GENETIC VARIABILITY FOR QUANTITATIVE CHARACTERS UNDER DIFFERENT SOWING CONDITION IN BREAD WHEAT (*Triticum aestivum* L.)

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ABSTRACT

An experiment was conducted to evaluate fifty stable F_6s genotypes of bread wheat for genetic variability. Analysis of variance revealed that mean squares due to genotypes were highly significant for all the characters. The high values of GCV was recorded for number of effective tillers per plant in early sowing, length of main spike in timely sowing and number of effective tiller per plant in late sowing. This indicated the presence of wide genetic variation for these characters. Similarly, high values of PCV was recorded for plant height, length of main spike, number of spikelets per main spike, peduncle length, grain yield per plant and harvest index in early sowing; for length of main spike, grain yield per plant and harvest index in timely sowing; and for number of effective tillers per plant, length of main spike, grain yield per plant and harvest index in late sowing condition. The high heritability (broad sense) values were observed for number of effective tillers per plant in early sowing, for length of main spike in timely sowing and grain filling period in late sowing, indicated that heritability may be due to higher contribution of genotypic component in these traits. The genetic advance expressed as percentage of mean were found high for number of effective tillers per plant in early sowing and for length of main spike in timely and late sowing condition.. The values of genotypic correlation were higher as compared to the corresponding phenotypic correlation, indicating that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. The grain yield per plant exhibited significant and positive genotypic and phenotypic correlation with days to maturity, harvest index and 100 grain weight in early sowing; plant height, number of spikelets per main spike, length of main spike, biological yield and harvest index in timely sowing; and with days to maturity, plant height and number of grain per main spike in late sowing condition. The yield components exhibited varying trends of association among themselves. Thus, biological yield per plant, number of effective tillers per plant, plant height, number of spikelets per main spike, harvest index and days to maturity were the most important traits, which may contribute considerably towards higher grain yield.

KEY WORDS: Correlation, genetic variability, heritability, genetic advance, wheat.

INTRODUCTION

Wheat (*Triticum spp*. L.) is an annual plant that belongs to the grass family *Poaceae*, tribe *Triticeae* and subtribe *Triticineae*. It has been described as the 'King of cereals' because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. It is one of the most important and widely cultivated crops in the world, used mainly for human consumption and support nearly 35 per cent of the world population (Mohammadi-joo *et al*., 2015). It is a unique gift of nature to the mankind. Once wheat grain is converted into dough, it can be moulded into innumerable products like chapatis, breads, cakes, biscuits, pasta and many hot and ready-to-eat breakfast foods. Wheat grain contains starch (60-68%), protein (6-21%), fat (1.5-2.0%), cellulose (2.0-2.5%), minerals (1.8%) and vitamins (Das, 2008). The phenotypic and genotypic variations of the yield contributing characters are considerably high in wheat [Dwivedi and Pawar (2004); Kumar *et al.* (2014)], which point out the possibility of developing a variety with high yield. Heritability is the heritable portion of phenotypic variation and it is a good index of transmission of a character from parents to their off springs. Heritability determines the expressivity of genes carried by a genotype. If the heritability of a character is high, the phenotypic value provides a fairly close measure of the genotypic value and thus, breeder can utilize the basis of his selection on the phenotypic performance, thereby the knowledge of heritability helps the plant breeder in pre-assessing the results of selection for a particular character.

Yield being a complex character is a function of several component characters and their interaction with environment. Probing of structure of yield involves assessment of mutual relationship among various characters contributing to the yield. In this regards, genotypic and phenotypic correlation reveals the degree of association between different characters and thus, aid in selection to improve the yield and yield attributing characters simultaneously.

MATERIALS AND METHODS

The present study was carried out to assess genetic variability in fifty stable F_6s genotypes of bread wheat grown as early (November 3, 2014), normal (December 23, 2014) and late sowing (January 15, 2015) condition in a Randomized Block Design with three replications at the Wheat Research Station, Junagadh Agricultural University, Junagadh during *rabi* 2014-15. Each entry was accommodated in a single row of 1.5 m length with a spacing of 22.5 cm. The recommended agronomical practices and plant protection measures were followed for the successful raising of the crop. The observations were recorded on 13 different quantitative characters *viz*., days to 50 per cent flowering, days to maturity, grain filling period (day), plant height (cm), peduncle length (cm), number of effective tillers per plant, length of main spike (cm), number of spikelets per main spike, number of grains per main spike, 100 grain weight (g), grain yield per plant (g), biological yield per plant (g) and harvest index (%). Analysis of variance was carried out as per methodology given by Panse and Sukhatme (1985). The genotypic and phenotypic coefficients of variation, which measures the magnitude of genetic and phenotypic variation present in a particular character, were estimated as per the formula suggested by Burton and DeVane (1953). Heritability was calculated according to formula suggested by Allard (1960). Genetic advance as percentage of mean was categorised as low, moderate and high as given by Johnson *et al.* (1955). The phenotypic and genotypic correlation coefficients of all the characters were worked-out as per Al-Jibouri *et al.* (1958).

RESULTS AND DISCUSSION

The analysis of variance revealed that mean square due to genotypes were significant for all the traits in individual sowing condition (Table 1) as well as pooled over years, except plant height (Table 2) indicating the presence of sufficient amount of genetic variability among the genotypes for seed yield per plant and other yield contributing traits. These findings of mean sum of squares are in accordance with the findings of Asif *et al.* (2005), Dwivedi and Pawar (2004) and Malav (2015), who also observed significant variability in wheat germplasm. Hence, it can be noted that systematic crossing among selected genotypes in self-pollinated crop like wheat generates variability in subsequent generation.

Genetic variability is pre-requisites for genetic improvement in a systematic breeding programme. There is more genetic potentiality in the genetically variable populations and thus the chances to obtain the desired types are increased. The estimates of genetic parameters are helpful for plant breeders to predict the performance of genotypes in the subsequent generations. So, it is necessary to split the phenotypic variability into heritable and non-heritable components. The present experimental material showed a wide range of variation for plant height followed by number of grain per main spike, grain yield per plant, number of effective tillers per plant, days to maturity and grain filling period. The harvest index, number of spikelet per main spike, days to 50 per cent flowering expressed a moderate range of variation (Table 3).

The better index for measuring the genetic variation is genetic co-efficient of variation (GCV) as described by Burton and De Vane (1953) for comparing the genetic variability present in different traits. Narrow difference between phenotypic and genotypic coefficient of variation in most of the characters indicated that they were comparatively stable to environmental variation. This also suggested that genetic factors were pre-dominantly responsible for the expression of these attributes and selection could be made effectively on the basis of phenotypic performance. However in certain cases like harvest index (%) and plant height (cm) has considerable difference between PCV and GCV. This clearly indicated the significant role of environmental factors in the expression of above said traits. It is a well-known fact that forced maturity may result due to sudden rise of temperature. The estimates of genotypic and phenotypic coefficient of variability indicated that the values of phenotypic coefficient of variation were slightly higher than that of genotypic coefficient of variation for all the traits studied (Table 3), indicating less effect of environment on the expression of characters studied. Similar results have been reported by Dwivedi and Pawar (2004), Kumar *et al.* (2014), Desheva and Cholakov (2014) and Malav (2015).

In early sown, highest values of GCV were observed for number of effective tillers per plant followed by number of grains per main spike and harvest index (Table 3). High GCV estimates in wheat have been reported for number of effective tillers per plant (Dhakar *et al.*, 2012; Singh *et al.*, 2012; Tambe *et al.*, 2013 and Malav, 2015). The moderate values of GCV were observed for number of grains per main spike, length of main spike and grain yield per plant. The findings of these characters are supported by earlier report of and Nukasani *et al.* (2013). In timely sown, highest values of GCV were observed for length of main spike followed by harvest index and grain yield per plant (Table 3). In late sown, highest value of GCV were found in harvest index followed by number of effective tillers per main spike and length of main (Table 3). The low value of GCV was observed for 100 grain weight, plant height, number of spikelet per main spike, grain filling period, days to maturity and days to 50 per cent flowering. The findings of these characters are supported by earlier reports of Baranwal *et al.* (2012) and Desheva and Kyoshev (2015). In early sown, highest phenotypic coefficient of variation was observed for number of effective tillers per plant followed by number of grain per main spike, harvest index and grain yield per plant. The length of main spike, number of spikelet per main spike and plant height exhibited moderate value of phenotypic coefficient of variation, whereas grain filling period, 100 grain weight, days to maturity and days to 50 per cent flowering noted low values of phenotypic coefficient of variation. High estimates of PCV for grain yield per plant and some other yield components in wheat were also reported by Tambe *et al.* (2013), Nukasani *et al.* (2013), Maurya *et al.* (2014), Desheva and Cholakov (2014), Desheva and Kyosev (2015) and Malav (2015). In timely sown, highest phenotypic coefficient of variance was found for number of spikelets per main spike followed by harvest index and grain yield per plant. In late sown, highest phenotypic coefficient of variance was observed for harvest index followed by number of effective tillers per plant and length of main spike.

High heritability (broad sense) values were observed for number of effective tillers per plant, number of grains per main spike, days to 50 per cent flowering, number of spikelets per main spike and length of main spike in all three dates *viz.*, early, timely and late sown, while moderate estimates for early sown were observed for length of main spike, plant height, number of spikelets per main spike, for timely sown, plant height and peduncle length and for late sown, plant height, biological yield and 100 grain weight noted moderate value. The characters like grain filling period, days to maturity, biological yield per plant and 100 seed weight recorded low estimates of heritability in early sown. The high heritability values for number of effective tillers per plant, number of grains per main spike, days to 50 % flowering, number of spikelets per main spike and length of main spike in all three dates *viz.* early, timely and late sown, indicated that heritability may be due to higher contribution of genotypic component in these traits. High magnitude of heritability have been reported for number of effective tillers per plant (Sidharthan and Malik, 2007 and Dhakar *et al.*, 2012), for number of grains per spike (Pawar *et al.*, 2002; Pawar *et al.*, 2002 and Sidharthan and Malik, 2007), Length of main spike (Pawar *et al.*, 2002 and Sidharthan and Malik, 2007) and for days to 50 per cent flowering (Singh *et al.*, 2001 and Pawar *et al.*, 2002).

The genetic advance at 5% selection intensity (k=2.06) was found moderate for plant height in all three dates *viz.* early, timely and late sown, peduncle length in early and late sown, number of grains per plant and number of grains per main spike in timely and late sown. It was low for all the remaining traits *viz.*, grain filling period, grain yield per plant, length of main spike and 100 grain weight in all three dates *viz.*, early, timely and late sown, number of spikelets per main spike in timely and late sown and biological yield in early and late sown. These results supported by the reports of some earlier researchers. Baisakh and Nayak (1991) reported for moderate genetic advance for plant height and days to heading and Kumar *et al.* (2014) for harvest index and test weight. Kumar and Luthra (1995) observed low genetic advance for yield per plant, number of spilelets per main spike, number of grains per spike, grain filling period, biological yield and Ahmed *et al.* (2010) for spike length.

The coefficient of variation does not offer full scope to estimate the heritable variation. The relative amount of heritable portion of variation is assessed with the help of heritability estimate and genetic advance expressed as percentage of mean (genetic gain). The success of selection depends on the breeding value of a genotype recognized from its phenotypic expression. The degree of correspondence between phenotypic value and breeding value for a character is measured by heritability, which indicates reliability of the former as a guide to the later. The heritability expresses the proportion of total variance that is attributed to the average effect of genes and determines the degree of resemblance between relatives. It is a good index of transmission of characters from parents to their off-springs (Falconer, 1981). High values of heritability in broad sense are helpful in identifying the appropriate character for selection and enabling the breeder to select superior genotypes on the basis of phenotypic expression of quantitative traits (Johnson *et al.*, 1955).

The genetic advance expressed as percentage of mean were found high for number of effective tillers per plant followed by, number of grains per main spike, harvest index and grain yield per plant, while moderate for grain filling period and biological yield per plant in early sown and low for days to maturity (Table 3). In timely sown, genetic advance expressed as percentage of mean were found high for length of main spike and number harvest index. The values of genetic advance expressed as percentage of mean were moderate for plant height, grain filling period, and days to maturity. In late sown, genetic advance expressed as percentage of mean were found high for length of main spike, number of effective tillers per plant and harvest index. The values of genetic advance expressed as percentage of mean were moderate for grain filling period, days to maturity and 100 grain weight. High values of genetic advance expressed as percentage of mean have been reported in wheat for grain yield per plant by Dhakar *et al.* (2012), Singh *et al.* (2012), Bhushan *et al.* (2013), Nukasani *et al.* (2013), Maurya *et al.* (2014) and Malav (2015); for number of effective tillers per plant by Kumar and Mishra (2004), Sidharthan and Malik (2007), Dhakar *et al.* (2012), Singh *et al.* (2012) and Malav (2015); for length of main spike by Dhakar *et al.* (2012), Nukasani *et al.* (2013), Desheva and Cholakov (2014), Desheva and Kyosev (2015) and Malav (2015); and for number of grains per main spike by Sidharthan and Malik (2007), Majumder *et al.* (2008) and Malav (2015).

High heritability with high genetic advance expressed as percentage of mean was also reported earlier for number of effective tillers per plant in early and late sown by Kumar and Mishra (2004), Sidharthan and Malik (2007) and Dhakar *et al.* (2012); for number of spikelets per main spike, number of grains per main spike, peduncle length and harvest index by Dhakar *et al.* (2012), Tambe *et al.* (2013), Bhushan *et al.* (2013) and Degewione *et al.* (2013), for length of main spike, days to 50 per cent flowering, biological yield and grain yield per plant by Majumder *et al.* (2008), Dhakar *et al.* (2012), Bhushan *et al.* (2013) and Degewione *et al.* (2013) and for biological yield per plant by Sidharthan and Malik (2007), Bhushan *et al.* (2013) and Malav (2015).

Correlation among traits may result from pleiotrophy, linkage or physiological associations among characters. The linkage is a cause of transit correlations particularly in a population derived from crosses between divergent strains. The correlation is the overall or net effect of the segregating genes; some of the genes may increase both the characters causing the positive correlation, while the others may increase the one and decrease the other causing the negative correlation (Falconer, 1981). Thus, to accumulate optimum combination of yield contributing characters in a single genotype, it is essential to know the implication of the interrelationship of various characters.

In general, the values of genotypic correlation were higher than their corresponding phenotypic correlation in the present investigation (Table 4). This indicated that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. The study of genotypic correlation gives an idea of the extent of relationship between different variables. This relationship among yield contributing characters as well as their associations with yield provides information for exercising selection pressure for bringing genetic improvement in seed yield.

In present investigation, seed yield per plant showed significant and positive correlation with plant height at genotypic level, 100 grain weight and harvest index in early sowing condition (D_1) (Table 4), while it had significant and positive correlation in timely sown condition (D_2) with plant height and number of spikelets per main spike at genotypic level, and with length of main spike, biological yield per plant and harvest index at both the levels. In late sowing condition (D_3) seed yield per plant showed significant and positive correlation with days to maturity, number of grains per main spike and plant height at genotypic level and harvest index. This indicated that importance of these traits as compliment of seed yield. The significant and positive correlation of grain yield per plant with biological yield per plant also reported by Bhushan *et al.* (2013), Fellahi *et al.* (2013) and Malav (2015); with harvest index by Ahamed *et al.* (2010) and Zeeshan *et al.* (2014); and with days to maturity by Singh *et al.* (2012).

In present study, correlations among different characters were also significant over the environments. The yield components exhibited varying trends of association among themselves (Table 4). Days to 50% flowering recorded significant and negative association with grain filling period and 100 grain weight in late sowing condition (D_3). Days to maturity recorded negative and significant correlation with plant height in early sown (D_1), peduncle length in late sown (D_2), and grain filling period and biological yield per plant at phenotypic level in late sown (D_3). Grain filling period recorded significant and positive association with number of grains per main spike in early sown (D_1), number of spikelets per main spike at phenotypic level and significant but negatively correlated with peduncle length in timely sown (D_2). Plant height showed significant but negative correlation with number of effective tillers per plant and length of main spike in early sown (D_1), number of spikelets per main spike and number of grains per main spike and length of main spike at genotypic level in timely sown (D_2) and peduncle length and 100 grain weight, number of spikelets per main spike at phenotypic level, while it was positive and significant with harvest index in late sown (D_3). Number of effective tillers per plant recorded positive and significant correlation with number of spikelets per main spike and 100 grain weight in timely sown (D_2), while number of spikelets per main spike at genotypic level in late sown (D_3). Length of main spike showed positive and significant correlation with number of spikelets per main spike, number of grains per main spike and peduncle length in early sown (D_1), while number of spikelets, number of grains per main spike at phenotypic level in timely sown (D_2) and number of grains per main spike at genotypic level in late sown (D_3). Number of spikelets per main spike recorded positive and significant correlation with number of grains per main spike and peduncle length at genotypic level in early sown (D_1), while number of grains per main spike in timely sown (D_2) and late sown (D_3). Singh *et al.* (1985) found significant and positive correlation between spikelets per spike and grains per spike. Number of grains per main spike showed positive and significant correlation with harvest index in late sown (D_3). Peduncle length recorded significant but negative correlation with harvest index at phenotypic level in late sown (D_3). Biological yield recorded positive and significant correlation with harvest index in early sown (D_1). Similar results were found by Mohammad *et al.* (2005) reported significant and positive correlation between biological yield with harvest index, while its negative and significant correlation with harvest index in timely sown (D_2) and late sown (D_3).

CONCLUSION

The present investigation, thus, revealed that moderate to high heritability coupled with high genetic advance expressed as percentage of mean were observed for grain yield per plant, number of effective tillers per plant, biological yield per plant, length of main spike and number of grains per main spike, which may be attributed to the preponderance of additive gene action and possessed high selective value and thus, selection pressure could profitably be applied on these characters for their rationale improvement. Based on correlation analysis, it is concluded that harvest index, number of spikelets per main spike, length of main spike, biological yield per plant, plant height, 100 grain weight and number of grains per main spike may contribute considerably towards higher grain yield. The interrelationship among yield components would help in increasing the yield levels and, therefore, more emphasis should be given to these components, while selecting better types in wheat.

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Table 1: Analysis of variance for different characters in 50 genotypes of bread wheat under three different sowing conditions (D_1: Early sown condition; D_2: Timely sown condition and D_3: Late sown condition)

Source of Variation	d. f.	Days to 50 Per Cent Flowering			Days to Maturity			Grain Filling Period			Plant Height (cm)		
		D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
Replications	02	1.24	3.39	1.42	153.58**	158.79**	4.03	0.13	1.02	1.14	100.84	225.78**	11.77
Genotypes	49	52.83**	39.25**	30.60**	28.18**	58.55**	46.20**	13.90**	16.43**	6.97**	172.26**	69.28**	17.12**
Error	98	2.20	2.85	3.87	9.51	9.05	1.18	0.95	0.92	1.17	103.14	30.90	7.87

Source of variation	d. f.	Number of Effective Tillers Per Plant			Length of Main Spike (cm)			Number of Spikelets per Main Spike			Number of Grains per Main Spike		
		D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
Replications	02	1.71**	0.18	0.71	1.17**	1.56**	0.26	2.48	2.26	0.34	0.21	5.11**	1.37
Genotypes	49	32.24**	2.83**	5.58**	2.75**	4.18**	3.95**	8.80**	7.97**	8.95**	228.07**	79.39**	25.06**
Error	98	0.05	0.21	1.08	0.07	0.26	0.06	0.71	1.44	0.30	3.03	9.31	0.83

Source of variation	d. f.	Peduncle Length (cm)			Grain Yield Per Plant (g)			Biological Yield Per Plant (g)			Harvest Index (%)			100 Grain Weight (g)		
		D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
Replications	02	23.99**	0.21	0.37	1.20	3.09	0.95	7.61	43.56**	0.02	6.71	25.20	6.30	0.13	0.19	0.07
Genotypes	49	44.01**	22.92**	25.06**	19.01**	15.10**	6.01**	19.18**	45.33**	21.46**	132.64**	108.95**	55.39**	0.21**	0.31**	0.16**
Error	98	1.58	6.46	0.83	3.25	1.03	1.23	5.12	3.84	5.14	5.12	13.42	12.74	0.05	0.08	0.07

**, ** Significant at 5% and 1% levels, respectively*

Table 2: Analysis of variance showing mean sum of square for 13 characters in bread wheat over three dates

Source of Variation	d. f	Days to 50 Per Cent Flowering	Days to Maturity	Grain Filling Period	Plant Height (cm)	Number of Effective Tillers Per Plant	Length of Main Spike (cm)	Number of Spikelets per Main Spike
Environment	02	49.252**	3981.440**	219.041**	4061.589**	13.490**	25.107**	57.729**
Genotypes	49	32.934**	19.715**	9.135**	31.604	6.094	2.307**	5.162**
Genotypes x Environment	98	5.480**	12.297**	1.650**	27.308	3.728	0.660**	1.707**
Pooled error	294	0.991	2.194	0.338	15.767	0.148	0.043	0.272

Source of Variation	d. f	Number of Grains per Main Spike	Peduncle Length (cm)	Grain Yield Per Plant (g)	Biological Yield Per Plant (g)	Harvest Index (%)	100 Grain Weight (g)
Environment	02	954.578**	6.303**	674.565**	53.776**	97.364**	13.183**
Genotypes	49	65.363**	22.477**	7.223**	16.691**	44.882**	401.188**
Genotypes x Environment	98	31.287**	7.605**	3.076	5.980	27.007	9.558**
Pooled error	294	2.160	0.443	0.612	1.566	5.850	0.022

, ** Significant at 5% and 1% levels, respectively

Table 3: Range of variation, mean, phenotypic and genotypic coefficients of variation, heritability (Broad Sense), genetic advance and genetic advance expressed as percentage of mean for different characters in 50 genotypes of bread wheat under early, timely and late sown conditions

Character	Range	Mean	Phenotypic Coefficient of Variation (%)	Genotypic Coefficient of Variation (%)	Heritability (Broad Sense)	Genetic Advance	Genetic Advance Expressed as Percentage of Mean
Early sown - D_1							
Days to 50 Per Cent Flowering	46.60 to 64.60	56.12	13.13	12.86	95.95	14.56	25.95
Grain Filling Period	40.93 to 51.93	47.48	8.03	7.76	13.59	7.34	15.46
Days to Maturity	99.13 to 112.67	105.93	5.55	4.72	72.44	8.76	8.28
Plant Height (cm)	60.38 to 112.00	70.29	22.09	16.71	57.21	18.30	26.03
Number of Effective Tillers per Plant	3.80 to 17.13	8.87	64.02	63.97	99.85	11.69	82.52
Length of Main Spike (cm)	5.40 to 10.39	7.69	21.77	21.48	97.43	3.36	43.68
Number of Spikelet per Main Spike	11.53 to 19.67	15.20	20.03	19.25	92.32	5.79	38.09
Number of Grains per Main Spike	23.93 to 62.07	42.36	35.83	35.59	98.68	30.85	72.83
Peduncle Length (cm)	17.03 to 34.57	29.04	23.11	22.70	96.50	13.34	45.95
Grain Yield Per Plant (g)	10.65to 23.00	16.87	27.28	25.10	84.63	8.02	47.57
Biological Yield Per Plant (g)	34.47 to 46.88	39.56	12.01	10.56	77.31	7.57	19.14
Harvest Index (%)	28.05to 55.17	42.83	28.60	25.95	82.84	20.77	48.51
100 Grain Weight (g)	2.96 to 4.17	3.59	13.66	12.23	12.23	0.81	22.55
Timely Sown – D_2							
Days to 50 Per Cent Flowering	49.27 to 64.27	56.73	11.31	10.91	93.07	12.30	21.68
Grain Filling Period	40.93 to 53.47	47.79	8.64	8.40	94.57	8.04	16.83
Days to Maturity	91.40 to 113.33	106.00	7.58	7.03	85.98	14.23	13.43
Plant Height (cm)	70.33 to 92.71	84.42	11.23	9.09	65.62	12.82	15.80
Number of Effective Tillers per Plant	7.27 to 14.07	9.04	19.06	18.37	92.88	3.30	36.47
Length of Main Spike (cm)	6.63 to 12.92	8.94	23.35	22.65	94.07	4.04	45.25
Number of Spikelet per Main Spike	13.07 to 23.60	17.35	17.23	15.78	83.92	5.17	29.79
Number of Grains per Main Spike	32.13to 59.67	50.00	18.50	17.47	89.13	16.99	33.97
Peduncle Length (cm)	20.83 to 34.30	28.45	18.34	16.02	76.26	8.20	28.81

Table 3 Cont….

Grain Yield Per Plant (g)	14.73 to 26.77	18.88	21.04	20.35	93.50	7.65	40.53
Biological Yield Per Plant (g)	32.98 to 50.70	39.85	17.36	16.65	91.98	13.11	32.90
Harvest Index (%)	36.71 to 61.64	47.74	22.76	21.41	88.62	19.82	41.52
100 Grain Weight (g)	3.63 to 4.97	4.29	14.16	12.47	77.54	0.97	22.61
Late Sown – D_3							
Days to 50 Per Cent Flowering	42.20 to 62.00	54.79	11.85	11.30	90.83	12.15	22.18
Grain Filling Period	40.53 to 48.80	42.02	6.33	5.83	84.92	4.87	11.06
Days to Maturity	82.20 to 100.73	106.00	7.57	7.47	97.49	13.78	15.21
Plant Height (cm)	61.79 to 73.22	67.67	6.99	5.63	64.83	6.32	9.33
Number of Effective Tillers per Plant	8.20 to 17.90	9.84	25.50	23.22	82.93	4.29	43.56
Length of Main Spike (cm)	6.78 to 13.02	8.89	22.46	22.29	98.55	4.05	45.58
Number of Spikelet per Main Spike	13.44 to 23.30	16.40	18.45	18.14	96.74	6.03	36.76
Number of Grains per Main Spike	32.47 to 49.86	49.86	18.04	17.23	91.22	16.89	32.89
Peduncle Length (cm)	19.24 to 34.22	28.43	17.80	17.51	96.75	10.09	35.48
Grain Yield Per Plant (g)	8.80 to 15.22	11.76	22.23	20.13	81.90	4.41	37.54
Biological Yield Per Plant (g)	31.94 to 45.13	37.93	13.15	11.72	79.35	8.15	21.50
Harvest Index (%)	22.82 to 41.58	31.21	25.61	22.91	80.05	13.18	42.23
100 Grain Weight (g)	2.73 to 3.72	3.30	13.74	11.24	66.95	0.62	18.95

Table 4: Genotypic (rg) and phenotypic (rp) correlation coefficients among 13 characters in 50 genotypes of bread wheat under early, timely and late sown conditions

Characters		Days to 50 Per Cent Flowering	Days to Maturity	Grain Filling Period	Plant Height (cm)	Number of Effective Tillers Per Plant	Length of Main Spike (cm)	Number of Spikelets per Main Spike	Number of Grains per Main Spike	Peduncle Length (cm)	Grain Yield Per Plant (g)	Biological Yield Per Plant (g)	Harvest Index (%)
Early sown - D_1													
Grain yield per plant (g)	rg	0.0348	-0.2913*	-0.0538	0.2914*	0.0698	0.1060	0.0342	0.1230	0.0541	0.1902	0.9164**	0.9651**
	rp	0.0243	-1.3347**	-0.0447	0.1757	0.0622	0.0914	0.0454	0.1138	0.0425	0.1709	0.9039**	0.9082**
Days to 50% flowering	rg		0.2913	0.2693	0.0027	0.0327	0.2345	0.0967	0.2000	0.1920	-0.1127	0.0768	-0.0395
	rp		0.2791	0.2619	0.0004	0.0320	0.2268	0.0939	0.1961	0.1884	-0.1046	0.0653	-0.0492
Days to maturity	rg			0.0051	-0.3887**	0.0492	0.1809	0.0396	0.0460	-0.0627	-0.1241	-0.1745	0.1395
	rp			0.0157	-0.7824**	0.0591	0.2180	0.0224	0.0508	0.0618	-0.1340	-0.2344	0.1746
Grain filling period	rg				0.0507	-0.0777	0.0913	-0.0122	0.2921**	-0.1947	0.0178	-0.0654	0.1614
	rp				0.0755	-0.0828	0.0866	-0.0121	0.2880**	-0.2112	0.0260	-0.0761	0.1945
Plant height (cm)	rg					-0.3348**	-0.3737**	-0.0579	0.2756	-0.2343	0.1051	0.2307	-0.1102
	rp					-0.2858*	-0.2827*	-0.0540	0.1641	-0.1256	0.0146	0.1591	-0.0357
Number of effective tillers per plant	rg						0.0476	-0.0242	-0.1780	0.0410	-0.0354	0.1007	0.0893
	rp						0.0471	-0.0233	-0.1763	0.0393	-0.0327	0.0899	0.0780
Length of main spike (cm)	rg							0.2925*	0.4760**	0.3122**	0.0591	0.0756	-0.0599
	rp							0.2881*	0.4667**	0.2994**	0.0487	0.0643	-0.0466
Number of spikelet per main spike	rg								0.4636**	-0.1712	0.3105**	-0.0941	-.3012**
	rp								0.4251**	-0.1646	0.2671**	-0.0705	-0.2425
Number of grains per main spike	rg									0.0930	0.0903	-0.1540	-0.1440
	rp									0.0896	0.0727	-0.1372	-0.1260
Peduncle length (cm)	rg										-0.0817	0.0871	-0.0454
	rp										-0.0681	0.0714	-0.0488
Biological yield per plant (g)	rg											0.2949*	-0.1584
	rp											0.2912*	-0.1283
100 grain weight (g)	rg												-0.1307
	rp												-0.0751

Table 4 Cont…													
Timely Sown – D_2													
Grain yield per plant (g)	rg	-0.0060	0.1445	-0.0460	0.3440**	0.1736	0.4103**	0.2792*	0.1344	0.1294	0.3922**	0.6447**	0.2121
	rp	-0.0013	0.1304	-0.0386	0.2050	0.1715	0.3742**	0.2413	0.1184	0.1218	0.3598**	0.0762	-0.1616
Days to 50% flowering	rg		0.2228	0.1556	0.0077	0.0130	0.1176	0.0339	0.1709	0.1992	-0.1169	0.0838	0.0132
	rp		0.1945	0.0166	-0.1230	0.0210	-0.0813	-0.0854	0.0156	-0.0741	-0.0417	0.0762	-0.0082
Days to maturity	rg			0.0155	-0.1842	0.0378	-0.1028	-0.1038	0.0140	-0.0916	-0.0415	0.2680	-0.2300
	rp			0.0166	-0.1082	-0.0874	0.1075	-0.1723	-0.1282	-0.3055**	0.0959	0.1876	-0.1674
Grain filling period	rg				-0.1506	-0.0939	0.1144	-0.2185	-0.1376	-0.3157**	0.1142	-0.1236	0.0091
	rp				-0.1082	0.1811	0.1047	0.3805**	0.2074	0.0047	0.1096	-0.1023	0.0099
Plant height (cm)	rg					0.2444	0.2862*	0.5750**	0.3889**	0.0075	0.1436	0.1872	0.1878
	rp					0.1811	0.2577	0.5305**	0.3301**	-0.2083	0.1797	0.0839	0.1336
Number of effective tillers per plant	rg						0.2721	0.5852**	0.1581	-0.2177	0.2055	-0.0100	0.4705**
	rp						0.2577	0.3245**	0.0961	-0.0916	0.1268	0.0088	0.3937**
Length of main spike (cm)	rg							0.3831**	0.1258	-0.0925	0.1411	0.2723	-0.0637
	rp							0.3245**	0.4249**	0.1088	0.1473	0.2403	-0.0458
Number of spikelet per main spike	rg								0.4934**	0.1290	0.1773	0.1068	0.0870
	rp								0.4249**	-0.0573	-0.0331	0.0947	0.1114
Number of grains per main spike	rg									-0.0655	-0.0432	0.1842	0.0459
	rp									-0.0573	0.1072	0.1567	0.0053
Peduncle length (cm)	rg										0.1133	0.0353	-0.1085
	rp										0.1072	0.0294	-0.0809
Biological yield per plant (g)	rg											-0.4451**	0.1864
	rp											-0.4681**	0.1338
100 grain weight (g)	rg												0.0652
	rp												0.0514
Late Sown – D_3													
Grain yield per plant (g)		0.0871	0.2933*	-0.0835	0.4946**	-0.0644	0.1142	0.1453	0.3354**	0.0099	0.0308	0.8738**	0.2489
		0.0559	-0.0764	-0.2539	-0.0198	0.1436	0.2190	0.2413	0.1162	0.0023	0.0051	0.8677**	0.2733

Table 4 Cont…

Days to 50% flowering			1.0001	-0.3143**	-0.0247	0.1800	0.2322	0.2613	0.1222	0.0065	-0.0211	0.0958	-0.4014**
			0.6800	-0.2564	0.0647	-0.1710	0.2230	-0.0836	0.1340	0.0159	0.2636	0.0991	-0.3294**
Days to maturity				-0.2873**	0.0848	-0.1892	0.2297	-0.0887	0.1459	0.0181	0.3052**	0.1006	-0.1787
				-0.2864*	0.0443	0.0507	0.0440	0.0757	-0.2056	-0.0446	-0.1993	0.1735	0.1703
Grain filling period					0.1004	0.0688	0.0535	0.0917	-0.2493	-0.0645	-0.2462	0.2065	0.2154
					0.0443	-0.1020	0.1307	0.0923	0.0377	-0.2479	0.0756	0.2338	-0.1932
Plant height (cm)						-0.1094	0.1720	0.1391	0.0740	-0.3051**	0.0601	0.3974**	-0.3076**
						-0.1020	0.2159	0.4865**	0.2192	-0.0778	0.1542	-0.1417	0.0745
Number of effective tillers per plant							0.2318	0.5461**	0.2602	-0.0904	0.2122	-0.1739	0.0455
							0.2159	0.2369	0.1274	-0.2401	0.1019	0.0432	-0.0335
Length of main spike (cm)								0.2410	0.1407	-0.2426	0.1222	0.0496	-0.0207
								0.2369	0.3049**	-0.0268	-0.0348	0.1490	0.0945
Number of spikelet per main spike									0.3312**	-0.0213	-0.0645	0.1770	0.1301
									0.3049**	-0.0023	0.0303	0.2390	-0.0283
Number of grains per main spike										-0.0093	0.0414	0.2891*	-0.0436
										-0.0023	-0.0592	0.0411	0.0014
Peduncle length (cm)											-0.0725	0.0512	0.0330
											-.0592	-0.4702**	-0.0900
Biological yield per plant (g)												-0.4572**	-0.2257
												-0.4702**	-0.1082
100 grain weight (g)													-0.0967
													-.0.1082

, ** Significant at 5% and 1% levels, respectively

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