

Original Article

J Genet Appl Biotechnol, 2026: e2026024

DOI: <https://doi.org/10.66432/p737za06>

Received: 29 Jan 2026; Revised: 05 Apr 2026; Accepted: 08 Apr 2026; Published online: 23 Apr 2026



Evaluation of Wheat Genotypes for Physiological and Yield Related Traits Under Rainfed Conditions

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Abstract

Wheat (*Triticum aestivum* L.) is staple food of more than two billion people across the world. Wheat farmer faces many constraints due to changing climatic conditions. About 50% yield losses occur due to inadequate rainfall in arid and semiarid region. Therefore, plant breeders have to evaluate and develop climate resilient wheat varieties to ensure food security. The prime objective of the study was to evaluate performance of spring wheat genotypes for various physiological and yield related traits under rainfed conditions. To achieve this objective, research was carried out at National Agricultural Research Centre (NARC) during the two consecutive Rabi seasons (2020-2021) and (2021-2022). The data was collected at different stages of crop for physiological traits viz. canopy temperature depression (CTD), spade chlorophyll content, relative water content, cell membrane stability, day to heading, day to maturity, yield related traits viz. plant height, Fertile tillers per plant, spike length, number of spikelets per spike, 1000 grain .weight, grain number per spike, yield per meter square. The data collected for all traits were subjected to analysis of variance (ANOVA).and correlation to ascertain the significance of result. The present study revealed that wheat genotypes NR-448, 18696, AAS-11 and Pakistan 13 showed best performance for grain yield under rainfed conditions. The grain yield was positively correlated with all the yield related parameters.

Keywords: Wheat, Rainfed, Physiological parameters, Yield

How to cite this article: Batool A, Ahmad M, Shahzad A, Khaliq F. Evaluation of Wheat Genotypes for Physiological and Yield Related Traits Under Rainfed Conditions. *J. Genet. Appl. Biotechnol.* 2026: e2026024. <https://doi.org/10.66432/3sj9s175>

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Introduction

Wheat (*Triticum aestivum* L.) is most important cereal crop belongs to family Poaceae. It is staple source of nutrient for large part of world population, about 40% of world population meets their dietary requirement through wheat. In developing countries, it is widely cultivated crop after rice so that it has an important role in food security (1). Wheat provides 20% of daily protein and main source of plant based protein as it contains 13% protein which is quite higher as compared to other cereals. Wheat is a leading source of dietary fiber and micronutrients. Area under wheat cultivation is increasing generally due to its high economic importance. Raw wheat is used for animal feed and as well in paper and adhesive industries (2).

In Pakistan, about 20% area of the wheat is under rainfed conditions, where water stress is the major limiting factor (3). When wheat grows in rainfed conditions it faces drought stress combined with high temperature. Pakistan ranks fourth in most drought prone countries in the world. Wheat farmers

face many constraints due to changing climatic conditions and about 50% yield loss occur due to inadequate rainfall in arid and semiarid agriculture region (4). Drought tolerance is a polygenic trait. Breeding for drought tolerance is difficult due to some complex factors such as high temperature, high radiations, toxicity of nutrients and various nutrient deficiencies can affect plant yield all together. In 2050 yield of staple crop like wheat will be needed to increase to almost 70% in order to feed human population (5).

Moisture stress reduces the dry matter production which ultimately cause decline in the fertile tillers per m⁻², number of grains and 1000 grain weight (6). Drought tolerance depends on number of physiological and yield related traits which are genetically complex difficult to manipulate therefore, direct selection for drought tolerance leads to misleading selection. High variability was observed among wheat genotype while studying these attributes (7). Physiological traits conferring drought tolerance are plant height, fertile tillers per plant, days to maturity, days to

heading, canopy temperature (CT), chlorophyll content, relative water content, and cell membrane stability. These traits have high influenced by genes that are directly related to yield. About 50 percent increase in yield is reported by incorporating desirable physiology of plant into wheat genotype. Chlorophyll content is not only associated with high yield but also associated to improve light interception and utilization in spring wheat (8).

To deal with such polygenic traits breeders mostly analyzed the genetics of these traits and physiology of plant to develop strategies that enhance yield in drought stress conditions. The main purpose of exploring genetic variability is to determine gene action that is not only worth for selection but also helps breeders to develop improved genotype by exploiting genetic makeup. It also helps in predicting to which extent specific quantitative trait of economic importance can be transferred to tolerant cultivar. The rate of selection for both physiological and yield related trait depends upon genetic variability that exists in wheat genotypes (9). Research work was conducted to evaluate the wheat genotypes for physiological and yield related trait under rainfed conditions and to study the association between physiological and yield related traits.

Materials and Methods

The present research work was conducted at the National Agricultural Research Centre (NARC) during the two consecutive Rabi seasons (2020-2021) and (2021-2022) in the mid of November to study the genetic variability in spring wheat for physiological and yield related attributes under rainfed conditions.

Research trials were carried out following Randomized Complete Block Design during both seasons. Twenty three genotypes were planted in three replications (Table 1). The distance among rows maintained as 30cm while 10 cm among plants.

The data were collected at different stages of crop for days to heading, days to maturity, spade chlorophyll unit, canopy temperature depression (CTD), cell membrane stability, relative water content, yield components including fertile tillers per plant, plant height, spike length, grains per spike, spikelets per spike, 1000 grain weight and yield per meter square. Canopy temperature depression (CTD) was recorded with infrared thermometer (Model AG-42, Tela-temp Crop, Fullerton, CA.). Data were recorded from five randomly selected plants and average was computed. CTD was estimated following $CTD = T_a - T_c$. Where T_a : Air temperature T_c : Canopy temperature (10). Cell membrane stability was recorded from fully expanded uppermost leaves. Leaf samples were cut into 1 cm pieces (11). Small pieces of leaf sample (0.5g) were put into deionized water for 90 minutes. Leaf samples were washed three times with deionized water. Two sets (control and stress) of samples were prepared. Samples (control) were kept at 10 °C for 24 hours in 15 ml deionized water. Samples (stress) were kept at 10 °C for 24 hours in 15 ml 25% polyethylene glycol 6000 solution. Samples were washed in deionized water for 90 minutes. The two sets (control and stress) were kept at 10 °C for 24 hours in 15 ml deionized water. EC (electrical

conductivity) of control (C1) and stress (T1) were recorded using EC meter. Leaf samples of both sets were autoclaved at 121 °C for 15 minutes. Afterwards second EC of control (C2) and stress (T2) was recorded. CMS was estimated following $CMS (\%) = [(1-(T1/T2)) / (1-(C1/C2))] \times 100$. The data collected for all traits were subjected to analysis of variance (ANOVA) with Statistical software Statistix 8.1. Correlation coefficient was also estimated (12).

Table 1: List of 23 wheat genotypes studied in the experiment

Sr. No.	Genotypes	Sr. No.	Genotypes
1.	Chakwal-50	13.	11196
2.	AAS-11	14.	11238
3.	Monal-1	15.	11272
4.	Pak-13	16.	11315
5.	Borloug-14	17.	18696
6.	AUR 0809	18.	11280
7.	AUR-810	19.	NR 514
8.	DH-13	20.	NR 448
9.	FSD-09	21.	Inqlab 91
10.	Galaxy-13	22.	Markaz 19
11.	11156	23.	Ghazi-19
12.	11170		

Results and Discussion

Phenological attributes

Days to heading recorded from date of sowing to the 50% plants show spike emergence from flag leaf. Days to heading are associated with early maturity. Plants use early maturity to escape from terminal drought and heat stresses. Average days to heading ranged from 97.42 - 114.40 days during year 2021-2022. Inqlab-91 took maximum days to heading followed by NR-514 and Markaz-19. AAS-11, 11238 and 11315. PAK-13 showed minimum number of days taken to heading. Days to heading had negative correlation with grain yield. Days to physiological maturity is a direct measure of earliness of a genotype. As in drought stress early maturing crop complete their life cycle early and escape from stress (13). Analysis of variance showed highly significant differences among genotypes for days to maturity. Average days to maturity ranged from 136.97 to 154.20 days during year 2021-2022. The maximum days to maturity were exhibited by Chakwal -50 and DH-31 followed by 11170. AUR 0809 took minimum number of days to maturity followed by AAS-11. Short heading and a longer maturity phase, according to (14), would result in a longer grain filling period for the development of grain weight in wheat.

Physiological attributes

Spring wheat faces mostly heat stress and drought stress issues due to changing climatic conditions. Canopy temperature plays important role in tolerating this stress. Therefore, breeders focus on determining its genetic mechanism to develop improved wheat cultivar. In this study ANOVA results for canopy temperature exhibited highly significant difference during both season. Mean values of canopy temperature varied between 5.3 to 7.16 during 2020-2021 whereas it ranged between 5.7 to 7.8 during 2021-2022. Highest value was recorded in DH-13 subsequently in AAS-

11and Galaxy-13 while in second experiment highest value was recorded by AAS-11. Whereas minimum value was found in Borloug-14 during first season whereas Monal 1 and NR-514 showed minimum value during second season. Chlorophyll content helps to predict photosynthesis activities and has high contribution in plant yield. Chlorophyll content is not only associated with high yield, but also associated to improve light interception and utilization in spring wheat during stress condition (15). ANOVA for 23 genotypes exhibited highly significant differences. Spade chlorophyll content varied from 17.21 to 30.81 during year 2020-21 while it ranged from 17.96 to 37.89 during year 2021-22. It was found that Inqlab 91, 18696, DH-31 exhibited highest value while Monal-1 and 11170 showed its minimum value during first year whereas AUR 0809, DH-31 and 11315 showed high chlorophyll content during second year while Ghazi showed minimum value.

RWC is most important physiological trait as it indicates the water state of cells and has strong correlation with biotic and abiotic stresses. It is one of the consistent standards to calculate water status of leaves to their fully turgid state. In this study ANOVA for 23 genotypes exhibited high significant difference among them (Table 2). Relative water content varied from 65.740 to 87.437 during year 2020-21 while it ranged from 56.630 to 81.5 during year 2021-22. It was found that AAS-11 and AUR-0809 exhibited highest value while Galaxy -13 showed its minimum value during both season. Due to disruption of membrane the cellular component gets assembled which is result of cellular volume reduction that can lead to denaturation of protein as well as viscosity through permeability enhancement in plasma membrane. Mean value of cell membrane stability in lines ranged from 54.72% - 75.15%. Maximum value recorded in PAK-13, AAS-11 and NR-44 whereas AUR-810, DH-31 and Monal-1 showed minimum cell membrane stability.

Morphological attributes

Plant height is an important trait in wheat breeding programs. It contributes indirectly to yield. Wheat varieties having short stature plants are more lodging resistant and shows positive response to inputs. NR-514, 11194, 11156 exhibited maximum height while DH-31 and chakwal-50 showed minimum height during both seasons. Number of fertile tillers is most important yield contributing trait that not only affect yield but also linked with biomass production (16). During the year 2020-21, Galaxy 13, Chakwal 50 and AAS-11 exhibited maximum number of tillers while 11194 showed its minimum value. During year 2021-22, AAS-11, AUR-0809 and 11272 had maximum tillers whereas 11194 exhibited its lowest value. Spike length contributes directly to grain weight and yield per plant. Spike length was maximum in Inqlab-91, PAK-13 and NR-448 and lowest in Monal-1 and 11280 during both cropping years. During second season AAS-11 also showed maximum spike length. Genotypes having longer spike are preferred in selection program in order to obtain higher yield. Number of spikelets per spike is a significant trait affecting both number of grains per spike and grain. yield per plant. The maximum numbers were observed in Inqlab-91, DH-31, 11156 And NR 514

Whereas minimum number of spikelet per spike were found in 11272 and 11280 during both seasons. High yield can be obtained by improving grain number per spike (17). Negative Correlation exists between grain weight and grain number as high increase in grain number reduces grain weight. In this study during year 2020-21, 11238, inqlab-91 and PAK 13 exhibited maximum grain number while AUR-0809 showed its minimum value. During year 2021-22, inqlab-91, AAS-11 and PAK-13 had highest grain yield whereas DH-31 exhibited 27.46. During year 2020-21, 11238, Inqlab-91 and PAK 13 exhibited maximum grain number while AUR-0809 showed minimum value. 1000 grain weight is a main yield related trait, and it has major contribution during cultivar development. High grain weight within certain limit and specific position might be highly efficient for increasing grain yield in stress condition. In present study it was found highest in the genotypes 11156, 18696, 11238 and lowest in 11280, 11194, AUR810 during both cropping years. During second season Pak-13(35.96) also showed maximum grain weight. Rapid improvement in grain yield is very important as in 2050 it is necessary to increase yield of staple crop like wheat to almost 70% in order to feed human population. Therefore, yield is most important trait in wheat breeding programs (18). Genotypes NR-448, 18696 and AAS-11 exhibited maximum yield per meter square while Borloug 14 showed its minimum value during both season.

Table 2: Analysis of variance of different plant traits studied in 23 genotypes during (2020-2021).

Source of Variation	Replication	Genotypes	Error
DF	2	22	44
Chlorophyll Content	1.4609	52.5663**	1.6038
Canopy Temperature Depression	0.08103	0.87973**	0.06463
Relative Water Content	16.452	116.83**	2.126
Plant Height	4.5362	82.1779**	11.415
Spike Length	0.91364	3.90298**	0.19462
No. of Tillers	1.49275	2.01845**	0.62912
Spikelet per Spike	2.7826	11.1199**	2.3432
Grain Number	20.913	96.025**	8.3827
1000 Grain Weight	2.3623	40.3887**	1.8017
Yield per Meter Square	2433.52	9538.72**	2361.82

Correlation for various traits

Correlation is commonly used to determine the degree of association between the traits. Correlation determination between different traits especially for yield related trait helps

and allows breeders to select the right components which go ahead to higher yield. It is valuable in plant breeding as it offers a center idea of the association among various yield contributing traits. Correlation analysis among different traits is presented in Table 4. During study relationship examination registered for morphological trait such as grain number highly significantly correlated with yield, spike length and spikelet per spike. The grain yield negatively correlated with day to maturity (-0.38) and heading (-0.25) whereas positively correlated with all other parameter. These results are similar to those reported earlier (3). Number of

tillers showed non-significant relation with canopy temperature and relative water content. Chlorophyll content and CMS also showed positive correlation with grain number and 1000 grain weight whereas CMS had negative correlation with plant height.

These results indicated that grain number, spike length, cell membrane stability, relative water content and spikelet per spike having positive correlation and had direct effect on grain yield. These traits can be used as selection criteria to develop high yielding wheat genotypes. Similar findings were reported earlier (14).

Table 3: Descriptive statistics of thirteen traits in 23 wheat genotypes during 2020-21 and 2021-2022 under rainfed conditions

	Minimum		Maximum		Mean		CV	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
CC	17.20	17.90	30.80	37.89	26.08	28.24	4.86	4.35
CTD	5.31	5.72	7.12	7.81	6.23	7.01	4.08	5.01
RWC	65.75	56.63	87.43	81.50	74.60	73.32	1.95	2.52
CMS	53.20	54.43	73.40	75.15	72.00	73.30	12.10	13.47
PH	77.30	76.03	95.30	94.40	86.16	85.44	3.92	3.47
NOT	4.30	3.30	7.00	7.30	5.55	5.56	14.29	10.45
SL	6.40	6.00	10.10	10.50	9.35	8.23	10.49	8.29
SPS	12.30	13.67	19.30	20.10	15.26	15.75	10.03	7.56
1000GW	24.60	26.40	37.33	38.70	28.86	29.69	4.65	6.72
GN	27.00	27.47	45.67	46.20	36.48	37.55	7.94	6.58
YPMS	297.00	303.60	487.60	500.10	374.48	400.10	12.98	0.90

Y1= 2020-21, Y2= 2021-22, CV= coefficient of variance, CC= Chlorophyll content, CTD= Canopy temperature depression, RWC= Relative water content, CMS= Cell membrane stability, PH= Plant height, NOT= Number of tillers per plant, SL= Spike length, SPS= Spikelet per spike, TGW= Thousand grain weight, GN= Grain number, YPMS= Yield per meter square

Table 4: Correlation analysis of physio-morphic traits

	Yield	Tillers	SPS	SL	RWC	PH	DM	GN	TGW	DH	CT	CMS
CC	0.3384*	0.083	0.1652	0.177	0.4508*	0.1266	-0.0914	0.3176*	0.1096	-0.1816	0.0786	0.1337
CMS	0.5654**	0.1966	0.2411	0.4298*	0.1712	-0.0566	-0.1732	0.5037**	0.4418*	-0.0722	0.0178	
CT	0.2077	-0.1337	-0.0152	-0.1001	-0.0214	0.0489	0.0832	0.0725	0.2486	0.1361		
DH	-0.251	-0.1447	0.1655	-0.0856	-0.098	0.04434	0.0304	-0.073	-0.0872			
TGW	0.38518*	0.1063	0.5552**	0.5459**	0.1596	0.3099*	-0.2351	0.597**				
GN	0.6136**	0.1269	0.3566*	0.6346**	0.364*	0.1766	0.477*					
DM	-0.3873	0.1288	0.1614	0.2913	-0.3583	-0.2278						
PH	0.08	0.2533	0.079	0.209	0.1128							
RWC	0.3981*	0.0555	0.1682	0.387*								
SL	0.3521*	0.1472	0.593**									
SPS	0.208	0.657										
Tiller	0.0436											

Conclusion

It is evident from the experiment results that genotypes AUR 0809, NR-448, 18696, AAS-11 and Pak 13 showed

best performance for grain yield under rain-fed conditions. The grain yield was positive correlates all the parameter except phenological traits. So, these results indicate that grain number, spike length, cell membrane stability, relative water content and spikelet per spike having positive correlation and direct effect on grain yield can be used as suitable criteria to develop high yielding wheat genotypes.

Acknowledgement: None.

Disclaimer: None.

Conflicts of Interest: The authors declare no conflict of interest.

Source of Funding: None

Ethics approval statement: Not Applicable

Authors' Contribution Statements: M.A. and A.S. conceptualized and designed the study. A.B and F.K. conducted the experiment, collected data, and performed the statistical analysis. A.B. and M.A. drafted the manuscript. M.A. and A.S. reviewed and edited the manuscript.

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