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Research Article

Heritability estimates in F_4 generation of wheat (*Triticum aestivum* L.) under the agro-climatic condition of Tandojam, Sindh-Pakistan

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Abstract

The research studies on heritability estimates were conducted to evaluate the performance of grain yield and various yield components of six F_4 segregating population originated from four parental varieties of bread wheat. The experiment was conducted in Randomized Complete Block Design with 3 replications. The results for six F_4 segregating populations and their four parental wheat varieties for the traits revealed highly significant differences at $P \leq 0.01$ and $P \leq 0.05$ level of probability. Different progenies showed different response for different traits. The progeny Sarsabaz x Bhittai took significantly more days to 75% maturity (128.3), more spike length (14.0 cm) and more spikelets spike^{-1} (21.6). Progeny Sarsabz x FD-83 showed significant increase in grain yield plant^{-1} (29.0g), 1000-grain weight (48.0 g) and tillers plant^{-1} (13.67) as compared to other progenies and the parental lines. The parent varieties Sarsabaz and Bhittai showed good performance with respect to number of tillers plant^{-1} (15.33) and spikelets spike^{-1}(24.3). The progeny FD-83 x Bhittai revealed significant in number of grain spike^{-1} (56.7) and biological yield kg ha^{-1} (22960) as compared to their respective parental lines. Two progenies Nesser x Bhittai and Nesser x FD-83 showed the highest heritability coupled with more genetic advance (GA) for most of the traits measured i.e., days to 75% maturity, spike length, grains spike^{-1} and grain yield plant^{-1}. Four progenies viz., Sarsabaz x Bhittai, FD-83 x Bhittai, Sarsabz x FD-83 and Nesser x Sarsabz showed better performance highest heritability associated with high genetic advance for other characters tillers plant^{-1}, spikelets spike^{-1},1000-grain weight and biological yield kg ha^{-1}. These results suggest that more effective selection could be obtained from these segregating populations for specific traits originated after these combinations.

Keywords: Agro-climatic condition; Heritability; Wheat

Introduction

Bread wheat (*Triticum aestivum* L.) belongs to family Poaceae (grass family) is a staple food for billions of people in the world. The most spread and cultivated species of wheat is *Triticum aestivum* (hexaploid) and the most used variety of wheat currently is *Triticum durum* (tetraploid). The other wheat species like Tritcum dicoccum and Triticum spelta are also cultivated in less quantity [1]. To feed the ever-increasing population in the country, the need for more wheat will continue. There are enough possibilities to increase wheat yields in Pakistan through developing new high yielding varieties and by adoption of proper package of technology [2, 3]. However, if a character or trait is controlled by non additive gene action it gives high heritability but low genetic advance, while the character ruled by additive gene action, heritability and genetic advance both would be high [4]. Heritability values can be used as a measuring scale to determine genetic relationship between parents and progeny. Better heritability values recorded points to the possibility of improvement in the parameters therefore attention may be focused on important traits while synthesizing genotypes. It is also necessary that the extent of association between the important characters be worked out which would serve as a basic for selection in segregating generation. Heritability estimates reported by several workers including [5-7], indicated that certain components of grain yield in wheat are more heritable than yield itself. Ansari [8] have also estimated heritability parameters for yield and yield related traits of the wheat in the segregation populations.

This suggested most likely that heritability is due to the additive genetic effects and selection could be effective in early segregating generations for these traits and the possibility of improvingS durum wheat grain yield through direct selection for grain yield related traits. Similar findings have been reported by Dwived et *al.* and Yousaf et *al*. [9, 10]. Using path coefficient analysis, it is easy to determine which yield component is influencing the yield substantially. Having this information, selection can then be based on that criterion thus making possible great progress through selection.

Materials and methods

The experiment was carried out at the Experimental Farm of Nuclear Institute of Agriculture (NIA), Tandojam during Rabi season 2011-12. Wheat breeding material for research work consisted of six F_4 populations of bread wheat (*Triticum aestivum* L.) along with their four parental lines were evaluated under field conditions. Heritability in broad sense was estimated as suggested by Gardener (1961) [11]. The experiment was laid out in randomized complete block design with three replications arranged in a plot size 0.45 m^2/single spike progeny row (1.35 $m^2/_3$ single spike progeny row) each 1.5 meter long.

There were ten genotypes under study;

Genotypes used under study: 10

Parental varieties: 04

1. Sarsabz
2. Bhittai
3. FD-83
4. Nesser

F_4 Cross combinations

1. Sarsabz x FD-83
2. Sarsabz x Bhittai
3. Nesser x Bhittai
4. FD-83 x Bhittai
5. Nesser x Sarsabz
6. Nesser x FD- 83

The agronomical parameters were observed

Number of tillers plant^{-1}, maturity, Spike length (cm), Number of spikelet spike^{-1}, Number of grains spike^{-1}, 1000-grains weight (g), Grain yield plant^{-1}(g) and Biological yield kg ha^{-1}.

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Results

Wheat breeding material for research work consisted of six F_4 populations of bread wheat (*Triticum aestivum* L.) along with their four parental lines. The observations were recorded on grain yield plant^{-1} and its associated traits to evaluate genetic potential of the F_4 populations.

Analysis of variance

Results suggested that the genotypes (parents and segregating progenies) were significantly ($P \leq 0.05$) different with each other for most of the traits studied under present studies. Mean squares from ANOVA of six F_4 segregating populations and their parental lines for the traits viz., number of tillers plant^{-1}, days to 75% maturity, spike length (cm), number of spikelet spike^{-1}, number of grains spike^{-1}, 1000-grains weight (g), grain yield plant^{-1} (g) and biological yield kg ha^{-1} were highly significant at $P \leq 0.01$ level of probability (Table 1 & 2).

Table 1. Analysis of variance showing mean squares for various morphological traits of six F_4 generations and 4 parental varieties of wheat

Source of variation	Mean square of various traits				
	D.F	**Days to 75 % maturity**	**Tillers plant^{-1}**	**Spike Length**	***Spikelets spike^{-1}***
Replications	2	8.133	2.8000	0.74145	*3.33333*
Genotype	9	126.519**	13.7074 **	4.28282*	*6.16296 $^{N.S}$*
Parents	3	89.4444**	31.6389*	5.03417*	*15.1111***
Hybrids	5	133.956**	5.68889 $^{N.S}$	2.99684 $^{N.S}$	*1.95556 $^{N.S}$*
Parents x Hybrids	1	200.559	0.006	8.4586	*0.3559*
Error	18	5.541	6.2074	1.41135	*3.18519*
Total	*29*				

** = Significant at P≤ 0.01 level of probability, * = Significant at P≤ 0.05, N.S = Non Significant

Table 2. Analysis of variance showing mean squares for various morphological traits of six F_4 generations and 4 parental varieties of wheat

Source of variation	Mean square of various traits				
	D.F	**Number of grains spike^{-1}**	**1000-grain weight**	**Grain yield plant^{-1}**	**Biological yield (kg ha^{-1})**
Replications	2	0.133	34.7338	35.0533	2543293
Genotype	9	284.356 $^{N.S}$	35.6835 $^{N.S}$	56.0183*	250359470.700**
Parents	3	70.0000 $^{N.S}$	26.7497 $^{N.S}$	27.2708 $^{N.S}$	1395253**
Hybrids	5	90.889 $^{N.S}$	37.7002 $^{N.S}$	77.4832 $^{N.S}$	38600000*
Parents x Hybrids	1	1894.67	52.402	34.932	2055714241
Error	18	161.133	33.2365	27.1800	8316090
Total	29				

** = Significant at P≤ 0.01 level of probability, * = Significant at P≤ 0.05, N.S = Non Significant

In Table 3 showed mean performance of F_4 populations and their parental lines. The results revealed that the progeny Sarsabz x Bhittai, Nesser x Bhittai, Sarsabz x FD-83 and FD-83 x Bhittai showed maximum days to 75% maturity (128.3, 127.3, 122.7 and122.7 respectively) as compared their parents. The progeny Nesser x Bhittai showed maximum number of tillers plant^{-1} (23.7) and FD-83 x Bhittai (10.7) as compared to its parents. The result indicated that the six progenies showed good performance as compared to its parents in spike length. The progeny of Nesser x Bhittai produced the longest spikelets spike^{-1} (38.3) and consequently produced maximum grains spike^{-1}. FD-83 x Bhittai (56.3) thus recorded superior performance in this regard. Results indicated that five progenies except FD-83 x Bhittai had significant increase in 1000-grain weight than all the parental varieties. Three progenies maximum in grain yield plant^{-1} was recorded in Sarsabz x FD-83 (29.0), Nesser x Sarsabz (23.0) and Sarsabz x Bhittai (22.3) as compared to its both the parents. Result indicated that five progenies except Nesser x Bhittai had significant increase in biological yield kg ha^{-1} than all the parental varieties.

Table 3. Comparison of mean performance of various traits of six F_4 populations and their 4 parental lines of wheat for various traits

Cross combination	Parents/ cross	Days to 75% Maturity	Tillers plant^{-1}	Spike Length (cm)	Spikelets Spike^{-1}	Grains Spike^{-1}	1000 Grain Weight (g)	Grain Yield plant^{-1} (g)	Biological yield (Kg ha^{-1})
Nesser x Sarsabz	♀	125.7	14.3	11.0	19.6	27.6	37.0	20.0	1307
	♂	114.3	15.3	10.7	20.3	30.7	41.0	19.0	2667
	⊕	127.3	14.0	11.7	21.0	43.0	43.3	23.0	17780
Nesser x FD- 83	♀	125.7	14.3	11.0	19.6	27.6	37.0	20.0	1307
	♂	115.3	8.7	11.3	19.6	35.0	44.0	24.0	2692
	⊕	114.7	11.3	13.6	20.3	45.6	45.6	22.0	20740
Nesser x Bhittai	♀	125.7	14.3	11.0	19.6	27.7	37.0	20.0	1307
	♂	114.7	10.0	13.6	24.3	38.6	40.3	17.0	1792
	⊕	138.33	23.7	2074	38.3	23.7	40.3	17.0	1792
Sarsabz x FD-83	♀	114.3	15.3	10.7	20.3	30.6	41.0	19.0	2667
	♂	115.3	8.7	11.3	19.6	35.0	44.0	24.0	2692
	⊕	122.7	13.7	11.6	22.3	45.0	48.0	29.0	19260
Sarsabz **x** Bhittai	♀	114.3	15.3	10.6	20.3	30.6	41.0	19.0	2667
	♂	114.7	10.0	13.6	24.3	38.6	40.3	17.0	1792
	⊕	128.3	11.7	14.0	21.6	50.6	45.0	22.3	12590
FD-83 x Bhittai	♀	115.3	8.7	11.3	19.6	35.0	44.0	24.0	2692
	♂	114.7	10.0	13.6	24.3	38.6	40.3	17.0	1792
	⊕	122.7	10.7	12.3	20.3	56.3	39.6	13.0	22960
Mean		120.2	12.1	12.2	21.1	42.7	42.2	21.3	12252.8
LSD at 0.05		4.706	4.274	2.080	3.061	21.77	9.928	8.884	4947

Mean performance of F_4 segregating population and their parental lines

Days to 75% maturity

The mean performance for days to 75% maturity is given in Table 4. Significant difference was observed among genotypes for their maturity period. The progenies Sarsabz x Bhittai and Nesser x Sarsabz matured in long duration, both took significantly (P ≤0.05) more days to maturity (128.3 and 127.3 days respectively) followed by parental variety Nesser (125.7 days). Other two progenies Sarsabz x FD-83 and FD-83 x Sarsabz also matured comparatively in longer time (122.7 days). Minimum days to maturity were taken by parental varieties Sarsabz, Bhittai, FD-83 and two progenies viz., Nesser x FD-83, Nesser x Bhittai (114.3, 114.7, 115.3, 114.7 and 116.7 days respectively); however the difference among genotypes was non-significant.

Tillers plant^{-1}

The data regarding the trait number of tillers plant^{-1} of the wheat varieties is depicted in Table 4. The parental line Sarsabz produced significantly the highest number of tillers plant^{-1}(15.3) as compared to all other parent varieties and F_4 progenies; whereas, the minimum number of tillers plant^{-1} (8.67) was recorded in parental line FD-83. All the progenies and parent variety Nesser had produce more number of tillers and the difference among them was non-significant.

Spike length (cm)

Several wheat breeders have reported that spike length is quantitatively inherited and exhibited transgressive segregation with high heritability. (Rajper *et al*., 1990) found a low estimate for spike length. Moderate heritability values recorded could be an indicative of improvement in spike length. The mean performance for spike length is given in (Table 4) showed that maximum spike length was (14.0cm) were produced by progeny Sarsabz x Bhittai; whereas minimum spikes (10.67 and 11.0 cm) were produced by parental lines Sarsabz and Nesser respectively.

Spikelets spike^{-1}

The number of spikelets spike^{-1} depends upon spike length and spike density. The mean performance for spikelets spike^{-1} and it is represented in Table 4 showed that maximum number of spikelets spike^{-1} was (24.3) were observed by parental line Bhittai; whereas, minimum number was recorded in Nesser, FD-83, Sarsabz and progenies FD-83 x Bhittai and Nesser x FD-83.

Grains spike^{-1}

The mean performance for grains spike^{-1} and it is represented in Table 4. Significantly the highest number of grains (56.3) was produced by the progeny FD-83 x Bhittai and lowest grains were produced by parental line Nesser (27.6).

1000-grain weight (g)

The trait 1000-grain weight is a main yield contributing trait. The mean performance for 1000-grain weight and it is represented in Table 5, wheat genotypes ranged between (37.0 to 48.0g). The highest 1000-grain weight recorded in Sarsabz x FD-83 followed by Nesser x FD-83 and Sarsabz x Bhittai.

Grain yield plant^{-1} (g)

Genotypes showed significant differences (p≤0.05) among each other for the main trait final yield. The result of mean performance in Table 5 for the trait grain yield plant^{-1}. The progeny Sarsabz **x** FD-83 showed significantly the highest grain yield plant^{-1} (29.0 g) as compared to other genotypes. The lowest grain yield plant^{-1} (13.0g) was observed in progeny FD-83 **x** Bhittai.

Biological yield (kg ha^{-1})

The result of mean performance in (Table 5) for the trait biological yield skg & kg ha^{-1} indicated the significant difference between F_4 progenies and their parental lines. Result indicated that five progenies except Sarsabz x Bhittai had significant increase in their dry mater weight (biological weight) than all the parental varieties.

Heritability estimates in F_4 generation of wheat

Genetic parameters such as genetic variance, environmental variance, phenotypic variance, heritability percentage in broad sense and genetic advance, for eight different morphological traits were calculated from each six F_4 cross combinations in wheat. The results in details are given as under.

Table 4. Mean performance of six F_4 populations and their 4 parental lines of wheat for various traits

Genotypes	Days to 75% maturity	Tillers plant^{-1}	Spike length (cm)	Spikelets spike^{-1}	Grains spike^{-1}
Nesser	125.7	14.3	11.0	19.6	27.6
Sarsabz	114.3	15.3	10.6	20.3	30.6
FD-83	115.3	8.66	11.3	19.6	35.0
Bhittai	114.7	10.0	13.6	24.3	38.6
Nesser **x** Sarsabz	127.3	14.0	11.6	21.0	43.0
Nesser **x** FD- 83	114.7	11.33	13.6	20.3	45.6
Nesser **x** Bhittai	116.3	11.33	12.3	21.6	54.6
Sarsabz **x** FD-83	122.7	13.67	11.6	22.3	45.0
Sarsabz **x** Bhittai	128.3	11.67	14.0	21.6	50.6
FD-83 **x** Bhittai	122.7	10.67	12.3	20.3	56.3
Mean	120.2	12.1	12.2	21.1	42.7
LSD at 0.05	4.706	4.274	2.080	3.061	21.77

Table 5. Mean performance of six F_4 populations and their 4 parental lines of wheat for various traits

Genotypes	1000-grain weight (g)	Grain yield plant^{-1}	Biological yield (kg ha^{-1})
Nesser	37.0	20.0	1307
Sarsabz	41.0	19.0	2667
FD-83	44.0	24.0	2692
Bhittai	40.3	17.0	1792
Nesser **x** Sarsabz	43.3	23.0	17780
Nesser **x** FD- 83	45.6	22.0	20740
Nesser **x** Bhittai	38.3	23.6	20740
Sarsabz **x** FD-83	48.0	29.0	19260
Sarsabz **x** Bhittai	45.0	22.3	12590
FD-83 **x** Bhittai	39.6	13.00	22960
Mean	42.2	21.3	12252.8
LSD at 0.05	9.928	8.884	4947

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Days to 75% maturity

The mean performance for days to 75% maturity is given in Table 6. The heritability percentage (h^2) in broad sense for the character days to maturity of progenies ranged from (16.0-99.39 %), in Sarsabz x Bhittai (16.0%), Sarsabz x FD-83 (66.6%), Nesser x FD-83 (78.0%), to Nesser x Bhittai (99.39%), Nesser x Sarsabz (98.1%) and (80.0 %) in FD-83 x Bhittai (Table 6). Two progenies Nesser x Bhittai, Nesser x Sarsabz showed the highest (99.39 % and 98.1% respectively) heritability (b.s) coupled with more genetic advance (G.A 15.05, and 8.43 % respectively).

Tillers plant^{-1}

The mean performance for Tillers plant^{-1} is given in (Table 6). The heritability percentage (h^2) in broad sense regarding the trait Tillers plant^{-1} ranged from (12.62 – 66.64 %) in Nesser x Bhittai (12.62%), Sarsabz x FD-83 (18.29%), (23.5%) Nesser x Sarsabz, FD-83 x Bhittai (26.92%) to Sarsabz x Bhittai (66.6 %), followed by Nesser x FD-83 (43.6 %). Both progenies Sarsabz x Bhittai and Nesser x FD-83 showed the highest heritability coupled with the high genetic advance (G.A 4.79, and 2.86 % respectively).

Spike length (cm)

The mean performance for spike length is given in (Table 7). The heritability percentage (h^2) in broad sense for the character spike length ranged from (6.89 & 84.78 %) in the progenies Nesser x Sarsabz (6.89%), Sarsabz x Bhittai (21.32%), Nesser x FD-83 (22.72 %), Nesser x Bhittai (90.27%), FD-83 x Bhittai (84.78%) and (64.6%) Sarsabz x FD-83. Two progenies showed maximum (90.27 % and 84.78%) heritability (b.s) coupled with more genetic advance (G.A 3.35 %, and 1.15 % respectively).

Spikelets spike^{-1}

The mean performance for spikelets spike^{-1} and it is represented in Table 7. The heritability percentage (h^2) in broad sense for the character spikelets spike^{-1} of progenies ranged from (5.33 %) in three progenies Nesser x Bhittai, Sarsabz x FD-83, Sarsabz x Bhittai to (62.5%) Nesser x Sarsabz. The highest heritability percentage was shown by FD-83 x Bhittai and Nesser x FD-83 (85.05 % and 83.95 % respectively). Both the progenies are good combiner and also showed highest genetic advanced value i.e. (5.39 and 5.21 % respectively)

Grains spike^{-1}

The mean performance for grains spike^{-1} and it is represented in (Table 8). The character grains spike^{-1} of all the progenies showed positive heritability percentage ranged from (57.96 % to 94.32 %). The highest heritability percentage was recorded in Nesser x Bhittai (94.32 %) followed by Nesser x FD-83 (93.75 %), coupled with more genetic advance (35.82 % and 42.83 % respectively).

1000-grain weight (g)

The mean performance for 1000-grain weight is given in (Table 8). In broad sense, the heritability %age of all the genotypes for the trait seed index (1000-grain weight g) varied from (4.03, 36.02,40.0,48.37& 65.97 %) in Nesser x FD-83, FD-83 x Bhittai, Nesser x Sarsabz, Sarsabz x Bhittai and Nesser x Bhittai to (89.83 %) in Sarsabz x FD-83. The highest heritability percentage was observed in Sarsabz x FD-83 (89.83 %), coupled with highest genetic advance (G.A 42.90 % respectively).

Grain yield plant^{-1}

The mean performance for grain yield plant^{-1} and it is represented in (Table 9). The character grain yield plant^{-1} of all the progenies showed positive heritability percentage ranged from 12.80 % in Sarsabz x Bhittai to 77.39 % in Nesser x FD-83. The highest heritability (h^2) percentage was recorded in Nesser x FD-83 (77.39 %) coupled with more genetic advance (18.22 %), in Nesser x Sarsabz (29.98%), Nesser x

Bhittai (40.63%), Sarsabz x FD-83 (47.8%), and FD-83 x Bhittai (62.05%). All the progenies showed minimum heritability percentage for the trait grain yield plant^{-1}.

Biological yield kg ha^{-1}

All the genotypes showed positive heritability percentage (h^2) in broad sense for the trait biological yield. All the progenies showed highest percentage regarding this trait. The mean performance for biological yield kg ha^{-1} is given in Table 9. The maximum heritability percentage was noted in Nesser x Sarsabz (99.9 %) followed by FD-83 x Bhittai (99.96 %) coupled with more genetic advance (G.A 11898.7 % and 9425.6 % respectively).

Table 6. Genetic parameters viz., genetic variance, heritability percentage and genetic advance for traits Days to 75% Maturity and Number of tillers plant-^{1}, of 6 F_4 populations of wheat

F_4 Progenies	Days to 75% Maturity				Tillers plant^{-1}			
	v.e	**v.g**	**h^2**	**G.A**	**v.e**	**v.g**	**h^2**	**G.A**
Nesser **x** Sarsabz	0.33	17.1	98.1	8.43	5.35	1.6	23.5	1.25
Nesser **x** FD-83	0.33	1.1	78.0	1.96	5.92	4.5	43.6	2.86
Nesser **x** Bhittai	0.33	54.1	99.39	15.05	8.17	1.18	12.62	0.75
Sarsabz **x** FD83	0.5	1.0	66.6	1.65	1.92	0.4	18.29	0.56
Sarsabz **x** Bhittai	0.42	0.08	16.0	0.23	4.17	8.3	66.64	4.79
FD-83 **x** Bhittai	0.5	2.0	80.0	2.60	4.75	1.7	26.92	1.36

Table 7. Genetic parameters viz., genetic variance, heritability percentage and genetic advance for traits Spike Length and Spikelets Spike-^{1}, of 6 F_4 populations of wheat

F_4 Progenies	Spike Length				Spikelets Spike^{-1}			
	v.e	**v.g**	**h^2**	**G.A**	**v.e**	**v.g**	**h^2**	**G.A**
Nesser **x** Sarsabz	1.35	0.1	6.89	0.14	1.5	2.5	62.5	2.55
Nesser **x** FD- 83	0.34	0.1	22.72	0.29	1.5	7.85	83.95	5.21
Nesser **x** Bhittai	0.32	2.97	90.27	3.35	1.42	0.08	5.33	0.12
Sarsabz **x** FD83	1.09	1.99	64.6	2.30	1.42	0.08	5.33	0.12
Sarsabz **x** Bhittai	1.07	0.2	21.32	0.50	1.42	0.08	5.33	0.12
FD-83 **x** Bhittai	0.06	0.39	84.78	1.15	1.42	8.02	85.05	5.39

Table 8. Genetic parameters viz., genetic variance, heritability percentage and genetic advance for traits Grains Spike^{-1} and 1000 Grain Weight, of 6 F_4 populations of wheat

F_4 Progenies	Grains Spike^{-1}				1000 Grain Weight (g)			
	v.e	**v.g**	**h^2**	**G.A**	**v.e**	**v.g**	**h^2**	**G.A**
Nesser **x** Sarsabz	40.5	71.5	63.83	13.73	19.4	13.02	40.0	4.69
Nesser **x** FD- 83	31.2	468.7	93.75	42.83	20.46	0.86	4.03	0.37
Nesser **x** Bhittai	19.4	322.9	94.32	35.82	8.89	17.24	65.97	6.84
Sarsabz **x** FD83	42.2	58.2	57.96	11.76	55.17	492.2	89.83	42.90
Sarsabz **x** Bhittai	33.4	127.0	79.17	20.60	11.10	10.4	48.37	4.57
FD-83 **x** Bhittai	24.1	86.3	78.12	16.88	45.13	25.41	36.02	6.22

Table 9. Genetic parameters viz., genetic variance, heritability percentage and genetic advance for traits Grain Yield plant-^{1} and Biological yield plot^{-1} kg ha^{-1}, of 6 F_4 populations of wheat

F_4 Progenies	Grain Yield plant^{-1}				Biological yield kg ha^{-1}			
	v.e	v.g	h^2	G.A	v.e	v.g	h^2	G.A
Nesser **x** Sarsabz	20.80	8.91	29.98	3.25	3154.25	34560277.8	99.9	11898.7
Nesser **x** FD-83	29.87	102.27	77.39	18.22	3942.75	11516238	99.16	6921.9
Nesser **x** Bhittai	15.03	10.29	40.63	4.14	3577.59	1642480.01	99.78	2616.3
Sarsabz **x** FD-83	20.98	19.22	47.8	6.13	6564.5	1635048.5	99.60	2612.8
Sarsabz **x** Bhittai	6.13	0.9	12.80	0.65	6199.34	6556994	99.90	5224.5
FD-83 **x** Bhittai	15.19	24.84	62.05	8.07	6987.84	21354058	99.96	9425.6

Discussion

The result obtained regarding heritability parameters for grain yield and its important yield components present as under.

The combined analysis of variance for all the genotypes (including four parents and their six F_4 progenies) depicted that both the parents and segregating populations differed significantly at P≥ 0.01 for most of the characters understudy, indicating the existence of great genetic variability among the genotypes (Table 1). The ANOVA for all the traits of six F_4 segregating populations are summarized in (Table 1 & 2). Results suggested that the genotypes (parents and segregating progenies) were significantly (P ≤0.05) different with each other for most of the traits studied under present studies. Mean squares from ANOVA of six F_4 segregating populations and their parental lines for the traits viz number of tillers plant^{-1}, days to 75% maturity, spike length (cm), number of spikelets spike^{-1}, number of grains spike^{-1}, 1000-grains weight (g), grain yield plant^{-1}(g) and biological yield plot^{-1} and kg ha^{1} were highly significant at P ≤ 0.01 level of probability.

The mean performance for days to 75% maturity is given in (Table 1) and ANOVA is represented in (Table 4). The progenies Sarsabz **x** Bhittai (128.3) and Nesser x Sarsabz (127.3) matured in long duration both took significantly (P≤0.05) maximum days to maturity. The results indicated that minimum days to maturity were taken by three parental varieties Sarsabz, Bhittai and FD-83 (114.3, 114.7, and 115.3 day respectively) and two progenies Nesser x FD-83 and Nesser x Bhittai (114.7 and 116.3 days respectively). Hence these progenies are considered as early maturing genotypes. These parental lines and progenies showed non-significant results for days to maturity. Rauf *et al*. **[12]** the rate and degree of seedling establishment are extremely important factors to determine both yield and time of maturity. This character implies the importance towards both vegetative and reproductive stages of crop.

The data regarding the trait number of tillers plant^{-1} of the wheat varieties is depicted in (Table 4), whereas mean square analysis of variance is represented in (Table 1). The results indicated significant differences among progenies at P≤0.01. The results showed that maximum number of tillers plant^{-1} was produced by parental line Sarsabz (15.3) as compared to all other parent varieties and F_4 progenies; whereas, the minimum number of tillers plant^{-1} (8.66) was recorded in parental line FD-83. All the progenies and parent variety Nesser had produce more number of tillers and the difference among them was non-significant. Memon *et al*. **[13]** reported that the expression of the trait number of tillers depends on its genetic control in their present hence transgressed to their hybrids. Thus it may be inferred that selection for number of tiller plant^{-1} would be effective. The results of this study corroborate with those of the findings of Mahmood and Shahid **[14]**.

The mean square of ANOVA in (Table 1) showed significant difference among the six F_4 progenies and their 4 parental lines of wheat for various traits. The mean performance in (Table 4) showed that maximum spike length was (14.0cm) in Sarsabz x Bhittai; whereas minimum spike length with (10.67 and 11.0 cm) were produced by parental lines Sarsabz and Nesser respectively. Pawar *et al.* **[15]** suggested that single spike and single plant selection could be used to supplement pedigree selection in early segregating generation.

Number of spikelets spike^{-1} may directly contribute towards grain yield. The analysis of variance showed significant difference among heritability values as shown in (Table 1). Generally spikes with more number of spikelets spike^{-1} are supposed to produce more grains per spike, consequently produce higher yield plant^{-1}. The mean performance in (Table 4) showed that the maximum number of spikelets spike^{-1} (24.3) were produced by parental line Bhittai; whereas, a comparison of mean value indicated that number of spikelets spike^{-1} was minimum in Nesser, FD-83, Sarsabz and in progenies FD-83 x Bhittai and Nesser x FD-83.

According to Rajaram *et al.* **[16]**, number of grains per spike is an important component of yield; therefore any change in grain number will ultimately affect grain yield. The mean performance showed significant difference at P≤0.01 among the progenies regarding the trait grains spike^{-1}, and it is represented in (Table 4). It indicated that a grain spike^{-1} was a highly variable character among genotypes and ranged from (56.3) was produced by the progeny FD-83 x Bhittai and lowest grains were produced by parental line Nesser (27.6).

The values of the heritability obtained for 1000-grain weight were low that matches with the values obtained by Al-Marakby *et al*. **[17]**. However, there are other studies, in which moderate and high values for the heritability regarding the 1000-grain weight have been obtained **[18, 19]**. Statistical analysis of the data revealed the significant differences among genotypes for 1000-grain weight. Highest heritability value is (48.00) recoded for genotype Sarsabz x FD-83, whereas, lowest heritability value is (37.00) produced by parental line Nesser.

Heritability estimates reported by Krayljevic (1986), Molotkov (1990), Nanda *et al*., (1982), Olivero Camargo (1989) and Rehman & Kronstad (1992) **[20-24]** indicated that certain components of grain yield in wheat are more heritable than others. The grain yield is the total out-put of yield components. The mean performances of progenies were highly significant at P≤0.01. The average performance of grain yield per plant of genotypes also showed significant differences (Table 5). The maximum grains spike^{-1} (29.0 g) were recorded in progeny Sarsabz **x** FD-83 as compared to other genotypes. The minimum grain yield plant^{-1} (13.0g) was observed in progeny FD-83 **x** Bhittai.

Highly significant differences were observed among wheat genotypes for biological yield in both the environments. The mean performances (Table 5) of progenies were highly significant at P≤0.01 among the progenies regarding the trait biological yield kg ha^{-1}. The maximum biological yield^{-1} kg ha^{-1} was showed by (22960) FD-83 x

Bhittai. This progeny showed significant increase in their dry mater (biological weight) than all the parental varieties. Both the progenies are good combiner and also showed Nesser x FD-83 and Nesser x Bhittai (2074). The yield is a total of genetic expression of all the yield components and believed to be a very complex character and its manifestation is influenced by the environmental as well as physiological factors **[25-28]**.

It is evident that earlier maturity of wheat may be caused by high heritability associated with low genetic advance and is probably due to non-additive gene (dominance and epistasis) effects **[29]**. The result on heritability percentage (h^2) in broad sense for the character days to maturity of progenies are shown in (Table 6). Two progenies indicates that heritability percentage estimates for days taken to maturity, maximum percentage was observed in Nesser x Bhittai followed by Nesser x Sarsabz (99.39 % and 98.1 %) coupled with more genetic advance (G.A 15.05, and 8.43 respectively).While the minimum heritability percentage was shown by Sarsabz x FD-83, Sarsabz x Bhittai and FD-83 x Bhittai and Nesser x FD-83 these progenies showed minimum heritability value for the parameters days to maturity.

The similar results were reported by Ansari *et al*. and Ansari **[9, 30]**.They reported high heritability coupled with high genetic advance in bread wheat hybrids therefore suggested that the selection scope for the number of tillers would be more effective for the improvement of trait and for yield as well. It is observed from (Table 6) that the progeny Sarsabz x Bhittai (66.6 %) reflected highest heritability (h^2) associated with the highest genetic advance (4.79 respectively). Kheiralla **[31]** they also observed moderate heritability and genetic advance values for productive tillers while studying the gene interaction for the inheritance of in hybrids of winter bread wheat.

Moderate to high range of heritability with higher coefficient of genetic variation for spike length have been reported by Kheiralla **[32]** in two cycles of selection. Similar results are also reported by Khan *et al*. **[33]** in F_2 population of six cross combinations indicating greater magnitude of heritability with greater genetic advance for yield and other agronomic characters. The heritability percentage in broad sense regarding the trait spike length (Table 4) that the progeny Nesser x Bhittai (90.27%) showed highest heritability percentage associated with the highest genetic advance (G.A 3.35 respectively). For effective selection, association of characters with yield and among themselves and the extent of environmental influence on the expression of these characters are necessary.

Number of spikelets spike^{-1} may directly contribute towards grain yield. The analysis of variance showed significant difference among genotypes and is represented ANOVA in (Table 1). Generally spikes with more number of spikelets spike^{-1} are supposed to produce more grains spike^{-1}, consequently produce higher yield plant^{-1}. High heritability in wheat has been observed by various researchers for spikelet spike^{-1} **[34, 35]**. The mean performance showed significant difference at P≤0.01 among the progenies regarding the trait grains spike^{-1}, and it is represented in (Table 7). Similarly, the cross that showed maximum heritability percentage was FD-83 x Bhittai (85.05 %) showed highest heritability (h^2) percentage coupled with more genetic advanced (G.A 5.39 respectively).

Our results are similar to those reported by Mothatasham *et al.*, (2009) and Sial *et al.* (2007). Hassan, (2003) **[36-38]** the parameters grains spike^{-1} has direct influence on yield while, more the number of grains will get more grains yield. The results of

average performance for character grains spike^{-1} is represented in (Table 7). The maximum grains spike^{-1} that the progeny Nesser x Bhittai (94.32 %) reflected highest heritability (h^2) associated with the highest genetic advance (42.83) followed by Nesser x FD-83 respectively. A fairly high heritability and genetic advance of all the combinations for grains spike^{-1} indicated that progenies of these crosses would be useful for improving grains spike^{-1}.
The analysis of variance showed significant difference at P≤0.01 among genotypes regarding the trait grains spike^{-1}, and is represented in (Table 1). High heritability associated with high genetic advance for different yield components have a better scope for selecting high yielding genotypes **[25]**. The heritability and genetic advance regarding the traits seed index 1000-grain weight (g) are shown in (Table 7). Similarly, the cross that showed maximum heritability percentage was Sarsabz x FD-83 (89.83 %), coupled with highest genetic advance (G.A 42.90 % respectively). While the five minimum progenies Nesser x FD-83, FD-83 x Bhittai, Nesser x Sarsabz, Sarsabz x Bhittai & Nesser x Bhittai showed positive value regarding this character. Hence, such genotypes should be utilized for further studies on heritability estimates as they may provides which more 1000-grain weight, consequently more yield in wheat.
Grain yield is governed by such matric traits and the correlation between different parameters. Several research studies have been carried out on relationship of various yield components and also climatic factors with grain yield and its related traits **[11]**. It is observed from (Table 8), the maximum heritability percentage was Nesser x FD-83 (77.39 %), associated with more genetic advance (18.22 respectively). Heritability estimates reported by Rehman and Kronstad **[26]** indicate that certain components of grain yield in wheat are more heritable than others.
The heritability and genetic advance regarding the traits biological yield kg ha^{-1} are presented in (Table 8). All the progenies showed positive heritability percentage (h^2) in broad sense, for the trait biological yield maximum yield per plant was exhibited by FD-83 x Bhittai (99.96 kg ha^{-1}), whereas; minimum yield was produced by Nesser x Sarsabz (99.9 kg ha^{-1}) coupled with more genetic advance (G.A 11898.7 and 9425.6 kg ha^{-1} respectively). Genetic parameters for yield traits in wheat under 976 biological yields were comparatively greater under rainfed environment.

Conclusion

It is concluded that four progenies Sarsabaz x Bhittai, FD-83 x Bhittai, Sarsabaz x FD-83, Nesser x FD-83 and Nesser x Bhittai showed better performance for maximum days to maturity as compared to their respective parental lines. Whereas, heritability was found

Authors' contributions

Conceived and designed the experiments: MA Siyal & R Khanzada, Performed the experiments: R Khanzad, S Bano & S Arain, Analyzed the data: AA Kaleri & S Sayed, Contributed materials/ analysis/ tools: MA Siyal, Wrote the paper: MK Soothar & S Nazeer.

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