Journal of Positive School Psychology http://journalppw.com
2023, Vol. 7, No. 1, 175-187

Screening Of Seven Bread Wheat Genotypes For Agro-Morphological Diversity In Sindh

Akhtiar Ahmed Kalhoro[1]*, Ali Sher[2], Basharat Ali[3], Waseem Hassan[4], Arshad Mahmood[5], Muhammad Amin[6], Nadia Manzoor[7], Sadia Noureen Zafar[8], Irum Hassan[9], Munawar Ali[10], Mahreen Khalid[7], Sabeen Alam[11], Hafsa Naeem[12], Khuram Shahzad[13]

[1]*Department of Botany, Shah Abdul Latif University, Khairpur 66022, Sindh Pakistan*
[2]*Department of Agriculture, Bacha Khan University, Charsadda, Pakistan*
[3]*Agronomic Research Station, Bahawalpur 63100, Pakistan*
[4]*Soil and Water Testing Laboratory, Bahawalpur 63100, Pakistan*
[5]*Unit of Soil Science and Plant Nutrients, Brunei Agricultural Research Center, Brunei Darussalam*
[6]*Vegetable Research Institute, Ayub Agricultural Research Institute, Punjab, Pakistan*
[7]*Regional Agricultural Research Institute, Bahawalpur 63100, Pakistan*
[8]*Department of Botany, Faculty of Sciences, Government College Women University, Faisalabad, Pakistan*
[9]*Atta-ur-Rahman School of Applied Biosciences, National University of Sciences and Technology, Sector H-12, Islamabad 44000, Pakistan*
[10]*National Center of Industrial Biotechnology, PMAS Arid Agriculture University, Rawalpindi, Pakistan*
[11]*Department of Horticulture, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Pakistan*
[12]*Department of Plant Pathology, Faculty of Crop Protection Sciences, The University of Agriculture, Peshawar, Pakistan*
[13]*Soil and Water Testing Laboratory, Gujranwala 52290, Pakistan*

Email: akhtiarahmed.k@gmail.com *(A.A.K)*

ABSTRACT

High yielding crop varieties are the need of time as the population is accelerating with an exponential rate. Genetic variability can be exploited to screen improved crop varieties to address the scarcity of food. We investigated the agro-morphology in seven bread wheat genotypes collected from International Wheat and Maize Improvement Centre Mexico (CIMMYT); Pakistan Atomic Energy Commission (NIA) Tando Jam and Wheat and Research Institute (WRI) Sakrand. The experimental study was conducted at Wheat Research Institute (WRI), Sakrand Sindh, Pakistan. The agro-morphological study of wheat is important for the enhancement of yield production. Phenotypic correlation was calculated in all traits. Results indicated the number of grains per spike had positive and significant correlation to grain yield per spike. The days for maturity showed positive and significant correlation with plant height. The grain filling period indicated positive and non- significant correlation to days for maturity, spike length, grain yield per spike, plant height, number of grains per spike. Grain yield per spike had negatively non-significant correlation to harvest index. It is concluded from this study that most promising genotypes ESWYT-136, ESWYT-104, ESWYT-123, and SKD-1 were morphologically different from each other and are recommended for breeding programs and cultivation.

Key words: Genotypes, agro-morphological, harvest index, wheat, grain yield, Phenotypic correlation.

INTRODUCTION

Wheat (Triticum aestivum L) is the most extensively grown grain food in the world providing dietary protein and calories [1].The estimated need of wheat to be 840 million tons to 1050 million tons, which is considered necessary to feed the growing population worldwide [2]. As a consequence, wheat breeders are interested to develop varieties, which are suitable for cultivation in wider range of environmental conditions [3]. On the other hand, the best yield traits of wheat are selected for breeding programs and new varieties are formed, for the increase of wheat production [4]. In 2020, wheat production for Pakistan was 24,946 thousand tons increasing from 6,476 thousand tons in 1971 to 24,946 thousand tons growing at an average annual rate of 3.11% putting Pakistan 8th among wheat producing countries [5]. Wheat production in the country, however, has been well below a potential variable. The main goal of this study was to screen different bread wheat genotypes for agro-morphological variations under field conditions in Sindh province.

Different morphological attributes of crop play an important role in determining the grain yield and considered as a basic requirement for plant breeding programs which increase the crop production in different environmental conditions. Ontogenetically, it is necessary to fix spike number as it is an important yield component in wheat and positively correlated with other yield traits. [6][7] Data recorded for days to heading and days to maturity gives an insight to wheat maturation period and prove helpful to save input costs. [8] Similarly, substantial differences among plant height show that tallest genotypes collect more photosynthates while short stature varieties are appropriate for rain fed areas as these varieties may accumulate more biomass in the form of grains under drought stress. Extended grain filling period is desirable for high grain yield and that data may contribute to wheat improvement programs. [9] In a number of studies harvest index was found to be negatively correlated with plant height while positively correlated with grain number per plant and yield per plant. [10] Flag leaf area is another important trait as it is main organ for photosynthesis that provides a major source for the growth and panicle development that sense and indicates environmental clues for ecological adaptation. [11][12] 45-58 % Photosynthetic performance is governed by flag leaf in wheat and about 41-43 % of the photosynthetic assimilates are used for grain filling. [13] Flag leaf area can be associated a prime component underlying grain yield. In this regard, flag leaf traits may lead to an increase to crop grain yield. [14] Excessive transpiration lost is checked by decreasing the leaf areas in cereal crops under terminal drought conditions. [15]

In the present study we studied different agro-morphological traits of seven bread wheat genotypes under same environmental conditions. The comparative performance for yield related traits of wheat genotypes were recorded. The maximum 14.02 grams, grain yield per plant was recorded in ESWYT-104 and 14.20 grams in ESWYT-123 while minimum 8.44 grams produced by SKD-1 genotype. The maximum plant height 97.66 centimeters recorded in ESWYT-104 and minimum 77 centimeters recorded in SKD-1. The ESWYT-136 produced maximum 66.33 grains/spike while genotype SKD-1 produced minimum 40.33 grains per spike. This information will help in future to secure wheat production through either improvement in harvest index or via exploiting the data collected for other agro-morphological traits.

MATERIAL AND METHODS

The current study was carried out at Wheat Research Institute (WRI), Sakrand, Sindh, Pakistan during the wheat growing season 2014-2015. The experimental material consisted of seven wheat genotypes. The four wheat genotypes ESWYT-136, ESWYT-104, ESWYT-107, ESWYT-123 were obtained from International Wheat and Maize Improvement Centre (CIMMYT), Mexico; two checks SARANG and SUNHERY from Pakistan Atomic Energy Commission, Nuclear Institute of Agriculture (NIA) Tandojam and one SKD-1 HD-2329 obtained from Wheat Research Institute (WRI) Sakrand. The randomized complete block design (RCBD) was used for the cultivation of seven wheat genotypes into three replicates with a row length of 1m and space of 30 cm respectively. Standard agronomic practices were carried out for ploughing, irrigation, fertilizer application and weed control during wheat growing season.

AGRO-MORPHOLOGICAL TRAITS

The data of the following agro-morphological traits were recorded at the different growth stages of wheat.

GERMINATION PERCENTAGE (G %)

In all cultivated wheat genotypes, germination percentage was recorded by calculating the number of germinated seeds according to the following formula.

DAYS TO HEADING (DH)

The days for heading were counted from the 1st day of sowing up to the time when 75% heads were produced in the wheat crop.

DAYS TO MATURITY (DM)

Days for maturity were recorded from the date of sowing up to the physically and physiologically maturity of wheat genotypes.

GRAIN FILLING PERIOD (GFP)

The grain filling period of wheat genotypes was noted by subtracting the number of days to heading from the number of days to maturity.

FLAG LEAF AREA (FLA) (cm^2)

The flag leaf area of wheat genotypes was taken by multiplying the flag leaf length and flag leaf area width.

PLANT HEIGHT (PH) (cm)

The height of the plant was measured in centimeters at the time maturity, from the base of plant to the tip of the spike without awns and data was recorded.

SPIKE LENGTH (SL) (cm)

The spike length from base to tip without awns was measured in centimeters from the fertile tillers of tagged plants from each replication.

SPIKELET PER SPIKE (SPS)

The number of spikelet each spikes was counted and average number of spikelet per spike from ten spikes was recorded.

GRAINS PER SPIKE (GPS)

The spikes of wheat genotypes were hand threshed and average number of grains per spike from each plant were counted and recorded.

TEN GRAINS LENGTH (TGL) (cm)

The ten grains length of each variety was measured in centimeters using measuring scale.

TEN GRAINS WIDTH (TGW) (cm)

The width of ten grains of wheat genotypes was measured in centimeters by foot scale.

HARVEST INDEX (%)

Harvest index is the ratio of grain yield which is obtained from biological yield. In accordance with the following formula.

Harvest index (%) = Grain yield / Biological yield × 100.

$$G\% = \frac{\text{Number of germinated Seeds}}{\text{Total number of seeds}} \times 100$$

DATA ANALYSIS

The basic statistics parameters such as standard error, maximum, minimum, standard deviations, co-efficient of variation and the mean comparative performance of the agro-morphological traits of wheat genotypes were measured through Duncan's Multiple Range Test (DMRT) and by using Microsoft excel 2013, which shows the variations among the traits. The Pearson product-moment correlation coefficient (or Pearson correlation coefficient, for short) was used for measuring linear correlation among genotype traits.

RESULTS AND DISSCUSION

Germination percentage: Non-significant differences (P>0.4) were observed among genotypes for germination. Mean data showed a range of 53.33 to 94.29 %. The genotype ESWYT-123 showed minimum 61.11% while genotype SARANG indicated maximum 84.44 germination rates. Germination rate is one of the important characters for plant breeding program which increases the crop production in different environmental conditions. [7]

Days to heading: In our study, highly significant differences (P< 0.0003) for this trait were observed among genotypes. The frequency distribution range for days to heading is 72-84. The genotype SKD-1 took minimum 72.66 days, while genotype ESWYT-104 took maximum 80.33 days to heading. The days for heading indicated negative and non-significant correlation to grain filling period, flag leaf area whilst, it showed positive and non-significant correlation to days to maturity, spike length, plant height and harvest index. This parameter is reported to be highly linked with maturity as genotype which takes minimum days to heading save time and escape time duration for drought. These findings were in accordance with. [5] [8]

Days to maturity: Statistically highly significant (P< 0.0002) differences were observed in days to maturity among different genotypes. The frequency distribution range for days to maturity is 113-122 days. The genotype SKD-1 registered minimum 113 days while genotypes ESWYT-104 and ESWYT-107 showed 118.5 days for maturity. Days for maturity showed negative and non-significant correlation with ten grains length, flag leaf area and harvest index. Whereas positive and significant correlation with plant height. Minimum days to maturity and low plant height may prove desired traits for the genotypes to be grown in the areas with terminal drought. [16][17][8]

Grain filling period: This parameter is documented to be strongly related to an increase in grain weight that can be registered as an important trait to screen in breeding process in wheat. [18] Non-significant differences (P> 0.0615) among genotypes were reported in our study. The frequency distribution range of grain filling period was 40-46 days. The genotypes ESWYT-104, SKD-1 had taken minimum 40 days while genotype SUNHERY took maximum 44.33 days in the period of grain filling. Grain filling period indicates the positive and non-significant correlation with flag leaf area, days to maturity, peduncle length, spike length, plant height and grain yield per spike. Grain filling period showed negatively non-significant correlation with the harvest index.

Number of grains per spike: Different spike populations can be the result of modifications in the ability of genotypes to generate and to sustain tillers. [6] The grains per spike indicated highly-significant (P< 0.00) differences among genotypes. The frequency distribution range for number of grains per spike is 40-70 grains. The genotype SKD-1 produced minimum 40.33 grains, while genotype ESWYT-136 with maximum 66.33 grains in one spike was noted. This finding suggests that ESWYT-136 can be used to produce maximum number of grains per spike. [18]

Grain yield per spike and grain yield per plant (g): For these traits highly significant differences (P<0.000) were recorded among wheat genotypes. The frequency distribution range for grain yield per spike is 01-07 g per spike. In the genotypes SKD-1 minimum 1.92 g while in genotype ESWYT-136 maximum 3.53 g grain yield per spike was recorded. This parameter showed the positive non-significant correlation with 100 grain weight and grain yield per plant. Grain yield per spike registers a complex correlation with other yield attributes as it shows positive correlation with specific traits while represents negative correlation with others such as harvest index in the present studies. These studies are in accordance with. [19][20] Highly significant (P<0.000) differences were observed in our study for grain yield per plant. The frequency distribution range for grain yield per plant is 8-17g. The genotypes SKD-1 produced minimum 8.44 g while ESWYT-104 and ESWYT-123 produced maximum 14.19-g grains per plant. The grain yield per plant indicated the positive and non-significant correlation with harvest index.

Ten grains length (cm) and ten grains width (cm): Significant differences (P<0.01) were observed for ten grain length trait. The frequency distribution range is 06-09 cm. In the genotypes ESWYT-107 minimum 6.01 cm length was measured, while in genotype SKD-1 maximum 8.01 cm ten grains length was measured. The frequency distribution range of ten grains width is 03-06 cm. Genotype ESWYT-107 had minimum 3.01 cm width while in genotypes ESWYT-136 and SUNHERY had maximum 3.28 cm ten grains width was observed.

Plant height (cm):

Plant height is controlled by both the genetic makeup and ecological factors. Positive direct effect of plant stature on crop yield has been documented by various authors. [21][22] The plant height indicated non-significant (P>0.0945) differences among 7 genotypes. The frequency distribution range of plant height is 77- 101 cm. In the genotypes SKD-1 minimum 76 cm while in genotype ESWYT-104 with maximum 97.06 cm plant height was recorded. The plant height showed negative and non-significant correlation with harvest index. These findings are in accordance with. [23]

Peduncle length: Spike length presented statistically significant differences across the tested seven genotypes (P<0.01).The frequency distribution range for peduncle length is 32-41 cm. In the genotype ESWYT-104 had minimum 32.55 cm peduncle length while in genotype SUNHERY maximum 38.33 cm long peduncle length was recorded. In our study Peduncle length indicated positive and non-significant correlation with grain yield per spike while it showed negative non-significant correlation with harvest index. The same results were reported by. [24] [21]

Spike length: Spike length registers vital role towards the grain yield and total yield in wheat plant. [5] Statistically non-significant P value (0.0601) was observed in the present study. The frequency distribution range for spike length is 10-16 cm. Genotypes SKD-1 had minimum 10.50 cm spike length while, in genotype ESWYT-107 the maximum 13.11 cm length was measured, which possibly linked to effective photosynthetic activities and hence more assimilate translocation in this genotype which increased the spike length. [22]

Number of spikelet per spike: This spikelet trait plays an important role to explain wheat grain yield and the effects of variable agronomy and genetics. [25] Statistically highly-significant (P<0.0004) differences were observed among genotypes. The frequency distribution range of spikelet per spike is 14-20. In the genotypes SKD-1 with minimum 14.78 spikelet while in genotype ESWYT-107 with maximum 18.55 spikelet were counted in the given study. The spikelet per spike indicated the positive and non-significant correlation to grains number per spike, ten grains width and grain yield per spike.

Flag leaf area (cm^2): Flag leaf area traits are determining factors that influence plant architecture and yield potential in wheat. [26] In our study non-significant difference (P>0.3278) for this trait was observed. The frequency distribution range for flag leaf area is 32-47 cm^2. The minimum flag leaf area 32.72 cm^2 recorded in genotype ESWYT-104 while the maximum 44.55 cm^2 flag leaf area was recorded for genotype SARANG. The positive non-significant correlation was noticed with peduncle length. Smaller and erect flag leaves are reported to be more tolerant to water loss due to rolling capability under drought stress than any other genotype with lax leaves that ultimately results in higher yield potential in wheat. [27] [28] On the other hand, larger flag leaf area helps to collect more photosynthetic products resulting in higher yield. [29]

Harvest index (%): Researchers suggest a higher harvest index of crops in single plant to accelerate yield gains in wheat varieties. [30] The mean comparison for harvest index indicated non-significant (P>0.5426) value for wheat genotypes. The maximum 50.30 and 49.24 harvest index % were recorded in genotypes ESWYT-104 and ESWYT-123 respectively. The genotypes ESWYT-107 and SKD-1 showed minimum 46.13 and 46.17 harvest index %.

Traits	ESWYT 136	ESWYT 104	ESWYT 107	ESWYT 123	SARANG	SKD-1	SUNHERY
Germination percentage%	63.333A	63.333A	74.443A	77.780A	84.443A	82.223A	81.110A
Days to heading	75.333B	80.333A	78.333A	74.333BC	75.667B	73.627C	73.333BC
Flag leaf area cm^2	44.500A	32.723A	35.253A	35.150A	45.657A	39.120A	40.067A
Plant height (cm)	95.16AB	97.57AB	97.44AB	89.27B	93.88AB	76.99B	117.77A
Grain filling period	42.667A	40.000B	41.667AB	42.000AB	41.667AB	40.000B	44.000A
Days to maturity	117.00AB	118.67A	118.33A	117.00AB	116.33B	113.00C	117.67AB
Peduncle length (cm)	34.497BC	32.550C	37.467AB	35.327BC	36.440AB	34.657BC	38.330A
Spike length (cm)	11.940AB	11.497BC	13.103A	11.497BC	11.327BC	10.493C	11.730ABC
Number of spikelets/spike	17.440AB	15.883BC	18.383A	16.883ABC	17.773AB	14.773C	16.327ABC
Number of grains/spike	66.333A	52.333AB	64.333A	50.833AB	53.333AB	40.333B	50.667AB
Grain yield/spike (g)	3.5300AB	2.4167BC	3.0367AB	3.7067A	2.5733ABC	1.7800C	2.5767ABC
Number of grains/plant	267.67AB	319.83A	326.17A	297.17AB	254.33AB	192.00B	250.17AB
Grain yield/plant (g)	11.727AB	14.017AB	12.627AB	17.113A	12.407AB	8.437B	11.647AB
Ten grains length (cm)	6.8000AB	6.4000BC	6.1000C	6.6333AB	6.4500BC	7.0833A	6.7167AB
Ten grains width (cm)	3.2833A	3.1500A	3.1333A	3.2500A	3.2000A	3.0167A	3.2833A
Harvest index %	48.23A	50.31A	46.13A	49.26A	47.64A	46.17A	47.17A

Table 1: Duncan's Multiple Range Test (DMRT) of agro-morphological traits in seven bread wheat genotypes

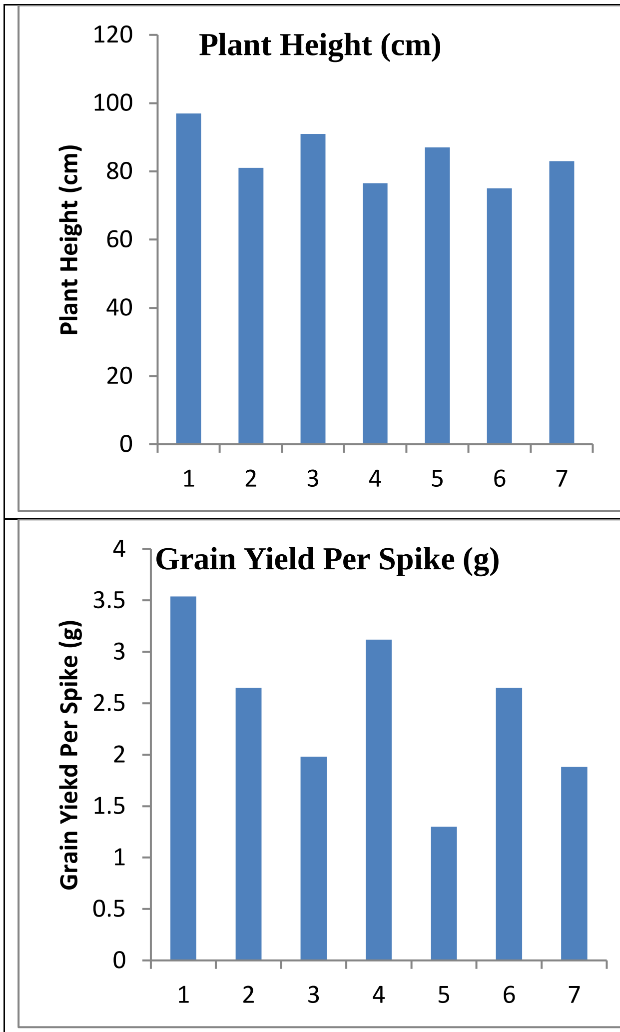
Traits	DH	GFP	DM	FLA	PH	PL	SL	NSPS	NGPS	TGW	GYPS	GYPP	HI
DH	1												
GFP	-0.39^{NS}	1											
DM	0.70 ^{NS}	0.34$^{N S}$	1										
FLA	-0.48 ^{NS}	0.39 ^{NS}	-0.36 ^{NS}	1									
PH	0.71 ^{NS}	0.29 ^{NS}	0.91 ^{S}	-0.03 ^{NS}	1								
PL	-0.38 ^{NS}	0.72 ^{NS}	0.11 ^{NS}	0.28 ^{NS}	-0.00 ^{NS}	1							
SL	0.51 ^{NS}	0.37 ^{NS}	0.74 ^{NS}	-0.19 ^{NS}	0.63 ^{NS}	0.42 ^{NS}	1						
NSPS	0.35 ^{NS}	0.38 ^{NS}	0.56 ^{NS}	0.22 ^{NS}	0.63 ^{NS}	0.45 ^{NS}	0.81 ^{NS}	1					
NGPS	0.47 ^{NS}	0.35 ^{NS}	0.64 ^{NS}	0.16 ^{NS}	0.73 ^{NS}	0.14 ^{NS}	0.84 ^{NS}	0.83 ^{NS}	1				
10GW	-0.09 ^{NS}	0.82 ^{NS}	0.55 ^{NS}	0.31 ^{NS}	0.60 ^{NS}	0.30 ^{NS}	0.32 ^{NS}	0.44 ^{NS}	0.49 ^{NS}	1			
10GL	-0.79 ^{NS}	0.02 ^{NS}	-0.77 ^{NS}	0.35 ^{NS}	-0.71 ^{NS}	-0.22 ^{NS}	-0.77 ^{NS}	-0.73 ^{NS}	-0.56 ^{NS}	-0.10 ^{NS}			
GYPS	0.37 ^{NS}	0.43 ^{NS}	0.63 ^{NS}	0.17 ^{NS}	0.71 ^{NS}	0.09 ^{NS}	0.76 ^{NS}	0.78 ^{NS}	0.97 ^{S}	0.63 ^{NS}	1		
GYPP	0.62 ^{NS}	0.15 ^{NS}	0.84 ^{NS}	-0.34 ^{NS}	0.81 ^{NS}	-0.13 ^{NS}	0.48 ^{NS}	0.51 ^{NS}	0.49 ^{NS}	0.58 ^{NS}	0.57 ^{NS}	1	
HI	0.11 ^{NS}	-0.72 ^{NS}	-0.26 ^{NS}	-0.69 ^{NS}	-0.42 ^{NS}	-0.62 ^{NS}	-0.52 ^{NS}	-0.63 ^{NS}	-0.66 ^{NS}	-0.54 ^{NS}	-0.60 ^{NS}	0.03 ^{NS}	1

Table 2: Pearson’s correlation coefficients among agro-morphological traits of seven bread wheat genotypes

DH; Days to heading, GFP: Grain filling period, DM; Days to maturity, FLA; Flag leaf area cm2, PH; Plant height (cm), PL: Peduncle length (cm), SL: Spike length (cm), NSPS; Number of spikelets/spike, NGPS; Number of grains/spike, TGW, Ten grains width (cm), TGL, Ten grains length (cm), GYPS, Grain yield/spike (g), GYPP, Grain yield/plant (g), HI, Harvest index%, HGW.

Traits	**Mean: SE**	**MAX**	**MINI**	**S. D**	**C.V**
Germination percentage	72.86±6.13	94.29	53.33	15.02	0.22
Days to heading	75.71±0.41	76.71	74.71	1.00	0.01
Flag leaf area(cm^2)	38.92±2.88	46.13	29.38	7.05	0.19
Plant height (cm)	91.28±2.21	97.57	83.71	0.52	0.06
Grain filling period	41.76±0.47	43.14	40.71	1.16	0.03
Days to maturity	116.86±0.38	117.86	115.86	0.92	0.01
Peduncle length (cm)	35.59±0.79	37.81	33.04	1.95	0.05
Spike length (cm)	11.66±0.37	13.06	10.71	0.90	0.08
Spikelet per spike (cm)	16.81±0.57	18.57	14.86	1.40	0.08
Grains per spike	54.02±4.42	70.29	41.29	10.38	0.20
Grain yield per spike (g)	2.75±0.23	3.54	1.88	0.58	0.21
Grain yield per plant (g)	12.24±2.38	20.51	5.05	5.82	0.38
Ten grains length (cm)	6.60±0.12	7.01	6.21	0.30	0.04
Ten grains width (cm)	3.19±0.09	3.47	2.93	0.21	0.07
Harvest index %	47.86±2.42	50.31	46.13	5.92	0.34

Table 3: S.E Standard error, Mean, Max; maximum; Min: minimum, SD: standard deviation, CV: coefficient of variations.



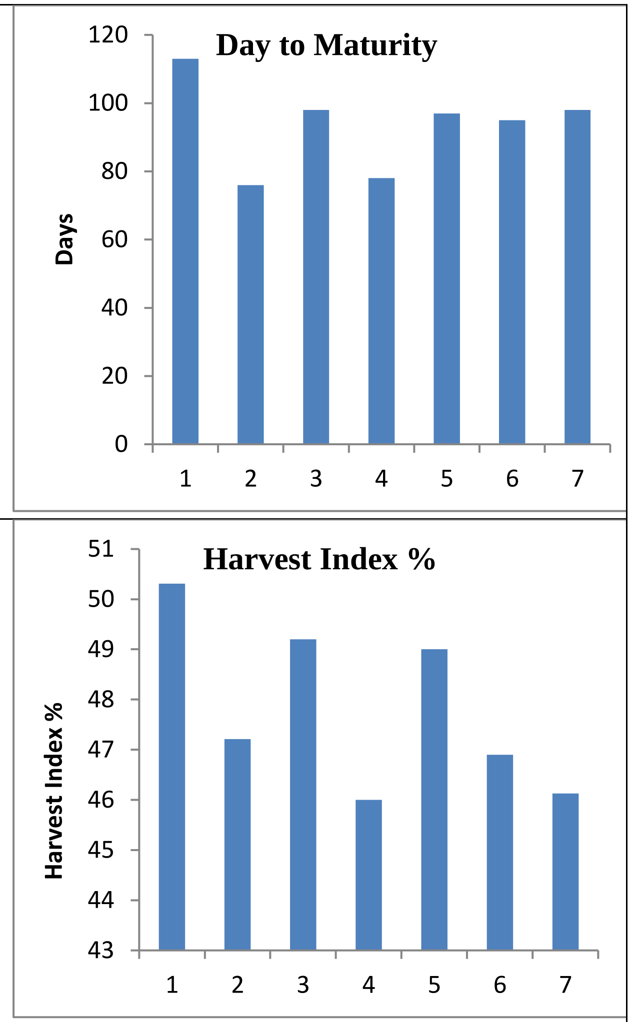


Fig: Plant Height (cm) and Grain Yield Per Spike of Seven bread Wheat Genotypes.

Fig: Days to Maturity (Days) and Harvest Index % of Seven bread Wheat Genotypes

CONCLUSION

Genotypic differences in the ability to show higher germination percentage suggests its role in crop establishment at earlier stage. Current research showed a significant improvement of our understanding for wheat phenological or agro-morphological variations that exists among different genotypes. The findings of our work can be used to screen and develop genotypes that will better adapt the changing ecological conditions. Traits like days to heading are correlated with days to maturity and plant height with other morphological traits that may play a key role for wheat breeders to screen genotypes expressing high biological growth and yield. It is concluded from this study that genotypes ESWYT-136, ESWYT-104, ESWYT-123, and SKD-1 were morphologically different from each other and are recommended for breeding programs and cultivation.

Declaration

Data availability

All data and materials are available from the corresponding author. Therefore, at a reasonable request, the corresponding author shared it via email.

Author Contributions Statement:

Conceptualization, A.A.K and A.S.; methodology, validation, formal analysis, investigation, data curation, B.A., W.H., A.M., M.A., and N.M.; writing—original draft preparation, A.A.K., S.N.Z, I.H and M.A.; writing—review and editing, M.K, S.A. and H.N.; supervision, A.S. and KS. All authors have read and agreed to the published version of the manuscript.

Funding
No fund was received for publication of this research article.

Conflict of interest
The author reports no conflicts of interest in this work.

Ethical approval: The ethical issues is not applicable

Consent of participate: Not applicable

Consent of publication: Not applicable

References

[1] Chowdhury MK, Hasan MA, Bahadur MM, Rafiqul Islam MD, Abdul Hakim MD, Muhammad AI, et al. Evaluation of Drought Tolerance of Some Wheat (Triticum aestivum L.) Genotypes through Phenology, Growth, and Physiological Indices. Agronomy. 2021; 11(9).

[2] Rosegrant MW, Agcaoili-Sombilla A, Perez, N. Global Food Projections to 2020. Implications for Investment, Food, Agriculture and the Environment. Discussion paper 5. Washington, D.C IFPRI. 1995; 1-54.

[3] Anwar J, Khan SB, Rasul I, Zulkiffal M, Hussain M. Effect of sowing dates on yield and yield components in wheat using stability analysis. Int J Agric Biol. 2007; 9 (1): 129-132.

[4] Mollasadeghi V, Imani AA, Shahryari R, Khayatnezhad M. Classifying bread wheat genotypes by multivariable statistical analysis to achieve high yield under after anthesis drought. Middle-East J Sci Res. 2011; 7(2): 217-220.

[5] Sohail A, Zulfiqar AM. Impact of temperature and rainfall on rice production in Punjab, Pakistan. Envi Dev Sust. 2021; 23: 1706-1728.

[6] Bulman P, Hunt LA. Relationships among tillering, spike number and grain yield in winter wheat (Triticum aestivum L.) in Ontario. Can J Pl Sci. 1988; 68: 583-596.

[7] Sabaghnia N, Janmohammadi M, Segherloo AE. Evaluation of agro-morphological traits, diversity in bread wheat genotypes. Biol. 2014; 79-92

[8] Rasool G, Ullah A, Jan A, Waris M, Tariq MA, Ahmad Q. Morphological evaluation of wheat genotypes for grain yield under arid environment of Balochistan. Pure Appl Biol. 2021;10 (4):1441-1449.

[9] Khan MA. Wheat crop management for yield maximizationed. CIMMYT. 2003; Available from: https://www.cimmyt.org/projects/wheat-productivity-enhancement-program-wpep/

[10] Ashfaq M, Khan AS, Ali Z. Studied the association of morphological traits with grain yield in wheat (Triticum aestivum L.). Int J Agri Biol. 2003; 5: 1560- 8530.

[11]Biswal AK, Kohli A. Cereal flag leaf adaptations for grain yield under drought: knowledge status and gaps. Mol Breeding. 2013; 31(4):749-66.

[12]Tian Y, Zhang H, Xu P, Chen X, Liao Y, Han B, et al. Genetic mapping of a QTL controlling leaf width and grain number in rice. Euphytica. 2015; 202(1):1-11.

[13] Xue S, Xu F, Li G, Zhou Y, Lin M, Gao Z, et al. Fine mapping TaFLW1, a major QTL controlling flag leaf width in bread wheat (Triticum aestivum L.). Theor Appl Genet. 2013; 126(8):1941-9

[14] Quarrie SA, Quarrie PS, Radosevic R, Rancic D, Kaminska A, Barnes JD, et al. Dissecting a wheat QTL for yield present in a range of environments: from the QTL to candidate genes. J Exp Bot. 2006; 57(11):2627-2637

[15] Xu Z, Zhou G, Shimizu H. Are plant growth and photosynthesis limited by pre-drought following rewatering in grass? J Exp Bot. 2009; 60(13):3737-3749

[16] Khan NU. Genetic analysis, combining ability and heterotic studies for yield, its components, fibre and oil quality traits in upland cotton (G. hirsutum L.). Ph.D Dissert. Sindh Agric. Univ. Tandojam, Pakistan. (2003).

[17] Mahpara SH, Ali ZU, Ahsan MU. Combining ability analysis for yield and yield related traits among wheat varieties and their F1 hybrids. Int J Agri Biol. 2008; 10(6): 599-604.

[18] Mahboob S, Kashif M, Khalid MN, Amjad I. Genetic diversity assay of the local wheat varieties and chinese crosses for yield linked attributes under local conditions. Bull Biol Al Sci Res. 2020; 5: 19-26.

[19] Knezevic D, Rosandic A, Kondic D, Radosavac A, Rajkovic D. Effect of gluten formation on wheat quality. J Agric Env Sci. 2017; 4(1):169-174.

[20] Mohsin T, Khan N, Naqvi FN. Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in synthetic elite lines of wheat. J Food Agri Envi. 2009; 7: 278-282.

[21] Shahzad MA, Din WU, Sahi ST, Khan MM, Ehsanullah, Ahmad M. Effect of sowing dates and seed treatment on grain yield and quality of wheat. Pak J Agri Sci. 2007; 44(4): 581-583.

[22] Naveed K, Muhammad AK, Mohammad SB, Kawsar A, Muhammad AN, Ejaz AK, et. Effect of different seeding rates on yield attributes of dual-purpose wheat. Sarhad J Agric. 2014; 30: 883-91.

[23] Marri PR, Sarla N, Reddy LV, Siddiq EA. Identification and mapping of yield and yield related QTLs from an Indian accession of Oryza rufipogon. BMC Genet. 2005; 13:33-39.

[24] Saleem U, Khaliq I, Mahmood T, Rafique M. Phenotypic and genotypic correlation coefficients between yield and yield components in wheat. Japan Agri Res. 2006; 44 (1).

[25] Zhou H, Andrew BR, Malcolm JH, William RW, Brian SA, Craig JS, Sacha JM. Determination of wheat spike and spikelet architecture and grain traits using X-ray Computed Tomography imaging. Pl Meth. 2021; 17-26.

[26] Delong Y, Yuan L, Hongbo C, Lei C, Jingjing C, Shouxi C, Mengfei L. Genetic dissection of flag leaf morphology in wheat (Triticum aestivum L.) under diverse water regimes. BMC Gen. 2016; 17: 94-109.

[27] Quarrie SA, Stojanović J, Sofija PJ. Improving drought resistance in small-grained cereals: A case study, progress and prospects. Pl Gr Regul. 1999; 29 (1):1-21.

[28] Innes P, Blackwell RD. Some effects of leaf posture on the yield and water economy of winter wheat. J Agric Sci. 1980; 101(2):367-76.

[29] Ma J, Tu Y, Zhu J, Luo W, Liu H, Li C, Li S, Liu J, Ding P, Habib A. Flag leaf size and posture of bread wheat: genetic dissection, QTL validation and their relationships with yield-related traits. Theor Appl Genet. 2020; 133: 297-315.

[30] Porker K, Michael S, James RH. Evaluation of G × E × M Interactions to Increase Harvest

Index and Yield of Early Sown Wheat. Front. Pl Sci. 2020; Front. Plant Sci. 11:994. doi: 10.3389/fpls.2020.00994.