Genetic Analysis of Eight Crosses for Quantitative and Qualitative Trait in Wheat (*triticum aestivum l.*) over the Environments

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Abstract— The is objective of the study was to estimate gene effects for quantities and qualitative traits *viz.,* Plant height, no of tillers per plant, no of spiklets per spike, no of grains per spike, grain weight per ear head, grain yield per plant (g), Days to heading, Protein content(%), Sedimentation value (ml), Beta carotene content (ppm) and 1000 seed wt.(g) using six generations of eight crosses was carried out during rabi season at two locations. Analysis of Variance revealed highly significant differences among the wheat genotypes for all the characters. In case of plot basis observations, the characters were mostly governed by dominance gene effects.

Keywords — Wheat; Six Parameter Models; Gene Effects

1. Introduction

Wheat is important winter cereal crop contributing about 32 per cent of total food grain production in India (Singh *et al.,* 2004). It is staple food crop in at least 43 countries.

Wheat is an annual plant belongs to tribe *Triticeae*, sub family *Pooideae* of family *Poaceae*. Wheat is having 7 pair of chromosomes (2n=14). Bread wheat, due to it's versatile nature is widely cultivated under different agro-climatic conditions. In India, wheat is considered as the second most significant food crop after rice. Wheat grown on 29.50 m ha with annual production of 93.60 m tonnes with an average productivity of 31.25 q/ha.

The choice of selection and breeding procedure for genetic improvement of any crop is largely depend upon the knowledge of the type and relative amount of genetic component. Information the type of gene action involved in the inheritance of characters is helpful in deciding procedure to be followed for improvement. Plant breeders frequently use generation to mean the analysis to obtain information on gene action controlling the economic traits in wheat. Therefore, the present study was carried out to obtain information about gene action on yield and it's components in the eight crosses. The main objective of Wheat breeding is to increase grain yield however, yield is a quantitative traits and is affected by many genetic and non- genetic factors. To increase yield, it is necessary to improve agronomic traits which affects grain yield, but in order to achieve this, more information on the inheritance pattern of these traits is necessary.

More significance of dominance gene effects are determined than additive gene effects for grain yield and its component traits. Also, additive x additive type of epistatic interaction was found to be significant for a number of tillers per plant .Pedigree method and simple selection were suggested for improvement of traits governed by additive, additive x additive gene effects in some crosses. Identification of optimum selection periods for these taits was aimed.

2. Materials and Methods

Six generations of eight crosses were planted during Rabi season 2011-12 carried out at two locations viz., Wheat Research Unit, (Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola, M.S) and Agriculture Research Station, Niphad (Mahatma Phule Krishi Vidyapeeth, Rahuri M.S) in Randomized Block Design with three replications. The data were first subjected to test the differences between parental genotypes by applied "t" test for Joint scaling test as indicated by was applied to test the adequacy of the genetic model controlling the studied characters. The genetic model (m, d & h) was applied when epitasis when absent, whereas, the presence of non-allelic interaction the analysis was proceeded to estimate the interaction types involved using the Six generations model i.e., (m, d, h, i, j & l).

3. Result and Discussion

The mean values and their standard errors for analyzed traits are presented in Table -1 (a & b) in the Pooled environmental condition. The means values were highly significant for various characters. The scaling test for the Pooled environmental condition were presented in Table - 2 (a & b) The estimates of generation mean components in eight crosses on plot and plant basis characters over the Pooled environmental condition were presented in Table - 3 (a & b)

3.1 The results and discussion related to plot basis observations were as followed

3.1.1 Days to Heading

Scaling tests were found to be non-significant for all cross, thereby indicating that the absence of non-allelic interaction in the expression of days to heading character. Data on components of generation mean revealed that significant dominant gene effects for days to heading in cross-HI-1418 x LOK-54 only, while rest of crosses showed only mean significant. Muhammad Aslam Chowdhary (2006) indicated that additive, dominance and epistatic genetic effects seemed to have played role in the inheritance of this character Ahmad *et.al* (2007) dominant x dominant (l) epistasis were more important than additive x additive (i) epistasis. The degree of dominance in most of the traits indicated the predominance of dominant gene effects.

3.1.2 1000 Seed Weight (g)

Significance of scaling test for 1000 seed weight in Cross-VI, AKAW-2978-12 x PHS-0722 indicated the inadequacy of additive-dominance model and character in those crosses was under the control of epistatic type of interactions. While rest of the crosses showed non-significance of scaling test indicated the adequacy of additive-dominance model.The dominance x dominance (l) was significant only in Cross-VI (AKAW-2978-12 x PHS-0722). The nature of epistasis is duplicate type. The epistasis was found insignificant for the rest of crosses. The dominance (h) gene effect is significant for cross-IV (AKAW-3997 x NIAW-35) and Cross-VI (AKAW-297-12 x PHS-0722). However, both additive (d) and dominance (h) component were found significant in Cross-III (HI-1418 x Lok-54), Cross-V (DL-788-2 x AKAW-3722) and Cross-VIII (GW-496 x AKAW-4651). Naeem Akhtar and Muhammad Aslam Chowdhary (2006) indicated that additive, dominance and epistatic genetic effects seemed to have played role in the inheritance of this character.

3.1.3 Protein content (%)

For protein content in Cross-III (HI-1418 x Lok-54) and Cross-V (DL-788-2 x AKAW-3722) result revealed that, the epistasis was found insignificant in both crosses, additive (d) is significant for Cross-III (HI-1418 x LOK-54) while dominance (h) is significant for cross-V (DL-788-2 x AKAW-3722).The interaction dominance x dominance (l) was larger than I and j interactions, while, among main effects, the dominance component (h) is greater than additive component (d). The nature of epistasis is duplicate type except for Cross-I (AKW-619 x DBW-31). The nature of epistasis is complementary type. Rahman *et al*. (2003) observed the partial dominance of the character of protein content. Kapoor and Luthra (1992) studied nature of gene effects governing inheritance of quality traits and reported that presence of non-additive gene effects for all quality traits viz. protein content, gluten content, sedimentation value, tryptophan content, methionine and lysine content. they suggested that selection within a single segregating population would be powerless to utilize such a variation. Therefore crosses between genetically diverse parents should be attempted and selection should be followed for few generations. Duplicate type of epistasis was indicted by all the quality traits. They indicated the nature and magnitude of gene effects may vary for same quality character with different crosses.

Zahid Akram et. al. (2007) reported additive genetic effects with partial dominance and suggested that selection could be practical in early segregating generations for improvement in these traits.

3.1.4 Sedimentation Value (ml)

Cross-V (DL-788-2 x AKAW-3722), Cross-VI (AKAW--2978-12 x PHS-0722) and Cross-VIII (GW-496 x AKAW-4651) in which the epistasis was found insignificant. In Cross-V (DL-788-2 x AKAW-3722 and Cross-VIII (GW-496 x AKAW-4651), the additive (d) and dominance (h) both component were significant while in case of Cross-VI (AKAW-2978-12 x PHS-0722), the additive (d) component was found significant. In case of Cross-I, AKW-619 x DBW-31 Cross-II, AKAW-3997 x AKAW-3722, Cross-IV, AKAW-3997 x NIAW-34 and Cross-III,HI-1418 x Lok-54 reported the presence of additive x dominance type of non-allelic interaction in the expression of sedimentation value. While, scale B and D were found significant in Cross-II, AKAW-3997 x AKAW-3722 and Cross VII,GW-496 x NIAW-301 which indicated the presence of additive x dominance and additive x additive type of non-allelic interaction for sedimentation value Among the interactions, the dominance x dominance interaction (l) was larger than i and j both component. Hence, the dominance (h) was greater than the additive (d) component. The nature of epistasis is duplicate type. Kapoor and Luthra (1992) reported that presence of non additive gene effects for the trait like sedimentation value. Bebyakin and Korobova (1989), Bebyakin and Starichkova, (1992) reported the additive and non additive gene effects predominantly control the sedimentation value. Dhaliwal *et al.* (1994) reported parent cultivars differed by partially dominant gene for low SDS sedimentation value.

Dhillon *et. al.* (2003) studied on six generations of four wheat crosses for grain yield per plant, grains per spike, 1000-grain weight, Protein content (%), β-carotene, semolina recovery (%), yellow berry (%) and sedimentation values. They observed that grain yield per plant showed moderate to high positive association with β-

carotene, but significant negative association with protein content indicated difficulty in simultaneous improvement in there traits. Grain per spike exhibited high magnitude of positive association with yellow berry, semolina recovery, β - carotene and sedimentation value, but negative with protein content. 1000-grain weight exhibited significant magnitude of negative correlation with yellow berry, β - carotene and protein content, but positive association with sedimentation value in all the crosses. For a more efficient approach towards improvement of grain quality along with yield and selection should be exercised based on quality component. Therefore study suggests that selection in durum wheat should be based on protein content sedimentation value and β - carotene along with yield per plant.

3.1.5 *β-carotene Content (ppm)*

Scaling test were found to be non-significant in Cross-III, HI-1418 x LOK-54, Cross-V, DL-788-2 x AKAW-3722, Cross-VI, AKAW-2978-12 x PHS-0722 and Cross-VIII, GW-496 x AKAW-4651, thereby indicating the absence of non-allelic interaction in the expression of β-carotene content. There is presence of dominance x dominance type of non-allelic interaction in Cross-II, AKAW-3997 x AKAW-3722.

Data presented on components of generation mean are, the interactions the dominance x dominance interactions was larger than I and j component. Except in Cross-II (AKAW-3997 x AKAW-3722), the additive x additive component (i) was larger than j and l component. The h and l was opposite direction, the nature of epistasis is duplicate type.

According to Meenakshi *et al*. (2005) β-carotene content is higher when a variety is grown in rainfed condition and it decreases when grown under irrigated condition and this is true in case of most of the varieties.

Zahid Akram *et al.* (2007) studied on eight wheat varieties selected on the basis of phenotypic diversity, to investigate the nature of gene action determining the inheritance pattern of protein, lysine, gluten and flour yield. In order to ascertain the gene action concerned in the inheritance of characters, the techniques such as analysis of variance of Hayman model and genetic component analysis were employed. Protein contents and flour yield being controlled by additive genetic effects with partial dominance suggested that selection could be practical in early segregating generations for improvement in these traits. Verma *et al.* (2009) reported by relative association between β- carotene and test weight in durum wheat.

3.2 *The results and discussion related to plot basis observations were as followed*

3.2.1 *Plant Height (cm)*

All scaling test were found to be significant in Cross-III, HI-1418 x LOK-54 and Cross-VII, GW-496 x NIAW-301 which indicate the presence of non-allelic interaction in the expression of plant height, Scale A, C and D were found significant in Cross-I, AKW-619 x DBW-31, which indicated the presence of non-allelic interaction, Scale A and D were found significant in Cross-II, AKAW-3997 x AKAW-3722, which indicated the presence additive x dominance and dominance x dominance type of non-allelic interaction in the expression of plant height. In case of Cross-IV, AKAW-3997 x NIAW-34, Scale C and D were found significant which indicated the presence of dominance x dominance and additive x additive type of non-allelic interaction. Scale B, C and D were found significant in Cross-V, DL-788-2 x AKAW-3722, for plant height. While, Scale A, B and D were found significant in Cross-VI, AKAW-2978-12 x PHS-6722. However, Scale A, B and C were found significant in Cross-VIII, GW-496 x AKAW-4651 in the expression of plant height.

The interaction components put together use larger than the combined main effects. Among the interactions, the dominance x dominance (l) was larger than I and j interaction effects, while among main effects, dominance (h) is greater than the additive component. The h and l are in opposite direction for four crosses Cross-II (AKAW-3997 x AKAW-3722), Cross-III (HI-1418 x Lok-54), Cross-VII (GW-496 x NIAW-301) and Cross-VIII (GW-496 x AKAW-4651), Hence, the nature of interaction is duplicate type, while h and l are in same direction for four crosses, Cross-I (AKW-619 x DBW-31), Cross-IV (AKAW-3997 x NIAW-34), Cross-V (DL-788-2 x AKAW-3722) and Cross-VI (AKAW-2978-12 x PHS-0722), hence the nature of interaction is complementary type.

Ahmad *et al.* (2007) are opined that dominant effect was the most contributor factor to inheritance of majority of traits in spring wheat, while Rahman *et al.* (2003) reported importance of partial dominance for plant height character.

The epistasis is insignificant for the Cross-VIII GW-496 x AKAW-4651). The dominance (h) is greater and significant than the additive component (d) for plant height trait. Muhammad Saleem (2005) also reported similar findings for the character plant height.

3.2.2 Number of Tillers per Plant

The dominance x dominance (l) was larger than I and j interaction effect. Except for Cross-IV (AKAW-3997 x NIAW-34), the additive x additive (i) was larger than j and l interaction effect. The nature interaction is duplicate type Cross-I (AKW-619 x DBW-31) and Cross-VII GW-496 x NIAW-301) while the rest of crosses the nature of interaction is complimentary type. The epistasis is insignificant for Cross-II (AKAW-3997 x AKAW-3722) and Cross-VIII (GW-496 x AKAW-4651) the dominance (h) is greater and significant than additive (d) component for number of tillers per plant. Neem Akhatar and Chowdhary (2006) showed (i), (j) and (l) type of epistatic effects together which indicated complex inheritance for this trait. Ojaghi and Akhundova (2010) reported duplicate epistasis for number of tillers per plant.

3.2.3 Number of Spikeletes per Spike

For number of spikeletes per spike, the interaction dominance x dominance (l) was larger than i and j interaction effects, while among interactions dominance x dominance (l) was larger than I and j interactions, while among main effects, dominance (h) is greater than the additive (d) component. The nature of epistasis is duplicate type for number of spikeletes per spike except for Cross-IV, AKAW-3997- x NIAW-34 in which the nature of epistasis is complementary type. Ojaghi and Akhundova (2010) reported duplicate epistasis for number of spikletes per spike.

3.2.4 Number of Grains per Spike

The result observed that the interaction dominance x dominance (l) was larger than I and j interaction effects except in Cross-V (DL-788-2 x AKAW-3722), hence the additive x additive component (i) was larger and significant than j and l interaction effects. The nature of espistatis for all crosses under study for number of grains per earhead is duplicate type. Neem Akhatar and Chowdhary (2006) showed dominance and dominance x dominance type of epistasis for number of grains per spike trait.

3.2.5 Grain Weight per Earhead (g)

The interactions dominance x dominance interaction (l) was larger than I and j interaction except in Cross-I (AKW-619 x DBW-31) and Cross-IV (AKAW-3997 x NIAW-34).

The dominance x dominance interaction (l) was larger than I and j interaction. The nature of epistasis is duplicate type except for Cross-IV (AKAW-3997 x NIAW-34) and Cross-V (DL-788-2 x AKAW-3722) the nature of epistasis is complimentary type.

Fatchi *et al.* (2004) observed higher value of additive gene effect comparing with dominant gene effect for this trait. Chowdhry *et al.* (2001) noted yield per plant was governed by over dominance type of gene action. Inamullah *et al.* (2006) noted significance of dominant component for this trait. Naeem Akhtar and Muhammad Aslam Chawdhary,(2006). Ahmad *et al.* (2007); showed presence of epistasis additive x dominance, dominance x dominance was important implication of breeding programme for stander hybridization and selection procedure. and useful for developing hybrid and also reported that epistasis was important for the expression of grain weight per ear and selection in later segregating generations would be more effective for improvement. Muhammad Munir *et al.* (2009) reported that grain weight per spike controlled by additive genes.

3.2.6 Grain yield per Plant (g)

For grain yield per plant result observed that the epistasis is found insignificant for Cross-V (DL-788-2 x AKAW-3722) and Cross-VIII (GW-496 x AKAW-4651) in both crosses dominance (h) is greater and significant than the additive component (d). The dominance x dominance interaction (l) was larger than I and j interaction. Among the main effects, dominance (h) is greater than additive component (d). The nature of epistasis is duplicate type. Fatchi *et al.* (2004) observed higher value of additive gene effect comparing with dominant gene effect for this trait. Chowdhry *et al.* (2001) noted yield per plant was governed by over dominance type of gene action. Inamullah *et al.* (2006) noted significance of dominant component for this trait. Shekhawat et.al.(2001) reported the dominance, dominance x dominance type o gene effect with higher magnitude and duplicate type of epistasis .Chowdhry *et al.* (2001) noted yield per plant was governed by over dominance type of gene action. Fatchi *et al.* (2004) also observed higher value of additive gene effect as compared with dominant gene effect for this trait. Inamullah *et al.* (2006) noted significance of dominant component for this trait. Ojaghi and Akhundova (2010) reported duplicate epistasis for number of tillers per plant.

Table 1(a): Mean performance of five characters recorded on plot basis in Pool environmental conditions

Crosses		Characters				
		Days to heading	1000 Seed weight (g)	Protein content (%)	Sedimentation value (ml)	Beta carotene (ppm)
Pool Environment Cross - I (AKW-619 x DBW-31)						
P_1	54.33 ± 2.29	42.45 ± 0.50	12.73 ± 0.24		29.33 ± 0.42	3.39 ± 0.18
P_2	55.50 ± 2.76	43.48 ± 0.56	11.88 ± 0.22		30.33 ± 0.61	2.76 ± 0.23
F_1	52.00 ± 1.80	41.64 ± 1.74	14.13** ± 0.43		36.50* ± 1.25	4.79 ± 0.28
F_2	51.66 ± 1.56	41.68 ± 1.74	12.65 ± 0.38		32.33 ± 1.20	4.62 ± 0.23
BC_1	54.33 ± 1.66	42.87 ± 0.57	12.21 ± 0.12		31.00 ± 0.44	4.08 ± 0.37
BC_2	53.72 ± 2.07	42.80 ± 1.06	12.18 ± 0.29		29.33 ± 0.66	3.21 ± 0.25
Pool Environment Cross -II (AKAW-3997 x AKAW-3722)						
P_1		57.00 ± 2.42	46.04 ± 3.93	11.35 ± 0.26	36.33 ± 1.76	3.75 ± 0.32
P_2		57.83* ± 2.77	45.60 ± 1.81	11.69 ± 0.28	30.33 ± 0.61	3.30 ± 0.27
F_1		54.16 ± 2.05	47.01 ± 3.91	13.99** ± 0.23	30.00 ± 1.26	4.90 ± 0.16
F_2		54.33 ± 2.10	48.24 ± 3.20	13.57** ± 0.32	28.16 ± 1.04	5.06 ± 0.27
BC_1		56.16 ± 2.85	46.91* ± 2.81	12.01 ± 0.22	27.66 ± 0.61	4.60 ± 0.28
BC_2		56.00 ± 3.44	47.10 ± 1.00	12.68 ± 0.31	28.00 ± 0.51	4.63 ± 0.82
Pool Environment Cross -III (HI-1418 x LOK-54)						
P_1		54.50 ± 2.48	40.80 ± 0.59	11.17 ± 0.25	31.66 ± 0.61	4.13 ± 0.26
P_2		55.66 ± 2.40	44.52 ± 1.56	11.99 ± 0.03	31.33 ± 0.66	4.01 ± 0.33
F_1		51.00 ± 0.89	51.12** ± 3.45	12.08 ± 0.33	32.50 ± 1.45	5.88** ± 0.17
F_2		53.16 ± 1.90	48.52 ± 0.95	11.64 ± 0.37	30.66 ± 0.84	5.57* ± 0.26
BC_1		52.83 ± 0.54	49.60* ± 1.32	12.11 ± 0.12	30.16 ± 0.40	4.88 ± 0.34
BC_2		54.00 ± 0.85	50.01* ± 0.75	11.79 ± 0.27	30.00 ± 0.44	4.20 ± 0.19
Pool Environment Cross -IV (AKAW-3997 x NIAW-34)						
P_1		57.33 ± 2.30	37.50 ± 0.23	11.63 ± 0.18	38.33** ± 1.74	4.07 ± 0.31
P_2		59.16** ± 1.42	37.10 ± 1.50	11.54 ± 0.36	38.66** ± 0.98	3.89 ± 0.38
F_1		55.16 ± 2.35	45.16 ± 1.72	13.51** ± 0.11	40.00** ± 0.51	4.93 ± 0.10
F_2		55.50 ± 2.63	42.79 ± 1.70	12.89 ± 0.22	37.50** ± 0.88	5.63* ± 0.40
BC_1		57.00 ± 2.12	41.48 ± 1.86	12.04 ± 0.31	36.00 ± 0.89	4.56 ± 0.56
BC_2		57.00 ± 1.86	39.55 ± 0.82	12.11 ± 0.13	34.66 ± 0.98	3.94 ± 0.17
Pool Environment Cross -V (DL-788-2 x AKAW-3722)						
P_1		54.50 ± 1.92	39.62 ± 0.90	11.65 ± 0.17	29.66 ± 0.33	4.26 ± 0.20
P_2		53.66 ± 1.96	44.06 ± 0.97	11.80 ± 0.13	35.50 ± 1.78	4.62 ± 0.46
F_1		51.50 ± 0.56	50.48** ± 2.08	12.55 ± 0.38	35.16 ± 0.60	5.53* ± 0.14
F_2		51.00 ± 1.77	48.11 ± 1.98	12.18 ± 0.21	32.83 ± 0.70	5.39 ± 0.30
BC_1		52.50 ± 0.56	46.25 ± 1.38	11.87 ± 0.22	33.66 ± 1.40	5.00 ± 0.45
BC_2		51.33 ± 2.29	48.01 ± 3.07	12.15 ± 0.13	33.83 ± 1.47	4.66 ± 0.24

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Crosses	Characters				
	Days to heading	1000 Seed weight (g)	Protein content (%)	Sedimentation value (ml)	Beta carotene (ppm)
Pool Environment Cross -VI (AKAW-2978-12 x PHS-0722)					
P$_1$	58.00* ± 1.86	38.78 ± 0.92	12.92 ± 0.17	40.16** ± 0.83	3.59 ± 0.33
P$_2$	56.50 ± 2.10	39.13 ± 0.81	12.70 ± 0.16	30.33 ± 0.95	4.40 ± 0.26
F$_1$	54.66 ± 1.52	45.81 ± 1.57	14.15** ± 0.26	38.00** ± 1.29	5.04 ± 0.32
F$_2$	54.83 ± 1.32	44.30 ± 1.75	13.81** ± 0.25	35.50 ± 1.58	4.87 ± 0.27
BC$_1$	58.00* ± 1.78	38.98 ± 0.79	14.30** ± 0.23	37.83** ± 0.40	4.05 ± 0.35
BC$_2$	57.83* ± 1.77	41.63 ± 1.10	13.54** ± 0.26	34.83 ± 1.16	4.33 ± 0.33
Pool Environment Cross -VII (GW-496 x NIAW-301)					
P$_1$	54.16 ± 1.57	42.11 ± 0.76	12.80 ± 0.18	35.16 ± 1.04	3.05 ± 0.25
P$_2$	58.66** ± 3.44	43.03 ± 1.06	12.81 ± 0.25	30.50 ± 0.50	4.98 ± 0.02
F$_1$	52.33 ± 1.66	48.04 ± 1.73	13.92** ± 0.22	39.16** ± 0.79	6.00** ± 0.30
F$_2$	57.00 ± 2.42	46.74 ± 2.54	13.83** ± 0.29	37.50** ± 0.61	5.76** ± 0.22
BC$_1$	58.00* ± 2.16	44.13 ± 1.24	12.30 ± 0.20	36.66* ± 2.40	4.02 ± 0.39
BC$_2$	57.50* ± 2.63	46.02 ± 1.49	12.55 ± 0.32	28.66 ± 0.98	4.74 ± 0.15
Pool Environment Cross -VIII (GW-496 x AKAW-4651)					
P$_1$	56.33 ± 2.30	39.95 ± 0.99	11.69 ± 0.48	29.50 ± 0.50	4.44 ± 0.26
P$_2$	56.00 ± 2.88	43.27 ± 0.86	12.08 ± 0.26	32.50 ± 1.20	4.47 ± 0.18
F$_1$	52.00 ± 1.98	53.45** ± 2.40	13.16 ± 0.11	35.50 ± 1.14	5.97** ± 0.48
F$_2$	52.50 ± 1.99	48.86* ± 1.53	12.55 ± 0.17	34.66 ± 0.98	5.50* ± 0.27
BC$_1$	56.33 ± 2.33	47.53 ± 0.92	12.09 ± 0.16	32.33 ± 1.38	4.78 ± 0.37
BC$_2$	55.66 ± 2.56	47.41 ± 0.96	12.09 ± 0.19	33.33 ± 0.95	5.26 ± 0.15
Mean	55	44.58	12.52	33.4	4.57
S.E.(M)±	0.9	1.5	0.23	1.06	0.31
C.D.(5%)	2.51	4.19	0.66	2.95	0.88

Table 1(b). Mean performance of six characters recorded on plant basis of six generations for eight crosses in Pooled environmental conditions

Crosses	Characters				
	Plant height (cm)	No. of tillers per plant	No. of spikletes per spike	No. of grains per spike	Grain weight per spike (g)	Grain yield per plant (g)
Pool Environment Cross - I (AKW-619 x DBW-31)					
P$_1$	80.90 ± 0.98	7.43 ± 0.04	18.06 ± 1.06	45.68 ± 1.34	1.43 ± 0.01	16.09 ± 0.22
P$_2$	82.51 ± 0.63	8.23 ± 0.01	18.53 ± 0.20	52.45 ± 0.91	1.54 ± 0.02	17.18** ± 0.19
F$_1$	85.38 ± 0.58	10.65** ± 0.01	19.66 ± 0.14	57.93 ± 0.96	1.91** ± 0.03	18.68** ± 0.31
F$_2$	87.34 ± 0.59	9.63** ± 0.07	19.04 ± 0.11	49.86 ± 0.58	1.98** ± 0.01	18.10** ± 0.16
BC$_1$	80.53 ± 0.94	7.40 ± 0.07	18.00 ± 0.17	45.73 ± 0.82	1.75* ± 0.03	16.73 ± 0.16
BC$_2$	82.31 ± 0.72	7.95 ± 0.02	18.76 ± 0.16	45.60 ± 0.87	1.84** ± 0.03	17.15* ± 0.25
Pool Environment Cross -II (AKAW-3997 x AKAW-3722)					
P$_1$	90.46** ± 0.94	6.48 ± 0.14	18.36 ± 0.16	49.66 ± 0.66	1.67 ± 0.02	15.69 ± 0.22

P_2	82.00 ± 0.75	6.60 ± 0.03	17.90 ± 0.27	45.26 ± 0.81	1.66 ± 0.04	15.90 ± 0.24
F_1	91.80** ± 0.81	8.70* ± 0.03	20.13* ± 0.22	58.68* ± 1.10	2.06** ± 0.02	16.99* ± 0.19
F_2	89.98 ± 0.48	7.44 ± 0.12	19.81 ± 0.13	58.48* ± 0.64	1.99** ± 0.57	16.91* ± 0.54
BC_1	86.51* ± 0.67	6.86 ± 0.03	18.86 ± 0.13	51.46 ± 0.80	1.81** ± 0.03	15.69 ± 0.25
BC_2	85.60 ± 0.56	6.96 ± 2.11	18.60 ± 0.14	52.80 ± 1.08	1.74 ± 0.04	16.17 ± 0.23
Pool Environment Cross -III (HI-1418 x LOK-54)						
P_1	80.23 ± 0.69	6.48 ± 0.09	17.80 ± 0.22	47.31 ± 1.12	1.55 ± 0.03	14.47 ± 0.23
P_2	79.91 ± 0.72	6.56 ± 0.05	18.53 ± 0.25	47.91 ± 0.83	1.65 ± 0.03	14.95 ± 0.15
F_1	90.73** ± 0.89	8.68** ± 0.04	21.63** ± 0.24	60.73** ± 1.09	2.01** ± 0.04	16.58 ± 0.30
F_2	88.96** ± 0.79	7.90 ± 0.09	20.33** ± 0.14	62.15** ± 0.62	1.80** ± 0.02	16.02 ± 0.18
BC_1	80.25 ± 1.15	6.86 ± 0.03	18.86 ± 0.20	52.95 ± 0.91	1.71 ± 0.02	15.05 ± 0.29
BC_2	80.01 ± 0.70	6.96 ± 0.01	19.13 ± 0.18	53.30 ± 1.04	2.01** ± 0.05	15.47 ± 0.23
Pool Environment Cross -IV (AKAW-3997 x NIAW-34)						
P_1	79.65 ± 0.86	4.95 ± 0.04	18.63 ± 0.19	53.45 ± 0.67	1.38 ± 0.03	14.56 ± 0.34
P_2	80.65 ± 1.24	6.08 ± 0.05	20.53** ± 0.28	54.11 ± 0.81	1.43 ± 0.03	14.82 ± 0.32
F_1	86.61** ± 0.72	8.61 ± 0.10	20.7** ± 0.25	63.06** ± 1.16	1.78* ± 0.03	16.8 ± 0.40
F_2	88.26** ± 0.68	7.93 ± 0.09	19.25 ± 0.13	60.11** ± 0.65	1.75* ± 0.01	16.21 ± 0.40
BC_1	81.96 ± 0.82	7.58 ± 0.07	19.26 ± 0.19	55.70 ± 1.09	1.65 ± 0.04	15.17 ± 0.20
BC_2	85.28 ± 0.64	7.06 ± 0.02	19.63 ± 0.19	57.05* ± 1.19	1.66 ± 0.03	15.43 ± 0.24
Pool Environment Cross -V (DL-788-2 x AKAW-3722)						
P_1	74.06 ± 0.78	5.33 ± 0.03	18.96 ± 0.27	49.10 ± 1.27	1.53 ± 0.02	14.95 ± 0.21
P_2	81.31 ± 0.64	6.70 ± 0.03	18.86 ± 0.23	51.80 ± 0.75	1.52 ± 0.02	15.07 ± 0.15
F_1	80.16 ± 0.83	8.70 ± 0.05	20.20** ± 0.24	53.96 ± 1.48	1.81* ± 0.04	16.62 ± 0.34
F_2	80.80 ± 0.63	7.64 ± 0.07	19.77 ± 0.22	57.50 ± 0.77	1.60 ± 0.42	16.16 ± 0.39
BC_1	76.00 ± 0.47	6.93 ± 0.02	18.50 ± 0.24	52.21 ± 0.97	1.61 ± 0.03	16.01 ± 0.36
BC_2	77.35 ± 0.56	7.30 ± 0.03	18.33 ± 0.19	52.98 ± 0.90	1.55 ± 0.03	15.66 ± 0.24
Pool Environment Cross -VI (AKAW-2978-12 x PHS-0722)						
P_1	76.08 ± 0.53	6.23 ± 0.16	17.26 ± 0.12	49.90 ± 0.79	1.52 ± 0.03	15.95 ± 0.30
P_2	89.86** ± 0.77	5.13 ± 0.14	17.90 ± 0.16	51.80 ± 0.96	1.48 ± 0.02	16.93* ± 0.30
F_1	86.46* ± 0.59	7.63 ± 0.13	20.66** ± 0.22	68.21** ± 0.76	1.66 ± 0.03	18.53** ± 0.34
F_2	85.42 ± 0.49	5.98 ± 0.11	20.28** ± 0.14	57.02 ± 0.65	1.62 ± 0.49	17.77** ± 0.45
BC_1	78.21 ± 0.48	6.68 ± 0.16	17.90 ± 0.16	52.17 ± 0.79	1.54 ± 0.03	16.65 ± 0.32
BC_2	83.56 ± 0.51	5.65 ± 0.13	18.26 ± 0.15	50.41 ± 0.72	1.51 ± 0.03	17.04** ± 0.33
Pool Environment Cross -VII (GW-496 x NIAW-301)						
P_1	81.96 ± 0.56	5.07 ± 0.06	18.20 ± 0.11	51.75 ± 1.03	1.43 ± 0.03	13.99 ± 0.17
P_2	89.63** ± 0.78	6.48 ± 0.05	18.10 ± 0.13	48.73 ± 0.69	1.41 ± 0.03	13.91 ± 0.28
F_1	88.81** ± 0.59	8.03 ± 0.02	19.26 ± 0.17	61.13** ± 1.33	1.61 ± 0.03	15.43 ± 0.20
F_2	85.23 ± 0.44	7.86 ± 0.10	18.73 ± 0.13	54.35 ± 0.84	2.04 ± 0.48	15.32 ± 0.43
BC_1	79.63 ± 0.80	6.61 ± 0.04	18.46 ± 0.16	52.13 ± 0.68	1.47 ± 0.01	14.97 ± 0.27
BC_2	79.13 ± 0.62	6.81 ± 0.01	18.00 ± 0.16	50.30 ± 0.81	1.49 ± 0.02	14.60 ± 0.17
Pool Environment Cross -VIII (GW-496 x AKAW-4651)						

P_1	80.20 ± 0.53	7.21 ± 0.04	17.33 ± 0.12	49.75 ± 0.71	1.43 ± 0.03	14.58 ± 0.27
P_2	79.48 ± 0.56	6.65 ± 0.04	17.83 ± 0.16	44.68 ± 0.73	1.39 ± 0.02	14.18 ± 0.16
F_1	84.35 ± 0.61	8.73** ± 0.05	20.16* ± 0.22	58.23 ± 0.79	1.66 ± 0.03	15.68 ± 0.26
F_2	80.59 ± 0.36	8.31 ± 0.20	19.51 ± 0.17	56.84 ± 0.59	1.56 ± 0.48	15.82 ±0.44
BC_1	79.33 ± 0.52	8.56* ± 0.05	17.10 ± 0.16	55.18 ± 1.06	1.43 ± 0.01	15.24 ± 0.18
BC_2	80.15 ± 0.48	8.01 ± 0.41	17.33 ± 0.19	50.91 ± 0.66	1.46 ± 0.02	15.30 ± 0.14
Mean	83.04	7.25	18.89	53.37	1.64	15.87
S.E.(M)±	1.09	0.42	0.36	1.54	0.04	0.35
C.D.(5%)	3.05	1.17	1.00	4.29	0.11	0.97

Table 2 (a). Scaling test results for eleven characters in eight crosses over the environments on plot basis character in Pool environmental conditions

Crosses	Characters				
	Days to heading	1000 seed weight	Protein content	Sedimentation value	Beta carotene
Pool Environment Cross - I (AKW-619 x DBW-31)					
A	2.33 ± 4.43	1.64 ± 2.15	-2.44** ± 0.55	-3.83** ± 1.60	-0.02 ± 0.82
B	-0.05 ± 5.31	0.47 ± 2.80	-1.66** ± 0.76	-8.16** ± 1.93	-1.12 ± 0.63
C	-7.16 ± 8.06	-2.48 ± 7.85	-2.29 ± 1.79	-3.33 ± 5.47	2.77* ± 1.13
D	-4.72 ± 4.10	-2.30 ± 3.70	0.90 ± 0.83	4.33 ± 2.53	1.96** ± 0.65
Pool Environment Cross - II (AKAW-3997 x AKAW-3722)					
A	1.16 ± 6.53	0.77 ± 7.9	-1.32** ± 0.57	-11.00** ± 2.49	0.54 ± 0.67
B		1.59 ± 4.75	-0.31 ± 0.73	-4.33* ± 1.74	1.06 ± 1.60
C	-5.83 ± 10.07	7.30 ± 15.64	3.25* ± 1.42	-14.00** ± 5.23	3.38** ± 1.20
D	-3.50 ± 6.14	2.46 ± 7.07	2.45** ± 0.75	0.66 ± 2.24	0.89 ± 1.02
Pool Environment Cross - III (HI-1418 x LOK-54)					
A	0.16 ± 2.85	7.28 ± 4.38	0.96 ± 0.48	-3.83* ± 1.77	-0.25 ± 0.75
B	1.33 ± 3.08	4.38 ± 4.08	-0.49 ± 0.64	-3.83 ± 1.83	-1.48 ± 0.54
C	0.50 ± 8.55	6.52 ± 8.06	-0.76 ± 1.67	-5.33 ± 4.54	2.39 ± 1.18
D	-0.50 ± 3.94	-2.57 ± 2.43	-0.61 ± 0.81	1.16 ± 1.70	2.06 ± 0.65
Pool Environment Cross - IV (AKAW-3997 x NIAW-34)					
A	1.50 ± 5.38	0.29 ± 4.12	-1.05 ± 0.65	-6.33** ± 2.55	0.11 ± 1.16
B	-0.33 ± 4.63	-3.15 ± 2.81	-0.81 ± 0.47	-9.33** ± 2.27	-0.94 ± 0.52
C	-4.83 ± 11.84	6.24 ± 7.80	1.38 ± 1.01	-7.00 ± 4.19	4.70** ± 1.69
D	-3.00 ± 5.97	4.55 ± 3.98	1.62** ± 0.56	4.33 ± 2.21	2.76** ± 0.99
Pool Environment Cross - V (DL-788-2 x AKAW-3722)					
A	-1.00 ± 2.30	2.40 ± 3.58	-0.46 ± 0.61	2.50 ± 2.89	0.20 ± 0.94
B	-2.50 ± 5.01	1.47 ± 6.57	-0.05 ± 0.49	-3.00 ± 3.49	-0.83 ± 0.69
C	-7.16 ± 7.67	7.80 ± 9.04	0.16 ± 1.17	-4.16 ± 3.55	1.60 ± 1.35
D	-1.83 ± 4.25	1.96 ± 5.20	0.34 ± 0.50	-1.83 ± 2.47	1.12 ± 0.80
Pool Environment Cross - VI (AKAW-2978-12 x PHS-0722)					
A	3.33 ± 4.31	-6.62** ± 2.41	1.53** ± 0.57	-2.50 ± 1.73	-0.51 ± 0.85
B	4.50 ± 4.40	-1.68 ± 2.83	0.21 ± 0.60	1.33 ± 2.83	-0.78 ± 0.78
C	-4.50 ± 6.73	7.69 ± 7.79	1.30 ± 1.16	-4.50 ± 6.90	1.40 ± 1.34

D	-6.16 ± 3.66	8.00* ± 3.76	-0.22 ± 0.61	-1.66 ± 3.40	1.35 ± 0.73
Pool Environment Cross - VII (GW-496 x NIAW-301)					
A	9.50 ± 4.89	-1.89 ± 3.12	-2.12** ± 0.49	-1.00 ± 4.98	-1.01 ± 0.88
B	4.00 ± 6.50	0.97 ± 3.61	-1.62* ± 0.72	-12.33** ± 2.18	-1.50** ± 0.43
C	10.50 ± 10.92	5.73 ± 10.83	1.85 ± 1.30	6.00 ± 3.16	3.00** ± 1.12
D	-1.50 ± 5.92	3.32 ± 5.44	2.80** ± 0.70	9.66** ± 2.87	2.76** ± 0.62
Pool Environment Cross - VIII (GW-496 x AKAW-4651)					
A	4.33 ± 5.57	1.65 ± 3.18	-0.67 ± 0.60	-0.33 ± 3.03	-0.85 ± 0.93
B	3.33 ± 6.21	-1.90 ± 3.19	-1.05* ± 0.48	-1.33 ± 2.53	0.07 ± 0.60
C	-6.33 ± 9.64	5.30 ± 7.91	0.11 ± 0.90	5.66 ± 4.75	1.15 ± 1.51
D	-7.00 ± 5.28	2.78 ± 3.34	0.92* ± 0.42	3.66 ± 2.59	0.96 ± 0.68

Table 2 (b). Scaling test results for six characters on plant basis in eight crosses for Pool environmental conditions

Crosses	Characters					
	Plant height	**No. of tillers per plant**	**No. of spikletes per spike**	**No. of grains per spike**	**Grain weight**	**Grain yield per plant**
Pool Environment Cross - I (AKW-619 x DBW-31)						
A	-5.11* ± 2.21	-3.28** ± 0.75	-1.73 ± 1.13	-12.15** ± 2.33	0.15 ± 0.09	-1.33* ± 0.52
B	-3.22 ± 1.67	-2.98** ± 1.00	-0.66 ± 0.41	-19.18** ± 2.19	0.24** ± 0.08	-1.55* ± 0.61
C	15.34** ± 2.86	1.56 ± 1.10	0.24 ± 1.21	-14.53** ± 3.44	1.11** ± 0.11	1.73 ± 0.97
D	11.83** ± 1.67	3.91** ± 0.67	1.32** ± 0.32	8.40** ± 1.67	0.35** ± 0.06	2.31** ± 0.45
Pool Environment Cross - II (AKAW-3997 x AKAW-3722)						
A	-9.23** ± 1.84	-0.30 ± 0.65	-0.76 ± 0.39	-6.18** ± 2.07	-0.11 ± 0.07	-1.28* ± 0.59
B	-2.60 ± 1.59	0.23 ± 0.60	-0.83 ± 0.45	3.40 ± 2.57	-0.20* ± 0.09	-0.71 ± 0.56
C	3.88 ± 2.78	-0.07 ± 0.84	2.73** ± 0.76	20.65** ± 3.57	0.52** ± 0.11	0.21 ± 1.03
D	7.86** ± 1.30	0.00 ± 0.53	2.16** ± 0.32	11.71** ± 1.88	0.42** ± 0.07	1.10 ± 0.57
Pool Environment Cross - III (HI-1418 x LOK-54)						
A	-10.46** ± 2.57	-1.45** ± 0.53	-1.73** ± 0.53	-2.15 ± 2.41	-0.16* ± 0.08	-0.94 ± 0.71
B	-10.61** ± 1.82	-1.36** ± 0.49	-1.93** ± 0.51	-2.05 ± 2.49	0.35** ± 0.09	-0.59 ± 0.57
C	14.25** ± 3.79	-0.71 ± 0.68	1.66* ± 0.85	31.92** ± 3.57	-0.04 ± 0.14	1.49 ± 1.00
D	17.66** ± 2.10	1.05* ± 0.42	2.66** ± 0.40	18.06** ± 1.85	-0.12 ± 0.07	1.50** ± 0.53
Pool Environment Cross - IV (AKAW-3997 x NIAW-34)						
A	-2.33 ± 2.01	1.60 ± 0.62	-0.80 ± 0.51	-5.12 ± 2.57	0.14 ± 0.10	-1.01 ± 0.66
B	3.30 ± 1.94	-0.57 ± 0.61	-1.96** ± 0.54	-3.08* ± 2.78	0.12 ± 0.09	-0.76 ± 0.71
C	19.55** ± 3.45	3.48** ± 0.93	-3.54** ± 0.83	6.77 ± 3.66	0.62** ± 0.12	0.49 ± 1.22
D	9.29** ± 1.72	1.22** ± 0.46	-0.39 ± 0.39	7.48** ± 2.08	0.17** ± 0.07	1.14* ± 0.51
Pool Environment Cross - V (DL-788-2 x AKAW-3722)						
A	-2.23 ± 1.49	-0.17 ± 0.61	-2.16** ± 0.61	1.37 ± 2.76	-0.13 ± 0.10	0.45 ± 0.85
B	-6.78** ± 1.55	-0.80 ± 0.65	-2.40** ± 0.52	0.20 ± 2.46	-0.23** ± 0.09	-0.37 ± 0.62
C	7.50* ± 3.20	1.14 ± 0.88	0.88 ± 1.07	21.16** ± 4.55	-0.21 ± 0.14	1.40 ± 1.05
D	8.26** ± 1.47	1.05* ± 0.47	2.72** ± 0.54	9.80** ± 2.04	0.08 ± 0.07	0.66 ± 0.58
Pool Environment Cross - VI (AKAW-2978-12 x PHS-0722)						
A	-6.11** ± 1.26	-0.50 ± 0.39	-2.13** ± 0.42	-13.78** ± 1.94	-0.09 ± 0.08	-1.18 ± 0.80
B	-9.20** ± 1.43	-1.46** ± 0.34	-2.03** ± 0.41	-19.18** ± 1.91	-0.11 ± 0.09	-1.39 ± 0.82

C	2.83 ± 2.51	-2.67** ± 0.59	4.61** ± 0.75	-10.04** ± 3.22	0.15 ± 0.11	1.13 ± 1.17
D	9.07** ± 1.23	-0.36 ± 0.32	4.38** ± 0.37	11.46** ± 1.66	0.18** ± 0.07	1.85* ± 0.64
Pool Environment Cross - VII (GW-496 x NIAW-301)						
A	-11.51** ± 1.81	0.13 ± 0.45	-0.53 ± 0.38	-8.61** ± 2.18	-0.08 ± 0.06	0.52 ± 0.61
B	-20.18** ± 1.59	-0.88 ± 0.65	-1.36** ± 0.40	-9.73** ± 2.25	-0.05 ± 0.07	-0.13 ± 0.49
C	-8.30** ± 2.37	3.85** ± 0.63	0.10 ± 0.68	-6.06 ± 4.43	0.19* ± 0.10	2.50** ± 0.78
D	11.70** ± 1.36	2.30** ± 0.40	1.00** ± 0.36	6.14** ± 1.97	0.17** ± 0.04	1.05* ± 0.43
Pool Environment Cross - VIII (GW-496 x AKAW-4651)						
A	-5.88** ± 1.32	1.18 ± 1.02	-3.30** ± 0.42	2.38 ± 2.38	-0.22** ± 0.06	0.22 ± 0.54
B	-3.53** ± 1.26	0.65 ± 0.95	-3.33** ± 0.49	-1.08 ± 1.72	-0.12 ± 0.07	0.78 ± 0.43
C	-6.11** ± 2.06	1.91 ± 1.25	2.56** ± 0.85	16.47** ± 3.03	0.09 ± 0.13	1.64 ± 0.96
D	1.65 ± 1.01	0.04 ± 0.77	4.60** ± 0.43	7.58** ± 1.73	0.22** ± 0.06	0.31 ± 0.44

Table 3 (a). Estimates of generation mean components in eight crosses on plot basis characters over the Pool environmental condition

Charac-ters	M	d	h	i	j	l	Nature of gene action
Crosses	**Days to heading**						
I	54.63** ± 1.49	-0.06 ± 1.48	-2.82 ± 2.54				
II	57.16** ± 1.64	-0.27 ± 1.7	-3.29 ± 2.75				
III	55.49** ± 1.04	-0.96 ± 0.85	-4.38** ± 1.66				
IV	58.29** ± 1.24	-0.77 ± 1.21	-3.21 ± 2.49				
V	53.34** ± 1.01	0.39 ± 1.02	-1.96 ± 1.27				
VI	57.52** ± 1.20	0.58 ± 1.22	-2.55 ± 2.06				
VII	57.56** ± 1.59	-2.32 ± 1.6	-3.75 ± 2.44				
VIII	56.34** ± 1.60	0.31 ± 1.62	-4.09 ± 2.69				
Crosses	**1000 seed wt. (g)**						
I	43.00** ± 0.37	-0.43 ± 0.35	-0.51 ± 1.07				
II	46.01** ± 1.90	0.17 ± 1.71	2.20 ± 3.41				
III	42.74** ± 0.75	-1.81* ± 0.70	12.43** ± 1.90				
IV	36.82** ± 0.63	0.68 ± 0.63	7.78** ± 1.63				
V	41.97** ± 0.65	-2.17** ± 0.64	9.77** ± 1.77				
VI	44.3** ± 1.75	-2.64 ± 1.36	-9.15 ± 7.72	-16.00* ± 7.53	-2.46 ± 1.49	24.31* ± 9.51	Duplicate
VII	42.6** ± 0.63	-0.61 ± 0.62	5.29** ± 1.55				
VIII	41.68** ± 0.64	-1.30* ± 0.59	12.00** ± 1.58				
Crosses	**Protein content (%)**						
I	12.65** ± 0.38	0.03 ± 0.31	0.02 ± 1.72	-1.80 ± 1.66	-0.39 ± 0.359	5.90** ± 2.20	Complimentary
II	13.57** ± 0.32	-0.67 ± 0.39	-2.43 ± 1.53	-4.90** ± 1.50	-0.50 ± 0.44	6.54** ± 2.11	Duplicate
III	11.75** ± 0.10	-0.24* ± 0.10	0.57 ± 0.28				
IV	12.89** ± 0.22	-0.07 ± 0.34	-1.32 ± 1.15	-3.24** ± 1.12	-0.11 ± 0.398	5.11** ± 1.70	Duplicate
V	11.71** ± 0.10	-0.10 ± 0.10	0.75** ± 0.20				
VI	13.81** ± 55.10	0.76* ± 2.17	1.78 ± 1.41	0.45 ± 0.36	0.66 ± 1.769	-2.20 ± -1.20	Duplicate
VII	13.83** ± 0.29	-0.25* ± 0.38	-4.48** ± 1.43	-5.60** ± 1.41	-0.24 ± 0.412	9.35** ± 2.008	Duplicate
VIII	12.55** ± 0.171	-0.03 ± 0.259	-0.53 ± 0.91	-1.84* ± 0.85	0.19 ± 0.378	3.58* ± 1.38	Duplicate
Crosses	**Sedimentation value (ml)**						
I	32.33** ± 1.20	1.66* ± 0.80	-2.00 ± 5.23	-8.66 ± 5.06	2.16** ± 0.88	20.66** ± 6.35	Duplicate
II	28.16** ± 1.04	-0.33 ± 0.80	-4.66 ± 4.75	-1.33 ± 4.48	-3.33** ± 1.23	16.66** ± 6.14	Duplicate

III	30.60** ± 0.84	0.16 ± 0.60	-1.33 ± 3.89	-2.33 ± -0.65		10.00 ± 1.94	Duplicate
IV	37.50** ± 0.88	1.33 ± 1.33	-7.167 ± 4.57	-8.66 ± 4.43	1.50 ± 1.668	24.33** ± 6.787	Duplicate
V	31.85** ± 0.7	-2.18** ± 0.72	3.16** ± 1.00				
VI	35.05** ± 0.59	4.39** ± 0.54	1.80 ± 1.20				
VII	37.50** ± 0.61	8.00** ± 2.59	-13.00* ± 5.84	-19.33** ± 5.75	5.66* ± 2.663	32.66** ± 10.87	Duplicate
VIII	30.98** ± 0.57	-1.41* ± 0.57	4.75** ± 1.22				
Crosses	**Beta carotene (ppm)**						
I	4.62** ± 0.23	0.86 ± 0.45	-2.20 ± 1.34	5.06 ± 2.14	-3.92* ± 1.31	0.54** ± 0.48	Duplicate
II	5.06** ± 0.27	-0.03 ± 0.87	-0.40 ± 2.07	0.17 ± 3.70	-1.78 ± 2.05	-0.26 ± 0.90	Complimentary
III	5.57** ± 0.26	0.67 ± 0.39	-2.32 ± 1.33	5.86 ± 1.97	-4.13** ± 1.30	0.61** ± 0.45	Duplicate
IV	5.63** ± 0.40	0.62 ± 0.58	-4.58* ± 2.00	6.36* ± 2.89	-5.53** ± 1.98	0.53 ± 0.64	Duplicate
V	4.34** ± 0.19	-0.02 ± 0.19	1.19 ± 0.26				
VI	3.99** ± 0.19	-0.37 ± 0.19	1.02** ± 0.37				
VII	5.76** ± 0.22	-0.72 ± 0.41	-3.54** ± 1.27	8.04** ± 2.01	-5.52** ± 1.23	0.24 ± 0.44	Duplicate
VIII	4.45** ± 0.15	-0.05 ± 0.14	1.56** ± 0.34				

Table 3(b). Estimates of generation mean components in eight crosses on plant basis characters over the Pool environmental condition

Charac-ters	M	D	h	i	j	l	Nature of gene action
Crosses	**Plant height (cm)**						
I	87.34** ± 0.58	-1.78 ± 1.19	-20.12** ± 3.44	-23.67** ± 3.34	-0.95 ± 1.33	32.01** ± 5.56	Duplicate
II	89.98** ± 0.47	0.91 ± 0.88	-10.15** ± 2.70	-15.72** ± 2.60	-3.31 ± 1.07	27.55** ± 4.51	Duplicate
III	88.96** ± 0.80	0.23 ± 1.35	-24.67** ± 4.31	-35.33** ± 4.19	0.07 ± 1.446	56.41** ± 6.62	Duplicate
IV	88.27** ± 0.68	-3.31** ± 1.04	-12.12** ± 3.59	-18.58** ± 3.44	-2.81** ± 1.29	17.62** ± 5.43	Duplicate
V	80.80** ± 0.63	-1.30 ± 0.74	-14.04** ± 3.09	-16.52** ± 2.93	2.27 ± 0.89	25.53** ± 4.36	Duplicate
VI	85.42** ± 0.50	-5.35** ± 0.71	-14.65** ± 2.56	-18.14** ± 2.45	1.54 ± 0.85	33.46** ± 3.79	Duplicate
VII	85.23** ± 0.45	0.50 ± 1.01	-20.38** ± 2.82	-23.40** ± 2.71	4.33 ± 1.12	55.10** ± 4.70	Duplicate
VIII	80.56** ± 0.36	-0.81 ± 0.70	1.20 ± 2.15	-3.30 ± 2.02	-1.17 ± 0.80	12.71** ± 3.49	Complimentary
Crosses	**No. of tillers per plant**						
I	9.63** ± 0.20	-0.55 ± 0.53	-5.01** ± 1.40	-7.83** ± 1.35	-0.15 ± 0.59	14.10** ± 2.42	Duplicate
II	6.17** ± 0.12	0.33 ± 0.13	2.50** ± 0.22				
III	7.44** ± 0.13	-0.10 ± 0.31	0.04 ± 0.85	-2.11* ± 0.83	-0.04 ± 0.35	4.92** ± 1.43	Duplicate
IV	7.93** ± 0.15	0.51 ± 0.34	0.64 ± 0.98	-2.45** ± 0.91	1.08 ± 0.37	1.42** ± 1.66	Complimentary
V	7.64** ± 0.14	-0.36 ± 0.36	0.57 ± 0.98	-2.11** ± 0.93	0.31 ± 0.39	3.07 ± 1.70	Complimentary
VI	5.98** ± 0.11	1.03** ± 0.21	2.66** ± 0.66	0.71 ± 0.63	0.48** ± 0.24	1.25 ± 1.04	Complimentary
VII	7.86** ± 0.10	-0.20 ± 0.34	-2.34** ± 0.83	-4.60** ± 0.80	0.50 ± 0.37	5.35** ± 1.49	Complimentary
VIII	7.07** ± 0.20	0.31 ± 0.20	2.03** ± 0.39				
Crosses	**No. of spikeletes per spike**						
I	19.04** ± 0.11	-0.76** ± 0.23	-1.27 ± 0.86	-2.64** ± 0.65	-0.53 ± 0.59	5.04** ± 1.54	Duplicate
II	19.81** ± 0.13	0.26 ± 0.20	-2.33** ± 0.71	-4.33** ± 0.65	0.03 ± 0.26	5.93** ± 1.10	Duplicate
III	20.33** ± 0.14	-0.26 ± 0.27	-1.83* ± 0.86	-5.33** ± 0.80	0.10 ± 0.32	9.00** ± 1.38	Duplicate
IV	19.25** ± 0.13	-0.36 ± 0.27	1.89** ± 0.84	0.77 ± 0.78	0.58 ± 0.32	1.98 ± 1.37	Complimentary
V	19.77** ± 0.22	0.16 ± 0.31	-4.16** ± 1.12	-5.44** ± 1.08	0.11 ± 0.36	10.01** ± 1.65	Duplicate
VI	20.27** ± 0.14	-0.36 ± 0.22	-5.69** ± 0.76	-8.78** ± 0.72	-0.05 ± 0.25	12.94** ± 1.18	Duplicate
VII	18.73** ± 0.13	0.46* ± 0.23	-0.88 ± 0.74	-2.00* ± 0.71	0.41 ± 0.25	3.90** ± 1.14	Duplicate
VIII	19.51** ± 0.17	-0.23 ± 0.26	-6.61** ± 0.9	-9.20** ± 0.86	0.01 ± 0.28	15.83** ± 1.35	Duplicate
Crosses	**No. grains per earhead**						
I	49.86** ± 0.58	0.13 ± 1.19	-7.93 ± 3.57	-16.80** ± 3.34	3.51 ± 1.45	48.13** ± 5.89	Duplicate
II	58.35** ± 0.65	-2.68 ± 1.35	-12.10** ± 3.94	-23.43** ± 3.75	-4.79 ± 1.45	26.21** ± 6.48	Duplicate
III	62.15** ± 0.61	-0.35 ± 1.38	-23.00** ± 3.9	-36.12** ± 3.70	-0.05 ± 1.55	40.32** ± 6.59	Duplicate
IV	60.11** ± 0.65	-1.35 ± 1.62	-5.68 ± 4.35	-14.96** ± 4.16	-1.01 ± 1.70	23.16** ± 7.44	Duplicate
V	57.5** ± 0.77	-0.76 ± 1.32	-16.08** ± 4.41	-19.60** ± 4.08	0.58 ± 1.52	18.03** ± 6.99	Duplicate

VI	57.02** ± 0.63	1.75 ± 1.07	-5.55 ± 3.47	-22.92** ± 3.32	2.70 ± 1.25	55.88** ± 5.38	Duplicate
VII	54.17** ± 0.82	2.06 ± 1.07	-1.39 ± 4.20	-12.28** ± 3.93	0.55 ± 1.25	30.63** ± 6.18	Duplicate
VIII	56.84** ± 0.59	4.26** ± 1.25	-4.16 ± 3.58	-15.17** ± 3.45	1.73 ± 1.35	13.87* ± 5.86	Duplicate
Crosses	**Grain weight per earhead (g)**						
I	1.98** ± 0.01	-0.09 ± 0.04	-0.28 ± 0.13	-0.70** ± 0.12	-0.04 ± 0.05	0.30 ± 0.23	Duplicate
II	1.99** ± 0.02	0.04 ± 0.05	-0.45** ± 0.13	-0.84** ± 0.13	0.04 ± 0.06	1.16** ± 0.23	Duplicate
III	1.80** ± 0.02	-0.30** ± 0.04	0.65** ± 0.14	0.23 ± 0.13	-0.25** ± 0.05	-0.42 ± 0.23	Duplicate
IV	1.75** ± 0.01	-0.01 ± 0.05	0.01 ± 0.14	-0.35** ± 0.13	0.01 ± 0.06	0.08 ± 0.25	Complimentary
V	1.61** ± 0.02	0.06 ± 0.05	0.13 ± 0.14	-0.15 ± 0.13	0.05 ± 0.06	0.51* ± 0.25	Complimentary
VI	1.62** ± 0.02	0.02 ± 0.05	-0.19 ± 0.13	-0.36** ± 0.13	0.01 ± 0.05	0.57* ± 0.24	Duplicate
VII	1.56** ± 0.01	-0.01 ± 0.03	-0.15 ± 0.09	-0.34** ± 0.08	-0.01 ± 0.04	0.48** ± 0.17	Duplicate
VIII	1.56** ± 0.02	-0.02 ± 0.03	-0.19 ± 0.12	-0.44** ± 0.11	-0.04 ± 0.04	0.79** ± 0.18	Duplicate
Crosses	**Grain yield per plant (g)**						
I	18.09** ± 0.16	-0.43 ± 0.29	-2.57** ± 0.96	-4.62** ± 0.89	0.10 ± 0.33	7.51** ± 1.53	Duplicate
II	16.44** ± 0.22	-0.39 ± 0.34	-1.006 ± 1.16	-2.20 ± 1.13	-0.29 ± 0.38	4.19** ± 1.73	Duplicate
III	16.02** ± 0.18	-0.41 ± 0.37	-1.14 ± 1.10	-3.01* ± 1.05	-0.17** ± 0.40	4.54 ± 1.80	Duplicate
IV	15.87** ± 0.19	-0.25 ± 0.31	-0.172 ± 1.11	-2.28** ± 1.01	-0.12 ± 0.39	4.06** ± 1.75	Duplicate
V	15.05** ± 0.12	-0.005 ± 0.12	1.75** ± 0.29				
VI	17.77** ± 0.21	-0.38 ± 0.47	-1.61 ± 1.33	-3.70** ± 1.27	0.10 ± 0.51	6.28** ± 2.22	Duplicate
VII	15.32** ± 0.14	0.36 ± 0.32	-0.63 ± 0.89	-2.11* ± 0.85	0.32 ± 0.36	1.71 ± 1.51	Duplicate
VIII	14.45** ± 0.14	0.14 ± 0.13	1.59** ± 0.27				

4. Conclusion

The present investigation concluded that early segregating generation used for Biparental mating and/or mating which help in developing wheat population, which upon selection will result into high yielding varieties.

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