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Variability and Interrelationship of Nine Quantitative Characters in F_5 Bulks of Five Wheat Crosses

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Abstract: Variability, heritability, genetic advance and association of nine characters including yield in fifty F_5 bulk lines of five wheat crosses viz. Kanchan×DSN-34 (1), Kanchan×YC-17 (2), Kanchan×YC-16 (3), Kanchan×BW-115 (4) and Kanchan×Ad-119 (5) were studied. All the characters studied e.g. days to anthesis, grain filling duration, spikes plant^{-1}, plant height, grains spike^{-1}, 100-grain weight, biomass plant^{-1}, harvest index and yield plant^{-1} showed significant variation in all crosses. However, the expression of the traits in all crosses was not similar. Very high heritability and moderate genetic advance for days to anthesis and biomass plant^{-1} in crosses 1, 2 and 3 suggested the predominance of additive genetic variation for this two traits. Similar expression was observed for grain filling duration in crosses 1 and 2. Very high heritability and moderate to high genetic advance were observed for spike plant^{-1} in crosses 2, 4 and 5; plant height in crosses 1, 2 and 4; harvest index in crosses 2 and 3; grains spike^{-1} and yield plant^{-1} in all crosses. The heritability for 100-grain weight however, was moderate to high with low to very low genetic advance. Days to anthesis showed negative association with grain filling duration in crosses 1 and 3 and significant positive correlation with plant height, biomass plant $^{-1}$ and yield plant^{-1} in cross 1 and with grains spike^{-1} in crosses 1 and 4. Grain filling duration showed mostly significant or non-significant negative correlation with all the traits with one exception where it showed significant positive correlation with 100-grain weight in cross 4. Spikes plant^{-1} and plant height showed significant positive correlation with biomass plant^{-1} and yield plant^{-1} in most crosses with few exception. The trait 100-grain weight did not show any significant correlation with any trait except in one occasion. Biomass plant^{-1} and harvest index showed significant positive correlation with yield plant^{-1} in most crosses, however, they did not show any significant correlation between biomass and harvest index.

Key words: Variability, heritability, genetic advance, wheat cross, F_5 bulk, yield

INTRODUCTION

Yield is a complex trait, which is the result of interaction between a number of inherent potentialities and the environment. The grain yield of wheat can be improved through indirect selection on the basis of yield components. But an increase in one component might result in an increase or decrease of the other components because of the competition for available assimilates. So, favorable combination of yield contributing characters into a genotype may improve its yielding capacity. But it is difficult to judge the proportion of the heritable and environmental variability. The magnitude of heritable variability and more particularly its genetic components is clearly the most important aspects of the genetic constitution of the breeding material, which has a close bearing on its response to selection. Selection of high yielding genotype is therefore, necessary for a particular set of growing environment. The success and efficiency of such selection mainly depends on the type and direction of correlation between yield and its components[1,2]. Indirect selection based on one or more grain yield components has been considered to be more effective than the direct selection for grain yield[3]. As a result, the inheritance and interrelationship of grain yield and its components are important. Gebeyehou *et al.*[4] reported the length of grain filling period as one of the important factor to increase the grains per spike and yield in durum. But Nass and Reiser[5], Metzger *et al.*[6] reported that the length of the grain filling period was not an important factor in determining yield in wheat and barley. It would be easier to increase total yield by selecting yield components such as thousand kernel weight, number of plants per unit area, average number of

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kernels per spike, spike length, harvest index and biomass, etc[7]. Success of selection on grain yield components depends on the correlation between the yield components and the yield[2]. Knowledge of genetic variability, nature and extent of association of various component characters with yield are, therefore, important for genetic improvement of yield and other characters. Considering these facts the present study was undertaken to measure variability, heritability, genetic advance and association of nine characters on fifty F_5 bulk lines of five wheat crosses including their common parent.

MATERIALS AND METHODS

The present study was conducted at the experimental farm of Bangladesh Agricultural University, Mymensingh during 1999-2000.The experimental materials consisted of fifty F_5 bulk lines obtained from five different crosses (10 lines from each cross) and one common parent, 'Kanchan' of the crosses. These crosses were Kanchan × DSN-34, Kanchan × YC-17, Kanchan × YC-16, Kanchan × BW-115 and Kanchan × Ad-119. Seeds of F_5 bulk lines and their common parent 'Kanchan' were planted in a randomized complete block design with three replications at the Field Laboratory of the Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh. Two-row plot of 2.5 m long was used for each F_5 bulk line buffered by a single row of their common parent, Kanchan. So, there are 11 entries (10 F_5 bulk lines and Kanchan) for each cross in each replication. Entries of each cross were grown separately in the adjacent plots. Distance within and between the plants was 5 and 20 cm, respectively. At maturity 5 plants were randomly selected from the middle part of the two rows of each F_5 bulk line for recording data on spike plant^{-1}, grains spike^{-1}, plant height, biomass plant^{-1} and grain yield plant $^{-1}$. Data on days to anthesis and grain filling duration were recorded on whole plot basis and mean values were subjected to statistical analysis. The mean data for different traits were analyzed for variance and means were separated by DMRT as cited by Zaman *et al.*[8]. Genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance were estimated following the method suggested by Singh and Chaudhury[9] and Allard[10]. Simple correlation was also determined among the characters studied.

RESULTS AND DISCUSSION

The analysis of variance in five crosses as presented in Table 1 showed highly significant variations among the entries of different crosses for all the traits studied. The mean value of five crosses exhibited that the cross Kanchan×BW-115 required the lowest duration (72 days) for anthesis while it was the highest (78 days) in the cross Kanchan×YC-16. The mean grain filling duration was similar (38 days) in all crosses except Kanchan×YC-17 (43 days). The variability for days to anthesis was lower than that of grain filling duration. Among the crosses the variability and ranges for days to anthesis and grain filling duration were lower in Kanchan×BW-115 and Kanchan×Ad-119 than other three crosses. High heritability, but low genetic advance for days to anthesis and moderate heritability with low to very low genetic advance were observed in these two crosses. This result suggested the importance of additive genes for controlling this character in first three crosses (Table 2). This result is in close agreement with the observation of Moghaddam *et al.*[11-13]. Days to anthesis was negatively correlated with grain filling duration, spike plant^{-1}, 100-grain weight and it was positively correlated with grain spike^{-1}, biomass plant^{-1}, harvest index and yield plant^{-1} in most of the crosses. Grain filling period was significantly and negatively correlated with grain spike^{-1}, which means longer grain filling period is accompanied with lower grain number. It was also negatively correlated with biomass plant^{-1}, harvest index and yield plant^{-1} in some of the crosses. But Budak[14] reported that there were no significant correlation between grain yield and heading date in both durum and bread wheat.

Very high genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance were found in two crosses, viz., Kanchan×YC-17 and Kanchan×Ad-119 for spike plant^{-1}. This result indicating that the character was mainly controlled by additive gene action in these two crosses. Significant positive correlation between biomass and grain yield was also found in these two crosses. This is because the higher number of spike in a plant might give higher biomass and grain yield. Similar results were reported by Yadav and Mishra[15] and Tiwari and Rawat[16].

The average plant height was the highest in Kanchan×DSN-34 cross. Very high GCV, PCV, heritability and genetic advance for plant height were also found in this cross. The difference between GCV and PCV was very small in all the crosses, which suggested that the expression of this character was mainly due to genetic effects and could be modified by selection. Significant positive correlation of this trait with grain yield and biomass was observed in first three crosses (Table 3). Plant height also showed significant positive correlation with days to anthesis and significant negative correlation with grain filling period in cross KanchanxDSN-34. This result is similar to the findings of Budak and Yildirim[17], Pandit and Islam[18], Yagbasanlar *et al.*[19].

Table 1: Analysis of variance for the measured traits of F_5 bulk lines in five wheat crosses

		Traits								
Crosses	Sources of variation	Days to anthesis	Grain filling duration	Spike plant^{-1}	Plant height	Grains spike^{-1}	100-grain weight	Biomass plant^{-1}	Harvest index	Yield plant^{-1}
Kanchan ×DSN-34	Replication(2 df)	2.45	0.98	0.38	8.26	18.05*	0.01	2.54	1.49	0.10
	Entry(10 df)	113.67**	102.43**	4.67**	1979.31**	371.77**	0.14**	106.92**	15.17**	17.67**
	Error(20 df)	0.76	2.72	0.28	8.35	1.98	0.02	0.81	0.81	0.38
Kanchan ×YC-17	Replication(2 df)	2.03	11.69	0.34	6.04	4.67	0.04	3.31	0.02	0.21
	Entry(10 df)	70.39**	62.76**	2.32**	301.77**	662.76**	0.40**	85.63**	260.67**	19.03**
	Error(20 df)	1.40	2.72	0.51	4.99	1.84	0.05	1.41	0.93	0.14
Kanchan×YC-16	Replication(2 df)	11.72	0.46	2.49	21.75	4.18	0.02	2.08	1.07	1.14
	Entry(10 df)	62.89**	45.56**	2.08**	71.36**	606.65**	0.42**	62.99**	359.96**	18.06**
	Error(20 df)	1.79	8.27	0.34	2.51	1.44	0.05	1.08	0.41	0.24
Kanchan×BW-115	Replication(2 df)	1.12	5.17*	0.12	2.18	1.75	0.02	2.37	0.98	0.48
	Entry(10 df)	22.30**	3.72**	4.63**	358.24**	247.79**	0.72**	20.96**	95.78**	10.34**
	Error(20 df)	1.49	1.07	0.36	2.45	1.90	0.07	3.11	0.36	0.52
Kanchan ×Ad-119	Replication(2 df)	4.46	32.10	0.99	13.29	6.83	0.06	2.42	0.28	0.45
	Entry(10 df)	21.21**	28.35**	3.70**	43.46**	72.83**	0.12**	24.68**	32.67**	5.90**
	Error(20 df)	1.89	5.17	0.31	2.01	2.71	0.03	3.72	0.53	0.73

*, ** Significant at 0.05 and 0.01% level of probability, respectively

Table 2: Estimates of genetic parameters for different traits of five wheat crosses

				Coefficient of variation			
Characters	Crosses	Mean ± SE	Range	GCV	PCV	Broad sense heritability h2b(%)	Genetic advance (%)
Days to anthesis	Kanchan ×DSN-34	77.09±0.50	67.67-84.00	7.96	8.04	98.02	16.23
	Kanchan ×YC-17	73.61±0.68	68.67-86.33	6.51	6.71	94.27	13.03
	Kanchan×YC-16	77.55±0.77	70.67-84.67	5.81	6.07	91.88	11.49
	Kanchan×BW-115	72.30±0.70	68.00-76.33	3.64	4.01	82.33	6.81
	Kanchan ×Ad-119	74.10±0.79	70.33-78.33	3.43	3.89	77.32	6.20
Grain filling duration	Kanchan ×DSN-34	37.64±0.95	29.67-47.33	15.32	15.93	92.45	30.34
	Kanchan YC-17	43.15±0.89	35.33-49.67	10.39	11.00	89.27	20.23
	Kanchan×YC-16	38.30±1.66	29.33-44.00	9.68	12.26	62.45	15.77
	Kanchan×BW-115	38.81±0.60	37.33-40.67	2.42	3.59	45.39	4.89
	Kanchan ×Ad-119	38.66±1.31	34.00-44.00	7.19	9.29	59.90	11.46
Spikes plant^{-1}	Kanchan ×DSN-34	6.21±0.22	5.27-7.53	9.31	11.16	69.58	16.00
	Kanchan ×YC-17	4.45±0.13	1.57-6.20	30.22	30.63	97.31	61.41
	Kanchan×YC-16	5.36±0.16	4.43-6.07	8.20	9.72	71.21	14.18
	Kanchan×BW-115	6.13±0.16	5.27-7.27	11.65	12.53	86.52	22.23
	Kanchan ×Ad-119	5.76±0.15	4.00-8.27	20.63	21.14	95.47	41.57
Plant height	Kanchan ×DSN-34	111.23±1.38	78.40-138.50	22.65	22.76	99.10	46.46
	Kanchan ×YC-17	90.68±1.29	75.87-104.70	10.97	11.24	95.19	22.04
	Kanchan×YC-16	91.12±0.91	82.87-99.00	5.26	5.54	90.15	10.28
	Kanchan×BW-115	98.34±1.35	81.80-120.10	11.03	11.28	95.57	22.21
	Kanchan ×Ad-119	93.86±0.82	87.80-102.20	3.96	4.24	87.29	7.62
Grains spike^{-1}	Kanchan ×DSN-34	51.64±0.81	39.03-67.40	21.50	21.67	98.41	43.93
	Kanchan ×YC-17	36.25±0.78	11.93-54.20	39.67	39.67	99.11	81.39
	Kanchan×YC-16	34.48±0.70	15.60-51.80	41.20	41.35	99.28	84.56
	Kanchan×BW-115	41.86±0.80	28.60-53.93	21.63	21.88	97.73	44.05
	Kanchan ×Ad-119	42.49±0.95	34.13-48.93	11.38	12.02	89.62	22.19
100-grain weight	Kanchan ×DSN-34	4.48±0.07	4.17-4.86	4.52	5.33	71.93	7.89
	Kanchan ×YC-17	4.64±0.13	3.80-5.12	7.28	8.75	69.10	12.47
	Kanchan×YC-16	4.54±0.13	3.85-5.12	7.83	9.16	72.78	13.70
	Kanchan×BW-115	4.31±0.15	3.28-4.73	10.84	12.39	76.49	19.52
	Kanchan ×Ad-119	4.69±0.11	4.42-4.95	3.57	5.13	48.28	5.11
Biomass plant^{-1}	Kanchan ×DSN-34	27.24±1.25	20.20-36.40	21.65	22.09	96.04	43.70
	Kanchan ×YC-17	19.48±0.69	8.33-26.67	27.20	27.88	95.21	54.68
	Kanchan×YC-16	21.73±0.60	15.53-28.27	20.90	21.45	94.98	41.96
	Kanchan×BW-115	21.87±1.20	16.27-26.43	11.15	13.76	65.65	18.61
	Kanchan ×Ad-119	21.79±1.11	18.53-26.73	12.12	15.01	65.22	20.17
Harvest index	Kanchan ×DSN-34	40.54±0.52	35.47-43.65	5.40	5.84	85.52	10.29
	Kanchan ×YC-17	31.19±0.56	16.03-47.08	29.83	29.99	98.94	61.10
	Kanchan×YC-16	31.61±0.37	17.97-48.14	34.63	34.69	99.66	71.22
	Kanchan×BW-115	39.47±0.35	28.37-45.22	14.29	14.37	98.86	29.26
	Kanchan ×Ad-119	41.39±0.42	36.92-47.15	7.70	8.10	90.48	15.10
Yield plant^{-1}	Kanchan ×DSN-34	11.06±0.36	8.15-15.13	21.71	22.41	93.84	43.33
	Kanchan ×YC-17	6.09±0.22	2.57-10.00	41.21	41.68	97.76	83.79
	Kanchan×YC-16	6.79±0.29	2.87-9.60	35.89	36.61	96.06	72.45
	Kanchan×BW-115	8.69±0.42	5.60-11.93	20.80	22.38	86.38	39.66
	Kanchan ×Ad-119	9.04±0.49	7.07-11.83	14.51	17.30	70.33	25.07

Table 3: Correlation coefficient among the traits measured in the F_5 generation of five wheat crosses

Crosses	Characters correlated	Grain filling duration	Spikes plant^{-1}	Plant height	Grains spike^{-1}	100-grain weight	Biomass plant^{-1}	Harvest index	Yield plant^{-1}
Kanchan ×DSN-34	Days to anthesis	-0.79**	-0.16	0.86**	0.83**	0.17	0.80**	0.27	0.87**
	Grain filling duration		0.46	-0.93**	-0.85**	-0.22	-0.70*	-0.08	-0.72**
	Spikes plant^{-1}			-0.32	-0.21	0.22	0.21	-0.14	0.14
	Plant height				0.92**	0.01	0.74**	0.24	0.78**
	Grains spike^{-1}					0.05	0.72**	0.28	0.80**
	100-grain weight						0.31	-0.20	0.23
	Biomass plant^{-1}							-0.08	0.94**
	Harvest index								0.20
Kanchan ×YC-17	Days to anthesis	-0.42	0.24	0.47	0.19	-0.17	0.23	-0.01	0.19
	Grain filling duration		-0.25	-0.54	-0.13	-0.01	-0.05	-0.43	-0.36
	Spikes plant^{-1}			0.76**	0.65**	-0.04	0.87**	0.36*	0.83**
	Plant height				0.30	0.22	0.71**	0.27	0.67**
	Grains spike^{-1}					-0.51**	0.33	0.75**	0.78**
	100-grain weight						0.24	-0.44*	-0.20
	Biomass plant^{-1}							-0.01	0.62**
	Harvest index								0.75**
Kanchan ×YC-16	Days to anthesis	-0.69*	-0.44	0.26	0.42	-0.58	0.01	0.18	0.25
	Grain filling duration		0.18	-0.57	-0.71**	0.14	-0.30	-0.45	-0.64*
	Spikes plant^{-1}			0.31	-0.22	0.63**	0.52**	-0.38	-0.08
	Plant height				0.52**	0.08	0.71**	0.26	0.63**
	Grains spike^{-1}					-0.21	0.14	0.89**	0.93**
	100-grain weight						0.27	-0.29	-0.13
	Biomass plant^{-1}							-0.16	0.33
	Harvest index								0.84**
Kanchan ×BW-115	Days to anthesis	-0.46	-0.68*	0.42	0.72**	-0.23	0.29	0.33	0.36
	Grain filling duration		0.36	0.41	-0.63*	0.60*	-0.08	-0.38	-0.29
	Spikes plant^{-1}			-0.07	-0.12	0.14	0.22	0.26	0.34
	Plant height				0.63**	-0.17	0.53	-0.03	0.34
	Grains spike^{-1}					-0.38*	0.42*	0.59**	0.62**
	100-grain weight						0.26	-0.06	0.19
	Biomass plant^{-1}							0.19	0.68**
	Harvest index								0.76**
Kanchan ×Ad-119	Days to anthesis	0.13	-0.12	0.51	0.26	0.12	0.20	-0.08	0.01
	Grain filling duration		-0.11	-0.36	-0.59	0.13	-0.05	-0.46	-0.38
	Spikes plant^{-1}			-0.25	0.01	0.05	0.65**	0.28	0.65**
	Plant height				0.25	0.13	-0.08	0.11	0.06
	Grains spike^{-1}					0.14	0.40*	0.33	0.56**
	100-grain weight						0.05	-0.04	0.09
	Biomass plant^{-1}							0.04	0.77**
	Harvest index								0.57**

*, ** Significant at 0.05 and 0.01% level of probability, respectively

In all the crosses, very high heritability along with high to very high genetic advance were registered for grains spike^{-1} suggesting that the character was predominantly controlled by additive genes. The result also indicated that this character was highly heritable and therefore, selection for this character would give positive response towards the improvement of this trait. Although the variability for this character was high in all the crosses, the range was very high in cross Kanchan×YC-17 (42) and higher grain number per spike (52) was found in Kanchan×DSN-34 (Table 2). Grains spike^{-1} had significantly negative association with 100-grain weight in Kanchan ×YC-17 and Kanchan× BW-115 and there were very poor value in the remaining crosses. Raina *et al.*[20] and Jaglan *et al.*[1] reported that grains spike^{-1} was negatively correlated with 100-grain weight. Such relationship between grains spike^{-1} and 100-grain weight could be due to compensation of grain weight by earlier formed grains spike^{-1} for photosynthetic product. Bingham[21] reported that such compensation was not complete. However, this trait showed a strong positive and significant relationship with yield plant^{-1} in all of the five crosses indicating that high yielding genotypes might have high number of grains spike^{-1}. This result might be obtained through the increase either biomass or harvest index or both. Amin *et al.*[22] and Singh *et al.*[23] found similar result, which had a close bearing of the present findings.

Lower values for GCV and PCV were obtained for the character 100-grain weight among all the studied characters. But moderately high to high heritability and very low to low genetic advance were registered for this character indicating the importance of both additive and non-additive genetic effects. Previously Moghaddam

et al.[24] reported similar result. It was observed that hundred-grain weight failed to contribute significantly towards the increase in grain yield in the material used, which could happen due to higher number of grains per spike with their smaller weight. Some authors also reported non-significant[25] and poor negative relationship[26] between 100-grain weight and yield.

Higher biomass plant^{-1} was registered in the cross Kanchan × DSN-34 and lower in Kanchan × YC-17 with high variability. Other three crosses showed average value. Very high GCV and PCV and little differences between these two genetic parameters were observed in the first three crosses. Heritability and genetic advance were also very high in these crosses. These result indicated that the expression of this character was mostly genetical and the effect of additive genes. Similar result was reported by Barma *et al.*[27] and Krishnawat and Sharma[28]. Biomass showed highly positive and significant relation with yield in all the crosses except in Kanchan × YC-16. This character also showed positive correlation with days to anthesis, spike plant^{-1}, grain spike^{-1}, 100-grain weight, But it was negatively correlated with days to grain filling and harvest index. A strong positive correlation between grain yield and biomass indicated that biomass of a line is a good prediction of its grain yield under the spaced-plant growing condition of these materials. These findings confirm with those of Barma *et al.*[27] and Budak and Yildirim[29].

Wide range of variation for harvest index was found in Kanchan × YC-17 and Kanchan × YC-16. The difference between GCV and PCV was very low in all the crosses indicating the variation for this character was mainly due to genetic effect. High heritability and genetic advance were found in all crosses except low genetic advance in Kanchan × DSN-34 and Kanchan × Ad-119. This result implied that additive genes were mainly responsible for the control of this character. Krishnawat and Sharma[28] and Sharma *et al.*[30] also reported similar result. This trait showed a strong positive and significant correlation with yield in all crosses except the cross Kanchan × DSN-34. This trait also showed a positive relation with grains spike^{-1}. This finding was similar to that of Budak and Yildirim[29], Pandit and Islam[18]. Therefore, harvest index can be considered as a promising yield selection criterion because of its acceptable heritability value and positive correlation with grain yield. The mean grain yield was higher in cross Kanchan×DSN-34. The low difference between GCV and PCV, high heritability and genetic advance indicated the involvement of additive gene for this character.

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