Research Article

Assessment of the agro-morphological variations in bread wheat genotypes under field conditions

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Citation

Akhtiar Ahmed Kalhoro, Hadi Bux Bozdar, Hakim Ali Sahito, Tasneem Kousar, Wali Muhammad Mangrio and Muhammad Aslam Korai. Assessment of the agro-morphological variations in bread wheat genotypes under field conditions. Pure and Applied Biology. Vol. 11, Issue 3, pp778-792. <http://dx.doi.org/10.19045/bspab.2022.110079>

Received: 08/09/2021

Revised: 13/11/2021

Accepted: 17/11/2021

Online First: 19/11/2021

Abstract

The agro-morphological traits of seven bread wheat genotypes were assessed 4 genotypes were collected from International Wheat and Maize Improvement Centre Mexico, 2 from Nuclear Institute of Agriculture Tandojam, and 1 from Wheat Research Institute Sakrand, based on (RBCD) with 3 replications. The results indicated the number of grains/spikes were 41.29-70.29 grains with mean 54.02 ± 4.42 and 0.20 coefficient variance. The grain yield/spikes were 1.88-3.54 grams with mean 2.75 ± 0.23 at 0.21 coefficient variance with grain yield/plant were 5.05-20.51 grams with mean of 12.24 ± 2.38 were obtained. The maximum 14.02 grams, grain yield/plant were recorded in ESWYT-104 and 14.20 grams in ESWYT-123, while minimum 8.44 grams in SKD-1 genotype. The maximum plant height was 97.66 centimeters in ESWYT-104 and minimum 77 centimeters in SKD-1. The ESWYT-136 produced maximum 66.33 while; genotype SKD-1 minimum of 40.33 grains/spike. The grains/spike showed positive with significant correlation in grain yield/spike 0.97 days for maturity and plant height 0.91. The grain yield/meter with positively non-significant correlation in grain yield/spike 0.16, grain yield/plant 0.00, and 100-grain weight 0.07. The plant height with negative, non-significant correlation to peduncle length -0.00, the number of tillers/meter -0.00, ten grains length -0.71, and harvest index -0.42. The analysis of variance showed significant and highly significant variations for agro-morphological traits in booting, flowering, heading, awns length, maturity, number of grains/spike, grain yield/spike, grain yield/meter, peduncle length, and ten grains length. Among these genotypes, ESWYT-136, ESWYT-104, and ESWYT-123 were observed beneficial for yield-related traits and are recommended for future cultivation breeding perspectives.

Keywords: Agro-morphological; Booting; Flowering; Grains/spike; Wheat genotypes

Introduction

Wheat (*Triticum aestivum* L.) is a member of the grass family; Graminae and it has a dominant position in the agriculture sector also is

essential food crop in the world, normally cultivated in the Rabi season, the tribe Triticeae, contains approximately 13-26 genera, 350 species, and it consisted of wheat

(*Triticum*) and ryes (*Secale*) along with *Aegilops*, *Agropyron*, *Eremopyron* and *Haynalidia* [1]. The early classification systems were based on morphological characteristics. The true spikes of wheat, contain one to several sessile spikelets which are alternatively present on the opposite sides of the rachis. In 1753 Linnaeus first classified wheat. In 1918, Sakamura classified wheat into three groups based on chromosomes number. Diploids 14 ($n=7$), tetraploid 28 ($n=14$) and hexaploids 42 ($n=21$) chromosomes. The major species of wheat are *Triticum aestivum*, *Triticum durum*, and *Triticum compactum*. It was estimated that the need for wheat started from 840 million tons to 1050 million tons, which is considered necessary to feed the growing population of the world [2]. About 600 million tons of wheat is cultivated on an annual basis and apart from rice and corn, wheat is considered to be the major product [3]. More than 40 countries cultivate the wheat crop annually to complete the requirement of food, which satisfies about 35% population of the globe.

About 14-million-acre land of Sindh is engaged in wheat production whereas 1.8-million-acre land produces two crops in a year. In the Sindh province of Pakistan, the wheat area is around 0.9 million hectares with production of 2.47 million tons and the average wheat yield was around 27 kg ha⁻¹ [4]. Planting at an inappropriate time may cause a drastic reduction in wheat yield. The sowing of the wheat crop in November produces the best yield and late sowing decreases the productivity of the seed index, tillers and grain yield. In Sindh, wheat breeders have developed varieties, which are suitable for cultivation in a wider range of environmental conditions [5].

The abiotic factors such as drought, salinity, water-logging, high temperature, and nutrient deficiency affect wheat crops and decrease wheat production in Pakistan. Drought is the main abiotic stress, which affects the growth and yield of wheat crops. The agro-morphological traits such as tillers, grain yield, and harvest index, quality, and quantity of grains per spike are also affected due to drought

and the grain filling period [6]. Salinity is major abiotic environmental stress, which affects wheat crop production, induces harmful effects on growth, and reduces the photosynthesis in wheat plants, germination percentage, and root length reduced due to salinity [7]. As the level of salts increases in the soil, the stem diameter and height of the plant are also reduced. Salinity weakened and reduced the grain yield, and harvest index of the wheat crop [8]. In Pakistan, water logging is the main problem that decreases the level of the nutrients nitrogen and increases the Fe and Mn nutrients in the soil. The frost damages can be reduced by late sowing of crop and the product can increase up to 2-3 folds higher than direct losses [9]. Potassium has a major role in the biochemical process of plants i-e., potassium activates the enzymes, synthesis of protein, and drought tolerance [10]. The yield losses occur if a shortage of potassium in the soil [11]. On the other hand, the best yield traits of wheat are selected for breeding programs and new varieties are formed, to increase wheat production. In many regions of the world, wheat production is increased by the replacement of modern wheat varieties [12], therefore; the assessment of the agro-morphological variations in bread wheat genotypes under field conditions was kept under observations.

Materials and Methods

Assessment of agro-morphological diversity in bread wheat genotypes

The study was carried out to assess the agro-morphological variations in seven wheat genotypes under field conditions at the Wheat Research Institute (WRI), Sakrand, Sindh, Pakistan. The randomized complete block design (RCBD) was used for the cultivation of seven wheat genotypes into three replications. Each genotype was cultivated in two rows. The row length was one meter and the space between the rows was 30 cm. The experimental material consisted of seven wheat genotypes. The four wheat genotypes were obtained from the International Wheat and Maize Improvement Centre (CIMMYT), Mexico, two from Pakistan Atomic Energy Commission,

Nuclear Institute of Agriculture (NIA) Tandojam, and one obtained from Wheat

Research Institute (WRI) Sakrand. The wheat genotypes detail is given in (Table 1).

Table 1. The detail of wheat genotypes cultivated at Wheat Research Institute (WRI) Sakrand-Sindh

S. #	Wheat genotypes	Pedigree/Parentage	Year	Breeding Institute
1	ESWYT-136	GAN/AE. SQUARROSA (897)	2012	CIMMYT: (International Wheat and Maize Improvement Centre)
2	ESWYT-104	YRSP/6 AOC	2012	CIMMYT
3	ESWYT-107	OPATAM 85	2012	CIMMYT
4	ESWYT-123	AOC-YR/ATTILA	2012	CIMMYT
5	SARANG	SHA4/WEAVER//SKA NZ2/SRMA	2012	NIA: (Nuclear Institute of Agriculture, Tandojam)
6	SKD-1	HD-2329	2006	WRI: (Wheat Research Institute, Sakrand)
7	SUNHERY	Cham4//URES/BOWS	2010	NIA

The data of the following agromorphological traits were recorded at the different growth stages of wheat

1. Germination percentage (G %)

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

2. Days to heading (DH)

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

3. Days to maturity (DM)

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

4. 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.

5. Tillers/plant (T/P)

The number of tillers in each plant was counted from marked plants, as well as the number of functional tillers, were counted.

6. Tillers/meter (T/m)

The number of tillers per meter of all wheat genotypes were recorded and counted.

7. Flag leaf area (FLA) (cm²)

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

8. Plant height (PH) (cm)

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

9. 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.

10. Spikes/meters

The number of spikes/meters in wheat genotypes were counted and recorded.

11. Spikelets/spike (SPS)

The number of spikelets each spike was counted and the average number of spikelets per spike from ten spikes were recorded.

12. Grains/spike (GPS)

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

13. Hundred Grains weight (HGW) (g)

A hundred grains of each variety were counted and weighed by using digital balance and average grains weight was recorded.

14. Ten Grains length (TGL) (cm)

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

15. Ten Grains width (TGW) (cm)

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

16. Harvest index (%)

Harvest index is the ratio of grain yield which was obtained from biological yield.

Statistically analysis

The basic statistics parameters such as; standard error, maximum, minimum, standard deviations, coefficient of variation for the agro-morphological traits of wheat genotypes were calculated by using Microsoft excel 2013. The frequency distribution of agro-morphological traits of wheat genotypes was calculated using through online calculator www.frequencydistribution.com/ statistical package online. Analysis of variance (ANOVA) is the collection of statistical models. It is used to analyze the variations among and between group means and their related procedures. In the ANOVA setting, detected changes in a particular variable are divided into components attributable to different sources of variation. The data were statistically calculated in software statistics 8.1 version. The Pearson's coefficient correlation among the agro-morphological traits of seven wheat genotypes were also observed. The mean comparative performances 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.

Results

Assessment of basic statistics with the frequency distribution of agro-morphological traits of seven bread wheat genotypes

The basic statistics and frequency distribution for germination percentage was recorded, which ranged from 53.33 to 94.29, percentage with the mean value of 72.86 ± 6.13 and co-efficient of variance was 0.22 presented in (Table 2), with the frequency distribution range was 61-88%. The genotype ESWYT-123 showed minimum of 61.11% while; genotype SARANG indicated maximum 84.44 germination percentage. The days to booting

were also calculated, which varied from 72 to 74 days with the mean value of 72.95 ± 0.39 and coefficient of variation was 0.01. The frequency distribution range for days to booting was 72-79 days. The genotype SUNHERY showed minimum of 70 days, while; genotype ESWYT-104 took maximum of 77 days for booting. The days to heading were recorded which were varied from 74.71 to 76.71 days with the mean value of 75.71 ± 0.41 and the co-efficient of variance was 0.01. The frequency distribution range for days to heading was 72-84. The genotype SKD-1 took minimum of 72.66 days, while; genotype ESWYT-104 took 80.33. The days to flowering were varied from 80.14 to 82.43 days with the mean value of 81.29 ± 0.44 with the coefficient of variance was 0.01. The frequency distribution range for days to flowering was 79-88. The genotype ESWYT-136 took minimum of 79.33 days, while; genotype SKD-1 took 85.13 days for flowering. The days to maturity ranged from 115.86 to 117.86 days, with the mean value of 116.86 ± 0.38 and the coefficient of variance was 0.01. The frequency distribution range for days to maturity was 113-122 days. The genotype SKD-1 took minimum of 113 days, while; genotypes ESWYT-104 and ESWYT-107 took 118.5 days for maturity. The grain filling period ranged from 40.71 to 43.14 days with the mean value of 41.76 ± 0.47 and the co-efficient of variations was 0.03. The frequency distribution range of the grain filling period was 40-46 days. The genotypes ESWYT-104, SKD-1 has taken minimum of 40 days, while; genotype SUNHERY took maximum of 44.33 days in the period of grain filling.

The tillers/plant ranged from 4.01 to 8.79 with the mean value of 6.07 ± 0.70 , the co-efficient variance was 0.29. The frequency distribution range was 5-8 with the minimum 5.44 number in ESWYT-136, while; maximum tillers 8 were present in the genotype SUNHERY. The tillers/meters varied from 26.43 to 59.29 with the mean value of 42.90 ± 4.98 and co-efficient of variance was 0.29. The frequency distribution range was 40-51 of tillers. In ESWYT-136, the minimum 33 tillers were

present, while; maximum of 49.83 tillers/meters was counted in the genotype SUNHERY. The grains/spike ranged from 41.29 to 70.29 with the mean value of 54.02 ± 4.42 and the co-efficient of variance was 0.20. The numbers of grains/spike were 40-70 in SKD-1 that produced a minimum of 40.33 grains, while; genotype ESWYT-136 with maximum of 66.33 grains in the one spike were counted. It was noticed for grains yield/spike varied from 1.88 grams to 3.54 grams with mean value of 2.75 ± 0.23 and the co-efficient of variance was 0.21. The grain yield/spike was 01-07 grams. In the SKD-1 minimum 1.92 grams, while; in genotype ESWYT-136 with maximum 3.53 grams, grain yield/spike. The grains/plant ranged from 146.14 to 414.71 with the mean value of 272.50 ± 42.60 and co-efficient of variance was 0.39. The frequency distribution range for grains/plants was 192-330. The genotypes SKD-1 produced minimum of 192 and ESWYT-107 produced maximum of 326 numbers. The grain yield/plant was noted which varied from 5.05 to 20.51 with the mean value of 12.24 ± 2.38 and co-efficient of variance was 0.48. The grain yield/plant was 8-17 in SKD-1 produced minimum of 8.44 grams, while; ESWYT-104 and ESWYT-123 produced maximum 14.19-grams grain yield/plant. The grain yield/meter also varied from 28.24 to 109.80 grams, with the mean value of 67.30 ± 12.42 and the co-efficient of variance was 0.48. The frequency distribution range for grains yield/meter was 40-88gm the genotype ESWYT-123 produced minimum of 40.12 grams, while; in genotype SARANG maximum of 86.55 gm. The ten grains length varied from 6.21 to 7.01cm with mean value of 6.60 ± 0.12 with the coefficient of variance being 0.04. The ten grains length was 06-09cm in the genotypes, ESWYT-107 in minimum 6.01cm length was measured, while in SKD-1 maximum 8.01cm ten grains length was measured. The ten grains width varied from 2.93 to 3.47cm with the mean value of 3.19 ± 0.09 and the co-efficient of variance was 0.07. The frequency distribution range of ten grains width was 03-06cm. In the genotypes, ESWYT-107 with minimum 3.01cm width,

while; in genotypes ESWYT-136 and SUNHERY found with maximum of 3.28cm ten grains width.

The hundred-grain weight was varied from 3.85 to 5.25 grams with the mean value of 4.66 ± 0.21 with the coefficient of variance was 0.11. The frequency distribution range for hundred grains weight was 4-7 grams. The genotype ESWYT-107 minimum 4.21 grams, while; in SUNHERY maximum 5.04 grams hundred-grain weight. The plant height varied from 83.71 to 97.57cm with the mean value of 91.28 ± 2.21 and the co-efficient of variance was 0.06. The frequency distribution range of plant height was found 77-101cm. SKD-1 minimum in 76cm, while; in ESWYT-104 maximum 97.06cm plant height was recorded. The peduncle length, which was varied from 33.04 to 37.81cm with the mean value of 35.59 ± 0.79 with the co-efficient of variance was 0.05. The frequency distribution range for peduncle length was observed 32-41cm. ESWYT-104 minimum in 32.55cm peduncle length, while; in genotype SUNHERY maximum at 38.33cm peduncle length. The spike length varied from 10.71 to 13.06cm with mean value of 11.66 ± 0.37 and the coefficient of variance was 0.08. The frequency distribution range for spike length was 10-16cm. SKD-1 minimum at 10.50cm spike length, while; ESWYT-107 the maximum 13.11cm length was measured. The spikelets/spike varied from 14.86 to 18.57 spikelets with the mean value of 16.81 ± 0.57 with the co-efficient of variance was 0.08. The frequency distribution range of spikelets/spike was 14-20. In the genotypes SKD-1 with minimum 14.78 spikelets, while; in genotype ESWYT-107 with maximum at 18.55 spikelets were counted. The awns length varied from 5.67 to 7.26cm with the mean value of 6.62 ± 0.25 and the co-efficient of variance was 0.09. The frequency distribution range of awns length was 5-11cm. ESWYT-136, the minimum length of 5.49cm was noted, while; in SUNHERY the maximum length of 7.14cm was measured. The basic statistics and frequency distribution for the flag leaf area were calculated. It varied from 29.38 to 46.13cm squares flag leaf area with mean value

of 38.92 ± 2.88 with the co-efficient of variance was 0.19. The frequency distribution range for flag leaf area was found 32-47cm square. The minimum flag leaf area of 32.72cm square was recorded in genotype ESWYT-104, while; the maximum 44.55cm square flag leaf area was recorded for genotype SARANG.

The phenotypic correlation coefficient of quantitative traits of seven bread wheat genotypes

The days for heading indicated a negative and non-significant correlation to grain filling period, flag leaf area, peduncle length, tillers/plant, ten grains length, ten grains width, and 100 grains weight. Days for heading showed positive and non-significant correlation in days to maturity, spike length, plant height, awn length, spikelets/spike, grains/spike, tillers/meter, grain yield/m, grain yield/spike, grain yield/plant, and harvest index also detailed description shown in (Table 3). The grain filling period indicates the positive and non-significant correlation with flag leaf area, days to maturity, peduncle length, spike length, plant height, awns length, and grain yield/spike, spikelets number/spike, tillers/plant, grains/spike, ten grains width, and ten grains length, grain yield/meter, grain yield/plant and 100 grains weight. The grain filling period showed a negatively non-significant correlation with the number of tillers/meter and harvest index. Days for maturity showed a negative and non-significant correlation with ten grains length, flag leaf area, and harvest index. Whereas positive and significant correlation with plant height. The positive and non-significant correlation was noticed with peduncle length, spike and awns length, grain yield/plant number of spikelets/spike, grain yield/spike, grains/spike, tillers/meter, tillers/plant, grain yield/meter, and 100 grains weight. The flag leaf area (cm^2) indicates a negative and non-significant correlation with the number of tillers/meters, plant height, spike and awns length, grain yield/plant, and harvest index. The positive

non-significant correlation was noticed with tillers number/plant, peduncle length, grain yield/meter, grain yield/spike, grains number/spike, ten grains width, ten grains length, and 100 grains weight.

The plant height showed negative and non-significant correlation with tillers/meter, peduncle, harvest index, and ten grains length. Plant height indicates positively non-significant correlation with spike length, spikelets/spike, awns length, grains/spike, tillers/plant, grains yield/spike, grains yield/meter, ten grains width, grains yield/plant, and 100 grains weight. Peduncle length indicates positive and non-significant correlation with spikelets per spike length, grains/spike, awns length, tillers/plant, tillers/meter, ten grains width, gain yield/spike, grain yield/meter, and 100-grain weight. The peduncle length showed negative non-significant correlation with grain yield/plant, ten grains length, and harvest index. Spike length showed positive, non-significant correlation to spike length, awns length, spikelets/spike, ten grains width, grain yield/meter, grain yield/plant, grains number/spike, and grain yield/spike. Spike length indicates negative and non-significant correlation to ten grains length, number of tillers/plant, tillers/meter, harvest index, and 100 grains weight. The awns length showed positive, non-significant correlation with spikelets number/spike, tillers/meter, ten grains width, grain yield/meter, 100 grains weight, grain yield/plant, tillers number/plant, and harvest index. The awns length showed a negative non-significant correlation with grain yield/spike, grains number/spike, and 10 grains length. The spikelets/spike indicates the positive and non-significant correlation to grain yield/meter, grains number/spike, ten grains width, 100 grains weight, and grain yield/spike. The negative non-significant correlation was noticed with the number of tillers per plant, tillers/ per meter, 10 grains length, and harvest index.

Table 2. Basic statistics and frequency distribution of agro-morphological traits of bread wheat genotypes

Traits	Mean: SE	Max.	Min.	S.D	C.V
Germination percentage	72.86±6.13	94.29	53.33	15.02	0.22
Days to booting	72.95±0.39	74.00	72.00	0.96	0.01
Days to flowering	81.29±0.44	82.43	80.14	1.09	0.01
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
Tillers per plant	6.07±0.70	8.79	4.01	1.70	0.29
Tillers per meter	42.90±4.98	59.29	26.43	12.20	0.29
Spike length (cm)	11.66±0.37	13.06	10.71	0.90	0.08
Awns length (cm)	6.62±0.25	7.26	5.67	0.16	0.09
Spikelets 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
Grains per plant	272.50±42.60	414.71	146.14	104.35	0.39
Grain yield per plant (g)	12.24±2.38	20.51	5.05	5.82	0.38
Grain yield per meter (g)	67.30±12.42	109.80	28.24	30.42	0.48
Hundred grains weight (g)	4.66±0.21	5.25	3.85	0.52	0.11
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

The grains/spike indicated a positively significant correlation with grain yield/ spike. The positive and non-significant correlation was noticed with ten grains width, grain yield/plant, grains yield/meter. The grains number/spike shows a negative non-significant correlation with tillers/plant, tillers/meter, ten grains length, harvest index, and 100 grains weight. The number of tillers/plants shows positive and significant correlation with the number of tillers/meters. The number of tillers/plant indicates the positive, non-significant correlation with grain yield/plant, 10 grains width, grain yield/meter, harvest index, and 100 grains weight. Tillers/plant shows the negative non-significant correlation, with, grain yield/ spike, 10 grains length. Several tillers/meters indicated the negative and non-significant correlation with ten grains length, grain yield/spike, ten grains width, grain yield/plant. Tillers/meter has shown a

positive non-significant correlation with 100 grains weight, grain yield/meter, and harvest index. The ten grains width indicated the negative non-significant correlation with harvest index and ten grains length. The non-significant and positive correlation was noticed with the grain yield/meter, grain yield/plant, grain yield/spike, and 100-grain weight. The ten grains length showed a negative non-significant correlation with grain yield/spike, grain yield/meter, grain yield/plant, and positively non-significant correlation was noticed with 100 grains weight and harvest index.

The grain yield/meter indicated positive and non-significant correlation with grain yield/spike, 100 grains weight, and grain yield/plant. A negative non-significant correlation was found with the harvest index. Grain yield/spike showed positive non-significant correlation with 100 grains weight

and grain yield/plant. The negative and non-significant correlation was observed with the harvest index. The grain yield/plant indicated positive and non-significant correlation with 100 grains weight and harvest index. The harvest index showed positively non-significant correlation with hundred grains weight. (Table 3), shows the Pearson's correlation coefficients among agro-morphological traits of seven bread wheat genotypes.

Analysis of variance (ANOVA) of yield and yield associated traits of bread wheat genotypes.

The ANOVA for agro-morphological traits in seven bread wheat genotypes is indicated in (Table 4). Germination percentage mean square for genotypes was 229.274 and error was 211.261 that found with its non-significant differences at $p=0.4236$. The days to booting were 15.1905 with the mean square for error was 1.3333 that shows highly significant differences at $p=0.0002$. The mean square for days to flowering was 10.4921 and the error was 1.3016 with its significant differences at $p=0.0012$. The days to heading were 22.6032 and the mean square for error was 2.0317 and highly significant p -value of 0.0003. The flag leaf area was 71.965 and error 55.311 with non-significant p -value of 0.3278. The plant height was 443.980 and error 186.310 indicated non-significant p -value of 0.0945. The grain filling period was 6.04762 and error 2.16667 with non-significant differences at 0.0615. The days to maturity were 10.6508 and the error was 0.9365 with highly significant differences at 0.0002. The peduncle length was 11.5634 and error 2.8209 was found with significant differences at $p=0.01$. The number of tillers/plant was 1.0330 and the error of 0.7740 which shows non-significant p -value of 0.3149. The number of tillers/meters was 135.270 and error 28.925 showed significant differences at $p=0.011$. The spike length was 1.84597 and error 0.65622 indicated non-significant differences at $p=0.0601$. The awns length was 1.16220 and error 0.11639 and highly significant differences were observed at $p=0.0004$. The spikelets/ spike was 4.51995 and

error 1.65062 with non-significant differences at $p=0.0649$. The number of grains/spike was 235.012 and error 82.982 indicated highly significant differences at $p=0.00$. The grain yield/spike was 1.34975 and error 0.46512 with highly significant differences at $p=0.000$ recorded. The number of grains per plant was 6530.7 and error 4760.3 with a non-significant p -value of 0.3012. The grain yield/plant was 20.7064 and an error of 20.7654 shows a non-significant p -value was 0.4698. The grains yield/meter was 2061.09 and error 1590.07 shows highly significant p -value of 0.000. The hundred grains weight was 0.23887 and the error was 0.19664 has non-significant p -value of 0.3633. The ten grains length 0.30040 and error 0.06665 show significant p -value of 0.01. The ten grains width was 0.02798 and error 0.02923 shows non-significant differences at $p=0.4921$. The mean square of harvest index for genotypes was 12.2044 and the mean square for error was 15.4245 found with non-significant differences at $p=0.5426$, respectively.

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

The mean comparison for germination percentage in wheat genotypes was studied, further described in (Table 5). The maximum 84.44 was noted in genotype SARANG and minimum of 61.11% was recorded for ESWYT-123. The days to booting mean comparison showed that ESWYT-104 took maximum of 77 days for booting and SKD-1, 71 days. The days to heading were recorded that ESWYT-104 took maximum of 80.33 and SUNHERY 73.33 days. The mean comparison for days to flowering was recorded with maximum of 84.33 days for SKD-1 and minimum 82 days in SUNHERY. The days to maturity for ESWYT-104, and ESWYT-107 took maximum of 118 days and SKD-1 minimum of 113 days. The grain filling period in SUNHERY took maximum 44.33 and ESWYT-104 and SKD-1 with 40 days. The mean comparison for tillers/plant counted in SKD-1, SARANG, and ESWYT-104 produced a maximum of 6.94, 6.61, and 6.33 tillers, while; ESWYT-136 and ESWYT-107

produced minimum 5.67 number. The tillers/meters were calculated in SARANG and ESWYT-104 produced maximum of 48 tillers while ESWYT-136 minimum with 33, respectively.

Some grains/spikes counted in ESWYT-136 produced maximum number of 66 grains, while; genotype SKD-1 with minimum 40. The grains yield/spike weighted in ESWYT-136 and ESWYT-107 produced maximum 3.53, and 3.16 grams, while; SKD-1 was found with minimum 1.66 grams, yield per spike. The number of grains/plant counted in ESWYT-107, that produced maximum number of 326, while; SKD-1 with minimum 192 numbers. The grain yield per plant weighted in ESWYT-104 and ESWYT-123 produced maximum 14.02 and 14.20 grams, while; SKD-1 with minimum 8.44 grams, grains yield/plant. The mean comparison for grain yield/meter was calculated among which the SUNHERY produced maximum 77.68 grams, while; ESWYT-123 produced minimum of 44.13 grams. The ten grains length was measured and the maximum length was 7.08cm noted in SKD-1 and the minimum 6.80cm length was recorded in ESWYT-136. The ten grains width measured and the maximum width 3.28cm was calculated for ESWYT-136 and SUNHERY,

while; the minimum width of 3.02cm was recorded for SKD-1. The hundred grains weight calculated in the SUNHERY produced maximum 5.04 grams, while; ESWYT-107 with minimum 4.21 grams. The plant height was measured in the ESWYT-104 appeared with maximum in 97.66cm height, while; SKD-1 with minimum 77.00cm. The peduncle length was measured with the maximum length of 38.33cm was recorded in SUNHERY, while; minimum 32.55cm in ESWYT-104. The mean comparison for spike length was measured amongst ESWYT-107 showed maximum 13.11cm spike length, while; SKD-1 appeared with minimum 10.50cm. The awns length was noted in SARANG and SUNHERY maximum at 7.07, 7.14cm, while; ESWYT-136 minimum at 5.49cm. Some spikelets/spikes were counted in ESWYT-107 that showed maximum number of 18 while SARANG minimum at 14. The harvest index indicated the maximum 50.30 and 49.24% were recorded in ESWYT-104 and ESWYT-123. The genotypes ESWYT-107 and SKD-1 showed minimum of 46.13 and 46.17%. The mean comparison for flag leaf area (cm²) was calculated in the wheat genotypes. The genotype SARANG showed maximum 45.66cm squares, while; genotype ESWYT-104 indicated minimum of 32.72cm.

Table 3. The phenotypic correlation coefficient of quantitative traits of seven bread wheat genotypes

Traits	DH	GFP	DM	FLA	PH	PL	SL	AL	NSPS	NGPS	NTPP	NTPM	TGW	TGL	GYPM	GYPS	GYPP	HI	HGW
	1																		
GFP	-0.39 ^{NS}	1																	
DM	0.70 ^{NS}	0.34 ^{NS}	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												
AL	0.31 ^{NS}	0.09 ^{NS}	0.46 ^{NS}	-0.35 ^{NS}	0.31 ^{NS}	0.37 ^{NS}	0.15 ^{NS}	1											
NSPS	0.35 ^{NS}	0.38 ^{NS}	0.56 ^{NS}	0.22 ^{NS}	0.63 ^{NS}	0.45 ^{NS}	0.81 ^{NS}	0.12 ^{NS}	1										
NGPS	0.47 ^{NS}	0.35 ^{NS}	0.64 ^{NS}	0.16 ^{NS}	0.73 ^{NS}	0.14 ^{NS}	0.84 ^{NS}	-0.22 ^{NS}	0.83 ^{NS}	1									
NTPP	-0.00 ^{NS}	0.33 ^{NS}	0.24 ^{NS}	0.13 ^{NS}	0.25 ^{NS}	0.39 ^{NS}	-0.14 ^{NS}	0.77 ^{NS}	-0.11 ^{NS}	-0.30 ^{NS}	1								
NTPM	0.12 ^{NS}	-0.10 ^{NS}	0.01 ^{NS}	-0.05 ^{NS}	-0.00 ^{NS}	0.19 ^{NS}	-0.26 ^{NS}	0.71 ^{NS}	-0.33 ^{NS}	-0.49 ^{NS}	0.87 ^S	1							
10GW	-0.09 ^{NS}	0.82 ^{NS}	0.55 ^{NS}	0.31 ^{NS}	0.60 ^{NS}	0.30 ^{NS}	0.32 ^{NS}	0.05 ^{NS}	0.44 ^{NS}	0.49 ^{NS}	0.21 ^{NS}	-0.29 ^{NS}	1						
10GL	-0.79 ^{NS}	0.02 ^{NS}	-0.77 ^{NS}	0.35 ^{NS}	-0.71 ^{NS}	-0.22 ^{NS}	-0.77 ^{NS}	-0.58 ^{NS}	-0.73 ^{NS}	-0.56 ^{NS}	-0.15 ^{NS}	-0.12 ^{NS}	-0.10 ^{NS}	1					
GYPM	0.34 ^{NS}	0.23 ^{NS}	0.34 ^{NS}	0.41 ^{NS}	0.52 ^{NS}	0.37 ^{NS}	0.32 ^{NS}	0.40 ^{NS}	0.39 ^{NS}	0.33 ^{NS}	0.64 ^{NS}	0.60 ^{NS}	0.12 ^{NS}	-0.45 ^{NS}	1				
GYPS	0.37 ^{NS}	0.43 ^{NS}	0.63 ^{NS}	0.17 ^{NS}	0.71 ^{NS}	0.09 ^{NS}	0.76 ^{NS}	-0.29 ^{NS}	0.78 ^{NS}	0.97 ^S	-0.36 ^{NS}	-0.62 ^{NS}	0.63 ^{NS}	-0.44 ^{NS}	0.16 ^{NS}	1			
GYPP	0.62 ^{NS}	0.15 ^{NS}	0.84 ^{NS}	-0.34 ^{NS}	0.81 ^{NS}	-0.13 ^{NS}	0.48 ^{NS}	0.37 ^{NS}	0.51 ^{NS}	0.49 ^{NS}	0.04 ^{NS}	-0.22 ^{NS}	0.58 ^{NS}	-0.66 ^{NS}	0.00 ^{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}	0.11 ^{NS}	-0.63 ^{NS}	-0.66 ^{NS}	0.20 ^{NS}	0.06 ^{NS}	-0.54 ^{NS}	0.17 ^{NS}	-0.65 ^{NS}	-0.60 ^{NS}	0.03 ^{NS}	1	
HGW	-0.31 ^{NS}	0.63 ^{NS}	0.24 ^{NS}	0.32 ^{NS}	0.30 ^{NS}	0.27 ^{NS}	-0.19 ^{NS}	0.35 ^{NS}	0.07 ^{NS}	-0.09 ^{NS}	0.55 ^{NS}	0.11 ^{NS}	0.79 ^{NS}	0.10 ^{NS}	0.07 ^{NS}	0.06 ^{NS}	0.41 ^{NS}	0.21 ^{NS}	1

Like; 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), AL; Awns length (cm), NSPS; Number of spikelets/spike, NGPS; Number of grains/spike, NTPP, Number of tillers/plant, NTPM, Number of tillers/meter, TGW, Ten grains width (cm), TGL, Ten grains length (cm), GYPM, Grain yield/meter (g), GYPS, Grain yield/spike (g), GYPP, Grain yield/plant (g), HI, Harvest index%, tHGW, Hundred grains weight (g)

Table 4. Analysis of variance (ANOVA) for agro-morphological traits of seven bread wheat genotypes

Source	Genotype	Replica	F	Error	P
Germination %	229.274 ^{NS}	39.651	1.09	211.261	0.4236
Days to booting	15.1905**	1.0000	11.39	1.3333	0.0002
Days to flowering	10.4921**	1.8571	8.06	1.3016	0.0012
Days to heading	22.6032**	0.1429	11.12	2.0317	0.0003
Flag leaf area	71.965 ^{NS}	156.089	1.30	55.313	0.3278
Plant height	443.980 ^{NS}	57.173	2.38	186.310	0.0945
Grain filling period	6.04762 ^{NS}	3.00000	2.79	2.16667	0.0615
Days to maturity	10.6508**	2.7143	11.37	0.9365	0.0002
Peduncle length	11.5634 *	13.1995	4.10	2.8209	0.0181
Tillers per plant	1.0330 ^{NS}	14.1477	1.33	0.7740	0.3149
Tillers per meter	135.270 *	562.369	4.68	28.925	0.0112
Spike length	1.84597 ^{NS}	1.45402	2.81	0.65622	0.0601
Awns length	1.16220**	0.88332	9.99	0.11639	0.0004
Spikelets per spike	4.51995 ^{NS}	4.34246	2.74	1.65062	0.0649
Grains per spike	235.012 **	149.190	2.83	82.982	0.000
Grain yield per spike	1.34975 **	1.76513	2.90	0.46512	0.000
Grains per plant	6530.7 ^{NS}	19832.9	1.37	4760.3	0.3012
Grain yield per plant	20.7064 ^{NS}	38.1012	1.00	20.7654	0.4698
Grain yield per meter	2061.09 **	3258.65	1.30	1590.07	0.000
Hundred grain weight	0.23887 ^{NS}	0.25680	1.21	0.19664	0.3633
Ten grains length	0.30040 *	0.07762	4.51	0.06665	0.001
Ten grains width	0.02798 ^{NS}	0.04298	0.96	0.02923	0.4921
Harvest index%	7.33 ^{NS}	57.46	0.39	18.64	0.87

P-value ≥ 0.05 is non-significant, p-value at 0.01 to 0.05 is significant * and p-value at 0.001 is highly significant **

Table 5. The Duncan's Multiple Range Test (DMRT) of agro-morphological traits in seven bread wheat genotypes

Traits	ESWYT 136	ESWYT 104	ESWYT 107	ESWYT 123	SARANG	SKD-1	SUNHERY
Germination percentage%	63.333 ^a	63.333 ^a	74.443 ^a	77.780 ^a	84.443 ^a	82.223 ^a	81.110 ^a
Days to booting	72.333 ^b	76.667 ^a	74.667 ^a	71.333 ^b	71.333 ^b	71.000 ^b	70.667 ^b
Days to flowering	79.333 ^d	80.333 ^{cd}	83.000 ^{ab}	80.333 ^{cd}	79.667 ^d	84.333 ^a	82.000 ^{bc}
Days to heading	75.333 ^b	80.333 ^a	78.333 ^a	74.333 ^{bc}	75.667 ^b	73.627 ^c	73.333 ^{bc}
Flag leaf area cm ²	44.500 ^a	32.723 ^a	35.253 ^a	35.150 ^a	45.657 ^a	39.120 ^a	40.067 ^a
Plant height (cm)	95.16 ^{ab}	97.57 ^{ab}	97.44 ^{ab}	89.27 ^b	93.88 ^{ab}	76.99 ^b	117.77 ^a
Grain filling period	42.667 ^a	40.000 ^b	41.667 ^{ab}	42.000 ^{ab}	41.667 ^{ab}	40.000 ^b	44.000 ^a
Days to maturity	117.00 ^{ab}	118.67 ^a	118.33 ^a	117.00 ^{ab}	116.33 ^b	113.00 ^c	117.67 ^{ab}
Peduncle length (cm)	34.497 ^{bc}	32.550 ^c	37.467 ^{ab}	35.327 ^{bc}	36.440 ^{ab}	34.657 ^{bc}	38.330 ^a
Number of tillers/plant	5.5700 ^a	6.3300 ^a	5.5667 ^a	5.5867 ^a	6.6133 ^a	5.6000 ^a	6.9400 ^a
Number of tillers/meter	33.000 ^b	48.333 ^a	41.167 ^{ab}	35.167 ^b	48.167 ^a	45.000 ^a	49.833 ^a
Spike length (cm)	11.940 ^{ab}	11.497 ^{bc}	13.103 ^a	11.497 ^{bc}	11.327 ^{bc}	10.493 ^c	11.730 ^{abc}
Awns length (cm)	5.4800 ^b	7.0233 ^a	6.8233 ^a	6.6833 ^a	7.0667 ^a	6.0300 ^b	7.1400 ^a
Number of spikelets/spike	17.440 ^{ab}	15.883 ^{bc}	18.383 ^a	16.883 ^{abc}	17.773 ^{ab}	14.773 ^c	16.327 ^{abc}
Number of grains/spike	66.333 ^a	52.333 ^{ab}	64.333 ^a	50.833 ^{ab}	53.333 ^{ab}	40.333 ^b	50.667 ^{ab}
Grain yield/spike (g)	3.5300 ^{ab}	2.4167 ^{bc}	3.0367 ^{ab}	3.7067 ^a	2.5733 ^{abc}	1.7800 ^c	2.5767 ^{abc}
Number of grains/plant	267.67 ^{ab}	319.83 ^a	326.17 ^a	297.17 ^{ab}	254.33 ^{ab}	192.00 ^b	250.17 ^{ab}
Grain yield/plant (g)	11.727 ^{ab}	14.017 ^{ab}	12.627 ^{ab}	17.113 ^a	12.407 ^{ab}	8.437 ^b	11.647 ^{ab}
Grain yield/meter (g)	66.36 ^{ab}	70.77 ^{ab}	74.76 ^{ab}	40.13 ^b	124.37 ^a	54.86 ^{ab}	77.68 ^{ab}
Hundred grains weight (g)	4.6467 ^a	4.5733 ^a	4.4800 ^a	4.9500 ^a	4.9267 ^a	4.2667 ^a	5.0300 ^a
Ten grains length (cm)	6.8000 ^{ab}	6.4000 ^{bc}	6.1000 ^c	6.6333 ^{ab}	6.4500 ^{bc}	7.0833 ^a	6.7167 ^{ab}
Ten grains width (cm)	3.2833 ^a	3.1500 ^a	3.1333 ^a	3.2500 ^a	3.2000 ^a	3.0167 ^a	3.2833 ^a
Harvest index %	48.23 ^a	50.31 ^a	46.13 ^a	49.26 ^a	47.64 ^a	46.17 ^a	47.17 ^a

Discussion

The agro-morphological study of wheat is important for the enhancement of yield production thus; the present study was focused on the agro-morphology in seven bread wheat genotypes. The traits such as; G%, DH, DB, DM, NTPP, NTP/m, PL, GYPP, GYPm, PH, SL, GPS and NGPP, TGL), HGW, SPS, TGW as described above were kept under observation during the growing season. The basic statistical parameters such as standard error (S.E), maximum, minimum, coefficient of variation (C.V), and standard deviation (S.D) were applied on collected data of agro-morphological characters of seven wheat genotypes. The differences amongst the agro-morphological characters of genotypes were recorded. The number of grains/plant showed the highest mean value 272.50. The lowest mean value 2.75 was recorded in grains yield/spike. The maximum 0.48 coefficient of variations were noted in grain yield/meter and the minimum 0.01 coefficient of variations were recorded in days for heading, days for flowering, and days for maturity. The number of grains/plant appeared with the highest 104.35 standard deviations and ten grains in minimum width 0.21 standard deviation. The same results have been reported by [13-15].

Duncan's multiple range tests were performed for the measured traits of tested wheat genotypes. The maximum germination percentage, (84.44%) was noted in the genotype SARANG. The minimum 63.33% was recorded in ESWYT-136 and ESWYT-104. The ESWYT-104 took maximum 77 days for days to booting and minimum 70.66 days for genotype SUNHERY. The maximum 84.33 days for flowering recorded in SKD-1 and minimum days for lowering were noted in ESWYT-136 and SARANG, 79.33 & 79.66 days respectively. The 118.33 days for maturity were recorded in genotypes ESWYT-104, ESWYT-107. A minimum of 113 days for maturity was observed in the genotype SKD-1. The maximum number of tillers/plant was recorded in the genotypes SUNHERY 6.94 tillers, genotype SARANG 6.61 tillers, and 6.33 tillers in ESWYT-104, and minimum 5.56

tillers/plants were noted in the genotypes ESWYT-136 and ESWYT-107. The maximum grain yield/spikes were produced by genotypes ESWYT-136, 3.53 grams and ESWYT-107, 3.16 grams, while; minimum yield was 1.78 grams noted in the genotype SKD-1. The maximum 326 grains number/plant was recorded in ESWYT-107 and the minimum number 192 grains/plant counted in the SKD-1 genotype. The genotype SUNHERY was calculated with the longest peduncle length 38.33 centimeters, while; genotype ESWYT-104 was observed with the shortest peduncle length of 32.55 centimeters. The same results were described by [16-18].

A phenotypic correlation was calculated in all traits. Results indicated the number of grains/spike with positive and significant correlation to grain yield/spike (0.97). The days for maturity showed positive and significant correlation with plant height (0.91). The grain filling period indicated positive and non-significant correlation to days for maturity (0.34), awns length (0.09), spike length (0.37), grain yield/spike (0.43), tillers/plant (0.33), plant height (0.29), grain yield/meter (0.23), grains/spike (0.38), 10 grains length (0.02), hundred grains weight (0.63), 10 grains width (0.82), and flag leaf area (0.39). The flag leaf area found with positively non-significant correlation to grains/spike (0.16), peduncle length (0.28), spikelets/ spike (0.22), ten grains length (0.35), tillers/plant (0.13), ten grains width (0.31), grain yield/spike (0.17), grain yield/meter (0.41), and 100 grains weight (0.32). Plant height showed positively non-significant correlation with tillers/plant (0.25), spike length (0.63), grain yield/spike (0.71), awns length (0.31), grains/spike (0.37), grain yield/meter (0.52), ten grains width (0.60), and 100 grain weight (0.30). The grain yield/spike indicated positively non-significant correlation to grain yield/plant (0.57) and hundred grains weight (0.06). The ten grains length found in positive non-significant correlation with harvest index (0.17) and 100 grains weight (0.10). The grain yield/meter found with positive and non-significant correlation to grain yield/plant (0.00), grain yield/spike (0.16), and

100 grains weight (0.07). The number of grains/spike calculated with negative and non-significant correlation to tillers/meter (-0.49), tillers/plant (-0.30), ten grains length (-0.56), and harvest index (-0.66). The grain filling period observed negative and non-significant correlation with the harvest index (-0.72) and the number of tillers/plants (-0.10). The flag leaf area with negatively non-significant correlation to spike length (-0.19), plant height (-0.03), grain yield/plant (-0.34), awns length (-0.35), tillers/meter (-0.05), and harvest index (-0.69). The plant height was found in a negatively non-significant correlation with ten grains length (-0.71), peduncle length (-0.00), tillers/meter (-0.00), and harvest index (-0.42). The grain yield/meter found in negative non-significant correlation with the harvest index (-0.65). Grain yield/spike found with negative non-significant correlation to harvest index (-0.60). Similar correlations were reported by [19-21].

Analysis of variances was carried out for agromorphological characters of wheat genotypes. The non-significant differences were recorded for germination percentage, grains filling period, tillers/plant, grain yield/plant, 100 grains weight, plant height, and spike length, spikelets per spike, and flag leaf area. Highly significant and significant variations were noticed for grains number/spike, grain yield/spike, grain yield/ meter, number of tillers/meter, days to booting, days for heading, peduncle length, and days for flowering, awns length, and ten grains length. The same findings were reported by [22, 23].

Conclusion and Recommendations

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.

Authors' contributions

The experiments performed: AA Kalhoro. The experiments were conceived and designated: HB Bozdar & HA Sahito. Data analyzed: T Kousar & MA Korai. Materials/ tools/ analysis: WM Mangrio.

Acknowledgment

The authors are highly thankful for the sample collection points, Wheat and Maize Improvement Centre Mexico, from which four, Nuclear Institute of Agriculture Tandojam from which two and Wheat Research Institute Sakrand farm which one bread wheat genotypes samples were collected, respectively. Again all co-authors of this valuable research paper are cheerfully pleased for corresponding of this paper, Dr. Hakim Ali Sahito for their restless admiral approaches and expertise which poured the soul of encouragement and hope amongst us. His revolutionary ideas lead us on the leading pathway by which we have reached this attempt.

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