RESEARCH ARTICLE

HETEROSIS AND CORRELATION ANALYSIS IN BREAD WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract: The present investigation was carried out to study heterosis, correlations, variance, genetic advance, heritability using diallel mating design at Research farm, during *rabi*, 2016-17. The experimental materials for the present investigation consisted of five lines *viz.*, Kalyan sona, WH-1080, PDW-215, DBW-90 and CPAN-1796 and one check *viz.*, PBW-725. The experiment was carried out in randomized block design and observations were recorded on ten characters namely days to booting, days to heading, days to anthesis, days to maturity, plant height, spike length, peduncle length, spikelets per spike, grain yield per plant, CPAN-1796 was identified as best general combiner for grain yield per plant followed by WH-1080 and PDW-215. WH-1080 × CPAN-1796 showed good specific combining ability for grain yield per plant, days to booting, days to heading, days to anthesis, days to maturity, peduncle length, number of productive tillers per plant, biological yield per plant, number of grains per plant and harvest index. The best heterotic cross for grain yield per plant was Kalyan Sona × WH-1080. Results revealed the variance analysis of grains per plant showed highly significant and positive genotypic correlations with days to booting, days to heading, spike length, plant height, harvest index and peduncle length.

Keywords: Diallel, Variance, Anthesis, Peduncle, Heterosis

Abbreviations: ANOVA, Analysis of variance; **GCA,** general combining ability; **SCA,** specific combining ability

INTRODUCTION

Triticum aestivum (bread wheat) belongs to the family Poaceae. It is an autogamous allo-hexaploid species (2n = 6x = 42) and three genomes, designated as A, B and D (AABBDD), were involved in its evolution. It combines the genomes of three diploid ancestrals, *Triticum urartu* (2n = 14, AA), *Aegilops squarrosa* (2n = 14, DD) and *Aegilops* species (2n = 14, BB). *Durum*, the only tetraploid form of wheat widely used today, and the second most widely cultivated wheat; *monococcum*, a diploid species with wild and cultivated variants; *dicoccum*, a tetraploid species, cultivated in ancient times but no longer has widespread use; *spelta*, another hexaploid species, which is cultivated in limited quantities. (Emmer wheat) are grown commercially in India, covering 86, 12, and 2 per cent of the total area under wheat, respectively[1]. It is a C_3 plant grown from irrigated to dry and high-rain-fall areas and from warm, humid to dry, cold environments. It is used to make flour for leavened, flat and steamed breads and most of the baked foods, for fermentation to make beer and alcohol. At the global level, India ranks second largest wheat producing nation with 13.43% global wheat production after china which contributes 17.7% to the world wheat production. There are many economically viable plants available in tropical areas which are a source of nutrition and are commercially exploited to sustain the economy of our country. Wheat is one of the most important and widely cultivated crops in the world, used mainly for human consumption and support nearly 35% of the world population[2]

The major wheat growing states of India are U.P., M.P., Punjab, Haryana, Rajasthan, Bihar, Gujarat, Maharashtra, Uttarakhand and West Bengal. Around 95 per cent of the wheat area is sown under *Triticum aestivum*, which is grown throughout the country, while durum and dicoccum wheat occupy nearly 5 per cent area. It is extensively cultivated in Pakistan and used as major staple food.

A feasible strategy to achieve quantum jump in the yield of wheat is the commercial production of hybrid varieties. The exploration of heterosis in wheat can be accomplished through the vigorous parental line and their subsequent evaluation for combing ability in cross combination to identify hybrid with high heterotic effect. For this purpose, the basic knowledge of genetic architecture of yield and yield components and nature of gene action is require. Among various genetic techniques, combining ability analysis developed by Kempthorne provide important information for selection of parents's in terms of the performance of their hybrids. There for the present studies conductive to access the relative of magnitude of general combining ability and specific combining ability to select the best combiner for successful wheat hybridation. Hybrid breeding in durum wheat (*Triticum durum* L.) is a promising avenue to appreciably enhance its yield potential and stability. A cost effective system of hybrid seed production is crucial for the successful development and commercialization of hybrid varieties[3]. The high cost

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of GM seed is a key factor in the high demand for and growth of chemical seed treatments[4].

The heterosis and combing ability studies are useful for the evaluation of newly developed lines for their parental usefulness and to know the gene actions involved in the inheritance of various characters. The magnitude of heterosis is associated with heterozygosity. The commercial exploitation of heterosis in wheat has limited applications of practical difficulties in hybrid seed production. The nature and magnitude of heterosis will also helpful in identifying the superior cross combinations that may produce transgressive segregants in advanced generations.

A diallel is a mating system that involves all possible crosses among a group of parents. This genetic design is used to study polygenic traits. Diallel mating designs have been used primarily to estimate genetic variances when parents are either random individuals or inbred lines from a random mating population in linkage equilibrium. The knowledge of combining ability is useful to assess differences among the genotypes and also, elucidate the nature and magnitude of gene actions involved. It has an important role to select parents and crosses and it helps to decide breeding methods to be followed to choose desirable individuals[5] . They have also been used to estimate combining ability and heterotic potential of fixed lines or varieties in crosses or for basic studies on the genetic structure of populations.

MATERIALS AND METHODS

Experimental site and location

The present study was conducted at the Agriculture Research Farm, Mata Gujri College, Fatehgarh Sahib (Punjab). This place is situated 13 km away from the Sri Fatehgarh Sahib. It is situated at latitude 30^0 56' N and longitude 76^0 40' E and at a height of 255 meters above mean sea level.

Climate and weather

The climatic condition of Fatehgarh Sahib is sub tropical with three distinct seasons i.e. winter, summer and rainy. During the winter (December-January), temperature fall 5-8 ^{0}C or even low, while in summer (May-June) it reaches as high as 42-45 ^{0}C occasional spell of frost and precipitation may be during winters. Most of rainfall is received in the middle of July to end of September after which the intensity of rainfall decreases. The mean annual rainfall about 67cm.

Experimental materials

The experimental material consisted of five varieties of wheat (*Triticum aestivum* L.) and their 10 crosses involving diallel (Excluding Reciprocal) method and one check varieties. The characteristics and sources of wheat varieties are mentioned in Table 1. The parents were selected on the basis of promising agronomic attributes and disease resistance. The parents were crossed in diallel mating design during Rabi 2016-17.

Layout

The five genotypes of wheat were sown in a Randomized Block Design (RBD) with three replications. Each genotype was grown in a double row, with distance between rows 22.5 centimeter with an appropriate plant to plant distance of 5-6 cm in each replication. Recommended agronomic package of practices were followed to raise a good crop.

Table 1. Detail of experimental materials

S. No.	Genotype	Description	Source
1.	Kalyan Sona	Timely sown; Irrigated conditions; yield: 46 q/ ha, grains amber, high tillering capacity, high adaptability to various agro climatic conditions, yield 36-40q/ha; Plant height: 80-90 cm; protein content: 10-11%.	I.I.W.B.R, Karnal
2.	DBW-90	Late sown, irrigated conditions; resistant to strip rust and leaf rust. Average yield: 42.7q/ha.	-do-
3.	WH-1080	Timely sown, rainfed conditions; Yield: 40 q/ha	-do-
4.	PDW-215	Timely sown; Irrigated conditions, Yield: 36-40 q/ ha; Days to maturity: Medium (141-145 days), Plant height: 80-90 cm, protein content:13-14%	-do-
5.	CPAN-1796	Timely sown, irrigated conditions	-do-
6.	PBW-725	Check	Market

Experimental Details: The experiment consisting 10 crosses of wheat along with five their parents and one check varieties were seeds sown in randomized complete block design with three replications in fully irrigated condition on 19 November, 2017. Each genotype was grown in double row, with row to row 22.5 centimeter with appropriate plant to plant distance of 5-6 centimeter in each replication. The recommended packages of practices were adopted for optimum crop growth. The fertilizer was applied

at the dose of 120:60:40 kg NPK/ha. The nitrogen was applied in two split at sowing time and at first node stage as well as P and K at sowing time. Five competitive plants were selected randomly and tagged from each genotype in all replications for the purpose of recording observations. The observations were recorded on the following characters.

Observations recorded

Five competitive plants were randomly selected from each plot for recording the observations for all the characters which were recorded under on replication basis. Average of the data from the sampled plants of each replication in respect of different characters was used for various statistical analysis. The observations were recorded on following quantitative characters:

Days to booting: Numbers of days recorded from the date of sowing to opening of flag leaf sheath and awns become visible at the leaf collar.

Days to Heading: Numbers of days recorded from the date of sowing to the date of 90 percent emerged from the flag leaf.

Days to anthesis: The anthesis stage lasts from the beginning to the end of the flowering period where greenish-yellow anther appear on heads per spike.

Number of tiller per plant: The number of tiller bearing ear heads, were counted at physiological maturity on per plant basis.

Plant height (cm): The height of the main shoot from the soil surface to the tip of the spike, excluding awns was measured at physiological maturity.

Spike length: The length of main spike from base of first spikelet to the tip of terminal spikelet excluding awns was measured.

Peduncle length (cm): Peduncle length not covered by leaf area sheath was measured.

Days to maturity: Number of days counted from date of sowing to date when 75 per cent plants exhibited physiological maturity.

Number of spikelets per spike: Total number of spikelets on main spike of each of the randomly selected plants was counted at physiological maturity.

Grain yield per plant (g): All the ear heads of five plants were harvested, threshed and cleaned. The total seed yield after threshing was weighed and average was taken to find the yield for one plant.

Hybridization Programme:

Each of the five lines was crossed randomly using diallel mating design for producing hybrids. The healthy spike which were at heading stage selected for emasculation and pollination. The selected spike were emasculated by hand using forceps in the evening hours between 4.00 pm to 5.00 pm. Emasculated spikes are covered with butter paper bag to avoid contamination by foreign pollen. Pollination of the emasculated flower was done next day morning during anthesis time (7.30 am to 10.30 am). Spikes at anthesis stage with dehisced anther were collected from the male parents, the bag was removed carefully and the stigma was touched with dehisced anther of male flowers. The female spike was covered with white colored butter paper bag immediately for easy identification and further avoiding the contamination from other pollen. The pedicel of each pollinated spike was tied with label, bearing information of female and male parents and date of crossing for identification.

Statistical analysis

Statistical analyses were performed utilizing the mean values of five plants in each plot of parents and F_1's in all the three replication. Data was analysis by Indo state software, Hyderabad.

Analysis of variance (ANOVA)

The analysis of variance is used for testing as to whether there exists a significant difference between the treatments or not. It was carried out following the procedure of Randomized Block design (RBD) analysis (Panse and Sukhatme, 1989) for each of the genotypes. The total variance was partitioned into three sources of variance, *viz*. replication, treatment and error.

RESULTS AND DISCUSSION

Analysis of Variance for the Design of the Experiment

The analysis of variance for 15 entries, five parents (Kalyan sona, DBW-90, WH-1080, PDW-215, CPAN-1796) and 10 crosses was done for fifteen yield and yield characters with the seasons 2017-18. The source of variation showed positive significance for all the yield traits; Days to booting, Days to heading, Days to Anthesis, Days to Maturity, Plant height, Spike Length, Peduncle length, Spikelets per spike, Grains per spike, Productive tillers per plant, test weight , Grain per plant, Grain yield per plant, Biological yield, Harvest index

Estimation of Heterosis

Exploitation of hybrid vigour for yield characters content provides an additional opportunity to improve and develops hybrids for yield traits along with adaptability for specific production environments. Estimates of mean squares for all the characters studied were highly significant indicating wide genetic differences among the genotypes. The heterotic effect in F_1 generation over better parent and standard check are presented in 4.2.1 to 4.2.15. Minimum number of days to booting and days to heading show early maturity of crop plant. All 18 cross combinations exhibited early maturity over commercial check. These findings are in accordance with the Ribadia[6] et al. (2007), Ismail[7] (2015), Thomas[8] et al. (2017) and Rajput and Kandalkar[9] (2018).

Days to Booting

The mean performance for days to booting were varies in cross combination from 82.85 (Kalyan Sona × PDW-215) to 90.74 (WH-1080 × PDW-215).

Two cross combination showed significant positive average heterosis 5.18 (DBW-90 × WH-1080) and

7.13 (WH-1080 × PDW-215) over mid parents while one cross combinations were found to be significant negative average heterosis -5.11 (Kalyan Sona × PDW-215) over mid parents.

A significant and high degree of heterosis for days to booting was observed in comparison to the better parent and the commercial genotype as well. None of the cross combinations shows significant positive and negative heterobeltiosis.

None of the cross exhibited significant positive useful heterosis for this trait. Two cross combinations showed significant negative useful heterosis having -6.06 (Kalyan Sona × CPAN-1796) and -12.90 (Kalyan Sona × PDW-215) over the commercial check

Days to Heading

The mean performance for days to heading were varies in cross combination from 88.23 (Kalyan Sona × PDW-215) to 95.31 (WH-1080 × PDW-215).

Two cross exhibited significant positive average heterosis 4.47 (DBW-90 × WH-1080) and 5.53 (WH-1080 × PDW-215) over mid parent while only one cross exhibited significant negative heterosis having -5.26 (Kalyan Sona × PDW-215).

All cross combinations exhibited significant negative useful heterosis ranging from -7.60 (WH-1080 × PDW-215) to -14.46 (Kalyan Sona × PDW-215) over the commercial check.

Days to Anthesis

The mean performance for Days to anthesis were varies in cross combination from 94.71 (Kalyan Sona × PDW-215) to 101.19 (Kalyan Sona × CPAN-1796).

Only two cross combinations showed significant positive average heterosis 4.28 (DBW-90 × WH-1080) and 5.14 (WH-1080 × PDW-215) over mid parents while one crosses were found to be significant negative average heterosis -5.39 (Kalyan Sona × PDW-215).

None of the cross combinations exhibited significant positive heterobeltiosis over better parent while one of the cross were found to be negatively significant heterosis from -5.39 (Kalyan Sona × PDW-215) over better parent.

None of the cross combinations exhibited significant positive useful heterosis over the commercial check while all ten cross combination exhibit significant negative heterosis ranging from -8.79 (WH-1080 × PDW-215) to -15.53 (Kalyan Sona × PDW-215) over the commercial check.

Days to maturity

The mean performance for days to maturity were varies in cross combinations from 18.79 (Kalyan Sona × PDW-215) to 126.31 (WH-1080 × PDW-215).

Two cross combinations showed significant positive average heterosis 3.31 (DBW-90 × PDW-215) and 3.98 (WH-1080 × PDW-215) over mid parents while one cross combination were found to be significant negative average heterosis -4.52 (Kalyan Sona × PDW-215) over mid parents.

None of the cross combinations exhibited significant positive heterobeltiosis over better parent while one cross combination were found to be negatively significant heterosis -4.57 (Kalyan Sona × PDW-215) over better parent.

None of the combination exhibited significant positive useful heterosis over the commercial check. All crosses exhibited negative useful heterosis ranging from -16.93 (Kalyan Sona × CPAN-1796) to -21.90 (Kalyan Sona × PDW-215).

Plant height

The mean performance for the plant height (cm) were varies in cross combinations from 68.12 (Kalyan Sona × WH-1080) to 104.11 (DBW-90 × WH-1080).

Five cross combinations showed significant positive average heterosis ranging from 10.47 (WH-1080 × PDW-215) to 23.03 (DBW-90 × WH-1080) over mid parents while three crosses exhibited negative significant average heterosis ranging from -12.19 (Kalyan Sona × PDW-215) to -23.75 (Kalyan Sona × WH-1080).

The plant height is an important trait by which growth and vigour of plants are measured. A significant and high degree of heterosis for plant height was observed in comparison to the better parent and the commercial genotype as well. Four cross combination showed significant positive heterosis ranging from 8.28 (DBW-90 × CPAN-1796) to 17.52 (DBW-90 × WH-1080) over better parent while three crosses exhibited negative significant heterosis ranging from -30.50 (Kalyan Sona × WH-1080) to -20.39 (Kalyan Sona × PDW-215) over better parent.

Spike Length

The mean performance for spike length were varies in cross combinations from 10.21 (WH-1080 × CPAN-1796) to 12.87 (WH-1080 × PDW-215).

Four cross combinations showed significant positive average heterosis ranging from 26.07 (Kalyan Sona × PDW-215) to 49.09 (PDW-215× CPAN-1796) over mid parent while none of the cross combination were found to be significant negative average heterosis.

One cross combination exhibited significant positive heterobeltiosis for spike length 42.07 (PDW215 × CPAN-1796) over better parent while none of the cross combination were found to be negatively significant heterosis over better parent.

Four cross combinations exhibited significant positive useful heterosis which ranging from 19.49 (DBW-90 × PDW-215) to 29.04 (WH-1080 × PDW-215) while none of the cross combination were found to be significant negative useful heterosis over commercial check for spike length.

Peduncle Length

The mean performance for the peduncle length (cm) were varies in cross combination from 26.62 (Kalyan

Sona × CPAN-1796) to 33.97 (PDW-215 × CPAN-1796).

Three cross showed significant positive average heterosis ranging from 13.13 (Kalyan Sona × WH-1080) and 18.10 (Kalyan Sona × PDW-215) over mid parents while one cross combination -9.33 (DBW-90 × CPAN-1796) were found to be significant negative over mid parents.

One of the cross combinations exhibited significant positive heterosis 13.56 (PDW-215 × CPAN-1796) over better parent while one cross (DBW-90 × CPAN-1796) were found to be negatively significant value -12.40 over better parent.

None of the cross combinations exhibited significant positive useful heterosis over the commercial check for peduncle length. Out of ten, two crosess exhibited negative significant useful heterosis ranging from -30.45 (Kalyan Sona × CPAN-1796) and -11.24 (PDW-215 × CPAN-1796) for this trait.

Grain yield per plant

The mean performance for grain yield per plant were varies in cross combinations from 27.87 (Kalyan Sona × DBW-90) to 37.20 (WH-1080 × CPAN-1796).

All ten cross combinations showed significant positive average heterosis ranging from 30.34 (PDW-215 × CPAN-1796) to 108.60 (WH-1080 × CPAN-1796) over mid parents while none of the cross combinations were found to be significant negative heterosis over mid parents.

Nine of the cross combination exhibited significant positive heterosis ranging from 29.38 (PDW-215 × CPAN-1796) to 65.65 (Kalyan Sona × WH-1080) whereas none of the cross combination found significant negative heterosis over better parent.

All cross combination exhibited significant positive useful heterosis ranging from 27.29 (Kalyan Sona × DBW-90) to 69.87 (WH-1080 × CPAN-1796) while none of the cross combination found significant negative useful heterosis over commercial check for grain yield per plant.

CONCLUSION

The association studies among different characters revealed that grain yield per plant had significant positive correlation with days to booting followed by spike length, number of grains per spike, number of productive tillers per plant, test weight and number of grains per plant at phenotypic levels. Thus, selection of genotypes based on the character will be useful in further breeding programmes in bread wheat.

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