The harvest index showed the maximum index in the genotypes NIA Saarang as 48.42 under control conditions. Whereas, under drought condition NIA-Saarang produced maximum harvest index as 45.22. The relative decrease was found more in NIA-Saarang as -3.61%.

4.2. Leaf area (cm²)

For this character TD-1 and NIA-Sunehri showed greater leaf area as compare to other genotypes for control condition and under drought stress TD-1 and NIA-Sunehri

showed maximum leaf area as 12.6 and 12.4, respectively. However, the relative decrease was more in Kiran-95 as -3.81.

4.2. Relative water content (%)

The RWC was found to be more in the genotypes Kiran-95 and TD-1 (72.96 and 67.06), respectively. Whereas, under drought condition again Kiran-95 showed maximum relative water content as 61.81. The relative decrease was found to be more in Kiran-95 as -11.28%.

4.2. Chlorophyll content %

The chlorophyll content% was more in the genotype NIA-Saarang and NIA-Sunehri as 70.35 and 70.17, respectively under control condition. Under drought condition also NIA-Saarang and NIA-Sunehri showed maximum chlorophyll. The relative decrease was found greater in Khirman as -2.21.

Table 4.6 Correlation coefficient (r) among various traits of wheat genotypes

Characters	Plant height (cm)	Number of tillers	Spike length (cm)	Spikelet's spike ⁻¹	Grains spike ⁻¹	Grain yield plant ⁻¹	1000-Grain weight (g)	Biological yield plot ⁻¹	Harvest index (%)	Leaf area	Relative Water Content
Number of tillers	0.856**										
Spike length (cm)	-0.733**	-0.848**									
Spiklets spike ⁻¹	-0.618**	-0.704**	0.784**								
Grains spike ⁻¹	0.831**	0.977**	-0.744**	-0.629**							
Grain yield plant ⁻¹	0.640**	0.654**	-0.627**	-0.347**	0.657**						
1000-grain weight	-0.314**	-0.600**	0.749**	0.660**	-0.494**	0.621**					
Biological yield plot ⁻¹	-0.447**	-0.698**	0.812**	0.67**	-0.605**	0.562**	0.906**				
Harvest index (%)	-0.147**	-0.339**	0.354**	0.344**	-0.364**	0.342**	0.583**	0.488**			
Leaf area	-0.678**	-0.727**	0.802**	0.946**	-0.624**	0.622**	0.684**	0.726**	0.599**		
Relative Water Content	-0.702**	-0.914**	0.902**	0.808**	-0.832**	0.586**	0.704**	0.774**	0.418**	0.805**	
Chlorophyll content	-0.832**	-0.675**	0.787**	0.722**	-0.466**	-0.435**	0.383**	0.410**	0.577**	0.790**	0.699**

**Significant at 0.01 probability level, *significant at 0.05 probability level

4.3 Correlation (r) coefficients among various traits in wheat genotypes

A correlation study between numerous yield-associated factors may provide insight into the appropriate selection criteria for genotypes with yield. According to Laghari et al.

(2010), the fact that it displays pleiotropic effects indicates that it most likely has a genetic foundation for the observed relationship.

4.3. Plant height

It was found that there was a correlation that was both positive and statistically significant between plant height and tiller number ($r= 0.856^{**}$), plant height (cm) ($r= 0.856^{**}$), and grains spike ($r= 0.831^{**}$). Number of tillers and grains spike. While spike length and leaf area showed negative and significant association ($r= -0.733^*$ and -0.678^{**}). Plant height exhibited significant association with grain yield ($r=0.640^{**}$) while others showed non-significant association.

4.3. Number of tillers plant⁻¹

Both the grain yield per plant and the grain yield per spike are positively correlated with this feature, as shown by a correlation coefficient of 0.977^{**} . It was shown that the spike length, spikelet's spike length, biological yield per plant, leaf area, relative water content, and chlorophyll content all had a negative and statistically significant link with one another ($r=-0.848^{**}$ ($r=-0.698^{**}$, $r=-0.727^{**}$ and $r=-0.914^{**}$, respectively). Spike length was also revealed to have a significant relationship with spikelet's spike length. It was clear from this evidence that these characteristics diminished as the number of tillers increased. On the other hand, none of the other characteristics showed an association that was statistically significant.

4.3. Spike length (cm)

This characteristic exhibits a positive and statistically significant association ($r=0.784^*$) with spike⁻¹ grain production, 1000-grain weight, plant biological yield, and leaf area. Additionally, all of these variables are related to spike⁻¹ grain output. This characteristic has a substantial negative correlation with spike⁻¹ grain output ($r=-0.744^{**}$), however it did not have a significant inverse correlation with plant-level grain yield ($r=-0.627^{**}$).

4.3. Spikelet's spike⁻¹

Positive and substantial correlations were found between this feature and a thousand grain weight ($r=0.660^*$), biological yield plant⁻¹ ($r=0.812^{**}$), leaf area ($r=0.802^*$), relative water content ($r=0.902^{**}$), and chlorophyll content ($r=0.787^*$). On the

other side, we found a negative association between grains spike⁻¹ and grain yield plant⁻¹, although it was not statistically significant ($r=-0.629^{**}$ and -0.347^{**} , respectively).

4.3. Grain yield plant⁻¹

Positive and substantial correlations were found between this characteristic and the following variables: thousand grain weight ($r=0.621^{**}$), biological yield per plant ($r=0.562^{**}$), leaf area ($r=0.622^{**}$), and relative water content ($r=0.832$). The harvest index and chlorophyll had a correlation of 0.342^{**} , which did not reach the level of statistical significance required to be considered significant.

4.3. 1000-Grain weight (g)

There was a correlation that was discovered to be both positive and statistically significant between this characteristic and the biological yield plot^{-1} (kg) ($r= 0.906^{**}$), the leaf area ($r= 0.694^*$) and the relative water content ($r= 0.704^{**}$). Whereas others indicated correlations that were either weak or inconsequential

4.3. Biological yield plant^{-1} (g)

Leaf area and relative water content were favorably linked with this feature ($r= 0.726^{**}$ and $r=0.774^{**}$, respectively), but this association did not reach the statistical significance level required to be considered statistically significant. In other instances, however, there was no correlation that could be considered statistically significant.

4.3. Harvest index (%)

There was a negative and insignificant correlation between the harvest index and leaf area, relative water content, and chlorophyll content.

4.3. Leaf area

This character showed positive highly significant association with relative water content and chlorophyll content as $r=0.805^{**}$ and $r=0.790^{**}$.

4.3. Relative water content (%)

This character showed highly significant correlation with chlorophyll content as $r=0.699^{**}$.

Discussion

Wheat is one of the cereal crops that is cultivated on the most land all over the world, and it is consumed by people in every region. The objective of this research was to evaluate drought-resistant genotypes that had optimal yields in addition to other characteristics. The results of an ANOVA on wheat showed significant differences between treatments, genotypes, and the interaction (genotype x treatment) for plant height, productive tillers plant^{-1} , spike length in centimeters, spikelet density, grain yield plant^{-1} , biological yield plant^{-1} and harvest index in percentage. These variables were measured in terms of percentage. In terms of physiological characteristics, such as relative water content (%), chlorophyll content (%) and leaf area (cm^2), there was also a significant association between genotypes, treatments, and the interaction. This relationship was significant at the P0.01 level. Despite this, there were a few small characters who you may engage with. According to Bilal et al. (2015), significant production losses may occur as a result of moisture deprivation at any stage of the wheat crop, from the seedling stage all the way to maturity.

Benazir and Khirman plants grown under circumstances of control and drought had, on average, lower plant heights and more tillers than those grown under conditions of drought alone. On the other hand, Kiran-95 had a relative decline of -33.33% over the duration of the drought. In response to any of the stresses, the length of the spikes produced by TD-1 and NIA-Sunehari were shown to have increased. According to Kilic and Yagbasanlar (2010), drought, a natural polygenic stressor, has had a deleterious influence on wheat production all over the world, especially in arid and semiarid areas. However, NIA-Sunehri and Khirman

had the maximum number of spikelet's, whilst Benazir and NIA-Saarang demonstrated the biggest decrease, with a value of -40.43 and -41.33%, respectively. Although Khirman's seed index is lower, it is greater than Kiran-95's; yet, the difference is -43.44%. Due to the fact that both Benazir and Khirman were shown to have increased grain yields in dry circumstances, they are potential genotypes for drought resistance. According to Zulkiffal et al. research from 2022, a significant decrease in wheat yields may be attributed to a lack of precipitation in these places, which results in a decreased availability of water throughout the developmental stages and physiological activities of the wheat plant. On the other hand, Kiran-95 had a more significant decline (-32.86%). During the drought, the Kiran-95 and Sunehri plants were found to have their maximum biological yield plant⁻¹. The NIA-Saarang genotype had the greatest harvest index (45.22), whereas the TD-1 and NIA-Sunehri lines had bigger leaf areas under control and drought circumstances, respectively. The NIA-Saarang genotype had the highest harvest index. On the other hand, Kiran-95 had a higher percentage decline, falling by -32.81. It was discovered that Kiran-95 and TD-1 had a higher RWC in comparison to the other genotypes. It was discovered that Kiran-95 had a greater relative decline, one that was 15.28%. The NIA-Saarang and NIA-Sunehri genotypes both performed better in terms of their chlorophyll content percentages whether the conditions were either normal or drought-like. These findings are in line with those discovered by another study (Abdulhamed et al., 2021).

Plant height had a positive and substantial correlation with both tiller plant density and plant height (cm) ($r = 0.856^{**}$), as well as plant height (cm) and grains spike ($r = 0.831^{**}$). Plant height also had a correlation with plant height (cm) and grains spike. All of the correlation correlations between spike length, spikelet's spike, biological yield plant, leaf area, relative water content, and chlorophyll content were found to be negative and statistically significant. These correlation coefficients were as follows: $r = -0.848$ ($r = -0.698^*$), $r = -0.727^{**}$ and $r = -0.914^{**}$. Spike length was shown to have a positive and statistically significant link with 1000 grain weight ($r = 0.749^{**}$), biological yield plant⁻¹ ($r = 0.812^{**}$), and leaf area ($r = 0.802^{**}$). Positive and substantial correlations were found between this feature and the findings of spike⁻¹ spikelet's One thousand grain weight ($r = 0.660^{**}$), biological yield plant⁻¹ ($r = 0.812^{**}$), leaf area ($r = 0.802^{**}$), relative water content ($r = 0.902^{**}$), and chlorophyll content ($r = 0.787^{**}$). There were found to be positive associations that were statistically significant between grain yield plant⁻¹ and thousand grain weight ($r = 0.621^{**}$), biological yield plant ($r = 0.562^{**}$), leaf area ($r = 0.622^{**}$), and relative water content ($r = 0.832^{**}$). The thousand grain weight, leaf area, and relative water content all had significant and positive correlation coefficients (0.906, 0.694, and 0.704, respectively). All of these correlation values were positive. Although the correlations between leaf area and relative water content and plant⁻¹ biological output were positive ($r = 0.726^{**}$ and $r = 0.774^{**}$, respectively), the statistical significance of these connections was not established. Although this link was not statistically significant, there was a negative correlation found between the harvest index and the leaf area, relative water content, and chlorophyll content of the leaves. There was a correlation that was both positive and significant between the total leaf area and the relative chlorophyll and water concentrations. The relative water content and chlorophyll concentration were shown to have a very significant association with one another. According to the findings of Kadan et al. (2022), M4 of two different crosses demonstrated a very significant and tightly related association between grain yield plant⁻¹ and seven other

parameters, including plant height, the number of grains spike⁻¹, the number of productive tillers plant⁻¹ and grain mass per 1000-grains.

Conclusions

Genetic variation is one of the key factors in tailoring the effective breeding programme in any crop. It is concluded from the present research that: The analysis of variance (ANOVA) for wheat genotypes revealed highly significant at $P \leq 0.01$ probability level for traits viz. plant height, productive tillers plant⁻¹, spike length (cm), number of spikelet's spike⁻¹, number of grains spike⁻¹, grain yield plant⁻¹, biological yield plant⁻¹ and harvest index (%) for treatments, genotypes and interaction (genotype x treatment). The physiological traits such as relative water contents (%), chlorophyll content (%) and leaf area (cm²) were also significant at $P \leq 0.01$ for genotypes, treatments and interaction. The mean performance showed that Benazir and Khirman showed short stature plant height and more number of tillers under both control and drought conditions. TD-1 and NIA-Sunehri possessed greater spike length. NIA-Sunehri and Khirman exhibited more spikelets spike. Seed index was found more in Khirman. Grain yield was found greater in Benazir and Khirman under drought condition. Kiran-95 and Sunehri exhibited more biological yield plant⁻¹. NIA-Saarang produced maximum harvest index. TD-1 and NIA-Sunehri greater leaf area. The RWC was found to be more in the genotypes Kiran-95 and TD-1, respectively. The chlorophyll content% was more in the genotype NIA-Saarang and NIA-Sunehri under control and drought conditions. Correlation analysis showed that plant height with number of tiller plant ($r = 0.856^{**}$), plant height (cm) (0.856^{**}) and grains spike ($r = 0.831^{**}$) exhibited positive and significant correlation. Spikelets spike⁻¹ showed significant and positive association with thousand grain weight ($r = 0.660^{**}$), biological yield plant ($r = 0.812^{**}$), leaf area ($r = 0.802^*$), relative water content (0.902^{**}) and chlorophyll content ($r = 0.787^{**}$). Grain yield plant⁻¹ also showed positive and significant associations with thousand grain weight ($r = 0.621^{**}$), biological yield plant ($r = 0.562^{**}$), leaf area ($r = 0.622^{**}$) and relative water content ($r = 0.832^{**}$).

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