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Heterosis and combining ability for grain yield and its contributing traits in bread wheat (Triticum aestivum L. em Thell.)

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Topic:

Heterosis and combining ability for grain yield and its contributing traits in bread wheat (Triticum aestivum L. em Thell.)

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Certificate

This is certified that this synopsis entitled **"Heterosis and combining ability for grain yield and its contributing traits in bread wheat (Triticum aestivum L. em Thell.)"** submitted in partial fulfilment of requirements for degree – **Master of Science in Genetics and Plant Breeding** by **Simerjeet Kaur**, Registraion no. **11716939** to **Department of Genetics and Plant Breeding, School of Agriculture, Lovely Professional University**, has been formulated and finalized by the student herself on the subject.

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LIST OF CONTENTS

Number	Title	Page No.
1	**Introduction**	**5-6**
2	**Review of Literature**	**6-9**
3	**Material and Methods**	**10-12**
4	**Reference**	**12-13**

1. INTRODUCTION

Wheat (Triticum aestivum L. emThell.) is a member of the family Poaceae and the world's leading cereal grain and most important food crop. Extensive and high adaptation of this plant as well as its diverse consumptions in the human nutrition it become as the most important cereal in the world, especially in developing countries and it can provide 20 percent food resources of the world people (Farzi and Shekari 2010a). Wheat ranks first in world crop production and is the National stable food of 43 countries_ Wheat is the second most important grain crop after rice in India and has tremendous yield potential. India produced 94.88 million tonnes of wheat on an area of 29.90 million hectare (3173.24 kg/ha) (FAO STAT_ 2014). Madhya Pradesh is the third largest producer of wheat with 16 10 million tonnes from the 5.40 million hectares area (Anonymous, 2014) but geometrical increase in India's population has been a challenge for agricultural scientists. To feed the ever-increasing population of India, there is a dire need of improving genotypes for better wheat yield potential per unit area basis. This could be achieved by exploring the maximum genetic potential from the available germplasm of wheat.

Wheat is largest grown cereal in the world and it supplements around 19 per cent of our total calories. It satiates the food security and wide adaptability in different agro-climatic conditions (Anon., 2014). This crop provides more nutrition to the human being in comparison to other food crops; hence, it is considered staple food for about 40% of the world's population. In India, wheat is the second most important food crop after rice occupying 30 million ha acre with production of 95.91 million tonnes during 2013-14(DES 2014).

Wheat is a self-pollinating annual plant plays a major role among the few crop species being extensively grown as staple food sources in the world (Mollasadeghi et. al. 2012).Wheat (*Triticum aestivum L. emThell.*) is an important cereal crop of the world. The grain yield in the wheat is a complex character that can be determined by several components, which reflect positive or negative effects upon this trait (Singh and Chaudhary, 2006). It was one of the first cereals to be domesticated, and is thought to have originated in the 'Fertile Crescent' (includes parts of Jordan, Lebanon, Palestine, Syria, Southeastern Turkey, Iraq and Western Iran) around 11,000 years ago and it had reached to Ethiopia, India, Great Britain, Ireland and Spain before 5,000 years ago (Dubcovsky and Dvorak), Globally, wheat is the leading source of cereal and vegetable protein in human food, having higher protein content than either maize (corn) or rice, the other major cereals. In terms of total production tonnages used for food, it is currently ahead of rice and maize as the main human food crop, after allowing for maize's more extensive use in animal feeds (Mollasadeghi et. al., 2012).

For the last several years, India is the second largest producer of wheat in the world. But even with this progress, there is no room for complacency as we will have more challenges in years to come primarily because of population increase in geometric progression thereby leading to increased demand of food. As per present population growth rate (1.6% per annum), population of India will be around 1.3 billion by 2020 AD. Assuming 20% more per capita requirement of food grains, due to better standard of living and increase in the demand of processing industries, required wheat production will be around 109 million tons by the year 2020 AD (Anonymous, 2007).

Heterosis and combining ability analysis were studied in a 8 × 3 (Line X Tester) set of bread wheat. Analysis of variance (ANOVA) revealed the presence of significant variance due to general combining ability (GCA) among the parents for all the traits, and due to specific combining ability (SCA) among the crosses. Combining ability analysis is the best technique for the proper choice of the parents for improving specific traits as well as the breeding value of the genetic variability which can be successfully used in future hybridization programs. Significant levels of heterosis have been reported in a number of self-pollinated crops, and were first observed in wheat by Freeman (1919). In wheat there are several reports on combining ability and heterosis (%) using F_1 generation.

OBJECTIVES:

1. To study *per se* performance of parents and hybrids
2. To estimate heterosis over mid parent (%), better parent (%) and standard parent (%) for yield.
3. To estimate the general combining ability effect of parent and specific combining ability effects of crosses for yield and its components.
4. To judge the nature and magnitude of the gene action involved in the inheritance of the traits.
5. Authentication of wheat hybrid by using SSR markers

2. REVIEW OF LITERATURE

The success of any plant improvement programme mainly depends on the right selection of material and its skillfull management. It is only possible when we possess knowledge of previous work done in the concerned field. In wheat substantial contribution has been made to the literature regarding its genetics and breeding in the recent years. The literature pertaining to the various aspects of the present study has been reviewed under the following heads:

2.1 Heterosis analysis

2.2 Combining ability

2.3 Gene action

2.4 SSR markers

2.1 Heterosis

The superiority of F1 hybrid over both its parents in terms of yield or some other characters or heterosis is increased vigours, growth, yield or function of a hybrid over the parents, resulting from crossing of genetically unlike organism. The term heterosis was first coined by Shull in 1914.

Chowdhryet. al., (2005). With respect to heterotic effects for tillers plant-1 , the hybrid Anmol-91 x Imdad-05 recorded maximum relative heterosis (106.35), followed by Anmol-91 x SKD-1 (72.36), while the maximum heterobeltiosis was shown by hybrid Anmol-91 x Imdad-05 (59.35), followed by Kiran-95 x Imdad-05 (45.49). It is well noted from above mentioned results that cross Anmol-91 x Imdad-05 not only displayed outstanding performance in terms of maximumtillers plant but also expressed maximum better parent heterosis, hence this cross combination may be preferred for upcoming breeding programs.

Baoet. al., (2009). For spike length**,** the hybrid WL-711 × C-271 performed best regarding heterosis (24.29%) and heterobeltiosis (19.22%) as comparison with its parents and had great potential to be used in further breeding programs to improve this trait. obtained positive significant values for spike length. Sixteen out of 19 crosses manifested negative significant heterosis while 3 crosses gave non-significant positive values for the parameter fertile tillers per plant. The estimation of heterobeltiosis indicated that all the crosses had negative significant heterobeltiosis

Zhongfuet. al., (2014). The higher relative heterosis was displayed by cross combinations of Imdad × TD-1 (10.37%) and Imdad × SKD-1 (10.16%); while the lower relative heterosis was displayed by the cross combination of Imdad × Moomal (3.59%) for seed yield plant−1 . The top high scorer F1 hybrids for heterobeltiosis were Imdad × TD-1, Imdad × SKD-1 and Imdad × Moomal with 16.04%, 10.03% and 6.04% heterobeltiosis for the seed yield plant−1 , respectively. The results of the present research are in accordance and reported significant variation in the heterosis among cross combinations for seed yield in wheat breeding programs

Mahpara, et. al.,(2015). Reported a fair amount of mid parent as well as better parent heterosis for seed index. The heterosis for total biomass plant-1 revealed that all the F1 hybrids recorded positive relative heterosis and heterobeltiosis.Hybrid Anmol-91 x Imdad-05 showed maximum relative heterosis (169.41), followed by Kiran-95 x Imdad-05 (151.86) and Kiran-95 x SKD-1 (129.98) for total biomass, whereas the cross Kiran-95 x Imdad-05 showed maximum heterobeltiosis (139.73), followed by Kiran-95 x SKD-1 (129.27). These crosses showed their superiority in heterosis for total biomass.

2.2 **Combining ability**

Combining ability is the capacity of an individual to transmit superior performance to its offspring. It is the phenomenon with which inbred lines when crossed give rise to hybrid vigour.The term was given by Sprague and Tatum (1942).

Esmailet. al., (2007). Four males and 12 females of bread wheat were studied for twelve components traits of yield. Characters studied were plant height, spike length, heading data, maturity date, seeds per spike, seed weight per spike, 1000-seed weight, biological yield, seed indexand yield per plant. Spike length and 1000-grain weight showed higher SCA variance than GCA variance for yield. Among the hybrids, BW459 × RAJ 3777, K9006 × UP2425 and HD2425 × UP2425 were potentially combiners for yield contributing traits.

Cifi and Yagdi (2010). The combining ability was estimated by using five lines and three testers of wheat in line × tester analysis mating fashion. They studied the morphological traits like spike length, plant height, grains per spike, spikelets per spike, grain weight per spike and 1000-grain weight. It was found that heredity of these traits was controlled by non-additive gene effects.

Majeed et. al.,(2011). Investigated the combining ability effects for yield and yield related traits using line × tester analysis. Among the lines, Drina NS 720, China 84- 40022, WW-7 and Nordresprez were good general combiners for grain yield. Characters like tillers per plant, spike length and 1000-grain weight. In bread wheat early flowering, early maturity, short plant height, high tillers per plant,The testers PBW 343 and Raj 3765 were the best general combiners for yield and yield related traits. Excellent combiners among the crosses were WW-7 × Raj 3765, Drina NS 720 × PBW 343, Nordresprez × PBW 343 and China 84-40022 × PBW 343.

Shamsi and Kobrae (2011). Five spring cultivars were evaluated for general and specific combining ability for yield and its contributing traits like plant height, spike length, spikelets per spike, plant tillers, biological yield per plant, 1000-seed weight, harvest index and yield per plant. It was observed that dominant genes were important in the inheritance of all traits.

2.3 Gene action

Inheritance of yield and its associated traits in wheat has been extensively studied by many researchers. Survey of previous research carried out for estimation of genetic architecture of yield and its components clearly showed that all types of gene actions were associated with expression of these characters. However, variation in gene actions was observed because of the use of different parental material, environment and their interactions. Gene effects for various characters as reported by different workers are presented as below:

Fida Hussain et al., (2008). revealed that grain yield per plant, tillers per plant, numberof grains per spike, 100-grain weight and number of spikelets per spike, spike length, and peduncle length. Analysis for genetic components indicated that additive (d) and dominant (h) were significant for all the traits.However, un-equal distribution of dominant alleles was present in the traits except spikelets per spike. The genetic informationobtained would be utilized in wheat breeding program for the development of leaf rust resistant wheat varieties with higheryield potential.

ImrenKutlu et al., (2015). Results revealed that significant variance among the genotypes to make diallel analyses for all traits and the scaling test suggested that the additive-dominance model was adequate for data analysis for all characters except for maturing date, spike length and grain weight per spike. Additive (a and d) and non-additive (b and H1, H2) gen effects were involved in the heritance of all traits according to diallel variance analyses and estimation of genetic parameters. The Wr/Vr graphs and (H1/D)0,5 value revealed that partial dominance for plant height, peduncle length, spikelet and grain number per spike, while over dominance for harvest index and grain yield per plant.

Houshmand et al., (2006). reported that number, plant height, harvest index and plant grain yield. Among the parents Dipper-6, was the best general combiners for grain yield per plant, Preion-1 for 100- grain weight and harvest index. The best specific cross for grain yield, Harvest index and 100- grain weight is Prion-1 × PI40098. Low or average GCA for almost of the traits for these two genotypes indicating that addition to additive effect, others type of gene action such as dominance, additive × dominance interactions and or maternal effect should be conceded for expression of traits. These hybrids are expected to produce desirable segregants and could be exploited successfully in durum wheat improvement programs.

Kaur et. al., (2010). Water availability predominantly affects the accumulation of some organic compatible solutes (e.g. sugars, betaines and proline), which adjusts the intercellular osmotic potential, and is an early reaction of plants to water stress. The dominant values (H1, H2) were greater than the additive values indicating dominance gene control for this trait.

2.4 SSR markers

Ahmed et al., (2011). studied 15 SSR primers of Xgwm series and 5 of X series to find out the codominant loci in the hybrid and single dominant loci in parents. Three primers from X series, namely, X66-5b, X-135-1a, and X-129-2b, gave the polymorphic band in hybrids but no single banding pattern in the parent, so it was concluded that these primers can be used to confirm the hybrids under study. Out of 15 primers, Xgwm-314 and Xgwm-311 gave the polymorphic banding pattern. The primer Xgwm-314 gave ambiguous polymorphic banding pattern that was not used to confirm the hybrids, while the primer Xgwm-311 showed the polymorphic dominant loci in the parents (LU26S, Mehraj 9272 and 9381) and codominant loci midway between theseParents. Therefore, this SSR primer was used to confirm the two best performing hybrids (LU26S x 9272 and Mehraj x 9381).

Hipi et al., (2013). revealed that the assessment of genetic purity of two hybrid varieties namely cv. Bima-3 and Bima-4, used specific markers. Forty samples of individual plants from each maize hybrid variety were tested. From five markers tested, three markers namely phi96100, phi328175 and phi072 produced polymorphic bands and capable to distinguish parental line of two maize hybrids. Microsatellite marker phi96100 was specifically used for testing hybrid purity of cv. Bima-4 and phi072 for cv. Bima-3. While phi 328175 was the specific marker for both maize hybrids. The genetic purity test of cv. Bima-3 and Bima-4 indicated that both varieties had purity levels of 97.5% and 80%, respectively. This study showed that SSR markers were more reliable for assessing hybrid purity as compared to morphological marker. The results of study are expected to be useful in the verification of purity of maize hybrid seeds accurately.

3. MATERIALS AND METHODS

The chapter comprises the details about the materials used and the methods adopted during the course of present investigation entitled "Heterosis and combining ability for grain yield and its contributing traits in bread wheat (Triticum aestivum L. em Thell.)*"*. Which was carried out in *rabi* season.

3.1 Experimental site

The experiment was conducted at breeding field, Department of Genetics and Plant Breeding, Lovely Professional University, Phagwara, (Punjab).

3.2 Climate and weather conditions

Humid subtropical climate with hot summer and cool winters .Summer last from April to June and winters from November to February .Temperatures in the summer vary from average highs of around 48°C to average lows of around 25°C .Winter temperatures vary from highs of 19°C to lows of 5°C. The average annual rainfall is about 70 cm.

3.3 Experimental material

The experimental material for this study comprised of 11 genotypes

Table Details of genotypes used in the study

Sr.No.	LINE	PEDIGREE/ SOURCE
1.	DPW-621-50	KAUZ//ALTAR-84/(AOS)AWNED-ONAS/3/MILAN/KAUZ/4/HUITES**[4361]** DBW-14/HD-2733//HUW-468**[4145]**
2.	JW-3211	SUPER-KAUZ/SLYCATCHER**[4281]**
3.	DBW-14	RAJ 3765/PBW343
4.	WH-1105	MILAN/S-87230//BABAX**[3589]**
5.	DBW-17	CMH-79-A-95/3*CIANO-79//RAJ-3777**[4138][4191][4281]**
6.	PBW-723	Indian Institute of Wheat and Barley Research, Karnal, Haryana (IARI Regional Research Station)
7.	DBW-725	Indian Institute of Wheat and Barley Research, Karnal, Haryana (IARI Regional Research Station)
8.	PBW-550	Indian Institute of Wheat and Barley Research, Karnal, Haryana (IARI Regional Research Station)
	TESTER	
1.	DBW-71	PRINIA/ UP 2425
2.	DBW-39	ATTILA/HUI
3.	CBW-38	CANDO,USA/R-143/ENTE/MEXICALI-2/3/AE.SQ(TR.TA)/4/WEAVER/5/2*PASTOR**[4138]**

3.4 Experimental details:

1st year (cross)

Crop	:	Wheat
Mating design	:	Line X Tester
Genotype	:	Different varieties of wheat crop
Parent	:	11(Lines 8, Testers 3)
Experimental year	:	2017-18 (crossing), 2018-19 (evaluation)
Row to Row distance	:	20 cm
Season	:	*Rabi*
2nd year (evaluation)		
Number of genotype	:	35 (hybrids 24, parents 11)
Design	:	RBD (Randomize Block Design)
Replication	:	3

3.5 Statistical analysis:

1. Analysis of variance (Panse and Sukhatme, 1952)
2. Estimation of heterosis(Fonseca and Patterson 1968)
3. Combining ability analysis (Griffing's method)
4. Analysis of gene action (Hill 1982, Lynch 1991)

3.6 OBSERVATIONS:

A	Quantitative traits	B	Physiological Traits
1	Days to 50% heading	14	Canopy temperature
2	Days to maturity	15	Chlorophyll content
3	Plant height (cm)		
4	Number of productive tillers plant^{-1}	**C**	**Quality Traits**
5	Number of spikelets ear^{-1}	16	Protein content
6	Ear length (cm)		
7	Ear weight (g)		
8	Number of ears plant^{-1}		
9	Number of grains ear^{-1}		
10	1000-grain weight (g)		
11	Biological yield plant^{-1} (g)		
12	Grain yield plant^{-1} (g)		
13	Harvest index (%)		

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