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Estimation of Genetic Variability, Heritability, and Genetic Advance among F3 Populations for Productive Traits of Bread Wheat (*Triticum aestivum L.*)

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Abstract

Heritability, genetic advance is essential to know about yield potential of crops. To find out heritability and genetic advance this study was designed at the research area of The Department of Plant Breeding and Genetics, The University of Agriculture, Peshawar, during 2021-22. The experiment was carried out by using 27 wheat genotypes comprising 9 parents and 18 F3 segregants and evaluated in RCB Design with 3 replications. Highly significant variation showed by analysis of variance among parents and F3 populations for plant height, days to heading, spikelet's spike^{-1}, flag leaf area, tillers plant-1, number of grains spike^{-1}, thousand grain weights and biomass yield. Highest heritability estimates 0.82 was observed by cross Watan × Janbaz for plant height; 0.88 for spike length by Fakhr-e- Sarhad × AUP-5008; 0.87 for spikelet's spike^{-1} by Pirsabak-2005 × AUP-5008; 0.89 for flag leaf area by Barsat × Tatara; 0.86 for fertile tillers plant^{-1} byFakhr-e- Sarhad × Tatara; 0.76 for grains spike^{-1} byPirsabaq-2005 × Tatara; 0.88 for days to heading by Watan × Tatara; 0.86 for days to maturity by Watan × AUP-5008 and AUP-4008 × Janbaz; 0.89 for grain yield by Barsat × Tatara; 0.87 for 1000-grain weight by Barsat x Janbaz; 0.86 for biological yield by Watan × AUP-5008 and 0.84 for harvest index by Barsat x Janbaz. Highest values for genetic advance were 32.71 cm for Fakhr-e- Sarhad × AUP-5008 for plant height; 20.33 cm^2 by Fakhr-e- Sarhad × Janbaz for flag leaf area; 35.08 days by Pirsabaq 2005 × Tatara for days to heading and 34.24 days for days to maturity by Watan × Tatara. The parental genotype, Janbaz, and Watan × AUP-5008, Pirsabak-2005 × AUP-5008, Saleem-2000 × Janbaz and Watan × Tatara were the most promising genotypes for yield contributing characters and are recommended to be evaluated in upcoming breeding schemes.

Keywords: Wheat; Heritability; Genetic advance

Introduction

Bread wheat *(Triticum aestivum L.)* has 42 chromosomes and is hexaploid belonging to family Poaceae. Being self-pollinated, annual it is also long day plant based on photoperiodism. It is basically originated from South East Asia. It is second largest mean for nutrient including food, feed, fodder, energy and globally being a staple food of the world humanism. Wheat provides 36 % food to the whole world and 20 % energy and being a staple food used almost all over the world which account approximately 240 million hectares as compared to other crops cultivation [1]. Irrigated and rain fed conditions were round about 8.74 million hectares while in Khyber Pakhtunkhwa cultivated area was on 0.74 million hectares yielding 1.36 million tonnes which has produced about 1860 kg ha^{-1}. One of the major causes of wheat yield reduction is the cultivation of varieties of low genetic potential [2].

For any breeding programme the main important parameter is genetic variability which provides the knowledge for selection of diverse parents which can be used in future hybridization programme. The genetic potential of diverse genotypes of distinct morphological yield traits is essential for a successful breeding program. Genetic variability is the basis for the enhancement of any plant breeding and varietal improvement activities. The breeder should identify the variation of desired character and select with his skill towards desired improvement of the crop. Genetic improvement is a major tool to develop high yielding drought tolerance varieties [3]. Heritability is the transfer of phenotypic and genotypic traits from parents to offspring and this is the best indication for breeder to evaluate correction of penetrance and expressivity by calculating variance of traits in offspring by crossing parental genotypes.

Improvement of crops in mean of genetic value of the selected plants per breeding cycle is known as genetic advance. Genetic advance shows the breeder improvement in experimental operation and make them deciding either progress is on the right direction or not. Therefore, heritability and genetic advance are the tools which are widely applicable by the researchers. Keeping these things in the view, an effort has been made in the present study to evaluate a set of promising genotypes with the objectives, to estimate the variability, heritability and genetic advance for yield and yield components traits. Heritability accompanied by high genetic advance would be a more beneficial tool for predicting the ensuing effect in genotype selection for yield and yield related traits. The presence of variability, heritability and genetic advance in different yield related characters of bread wheat improvement has been reported by different authors [4-6]. Keeping in view the importance of these traits the current study was conducted to evaluate the Genetic Variability, Heritability and genetic advances among F3 population for productive traits of Bread wheat.

Materials and Methods

To evaluate genetic diversity in F3 populations of bread wheat,

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the present study was carried out at The University of Agriculture Peshawar in experimental Block in year 2021-22. To minimize environmental influence Wheat genotypes were allocating in RCB design with 3 replications having plant to plant distance 15 cm and row to row distance was 30 cm in 4 rows of 3 m length. Data was taken from ten randomly selected plants from each genotype. All agronomic cultural practices were applied uniformly to control environmental error. For proper computation data was taken on the plant height (cm), spike length (cm), spikelet's spike^{-1}, flag leaf area (cm), tillers plant^{-1}, grains spike^{-1}, days to reach heading, days to physiological maturity, grain yield spike^{-1} (g), 1000 grain weight (g), biological yield (kg), and harvest index (%) at their proper time. For each parameter by selecting and tagging ten plants randomly from each entry and data was taken on those selected plant.

Statistical Analysis

Analysis of variance to test the significance for each trait was estimated as per methodology given by [7,8].

Heritability in broad sense (h2) were calculated by [9] H2 = VG/VP X 100

Where: VG = genotypic variance,

VP= Phenotypic variance

Genetic Advance as Percent of Mean

GAM = GA/($\bar{x}$) X 100

Where: GAM: Genetic advance as present of mean, GA: Genetic advance and $\bar{x}$ = Grand mean. Genetic advance as percent of mean was categorized into low: 0 to 10%, medium: 10 to 20% and high: >20% as suggested by [10].

Result and Discussion

Plant height

Data regarding mean square revealed ($P \leq 0.01$) significant amongst the genotypes, parents and F3 populations for plant height. Means for plant height expanded from 72.6 to 92.33 cm (Table 2). Highly significant differences were present among parents, F3 populations and Parents vs F3 populations for plant height (Table 3). Selection of tall plant could be helpful for biological yield. Maximum plant height (91.60 cm) was observed in parent Pirsabak-2005 while smallest (72.73 cm) was recorded for Watan. Among F3 populations, tallest plants (92.33 cm) were documented for Pirsabak-2005 × Janbaz, while the shortest plant (72.60 cm) was documented for Saleem-2000 × Janbaz. Similar findings was observed by [11] for plant height.

Heritability in broad sense for the trait plant height varied from 0.36 to 0.82 (Table 4). The uppermost heritability (0.82) was observed for cross, Watan × Janbaz followed by AUP-4008 × Janbaz (0.81) Saleem-2000 x Tatara (0.80) and Fakhr-e-Sarhad × Janbaz(0.79), while the minimum heritability (0.36) was recorded for cross, Fakhr e Sarhad x AUP-5008. Moderate and high value for inheritance related to plant height undermines the role additive gene action and of dominant gene action which is a good indication of non-environmental influence on the genotypes. Our result supports the findings of [12,13]. The greatest genetic advance (32.71 cm) was observed for cross combination, FS × AUP-5008 followed by Barsat × AUP-5008 (22.72 cm) and AUP-4008 × Tatara (13.18 cm) while the lowest genetic advance (0.13 cm) was found for Pirsabak-2005 × AUP-5008 (Table 5). High genetic advance for crosses is an evidence of improvement per breeding cycle. High genetic advance has also been reported [14,15].

Spike length

From the table of mean squares ($P \leq 0.01$) exhibiting highly considerable variations were present among the parents, parents Vs F3 and significant differences in F3 segregants for spike length. The mean spike length was 10.19 cm for parents while it was 10.69 cm for F3 populations. Over all mean for spike length ranged from 9.33 to 12.27 cm. In parents more spike length (11.13 cm) was observed for Barsat while lowest (9.33 cm) was observed for genotype, Watan. Among F3 population longer spike (12.27 cm) observed in P.S-2005 × AUP-5008

Table 1: List of 27 wheat genotypes including 9 parents and 18 F3 populations carried out during study.

Parents	F_3 populations	
Janbaz	AUP-4008 × Janbaz	Saleem-2000 × Janbaz
Pirsabaq-2005	Fakhr-e-Sarhad × Tatara	Watan × AUP-5008
Saleem -2000	AUP-4008 × AUP-5008	Saleem-2000 × AUP-5008
Fakhr-e-Sarhad	Pirsabak-2005 × Janbaz	Watan × Janbaz
Barsat	Pirsabak-2005 × Tatara	Pirsabak-2005 × AUP-5008
AUP-5008	Fakhr-e-Sarhad × AUP-5008	Barsat × AUP-5008
AUP-4008	Fakhr-e-Sarhad × Janbaz	Barsat × Janbaz
Tatara	AUP-4008 × Tatara	Watan × Tatara
Watan	Barsat × Tatara	Saleem-2000 × Tatara

Table 2: Mean squares for different traits of 27 wheat genotypes studied at The University of Agriculture, Peshawar during 2021-22.

SOV	DF	PH	SL	SIPS	FLA	TPP	GS	DH	DM	GYS	TGW	BY	HI
Reps	2	52.34	2.16	1.73	68.03	0.05	6.57	62.31	42.12	0.02	10.15	0.3	56.57
Genotypes	26	95.18**	1.25**	4.83**	74.43**	5.99**	63.79**	29.74**	9.31*	0.06**	36.33**	0.45**	89.85**
Parents	8	130.50**	1.34**	7.34**	118.08**	5.53**	39.53**	33.51**	11.08*	0.01	31.39**	0.35**	127.93**
F3	17	86.47**	1.02*	2.94**	44.11**	6.15**	69.43**	25.16**	8.41*	0.09**	36.95**	0.52**	76.26*
P vs. F3's	1	3.21	4.43**	25.92**	240.78**	6.80**	162**	77.43**	10.38	0.01	65.23**	0	16.17
Error	52	15.51	0.44	1.14	17.92	0.56	10.98	9.36	5.15	0.01	5.23	0.06	41.55
CV (%)	--	4.8	6.31	5.23	10.94	10.93	5.75	2.54	1.48	15.54	6.39	18.59	15.16

*, ** = significant, at 5% and 1% probability, respectively.
Abbreviations: PH - plant height, SL - spike length, SLPS - spike lets spike-1, FLA - flag leaf area, TPP - tillers plant-1, GS- Grins Spike-1, DH - days to heading, DM - days to maturity, GYS - grain yield spike-1 TGW - 1000-grains weight, BY - biological yield, HI -Harvest Index

Table 3: Means values for plant height, spike length and spikelets spike-1, Flag leaf area, Tiller plant-1 and Grains Spike-1 of 27 wheat genotypes evaluated at The University of Agriculture Peshawar during 2021-22.

Genotypes	PH	SL	SLPS	FLA	TPP	GPS
Parents						
AUP-4008	84.33	10.67	21.93	35.46	6.47	56.93
PirSabak-2005	91.6	10.93	18.73	50.23	5.53	52.67
Fakhr-e-Sarhad	86.47	9.8	20.2	33.62	10.4	54.47
Saleem -2000	74.27	9.4	18.2	29.75	7.13	53.67
Barsat	76.27	11.13	19.67	40.32	7.13	58.4
Watan	72.73	9.33	17.4	32.14	6.4	56.13
Janbaz	83.13	9.8	21.53	31.36	7.93	49.87
Tatara	84.8	10	19.4	34.3	7.4	62.6
AUP-5008	82.53	10.67	19.53	39.15	7.07	55.73
Means	**81.79**	**10.19**	**19.62**	**36.25**	**7.27**	**55.6**
F3 populations						
AUP-4008 × Janbaz	86.53	10.8	22.47	41.83	7.4	55.73
AUP-4008 × Tatara	84.27	10.87	21.13	39.25	6.93	60.87
AUP-4008 × AUP-5008	84	10.27	20.6	38.46	6.87	50.6
PirSabak-2005 × Janbaz	92.33	11.27	21.8	44.64	5.53	65
PirSabak-2005 × Tatara	90.67	10.93	20.87	44.87	6.67	60.27
PirSabak-2005 × AUP-5008	82.53	12.27	22.73	49.8	4.73	57.8
Fakhr-e-Sarhad x Janbaz	80.13	10.8	21.27	36.13	6.53	56.93
Fakhr-e-Sarhad × Tatara	82.33	10.13	19.93	38.1	8	59.67
Fakhr-e-Sarhad × AUP 5008	78.87	10.4	20.07	42.77	7.8	57.87
Saleem-2000 × Janbaz	72.6	10.6	21.8	37.24	4.73	68
Saleem-2000 × Tatara	80.07	9.8	20.47	40.29	8.4	55.8
Saleem-2000 × AUP-5008	87	10.67	20.07	35.99	9.8	62.2
Barsat × Janbaz	80.4	11.47	21.4	39.6	6.07	53.2
Barsat × Tatara	77.07	10.67	19.67	39.82	5.93	56.67
Barsat × AUP-5008	78.47	10.93	19.53	40.31	5.07	66.27
Watan × Janbaz	74.2	10.27	19.67	33.34	5.07	50.73
Watan × Tatara	90	10.07	20.07	37.71	8.4	59.87
Watan × AUP-5008	78.4	10.2	21.27	38.37	5.93	57.2
Means	**82.22**	**10.69**	**20.82**	**39.91**	**6.65**	**58.59**
LSD (0.05)	**6.45**	**1.09**	**1.75**	**6.94**	**3.37**	**12.51**

Table 4: Means values for days to heading, days to maturity and grain yield spike-1, Thousand grain weight, Biological Yield and Harvest Index of 27 wheat genotypes evaluated at The University of Agriculture Peshawar during 2021-22

Genotypes	DH	DM	GYS (g)	TGW (g)	BY (kg)	HI
Parents						
AUP-4008	123.33	156.67	0.5	33.1	1.15	44.95
PirSabak-2005	119.33	154.67	0.53	36.17	1.7	32.47
Fakhr-e-Sarhad	120.67	151.33	0.6	41.3	2.05	29.51
Saleem -2000	114.33	151.67	0.5	34.57	1.13	44.96
Barsat	118.67	150.67	0.52	37.9	1.28	41.75
Watan	114	152.33	0.52	39.13	1.17	44.98
Janbaz	120.67	154.67	0.64	41.67	1.52	42.93
Tatara	116.33	153.67	0.58	36.47	1.22	48.66
AUP-5008	122.33	153.33	0.44	33	0.95	46.78
Means	**118.85**	**153.22**	**0.54**	**37.03**	**1.35**	**41.887**
F3 populations						
AUP-4008 × Janbaz	123.33	152	0.54	37.5	1.47	37.19
AUP-4008 × Tatara	119.33	155	0.65	34.97	1.44	46.09
AUP-4008 × AUP-5008	122.33	153.33	0.64	37.3	1.45	44.91
PirSabak-2005 × Janbaz	121.33	156	0.35	36.87	0.92	37.55
PirSabak-2005 × Tatara	123.33	154.67	0.53	37.57	1.29	42.27
PirSabak-2005 × AUP-5008	125.67	155	0.26	24.87	0.7	37.93
Fakhr-e-Sarhad x Janbaz	122.67	156.33	0.42	38.1	1.03	40.57
Fakhr-e-Sarhad × Tatara	122.33	155.33	0.59	33.83	1.43	42.08
Fakhr-e-Sarhad × AUP 5008	125.33	154	0.74	37.4	1.81	40.63
Saleem-2000 × Janbaz	119.33	156.33	0.32	31.67	0.77	41.5
Saleem-2000 × Tatara	118.67	153.67	0.63	37.53	1.85	34.56
Saleem-2000 × AUP-5008	118	151.33	0.82	38.33	1.98	42.09
Barsat × Janbaz	121	154.33	0.45	36.1	1	45.74
Barsat × Tatara	119.67	153.67	0.67	32.93	1.16	57.74
Barsat × AUP-5008	116.67	151.67	0.47	35.73	1.02	45.96
Watan × Janbaz	119.33	154.33	0.5	31.57	1.13	44.45
Watan × Tatara	115	150.67	0.97	38.37	2.2	44.4
Watan × AUP-5008	123.33	154	0.63	31.7	1.42	45.37
Means	**120.93**	**153.98**	**0.57**	**35.13**	**1.33**	**42.83**
LSD (0.05)	**5.012**	**3.72**	**0.33**	**9.11**	**0.82**	**74.42**

while lowest (9.8 cm) was documented for crossS-2000 × Tatara. Highly significant differences among the genotypes are prominent indication of variance in spike length of all genotypes as observed [16].

The broad sense heritability estimates for spike length range from 0.23 to 0.88. The maximum heritability (0.88) was observed in cross combination, Fakhr-e-Sarhad × AUP-5008 followed by Watan × AUP-5008 (0.86), PS-2005 × Tatara (0.85) and Saleem 2000 × AUP-5008 (0.84), while the lowest heritability (0.23) was found in cross combination, Pirsabak- 2005 × Janbaz. The maximum genetic advance (7.33 cm) was found for cross, Watan × AUP-5008, followed by Watan × Janbaz (4.66) while the lowest genetic advance (0.0) was found for Barsat × Janbaz. Large percentage of heritability and genetic gain provides confidence for selecting better plants even at early stage, whereas, high genetic variance reflect the amount of variation and the chance of selection. High genetic advance with heritability for spike length was documented [17]. Similar results were also reported by previous researchers for plant height, days to heading, and spike length [18].

Spikelet's spike^{-1}

Analysis of data for spikelet's spike^{-1} revealed highly considerable variation ($P \leq 0.01$) among the genotypes, parents, F3 and parents vs. F3. The mean value for parents was 19.62 while it was 20.82 for F3 populations. The overall means ranged from17.4 to 22.73. In parents, the maximum spikelet'sspike^{-1} (21.93) were observed for AUP-4008 while minimum (17.4) were observed for genotype, Watan. Among F3 population the maximum spikelet's spike^{-1} (22.73) were recorded for Pirsabak-2005 × AUP-5008 while minimum (19.53) were recorded for Barsat × AUP-5008.Highly significant variances among genotypes and crosses for number of spikelet's spike^{-1} have also been reported [19] in wheat genotypes.

Broad sense heritability for spikelet's spike^{-1} was ranging from 0.24 to 0.87. The greatest heritability (0.87) was found for cross, Pirsabaq-2005 × AUP-5008 followed by Saleem-2000 × AUP-5008 (0.79), Watan ×AUP-5008 (0.76) and AUP-4008 × Tatara (0.73) however the less heritability (0.24) was found for crossP S 2005 × Janbaz. The highest genetic advancement the figure (5.56) was documented for cross, Watan × AUP-5008 followed by AUP-4008 × Janbaz (4.79) while the lowest genetic advance (0.00) was found for Barsat × Janbaz.High broad sense heritability and genetic advancement among F3 populations indicates the presence of fixable genes and, hence, selection in early generation would be fruitful. [20] Narrated same results about spike length.

Table 5: Heritability estimates of 12 different traits for 18 F3 populations of wheat evaluated at The University of Agriculture, Peshawar during 2021-22.

F3 populations	PH	SL	SLPS	FLA	TPP	GPS	DH	DM	GYS(g)	THW(g)	BY (kg)	HI
AUP-4008 × Janbaz	0.81	0.81	0.45	0.25	0.29	0.44	0.8	0.86	0.72	0.79	0.83	0.47
AUP-4008 × Tatara	0.62	0.81	0.73	0.25	0.48	0.37	0.56	0.33	0.88	0.45	0.85	0.49
AUP-4008 × AUP-5008	0.54	0.67	0.41	0.23	0.76	0.2	0.87	0.86	0.55	0.85	0.54	0.58
P S 2005 × Janbaz	0.43	0.23	0.24	0.33	0.45	0.5	0.37	0.36	0.86	0.73	0.79	0.52
P S-2005 × Tatara	0.66	0.85	0.39	0.52	0.57	0.76	0.57	0.58	0.48	0.79	0.39	0.56
PS 2005 × AUP-5008	0.46	0.76	0.87	0.54	0.18	0.73	0.51	0.84	0.51	0.85	0.61	0.39
F S × Janbaz	0.79	0.67	0.35	0.81	0.55	0.6	0.57	0.59	0.83	0.68	0.47	0.62
F S × Tatara	0.46	0.79	0.5	0.83	0.86	0.62	0.75	0.51	0.7	0.55	0.7	0.3
F S × AUP-5008	0.36	0.88	0.73	0.5	0.37	0.64	0.37	0.27	0.87	0.76	0.77	0.41
Saleem-2000 × Janbaz	0.43	0.41	0.43	0.49	0.3	0.28	0.52	0.58	0.85	0.84	0.85	0.43
Saleem-2000 × Tatara	0.8	0.83	0.6	0.63	0.67	0.28	0.49	0.78	0.83	0.22	0.5	0.29
Sal 2000 × AUP-5008	0.44	0.84	0.79	0.86	0.75	0.63	0.54	0.44	0.73	0.76	0.68	0.55
Barsat x Janbaz	0.4	0.38	0.7	0.23	0.47	0.35	0.72	0.69	0.23	0.87	0.42	0.84
Barsat × Tatara	0.42	0.5	0.35	0.89	0.71	0.53	0.83	0.24	0.89	0.39	0.41	0.52
Barsat × AUP-5008	0.72	0.67	0.46	0.34	0.34	0.43	0.51	0.66	0.23	0.68	0.39	0.38
Watan × Janbaz	0.82	0.66	0.72	0.39	0.5	0.63	0.31	0.65	0.78	0.46	0.78	0.82
Watan × Tatara	0.46	0.75	0.26	0.85	0.2	0.53	0.88	0.7	0.84	0.45	0.58	0.44
Watan × AUP-5008	0.75	0.86	0.76	0.87	0.65	0.33	0.76	0.87	0.74	0.76	0.86	0.42

PH - Plant Height, SL - Spike Length, SLPS - Spikelets Spike-1, FLA - Flag Leaf Area, TPP - Fertile Tillers Plant-1, GPS- Grins Spike -1, DH -Days to Heading, DM - Days to Maturity, GYS - Grain Yield Spike-1 TGW - 1000-grains Weight, BY - Biological Yield and HI - Harvest

Flag leaf area

Mean squares of flag leaf area exhibit considerable variations among the genotypes, parents, parents vs. F3 and F3 populations at ($P \leq 0.01$). The overall mean for the trait flag leaf area was 36.25 cm^2 for parents and 39.91 cm^2 for F3 populations. Overall means of flag leaf area ranged from 29.75 to 50.23 cm^2. In parents maximum flag leaf area (50.33 cm^2) was observed for Pirsabak-2005 while minimum (29.75 cm^2) was observed for genotype, Saleem-2000. In case of F3 populations, the wider flag leaf (49.48 cm^2) was observed in crossPirsabak-2005 × AUP-5008 while the minimum (33.34 cm^2) was observed in cross Watan × Janbaz.

For flag leaf area broad sense heritability varied from 0.23 to 0.89, analysis of data indicated that high heritability (0.89) observed in cross, Barsat × Tatara followed by Watan × AUP-5008 (0.87), Saleem-2000 × AUP-5008 (0.86), Watan × Tatara (0.85) and the lowest heritability (0.23) were observed in cross combination AUP- 4008 × AUP- 5008 (Table 4). The highest genetic advance (20.33 cm^2) was observed for cross combination FS × Janbaz followed by FS × Tatara (16.84 cm^2), while the lowest genetic advance (1.95 cm^2) was found for Barsat × AUP-5008. Highest values for the basic tools that is heritability and genetic advance for tall plant suggesting that these traits are less affecting by the environmental and climatic condition so the traits are wholly controlled by genetic factor due to the influence of additive gene so selection in early generation could be helpful have also mentioned medium to high heritability along with less genetic advance for flag leaf area.

Tillers plant^{-1}

Data regarding tillers plant^{-1} showed highly significant variation at ($P \leq 0.01$) for the parents, F3 populations and parent vs. F3 populations. The mean of the parents was 7.27 while the mean for the F3 populations was 6.65. Overall means ranged from 4.73 to 10.4. In parents maximum number of tillers plant^{-1} (10.4) was observed for Fakhr-e-Sarhad while minimum (5.53) was observed for Pirsabak-2005. Among F3 populations, the maximum number of tillers plant^{-1} (9.8) was observed forSaleem-2000 × AUP-5008 while (4.73) was observed for Pirsabak-2005 × AUP-5008. Significant variation among F3 wheat populations have also been mentioned [21].

The heritability estimates for No. of tillers plant^{-1} ranges from 0.18 to 0.86. The greatest heritability (0.86) was recorded for F3 Fakhr-e-Sarhad × Tatara, while the lesser heritability (0.18) was occurred in cross combination, Pirsabak-2005 × AUP-5008. The highest genetic advancement value (6.19) was observed for combination, Watan × Janbaz followed by AUP-4008 × Tatara (4.84), but low genic advancement (0) was found for F3 cross Barsat × Janbaz (Table 5). [22] found high broad sense heritability and high genetic advance in wheat populations. These finding suggest that most of the yield associated traits had different heritability so selection should be done on the basis of high heritable traits.

Grains spike^{-1}

Grains spike^{-1} mean squares data showed considerable variances ($P \leq 0.01$) for the genotypes, parental genotypes, F3 populations and parent cross F3 populations. The mean of grains spike^{-1} was 55.60 for parents while it was 58.59 for F3 populations. Means of grains spike^{-1} ranged from 49.87 to 68.0. In parents, the largest grains spike^{-1} (62.60) was observed for genotype, Tatara, while the smallest (49.87) grains spike^{-1} was mentioned for genotype, Janbaz. Among F3 populations the maximum number of grains spike^{-1} (68.00) was recorded for Saleem-2000 × Janbaz, while the minimum (50.6) was recorded for AUP-4008 × AUP-5008. [23] Have also reported comparable ranges for grains yield with high genetic advance and high heritability.

The heritability for grains spike^{-1} varied from 0.20 to 0.76. The high heritability (0.76) exhibited by Pirsabak-2005 × Tatara. High Heritability for grain spike^{-1} was also observed [24]. The lowest heritability (0.20) was observed for AUP-4008 × AUP-5008. The highest genetic advance value was (7.09) for F3 population Watan × AUP-5008, followed by AUP-4008 × Janbaz (6.74) however the lowest genetic advance (0.16) was found for Barsat × Janbaz. The observations are parallel with the findings [25]. The proper estimate of genetic advancement and heritability could be helpful in the process of desirable traits selection. have also reported less genetic advance and high heritability for most of crosses in wheat.

Days to heading

Days to heading mean squares exhibited large variance ($P \leq 0.01$) for parents, F3 populations and parents vs. F3 populations. The mean value for heading was 118.85 days for parents while for F3 populations the mean observed was 120.93 days. Mean number of days to heading range from 114.33 to 123.33 days. In parents, the greatest number of days to heading (123.33 days) was observed for genotype, AUP-4008, while lowest (114.00 days) was recorded for genotype, Watan. Among F3 population the maximum days to heading (125.67 days) was recorded for PirSabak-2005 × AUP-5008, while the minimum days to heading (115.00 days) was recorded for Watan × Tatara. Almost similar mean values and ranges for days to heading have also been reported [26,27].

The estimates of heritability in broad for days to heading varied from 0.31 to 0.88. The highest heritability (0.88) was revealed by cross combination, Watan × Tatara, followed by AUP-4008 × AUP-5008 (0.87) and Barsat × Tatara (0.83), though the lowest heritability (0.31) was noticed for Watan × Janbaz. The highest genetic progress (35.08 days) was documented for Pirsabak-2005 × Tatara, followed by AUP-4008 × AUP-5008 (33.40 days) and Saleem-2000 × Tatara (32.57 days) while the lowest genetic advance (0.06 days) was found for cross combination, Watan × Tatara. The highest heritability shows less environmental influence on days to heading. [28] Showed low genetic advance and high heritability for most of the crosses in wheat. Similar agreement were also reported by previous researchers for plant height by for days to heading, grain filling period and spike length [29].

Days to maturity

Analysis of variances for days to maturity exhibit considerable variations ($P \leq 0.01$) for parents and F3 populations. The mean numbers of days to maturity for parents were 153.22 days and for F3 populations were 153.98 days. Mean numbers of days to maturity ranged from 151.33 to 156.67 days (Table 6). In parents, the maximum days to reach maturity (156.67 days) were documented for genotype, AUP-4008, while the minimum (150.67 days) were recorded for genotype, Barsat. Among F3 populations, the maximum numbers of days to maturity (156.33 days) were recorded for cross Fakhr-e-Sarhad × Janbaz and Saleem-2000 × Janbaz, closely followed by PirSabak-2005 × Janbaz (156.00 days), whereas, the least numbers of days to maturity (150.67 days) were observed for Watan × Tatara.

The estimates of heritability for days to maturity range from 0.24 to 0.87. The highest heritability (0.87) was noted for Watan × AUP-5008 followed by AUP-4008 × Janbaz (0.86), AUP-4008 × AUP-5008 (0.86) and PS-2005 × AUP-5008 (0.84) while the lowest heritability (0.24) was found for Barsat × Tatara. The utmost genetic advance (34.24 days) was observed for cross Watan × Tatara followed by Saleem-2000 × AUP-5008 (33.58 days) and Saleem-2000 × AUP-5008 (33.57 days) although the lowest genetic advance (0.35) was found for Barsat × Janbaz. Differences among genotypes, parents and crosses having moderate to high heritability for days to reach physiological maturity along with low genetic advance have also been observed [31]. The opposite results to our finding were that of [30] who recorded high heritability with less genetic advance for this trait, this is might be the influence of environment.

Grain yield spike^{-1}

Analysis of data showed highly significant variations ($P \leq 0.01$) for grain yield in genotypes and F3 populations and no prominent variation among parents and parents vs. F3 populations. The mean values observed for parents was 0.54 (g), while for F3 populations it was 0.57 (g). Mean grain yield spike^{-1} varied from 0.32 to 0.97 g. In parents, the more grain yield spike^{-1} (0.64 g) was observed for Janbaz while the minimum (0.44 g) was recorded for AUP-5008. In case of F3 population, the maximum grain yield spike^{-1} (0.97 g) was recorded for Watan × Tatara followed by Saleem-2000 × AUP-5008 (0.82 g) while the minimum (0.26 g) was observed for Pirsabak-2005 × AUP-5008. Highly significant differences among genotypes and crosses have exhibited [32,33].

The heritability for grain yield spike^{-1} varied from 0.23 to 0.89. The highest inheritance rate (0.89) was observed for Barsat × Tatara followed by AUP-4008 × Tatara (0.88) and Pirsabak-2005 × Janbaz (0.86) while the lowest heritability (0.23) was found for both cross combinations Barsat × Janbaz and Barsat × AUP-5008.The highest genetic advance (0.47 g) was for Watan × AUP-5008 followed by Fakhr e Sarhad × AUP-5008 (0.38 g) and Fakhr-e-Sarhad × Janbaz (0.21 g), however the lowest genetic advance was (0) for Barsat × Janbaz.

Table 6: Genetic advance values of 12 different traits for 18 F3 populations of wheat evaluated at The University of Agriculture, Peshawar, during 2021-22.

F3 populations	PH	SL	SLPS	FLA	TPP	GPS	DH	DM	GYS(g)	THW(g)	BY(kg)	HI
AUP-4008 × Janbaz	8.93	0.08	4.79	2.23	1.26	6.74	10.98	0.43	0.12	2.24	0.41	4.63
AUP-4008 × Tatara	13.18	1.75	2.31	5.18	4.86	5.16	7.15	2.54	0.16	1.92	0.32	0.23
AUP-4008 × AUP-5008	10.54	0.54	5.22	2	1.43	1.01	33.4	13.94	0.08	3.78	0.3	5.76
P S 2005 × Janbaz	0.29	0.33	0.44	2.19	2.39	1.98	13.7	7.68	0.14	4.25	0.62	4.69
P S-2005 × Tatara	7.48	0.73	0.14	3.51	0.61	4.25	35.08	9.74	0.07	2.03	0.01	8.26
PS 2005 × AUP-5008	0.13	2.87	3.13	12.63	0.19	4.22	9.18	13.79	0.05	5.62	0.21	3.84
F S × Janbaz	7.37	1.61	0.74	20.33	0.6	3.39	1.83	2.17	0.21	3.27	0.23	7.67
F S × Tatara	3.65	0.73	0.82	16.84	3.21	2.73	22.99	1.38	0.1	3.6	0.47	3.46
F S × AUP-5008	32.71	3.47	0.79	4	0.26	2.27	18.37	0.96	0.38	4.63	0.45	4.26
Saleem-2000 × Janbaz	0.45	2.08	0.8	7.23	0.37	0.93	28.35	4.11	0.17	3.53	0.03	3.29
Saleem-2000 × Tatara	4.94	2.51	0.88	3.7	1.17	0.74	32.57	13.18	0.12	0.41	0.16	4.01
Sal 2000 × AUP-5008	2.17	3.36	1.94	9.97	0.45	0.33	4.99	33.58	0.12	4.28	0.02	7.81
Barsat x Janbaz	4.96	0	0	2.27	0	0.16	0.56	0.35	0	0.13	0	0.7
Barsat × Tatara	12.3	1.73	0.37	10.04	1.43	2.63	16.97	0.66	0.2	2.31	0.19	5.4
Barsat × AUP-5008	22.72	0.54	0.68	1.95	0.25	3.76	4.66	2.44	0.03	3.06	0.14	3.37
Watan × Janbaz	10.83	4.66	1.92	3.13	6.19	3.19	1.9	4.59	0.1	2.35	0	0.29
Watan × Tatara	4.55	0.12	0.28	10.75	2.95	2.12	0.06	34.24	0.1	10.91	0.38	12.4
Watan × AUP-5008	13.5	7.33	5.56	11.5	3.08	7.09	30.45	11.51	0.47	11.15	0.72	5.99

High heritability estimates coupled with low genetic advance indicates non-additive gene action and there for selection in early generation would be not helpful and fruitful, so later generation waiting would be needed. Highest heritability and low genetic advance for grain yield was also observed [34] too.

1000-grain weight

Mean squares for thousand grain weight exhibited notable variations ($P \leq 0.01$) among the genotypes, parents, F3 populations and parent vs. F3 populations. The means observed for parents and F3 populations was from 37.03 g to 35.13 g, respectively. The overall means ranged from 24.87 to 41.67 g. In parents, the largest weight for thousand grains (41.67 g) was observed for Janbaz while the minimum (33.0 g) was recorded for AUP-5008. Among F3 populations, the heaviest thousand grains (38.37 g) was documented for Watan × Tatara followed by Saleem-2000 × AUP-5008 (38.33 g) and Fakhr e Sarhad × Janbaz (38.1 g) while the minimum (24.87 g) was recorded for Pirsabak-2005 × AUP-5008.Highly significant differences among genotypes, parents and crosses have also been reported [35].

The heritability estimates for 1000-grain weight ranged from 0.22 to 0.87. The greatest heritability (0.87) was found for Barsat x Janbaz followed by AUP-4008 × AUP-5008 (0.85) and PS 2005 × AUP-5008 (0.85), while the lowest heritability (0.22) was found for Saleem-2000 × Tatara. The highest genetic advance (11.51 g) was observed for Watan × AUP-5008 followed by Watan × Tatara (10.91) and Pirsabak-2005 × AUP-5008 (5.62), while the lowest genetic advance (0.13 g) was found for Barsat × Janbaz. Highest rate of heritability as well as high genetic advance for the above mention trait were also documented [36] for 1000-grain weight.

Biological yield

Significant change at ($P \leq 0.01$) were observed among the genotypes, parents and F3 genotypes noted for Biological yield.The mean biological yield for parents was 1.35 kg and for F3 populations it was 1.33 kg. The overall means for biological yield ranged from 0.7 to 2.2 kg. The maximum biological yield in parents (2.05 kg) was observed for Fakhr-e-Sarhad while the minimum (0.95 kg) was recorded for AUP-5008. Among F3 population, the maximum biological yield (2.20 kg) was recorded for Watan × Tatara followed by Saleem-2000 × AUP-5008 (1.98 kg), Fakhr-e-Sarhad × AUP-5008 (1.81 kg) and Saleem-2000 × Tatara (1.85 kg) while the minimum yield (0.70 kg) was recorded for Pirsabak-2005 × AUP-5008.Highly significant differences among parents and F3 populations have been reported by.

The estimates of heritability for biological yield from figure 0.39 to 0.86. The greatest heritability (0.86) was observed by Watan × AUP-5008 followed by Saleem-2000 × Janbaz (0.85), AUP-4008 × Tatara (0.85) and Saleem-2000 × Janbaz (0.85) and AUP-4008 × Janbaz (0.83), while the lowest heritability (0.39) was found for Pirsabak-2005 × Tatara and Barsat × AUP-5008.The greatest genetic advance (0.72 kg) was exhibited by F3 Watan × AUP-5008 followed Pirsabak-2005 × Janbaz(0.62 kg) and Fakhr-e-Sarhad × Tatara (0.47 kg) whereas, the lowest genetic advance (0.00) was shown by Barsat × Janbaz and Watan × Janbaz. High broad sense heritability as well as high genetic advance for this trait has been revealed [37,38].

Harvest index

Data and observation regarding harvest index in which mean squares exhibited highly prominent variation ($P \leq 0.01$) in parents and in F3 populations.Mean values for harvest index (41.88) for parental genotypes in which the lowest mean was observed for PirSabak-2005 while the highest mean value was (48.66) shown by AUP-4008, In F3 population the mean value is (42.83) where the lowest value was observed in cross (37.19) by AUP-4008 × Janbaz and the highest value was observed for cross combination Barsat × Tatara (57.74) followed by parental genotype Tatara (48.66) The results were with the same channel with the findings of [39,40].

The heritability varied from 0.29 to 0.84, the highest value for heritability (0.84) was noted for Barsat × Janbaz followed by Watan × Janbaz (0.82) and Fakhr-e-Sarhad × Janbaz (0.62) on the other hand the lowest heritability (0.29) shown by Saleem-2000 × Tatara. Similarly, the highest genetic advance (12.40%) was observed for Watan × Tatara, Pirsabak-2005 × Tatara (8.26%) and Saleem-2000 × AUP-5008 (7.81%) while the lowest genetic advance (0.23 %) was found for AUP-4008 × Janbaz. Our finding are parallel with.

Conclusion

Analysis of variance exposed highly considerable variation among genotypes, parents and F3 populations for tall plants, spikelet's spike^{-1}, flag leaf area, tillers plant^{-1}, grains spike^{-1}, days to heading, thousand grain weight and biological yield. Differences were significant in F3 populations for spike length, days to maturity and harvest index. While non-significant variations were observed among parents for grain yield.

In parents, Janbaz showed shortest plants, more spikelets plant^{-1}, highest grain yield spike^{-1} and 1000-grain weight, days to heading and maturity; whereas in F3 populations, Pirsabak-2005 × AUP-5008 had shortest plants, highest spike length, more spikelets and grains spike^{-1}; Saleem-2000 × Janbaz is early maturing and highest grains spike^{-1} and Watan × Tatara had least numbers of days to heading and maturity and highest grain yield spike^{-1}, thousand grain weight and biological yield.

Based on highest heritability highest genetic advance and mean squares the parental genotype Janbaz and AUP-5008 and the cross combinations AUP-4008 × Janbaz, AUP-4008 × AUP-5008, Pirsabaq-2005 × AUP-5008, Barsat x Janbaz, Watan × Tatara, Watan × AUP-5008, AUP-4008 × Tatara, Pirsabaq--2005 × AUP-5008, Watan × Tatara, and Watan × AUP-5008 exhibited highest figures for yield contributing traits. The parental genotypes AUP-5008 could be used as a donor parent high yielding genotypes in further breeding program.

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