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Characterization of Agromorphological Diversity in Synthetic Bread Wheat (*Triticum aestivum* L.) Genotypes Targeted for Higher Yield Potential

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ABSTRACT

Background and Objective: *Triticum aestivum* (hexaploid genome i.e., AABBDD) belongs to family *Poaceae*-having five subspecies. The important species of are *Triticum monococcum* (einkorn), *Triticum dicoccon* (emmer) and *Triticum spelta* (spelt). The main objective of the study was to identify and evaluate different genotypes of wheat for potential yield. **Materials and Methods:** The current study evaluated 39 wheat genotypes of diverse origins with 20 agromorphological parameters based on ANOVA and LSD analysis, descriptive analysis and correlation test. The germplasm was planted in Randomized Complete Block Design (RCBD) with three replications and spacing between the rows was kept at 75 cm and the width was 12 cm. **Results:** Maximum grains per spike were observed in accession number 11 and recorded at 91.00 grains per spike while minimum grains per spike was observed in accession number 22 and recorded as 20.00 grains per spike. The greatest value of thousand-grain weight was observed in accession numbers 17 and 24 which were recorded as 50 g while the smallest value was observed in accession number 38 which was recorded as 30.24 g. The greatest harvest index was observed in accession number 11 which was 69.0084 while lowest value was observed in accession number 7 which was 30.4491. **Conclusion:** Combining the results of all parameters accession no 11, 17 and 24, are superior lines and may be used for increasing the yield potential of future synthetic wheat lines. Current study results may facilitate future wheat improvement programs as well as the development of agronomically desirable wheat cultivars.

KEYWORDS

Triticum aestivum, *Triticum spelta*, agromorphology, superior lines, yield potential, synthetic bred wheat, *Triticum dicoccon*

INTRODUCTION

Human population is increasing day by day and is expected to reach 9.4 billion by 2050 and it will reduce the world's agricultural land by 10-20%, due to urbanization, environmental pollution and utilization of agricultural lands for other purposes[1]. If the climatic changes continue and melt the Himalayan glaciers, changes in the monsoon or flooding patterns or drought regimes in Asia will result in the loss of world cereal production by up to 25%. Therefore, to meet the growing demand of global food shortage from the present cropland food production must increase by 50% at least to meet our demands of 2050[2].

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Wheat is an economical and rich source of energy and proteins and supplies one-fifth of all human calories for the world population[3]. Plant breeders are constantly trying to discover wheat germplasm having desirable traits to resist diseases and other environmental stresses[1,4].

About 35% of the world population in more than 40 countries use wheat as a staple food. As compared to other cereal crops wheat is cultivated in larger areas of the globe in different climates and its annual production is approximately 694 million tons[5]. The two common cultivated species are bread wheat (2n = 6×42) and durum wheat (4×28). The globally 95% of wheat is contributed by bread wheat while 5% is contributed by emmer (4×28), einkorn (2×14) and spelt (6×42)[6].

Triticum aestivum (Bread wheat 2n = 6×42) has a hexaploid genome (AABBDD) of 17 Gb[7,8]. The evolutionary history of threshing-free wheat (tetraploid Durum and hexaploid bread wheat) crops is still uncertain[9].

The hexaploid bread wheat of genome AABBDD has evolved from two different polyploidization events. The first event was completed about 0.5 million years ago when the diploid donor having A genome (*T. urartu*) hybridized with another species having B genome (*Aegilops speltoides*) resulting in tetraploid *Triticum turgidum*[10]. The second allo polyploidization event occurred (about 10,000 years ago) between the tetraploid *T. turgidum* spp., *dicoccum* and the diploid (D genome donor) *Aegilops tauschii*[6,11].

Wheat provides nearly 20% of the diet calories and contains about 55% carbohydrates. The study showed that 100 gm of wheat comprises carbohydrates (78.10%), protein (14.70%), fat (2.10%) and minerals (2.10%). Wheat also contain a significant amount of thiamine and vitamin B[12,13].

Botanically the wheat grain is called caryopsis having the pericarp and the true seed. About 72% of the protein is deposited in the seed endosperm. The wheat grains also contain riboflavin, pantothenic acid and sugars[14]. The aleurone and pericarp layer are used as nutritional sources of fibre and minerals like calcium, magnesium, phosphorus and potassium[13].

Cytological the world's wheat is classified into three main classes, diploid wheat, 2n = 2×14, chiefly used for fodder e.g. *Triticum monococcum*, Tetraploid or durum wheat, 2n = 4×28, e.g. *Triticum dicoccoides*, mostly used to make biscuits, pastries, noodle and pasta and *Hexaploid* or common/bread wheat, 2n = 6×42 which is used to make bread, nan, chapatti etc.[15].

More than 200 different types of wheat diseases have been reported which are mostly pathogenic and infectious and are transmitted from plant to plant. About 10-16% of the world yield is lost due to plant diseases excluding the postharvest loss of 8-12% of the underdeveloped countries[2,15].

Wheat is the most important cultivated crop that ranks first in acreage as well as production amongst all the cereals in Pakistan and all over the world. Population pressure urges food security. Due to the importance of wheat as a leading food crop in the farming system, many plant breeders are engaged in its improvement throughout the world[16,17]. There has been extensive research to pyramid such morphological traits that could partition adequate portion to grain yield resulting in high grain yield[18,19]. As the Khyber Pakhtunkhwa province comprises several ecological zones with different climates, the existing wheat cultivars are not giving us good yield because of inadequate moisture availability and an erratic distribution of rain in the province. Therefore, the research was proposed to study the morphological characterization of the germplasm and the production of their yield.

MATERIALS AND METHODS

The present research work was carried out in field conditions of Mansehra District during 2022-23. The 39 genotypes comprising 34 germplasm of synthetic wheat (*Triticum aestivum*) and 5 control lines

of common wheat (*Triticum aestivum*) were grown in a field opposite the Department of Botany Hazara University Mansehra. Although, original source of these synthetic lines and their derivatives is CIMMYT, Mexico.

The purpose of the study was to observe diversity in plant height, peduncle length, spike length, awn length, leaf flag area, number of tillers per plant, number of spikelets per spike, spike density, seed color, number of grains per spike, 1000 grains weight, yield per plant, biological yield, harvest index were accounted during the study details of all these traits is given below. The 39 wheat germplasm were planted in Randomized Complete Block Design (RCBD) with three replications. Seeds were grown in a suitable field and environmental conditions. Before sowing the seeds, the field was cleared manually from the debris of other plants and then three rows were made, spacing between the rows was kept at 75 cm and the width was 12 cm and common agricultural practices for spring wheat in Pakistan were used.

Statistical analysis: All data from the parameters analyzed was assembled as a Microsoft Excel sheet and basic statistics such as mean, median, mode, variance range etc., were computed. While, Analysis of Variance (ANOVA) as well as treatment means were separated by the Least Significant Difference (LCD) test at p = 0.05 using SPSS. Correlation analysis and cluster analysis were also carried out using SPSS trial version 16.

RESULTS

The current research work was carried out in the experimental field opposite to the Department of Botany, Hazara University Mansehra, various morphological traits of 39 synthetic wheat including 5 control checks were studied (Table 1-4).

Days to flowering:

Analysis of Variance (ANOVA) revealed that days to flowering were highly significant among the 39 genotypes of synthetic wheat. Maximum days to flowering were observed in accession numbers 6, 14 and 22 which was 122 days while minimum days to flowering were observed in accession number 37 and accounted for 113 days (Fig. 1). The mean value of days to flowering was 118.79, standard deviation was 5.794, variance was 33.578 and coefficient of variance (C.V) was 4.67 (Table 1).

Plant height: Maximum plant height was observed in accession number 2, 15, 25, 29 and 34 and recorded as 93 cm while minimum plant height was observed in accession number 36 and recorded as 43.00 cm (Fig. 2). The mean plant height value was 70.69 cm, standard deviation was 10.94, variance was 119.698 and C.V was 8.59 (Table 1).

Table 1: Descriptive analysis of important agro-morphological traits.

	Statistic		Mean		Statistic		
Traits	Minimum	Maximum	Statistic	Standard error	Standard deviation	Variance	C.V
Days to flowering	113.00	122.00	118.79	0.535	5.794	33.578	4.67
Plant height	43.00	93.00	70.69	1.011	10.940	119.698	8.59
Peduncle length	18.00	51.00	34.83	0.676	7.320	53.591	10.84
Spike length	6.70	15.00	10.66	0.158	1.712	2.932	7.37
Awn length	4.00	17.00	8.44	0.223	2.422	5.867	14.28
Flag leaf area	13.00	45.00	28.75	0.660	7.146	51.067	15.38
Tillers per plant	8.00	15.00	11.47	0.191	2.066	4.268	12.51
Spikelet's/spike	13.00	22.00	17.13	0.171	1.856	3.447	7.05
Spike density	5.00	79.00	7.70	0.620	6.707	44.987	8.53
Seed colour	1.00	3.00	1.74	0.080	0.872	0.761	6.53
Grains per spike	20.00	91.00	62.23	1.125	12.168	148.080	10.34
Days to maturity	171.00	185.00	178.76	0.272	2.951	8.714	

C.V: Coefficient of variance

Table 2: ANOVA show the agro morphology of different traits

Plant height	Peduncle length	Spike length	Awn length	Flag leaf area	Tillers per plant	Spikelet's per spike	Grains per spike
93.33^{cde}	41.667^{abcd}	14.000^{ab}	9.333^{cdefgh}	38.667^{bcde}	12.00^{bcdefghi}	17.000^{bcdefg}	42.333^{klmn}
75.00^{hijklmn}	38.667^{bcdefg}	10.667^{fghi}	8.833^{defghij}	29.667^{ghijk}	14.333^{abc}	17.000^{bcdefg}	45.000^{jklmn}
84.67^{defghi}	36.333^{cdefghij}	12.000^{bcdefgh}	7.333^{hijklm}	32.667^{cdefghij}	13.000^{abcdefg}	18.667^{abc}	48.333^{ijkl}
101.00^{abc}	42.333^{abcd}	8.667^{ij}	7.167^{ijklm}	33.000^{cdefghij}	12.333^{bcdefgh}	15.333^{fghij}	44.667^{jklmn}
81.00^{efghij}	44.333^{ab}	12.000^{bcdefgh}	9.333^{cdefgh}	47.667^{a}	13.333^{abcdef}	17.667^{abcde}	72.667^{abcd}
79.00^{fghijk}	32.333^{fghijklmn}	13.000^{abcde}	10.667^{bcd}	29.333^{ghijk}	11.667^{cdefghi}	17.667^{abcde}	37.000^{no}
75.33^{hijklm}	29.000^{jklmnopq}	11.333^{defgh}	8.333^{fghijklm}	34.667^{bcdefghi}	11.667^{cdefghi}	16.667^{cdefgh}	37.000^{no}
59.67^{opqr}	30.667^{hijklmno}	11.667^{cdefgh}	8.000^{ghijklm}	39.000^{bcd}	11.333^{defghi}	16.333^{defgh}	61.000^{efg}
54.00^{qr}	30.000^{ijklmno}	12.333^{bcdefg}	8.333^{fghijklm}	36.333^{bcdefgh}	10.333^{ghij}	17.333^{abcdef}	27.667^{o}
64.00^{mnopq}	30.333^{hijklmno}	11.167^{efgh}	7.167^{ijklm}	35.000^{bcdefghi}	10.333^{ghij}	14.667^{hij}	52.333^{ghij}
87.67^{cdefgh}	34.667^{defghijkl}	10.333^{ghi}	12.667^{b}	34.333^{bcdefghi}	13.000^{abcdefg}	18.667^{abc}	79.000^{a}
72.00^{ijklmno}	37.333^{bcdefghi}	7.333^{j}	15.667^{a}	32.667^{cdefghij}	14.333^{abc}	17.000^{bcdefg}	55.667^{fghi}
80.00^{efghij}	37.333^{bcdefghi}	11.667^{cdefgh}	8.500^{efghijkl}	35.000^{bcdefghi}	11.667^{cdefghi}	17.333^{abcdef}	56.333^{fg}
61.33^{nopqr}	28.333^{klmnopq}	12.667^{bcdef}	8.667^{defghijk}	32.333^{cdefghij}	12.000^{bcdefghi}	18.333^{abcd}	49.333^{hijkl}
66.00^{klmnopq}	35.000^{defghijkl}	13.667^{abc}	10.333^{cdef}	31.667^{defghij}	15.333^{a}	18.667^{abc}	64.667^{def}
68.33^{jklmnop}	27.667^{lmnopq}	13.667^{abc}	10.500^{cde}	34.000^{bcdefghi}	14.667^{ab}	19.333^{a}	64.333^{def}
80.67^{efghij}	32.000^{fghijklmn}	10.667^{fghi}	9.000^{cdefghi}	33.667^{bcdefghi}	11.667^{cdefghi}	14.333^{ij}	48.667^{ijkl}
75.33^{hijklm}	36.000^{cdefghijk}	13.000^{abcde}	8.333^{fghijklm}	38.333^{bcdef}	13.667^{abcde}	16.667^{cdefgh}	44.667^{jklmn}
114.00^{a}	49.000^{a}	11.667^{cdefgh}	9.333^{cdefgh}	40.333^{abc}	11.667^{cdefghi}	17.000^{bcdefg}	64.333^{def}
90.00^{cdefg}	35.333^{cdefghijkl}	15.000^{a}	8.333^{fghijklm}	37.333^{bcdefg}	12.333^{bcdefgh}	19.000^{ab}	47.000^{ijklm}
70.33^{jklmnop}	7.0000^{c}	11.667^{cdefgh}	8.000^{ghijklm}	28.000^{ijkl}	12.000^{bcdefghi}	16.333^{defghi}	40.000^{lmn}
52.67^{qr}	33.667^{efghijklm}	10.333^{ghi}	7.167^{ijklm}	27.333^{ijklm}	12.333^{bcdefgh}	16.333^{defghi}	28.000^{o}
100.00^{bc}	39.000^{bcdef}	10.233^{hi}	8.833^{defghij}	32.000^{defghij}	13.333^{abcdef}	17.000^{bcdefg}	74.667^{abc}
92.33^{cdef}	38.000^{bcdefgh}	10.333^{ghi}	8.500^{efghijkl}	23.333^{klm}	11.000^{efghi}	13.333^{j}	48.667^{ijkl}
96.33^{cd}	48.667^{a}	12.333^{bcdefg}	9.333^{cdefgh}	34.667^{bcdefghi}	12.000^{bcdefghi}	17.000^{bcdefg}	47.333^{ijklm}
91.00^{cdefg}	29.333^{jklmnop}	13.000^{abcde}	9.167^{cdefghi}	35.333^{bcdefghi}	14.333^{abc}	17.333^{abcdef}	51.000^{hijk}
85.33^{defghi}	31.000^{ghijklmno}	11.633^{cdefgh}	6.500^{lm}	31.333^{defghijk}	14.000^{abcd}	16.667^{cdefgh}	43.000^{jklmn}
84.33^{defghi}	34.667^{defghijkl}	12.000^{bcdefgh}	8.000^{ghijklm}	25.333^{jklm}	9.333^{ij}	16.000^{efghi}	38.333^{mn}
84.33^{defghi}	31.667^{fghijklmn}	11.333^{defgh}	8.333^{fghijklm}	30.667^{efghijk}	13.000^{abcdefg}	16.000^{efghi}	38.000^{mn}
72.67^{ijklmno}	26.667^{mnopq}	11.333^{defgh}	6.833^{jklm}	33.000^{cdefghij}	10.333^{ghij}	18.000^{abcde}	42.333^{klmn}
78.33^{ghijkl}	32.000^{fghijklmn}	11.433^{defgh}	6.833^{jklm}	30.667^{efghijk}	13.667^{abcde}	18.667^{abc}	52.000^{ghijk}
92.00^{cdefg}	43.000^{abc}	13.333^{abcd}	11.00^{0bc}	41.333^{ab}	12.667^{abcdefg}	19.000^{ab}	76.667^{ab}
81.00^{efghij}	32.000^{fghijklmn}	11.667^{cdefgh}	9.333^{cdefgh}	30.000^{ghijk}	9.667^{hij}	17.667^{abcde}	36.667^{no}
113.67^{ab}	40.333^{bcde}	11.667^{cdefgh}	9.667^{cdefg}	32.667^{cdefghij}	11.667^{cdefghi}	15.000^{ghij}	69.000^{bcde}
69.00^{jklmnop}	21.333^{q}	8.000^{j}	7.333^{hijklm}	19.667^{m}	12.667^{abcdefg}	15.000^{ghij}	50.000^{hijk}
49.33^{r}	21.667^{pq}	8.833^{ij}	6.667^{klm}	20.333^{lm}	10.333^{ghij}	17.000^{bcdefg}	58.667^{fgh}
72.00^{ijklmno}	24.667^{nopq}	11.000^{efgh}	6.833^{jklm}	33.333^{bcdefghij}	10.667^{fghi}	17.667^{abcde}	64.667^{def}
64.67^{lmnopq}	25.667^{nopq}	10.333^{ghi}	7.233^{ijklm}	30.333^{fghijk}	9.333^{ij}	17.333^{abcdef}	65.000^{cdef}
58.00^{pqr}	23.667^{opq}	10.333^{ghi}	6.267^{m}	29.000^{hijk}	7.667^{j}	17.667^{abcde}	80.000^{a}

Alphabets A to Z indicates the factors split in to levels in all possible combinations to compare different agromorphological traits

Table 3: Correlations show different traits

	DF	PH	PL	SL	AL	FLA	NTPP	NSPS	SD	SC	GS
PH	-0.032										
PL	0.225*	0.612**									
SL	0.161	0.137	0.196*								
AL	0.188*	0.178	0.308**	0.105							
FLA	-0.060	0.255**	0.421**	0.408**	0.210*						
NTPP	0.128	0.235*	0.257**	0.121	0.370**	0.201*					
NSPS	0.136	-0.111	0.039	0.376**	0.217*	0.188*	0.209*				
SD	-0.224*	0.083	0.117	-0.161	-0.119	0.107	0.106	-0.064			
SC	0.097	-0.028	0.248**	0.107	0.237*	0.206*	0.191*	-0.005	-0.079		
GS	-0.305**	0.163	0.063	-0.076	0.172	0.195*	0.063	0.179	0.222*	-0.036	
DM	0.211*	0.206*	0.207*	0.154	0.269**	0.156	0.107	0.157	-0.008	0.108	0.102

*Correlation is significant at the 0.05 level (2-tailed) and **Correlation is significant at the 0.01 level (2-tailed), DF: Days to flowering, PH: Plant height, PL: Peduncle length, SL: Spike length, AL: Awn length, FLA: Flag leaf area, NTPP: Number of tillers per plant, NSPS: Number of spikelets per spike, SD: Spike density, SC: Seed colour, GS: Grains per spike and DM: Days to maturity

Table 4: Analysis of Variance (ANOVA) of wheat genotypes for different agro-morphological traits at 0.05 probability level

	Sources	DF	SS	MS	F	P*
Days to flowering	Replicate	2	8.174E-27	4.087E-27		
	Genotypes	39	479.692	12.6235	9.1E+29	0.0000
	Error	76	1.055E-27	1.389E-29		
	Total	116	479.692			
Plant height	Replicate	2	31.5	15.752		
	Genotypes	39	27232.1	716.635	9.88	0.000
	Error	76	5514.5	72.559		
	Total	116	32778.1			
Peduncle length	Replicate	2	57.91	28.957		
	Genotypes	39	5234.32	137.745	6.07	0.0000
	Error	76	1725.42	22.703		
	Total	116	7017.66			
Spike length	Replicate	2	2.788	1.39410		
	Genotypes	39	289.936	7.62989	4.81	0.0000
	Error	76	120.505	1.58559		
	Total	116	413.229			
Awn length	Replicate	2	5.876	2.93778		
	Genotypes	39	369.185	9.71539	6.00	0.0000
	Error	76	123.104	1.61980		
	Total	116	498.165			
Flag leaf area	Replicate	2	20.46	10.2308		
	Genotypes	39	3312.67	87.1754	3.46	0.0000
	Error	76	1914.87	25.1957		
	Total	116	5248.00			
Number of tillers per plant	Replicate	2	2.786	1.39316		
	Genotypes	39	315.453	8.30139	2.90	0.0000
	Error	76	217.214	2.85807		
	Total	116	535.453			
Number of spikelet's per spike	Replicate	2	3.299	1.64957		
	Genotypes	39	211.299	5.56050	2.72	0.0001
	Error	76	155.368	2.04431		
	Total	116	369.966			
Spike density	Replicate	2	1.685E-29	8.424E-30		
	Genotypes	39	13.3333	0.35088	2.50	0.0000
	Error	76	10.6667	0.14035		
	Total	116	24.0000			
Seed colour	Replicate	2	8.284E-31	4.142E-31		
	Genotypes	39	98.6667	2.59649	21.14	0.0000
	Error	76	9.33333	0.12281		
	Total	116	108.000			
Grains per spike	Replicate	2	77.0	38.487		
	Genotypes	39	21581.7	567.941	15.58	0.0000
	Error	76	2770.4	36.452		
	Total	116	24429.1			
Days to maturity	Replicate	2	1.702E-26	8.511E-27		
	Genotypes	39	2956.31	77.7976	1.3E+30	0.0000
	Error	76	4.593E-27	6.043E-29		
	Total	116	2956.31			

*Significant at the 0.05 probability level and DF: Days to flowering

Peduncle length: Maximum peduncle length was observed in accession number 1 and recorded 51.00 cm while minimum peduncle length was observed in accession number 36 and recorded as 18.00 cm (Fig. 3). The mean peduncle length value was 34.83 cm, standard deviation was 7.32, variance was 53.59 and C.V was 10.84 (Table 1).

Spike length: Highest spike length was found in accession number 6 and 19 and recorded as 15.00 cm while the lowest spike length was observed in accession number 21 and recorded as 6.70 cm (Fig. 4). The mean spike length value was 10.66 cm, the standard deviation was 1.712, the variance was 2.93 and C.V was 7.37 (Table 1).

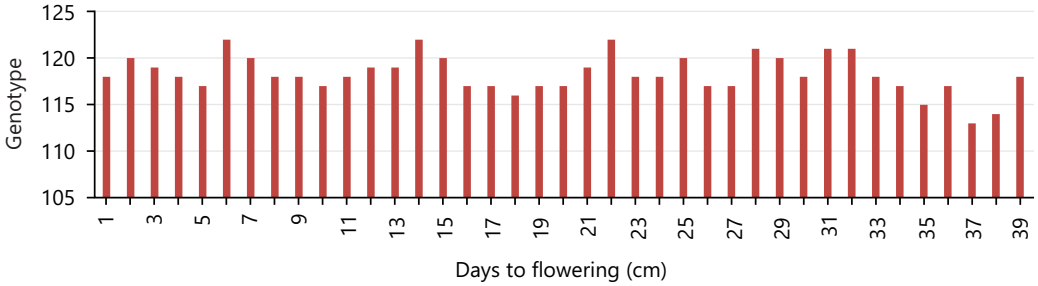

Fig. 1: Diversity in days to flowering among the 39 genotypes

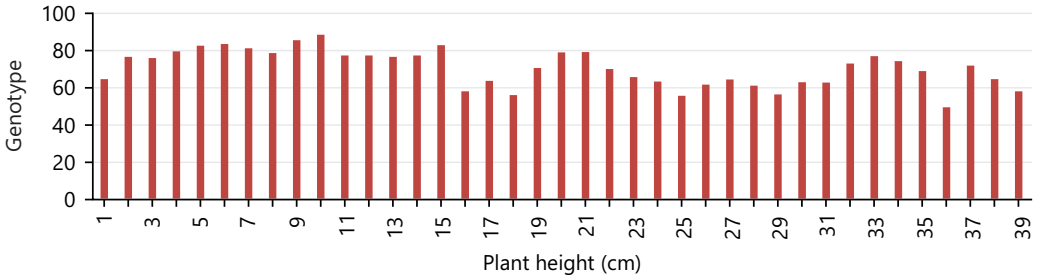

Fig. 2: Diversity in plant height among the 39 genotypes

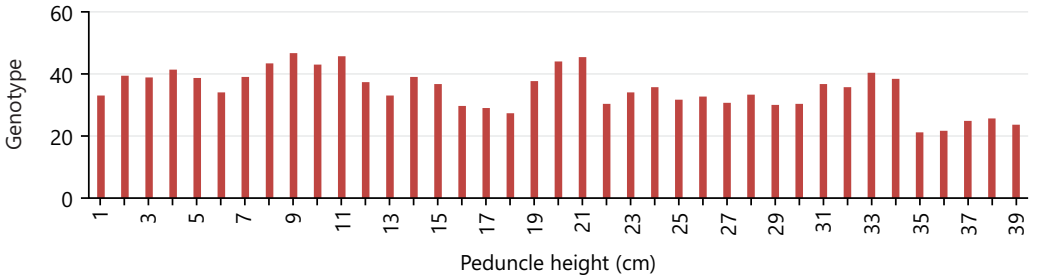

Fig. 3: Diversity in peduncle length among the 39 genotypes

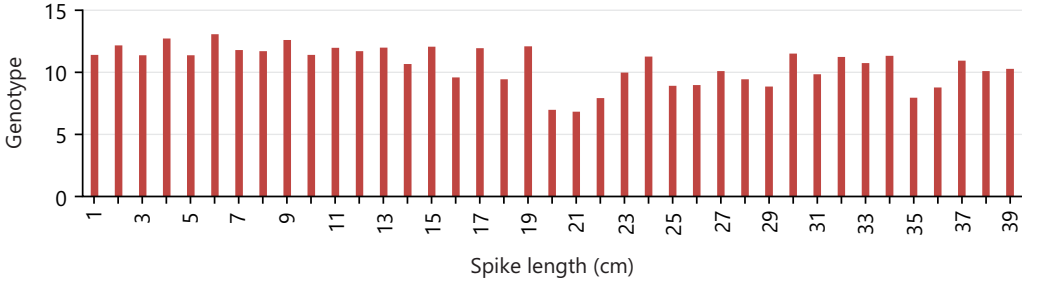

Fig. 4: Diversity in spike length among the 39 genotypes

Awn length: Maximum awn length was found in accession number 12 and recorded as 17.00 cm while the minimum awn length was observed in accession number 27 and recorded as 4.00 cm (Fig. 5). The mean awn length value was 8.44 cm, standard deviation was 2.42, variance was 5.867 and C.V was 14.28 (Table 1).

Flag leaf area: Maximum flag leaf area was observed in accession number 6 which was 43.00 cm while minimum flag leaf area was observed in accession numbers 35 and 36 which were 13.00 cm (Fig. 6). The mean value of flag leaf area was 28.75 cm, standard deviation was 7.146, a variance was 51.067 and C.V was 15.38 (Table 1).

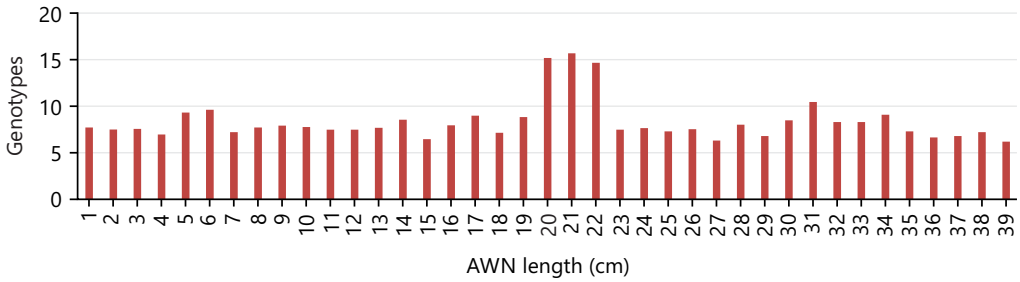

Fig. 5: Diversity in awn length among the 39 genotypes

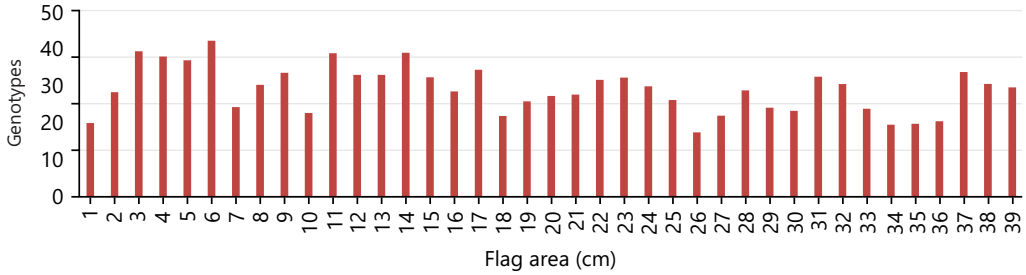

Fig. 6: Diversity in leaf flag area among the 39 genotypes

Fig. 7: Diversity in number of tillers per plant among the 39 genotypes

Number of tillers per plant: Maximum number of tillers per plant was observed in accession numbers 5, 12, 15, 27, 31 which were 15 tillers while minimum number of tillers per plant was observed in accession number 10 and 28 which was 8 tillers (Fig. 7). The mean value of number of tillers per plant was 11.47 tillers, standard deviation was 2.066, variance was 4.268 and C.V was 12.51 (Table 1).

Number of spikelets per spike: Maximum number of spikelets per spike was observed in accession number 16 and recorded as 22 spikelet while a minimum number of spikelets per spike was observed in accession number 17 and recorded as 13 spikelets (Fig. 8). The mean value of spikelets per spike was 7.13 spikelet's, standard deviation was 1.856, variance was 3.44 and C.V was 7.05 (Table 1).

Spike density: Highest spike density was found in accession number 12 which was very dense while the lowest spike density was observed in accession number 17 which was intermediate. The mean value of spike density was 7.70, standard deviation was 6.707, variance was 44.98 and C.V was 8.53 (Table 1).

Seed colour: Statistical analysis showed that the maximum seed colour was observed in accessions number 1, 2, 3, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34 which was purple in colour while minimum seed colour was observed in 4, 20, 23, 35, 36, 37, 38 and 39 accessions which were white in colour. The mean value of seed colour was 1.74, standard deviation was 0.872, a variance was 0.761 and C.V was 6.53 (Table 1).

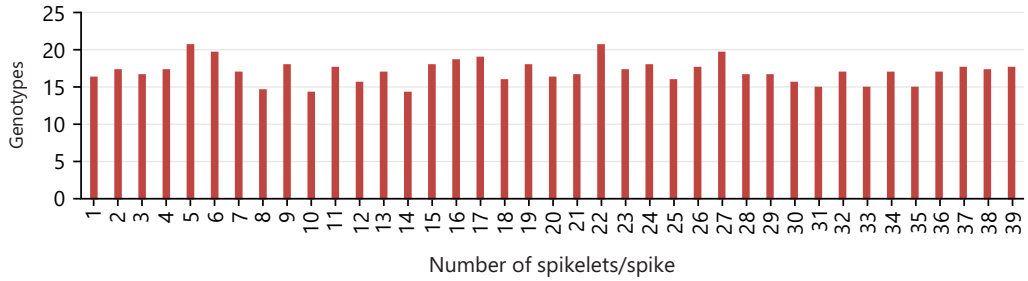

Fig. 8: Diversity in number of spikelets per spike among the 39 genotypes

Grains per spike: Maximum grains per spike were observed in accession number 11 and recorded at 91.00 grains per spike while minimum grains per spike were observed in accession number 22 and recorded as 20.00 grains per spike. The mean grains per spike value was 62.23, the standard deviation was 12.168, variance was 148.08 and C.V was 10.34 (Table 1).

Days to maturity: Maximum days to maturity were observed in accession number 23 and were counted as 185 days while minimum days to maturity were observed in accession number 10 and 35 were counted as 171 days. Mean value of days to maturity was 178.76 days. The standard deviation was 2.95 and variance was 8.714 (Table 1).

Thousand grains weight: Analysis exposed that the greatest value of thousand grain weight was observed in accession numbers 17 and 24 which were recorded as 50 g while the smallest value was observed in accession number 38 which was recorded as 30.24 g.

Biomass: After analyzing the data maximum biomass value was observed in accession number 25 which was 83 gm and the minimum value was observed in accession number 9 which was 32 g.

Yield per plant: Analysis showed that the maximum yield per plant was observed in accession number 11 which was 47.9609 g while the minimum yield per plant was observed in accession number 35 which was 12.4764 g.

Harvest index: Statistical analysis revealed that the greatest harvest index was observed in accession number 11 which was 69.0084 while lowest value was observed in accession number 7 which was 30.4491.

DISCUSSION

The current research work was carried out to investigate different morphological traits of 39 synthetic wheat including 5 control checks. These morphological traits include days to flowering, plant height, peduncle length, spike length, awn length, flag leaf area, number of tillers per plant, number of spikelets per spike, spike density, seed colour, grains per spike, grains weight, yield per plant, biomass, harvest index and days to maturity.

Wheat is one of the most important and widely cultivated crops having an annual production of 694 million tons. Wheat is used as a staple food in more than 40 countries[5]. Wheat is cultivated in larger areas than other cereals and modified to different climatic conditions. The current population of Pakistan is estimated to be 180 million, while in 2030 it is expected that it will be 300 million, that's means there is a dire need to increase the production per area to fulfil the demands of a rapidly growing population. The country's climatic conditions are well suited for the development of agriculture but still, the present

indigenous production of wheat is not sufficient to meet the needs of the growing population. Low crop yield per unit area is due to, the non-availability of improved seeds, late sowing, improper cropping pattern, shortage of irrigation water and diseases etc.

The experiments conducted were aimed at analyzing the varieties morphologically to identify their yield potential. Yield of wheat can be increased by converting the barren and wasteland under cultivation or by increasing its yield per unit area[20]. Presently, it is not possible to increase the cultivation of wheat crops due to other competitive Rabi crops. The only alternative is to obtain a higher yield per unit area by growing high yielding varieties and better crop management.

Analysis of variance revealed that days to flowering were highly significant among the 39 genotypes of synthetic wheat. Maximum days to flowering was 122 days while minimum days to flowering was 113 days. Maximum plant height was observed in accession numbers 2, 15, 25, 29 and 34 and recorded as 93 cm. The same work which was supported by Ahmad *et al.*[21] reported significant differences in wheat.

Statistical analysis showed that peduncle length among the genotypes was highly significant. Maximum peduncle length was observed in accession number 1 and recorded at 51.00 cm

Statistical analysis shows that spike length was highly significant among all the genotypes. Highest spike length was found in accession number 20 and recorded as 15.8 cm. Khan *et al.*[22] reported a significant positive correlation between spike length and plant height in wheat and also reported highly significant differences for spike length. Maximum awn length was found in accession number 12 and recorded as 17.00 cm. Maximum flag leaf area was observed in accession number 5 which was 45.00 cm. Maximum number of tillers per plant was observed in accession numbers 5, 12, 15, 27 and 31 which were 15 tillers. Maximum number of spikelets per spike was observed in accession number 16 and recorded as 22 spikelets.

Grains per spike were highly significant. Maximum grains per spike were observed in accession number 11 and recorded at 91.00 grains per spike. These results however contradicted the findings of Khan *et al.*[22], who reported a positive direct effect of plant per spike (0.137) were found. Maximum days to maturity were observed in accession number 23 and were counted as 185 days. Analysis exposed that the greatest value of thousand grain weight was observed in accession numbers 17 and 24 which were recorded as 50 g. After analyzing the data maximum biomass value was observed in the accession number 25 which was 83 g. Analysis showed that the maximum yield per plant was observed in accession number 11 which was 47.9609 g. Statistical analysis revealed that the greatest harvest index was observed in accession number 11 which was 69.0084. Present results were in line with the finding of Khan *et al.*[23], who also reported the non-significant differences in wheat genotypes. Such a non-significant difference between wheat and triticale showed that both traits have identical genetic backgrounds and hence can be collectively studied.

CONCLUSION

The 39 bread wheat genotypes were evaluated for morphological tests. Data recorded for morphological traits showed that different genotypes have the highest value in a variety of characters such as plant height, peduncle length, spike length, awn length, leaf flag area, number of tillers per plant, number of spikelets per spike, spike density, seed colour, number of grains per spike, 1000 grains weight, yield per plant, biological yield and harvest index. The ANOVA test shows significant differences among all the genotypes. These all genotype varieties give us better yield and we recommended these varieties of wheat for the future in order to get better wheat production.

SIGNIFICANCE STATEMENT

This study discovered the agromorphological characterization of 39 bread wheat genotypes for higher yield potential. Different genotypes showed the highest value in a variety of morphological characteristics. The statistical results showed significant differences among all the genotypes. This study will help the researchers to uncover the critical areas of different agromorphological characters and identification of wheat genotypes for better yield potential.

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