www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(7): 1325-1331

www.thepharmajournal.com
Received: 08-04-2023
Accepted: 11-05-2023

Anand Singh
Ph.D. Research Scholar, Department of Genetics and Plant Breeding, ANDUAT, Ayodhya, Uttar Pradesh, India

Vinod Singh
Associate Professor, Department of Genetics and Plant Breeding, ANDUAT, Ayodhya, Uttar Pradesh, India

Govind Mishra
Ph.D. Research Scholar, Department of Genetics and Plant Breeding, ANDUAT, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Govind Mishra
Ph.D. Research Scholar, Department of Genetics and Plant Breeding, ANDUAT, Ayodhya, Uttar Pradesh, India

Combining ability effects for yield and its attributes in bread wheat (*Triticum aestivum* L. em. Thell.) under sodic soil

Anand Singh, Vinod Singh and Govind Mishra

Abstract
The present investigation entitled "Combining ability effects for yield and its attributes in bread wheat (*Triticum aestivum* L. em. Thell.) under sodic soil*"* was carried out with 48 F1's developed by crossing of lines (FLW-15, FLW-8, KRL-20, K-402, HD-2851, KRL-1-4, DBW-14, CHIRYA-1, KRL-3-4, HI-1563, FLW-2, FLW-11, HD-2009, HI-3118, K-9006 and DBW-39) with 3 testers (NW-1067, PBW-778 and NW-2036) including three checks (KRL-19, KRL-210 and NW-1076). Seventy genotypes comprising 48 F_1, 16 parents and 3 checks (16 lines+3 testers + 3 checks) were evaluated in Randomized Complete Block Design with 3 replications in two environments/conditions (E_1= Timely Shown; E_2= Late Shown). Recommended cultural practices were followed to raise a good crop. Each plot consists of a single row of 3 m in length having row-to-row and plant-to-plant distances of 30 cm and 10 cm, respectively. Out of sixteen parents, five parents in E1 and four parents in E2 showed positive and significant GCA effects for seed yield and other important traits and could serve as valuable parents for hybridization programmes or multiple crossing programmes for obtaining high-yielding variety or transgressive segregants for developing varieties of wheat. The sca effect of the crosses is an estimate for making a selection of superior cross combinations. High specific combining ability denotes, undoubtedly a high heterotic response, however, this does not mean high performance of the hybrids as well. In general, a maximum number of crosses that showed significant sca effects were invariably associated with better per se performance for respective traits. A perusal of data revealed that the good specific combiners involved parents of low x low, average x high, average x low, low x high and high x high general combining ability effects. From these findings, it is obvious that best cross combinations are not always result from high x high general combiners, but may also be occurred in other types of parental combinations. However, in the majority of cases, the crosses exhibiting high sca effects were found to have both or one of the parents as a good general combiner for the characters under study.

Keywords: Parental, combiner, hybridization, transgressive and segregants

Introduction
Heterosis has been frequently exploited for the development and isolation of promising hybrids for further utilization in conventional as well as heterosis breeding programmes. The F1 hybrids in cross fertilized as well as self-fertilized crops are known to exhibit hybrid vigour but effective exploitation of this phenomenon for commercial cultivation has been limited in case of self- pollinated crop particularly a few crops like Wheat. Information on heterosis and combining ability for yield and its components traits in wheat will prove very useful in selection of appropriate parents for the development of superior hybrids. The line × tester analysis is one which is employed in the study of general combining ability (GCA) of the parents and specific combining ability (sca) of the hybrids and their effects. The exploitation of heterosis over better parent and standard variety is considered to be one of the outstanding works in several self-pollinated crops. However, the exploitation of heterosis as well as the identification of effective donors is meager in wheat with special reference to sodic soil.
Wheat (*Triticum aestivum* L. em. Thell, 2 n-42) is a self-pollinated crop of the member of Poaceae family and one of the most leading cereals of many countries of the world including India. 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 the most important food crop of India and is a main source of protein and energy. In India, wheat is the second most important food crop after rice both in terms of area and production. Wheat is consumed in a variety of ways such as bread, chapatti, porridge, flour, suji etc.

Wheat has relatively high content of niacin and thiamin which are principally concerned in providing the special protein called 'Glutin'. Wheat proteins are of special significance because Glutin provides the framework of the spongy cellular texture of bread and baked products.

The wheat grown in India is spring type belonging to species *Triticum aestivum* (bread wheat). Wheat is more nutritive as compared to the other cereals. It has a good nutrition profile with 12.1 percent protein, 1.8 percent lipids, 1.8 percent ash, 2.0 percent reducing sugars, 6.7 percent pentosans, 59.2 percent starch, 70 percent total carbohydrates and provides 314 K cal/100 g of food. It is also a good source of minerals and vitamins viz., calcium (37 mg/100 g), iron (4.1 mg/100 g), thiamine (0.45 mg/100 g), riboflavin (0.13 mg/100 g) and nicotinic acid (5.4 mg/100 mg) (Lorenz and Kulp, 1991). Unlike other cereals, wheat contains a high amount of gluten, the protein that provides the elasticity necessary for excellent bread making Hard wheat had high protein (10-17%) and yields flour. rich gluten, making it particularly suitable for yeast bread. The low-protein (6 to 10%) softer type yields flour lower in gluten and therefore, suited better for tender baked products, such as biscuits, pastries and cakes.

Materials and Methods

The experimental material for present investigation comprised of 48 F1's developed by crossing of lines (FLW-15, FLW-8, KRL-20, K-402, HD-2851, KRL-1-4, DBW-14, CHIRYA-1, KRL-3-4, HI-1563, FLW-2, FLW-11, HD-2009, HI-3118, K-9006 and DBW-39) with 3 testers (NW-1067, PBW-778 and NW-2036) including three checks (KRL-19, KRL-210 and NW-1076). Seventy genotypes comprising 48 F_1, 16 parents and 3 checks (16lines+3 testers + 3 checks) will be evaluated in Randomized Complete Block Design with 3 replications in two environments / conditions (E_1= Timely Shown; E_2= Late Shown). Recommended cultural practices will be followed to raise a good crop. Each plot consists of single row of 3 m length having row to row and plant to plant distance of 30 cm and 10 cm, respectively. Five competitive plants in each parent and F_1 will be randomly selected for taking observations in each replication.

Results and Discussion

Estimates of General Combining ability effects

Plant height

Among the lines under normal soil condition (E_1), significant positive GCA effects were recorded in FLW-2 (15.175), FLW-15 (7.842) and FLW-11 (7.742) while among testers only PBW-778 (2.810) showed positive and significant GCA effects. The lines FLW-8 (-14.392), KRL-20 (-9.858) showed negative and significant GCA effects while NW-1067 (-2.883) among testers showed negative and significant GCA effects.

Under soil conditions (E_2), positive and significant GCA effects were exhibited by FLW-2 (13.819), FLW-11 (7.385) and FLW-15 (4.352) among lines showed positive and significant GCA effects. The linesKRL-402 (-7.815), Chriya-1 (-7.481) showed negative and significant GCA effects.

Number of Tillers tillers per plants

Among the lines under normal soil condition (E_1), significant positive GCA effects were recorded in HI-1563 (1.821), KRL-1-4 (1.221) and FLW-11 (1.188) while among testers only PBW-778 (2.810) showed positive and significant GCA effects. The lines KRL-20 (-1.846), K-402 (-1.79) showed negative and significant GCA effects while NW-2036 (-0.879) among testers showed negative and significant GCA effects.

Under soil conditions (E_2), positive and significant GCA effects were exhibited by FLW-2 (1.054), HD-2009 (1.021) and KRL-1-4 (0.621) among lines showed positive and significant GCA effects. The lines KRL-20 (-1.079) and HD-2851 (-0.879) showed negative and significant GCA effects.

Number of Grains per ear

Among the lines under normal soil condition (E_1), significant positive GCA effects were recorded in K-402 (11.190) and HI-1563 (6.390) showed positive and significant GCA effects. The lines KRL-3-4 (-9.610) and HI-3118 (-7.944) showed negative and significant GCA effects.

Under soil conditions (E_2), positive and significant GCA effects were exhibited by FLW-2 (6.373) and FLW-15 (4.573) showed positive and significant GCA effects. The lines HI-1563 (-7.160) and KRL-3-4 and DBW-39 (-6.094) showed negative and significant GCA effects.

Biological yield per plant

Among the lines under normal soil conditions (E_1), significant positive GCA effects were recorded in DBW-14 (82.90) and HD-2851 (52.552) showed positive and significant GCA effects. The lines K-402 (-74.144) and KRL-3-4 (-58.034) showed negative and significant GCA effects.

Under soil conditions (E_2), positive and significant GCA effects were exhibited by DBW-14 (79.995) and HD-2851 (54.688) showed positive and significant GCA effects. The lines K-402 (-71.095) and HI-3118 (-56.542) showed negative and significant GCA effects.

Harvest Index

Among the lines under normal soil conditions (E_1), significant positive GCA effects were recorded in HD-2009 (2.953) and Chirya-1 (2.847) showed positive and significant GCA effects. The lines K-402 (-3.196) and FLW-2 (-0.738) showed negative and significant GCA effects.

Under soil conditions (E_2), positive and significant GCA effects were exhibited by HD-2851 (14.607) and HD-2009 (8.896) showed positive and significant GCA effects. The lines K-402 (-18.059) and HI-3118 (-10.130) showed negative and significant GCA effects.

Seed yield per plant

Among the lines under normal soil conditions (E_1), significant positive GCA effects were recorded in HD-2009 (31.614) and HD-2851 (28.290) showed positive and significant GCA effects. The lines K-402 (-37.285) and KRL-3-4 (-24.912) showed negative and significant GCA effects.

Under soil conditions (E_2), positive and significant GCA effects were exhibited by HD-2851 (35.065) and HD-2009 (21.355) showed positive and significant GCA effects. The lines K-402 (-43.351) and HI-3118 (-24.316) showed negative and significant GCA effects.

The available literature also indicates significant and positive GCA effects for seed yield and yield components in wheat Sattar *et al.* (1992) [13], Bhatti *et al.* (1984) [2] and Patil *et al.* (2008) [5]. The above maintained lines and testers may be recommended for exploitation in hybridization programme aimed at improving the yield components for which they emerged as good general combiners.

The above five parents in E_1 and four parents in E_2 showing positive and significant GCA effects for seed yield and other important traits as mentioned in above paragraphs may serve as valuable parents for hybridization programme or multiple crossing programme for obtaining high yielding variety or transgressive segregants for developing varieties of wheat.

Estimates of Specific Combining ability effects

Plant height

The negative & significant sca effect under normal soil condition (E_1). Among them 3 best crosses were FLW-8X NW-2036 (-3.340), HD-2009 x NW 20336 (-2.350) and KRL-20 x PBW-778 (2.310) On the other hand thirty-three. High order desirable sca effects were expressed by few cross-combination's crosses.

Under sodic soil condition (E_2), few cross combinations showed positive and significant sca effect whereas, fifteen cross combinations registered negative and significant sca effect. Desirable cross combinations, sorted out were K-402 x NW-1067 (3.488), KRL-20 x PBW-778 (3.402), FLW-2 x PBW778 (3.069) and FLW-15 x NW-2036 (2.423).

Number of tillers per plants

For this trait, sca no cross combinations showed positive & significant sca effect whereas, effect. Crosses exhibited no significant & negative sca effects for flag leaf area (cm^2), under normal soil condition (E_1).

Under sodic condition (E_2), sca no cross combinations showed positive & significant sca effect whereas, effect. Crosses exhibited no significant & negative sca effects for flag leaf area (cm^2), under normal soil condition (E_1).

Grains per Ear

In this case under normal condition (E_1), the Nine crosses combination showed positive and significantly sca effect. Among them the noteworthy crosses were FLW-8 x NW-2036 (4.881), K-402 x NW-2036 (3.748) and KRL-1-4 x PBW-778 (2.910). Six cross combinations showed negative sca effects.

In sodic condition (E_2), high order desirable sca effects were expressed by only two cross combinations which were Hi-1563 x NW-1067 (2.585) and FLW-15 x NW-1067 (2.052). On the other hand, two crosses exhibited negative significant effect.

Biological yield per plant

A perusal of sca values of crosses under normal soil (E1) for this trait, good specific combiners were identified. Out of which, the best two were KRL-1-4 x PBW-778 (33.344), HI-3118 x PBW-778 (32.930). While negative and significant sca effect were recorded by twenty-six cross combinations.

Cross combination was recorded by crosses out of forty-eight crosses, among them three best crosses were HD-2851 x PBW-778 (23.054), K-9006 x PBW-778 (19.854) and HI-1563 x PBW778 (19.405), cross combination with positive and significant sca effect under sodic soil condition (E_2). While negative and significant sca effects were recorded by twenty-eight cross combinations.

Harvest index

A perusal of sca values of crosses under normal soil (E1) for this trait, good specific combiners were identified. Out of which, the best two were FLW-11 x PBW-778 (2.112) and HD-2009 x PBW-778 (1.866). While negative and significant sca effect were recorded by Four cross combinations.

Cross combination was recorded by crosses out of forty-eight crosses, among them there was only a single cross found significant and that was HD-2851 x NW-1067 (2.104), cross combination with positive and significant sca effect under sodic soil condition (E_2). While negative and significant sca effect were recorded by a single cross combination K-402 x NW-1067 (-1.977).

Grain yield per plant

A perusal of sca values of crosses under normal soil (E1) for this trait, good specific combiners were identified. Out of which, the best two were KRL-1-4 x PBW-778 (12.191), HD-2009 x PBW-778 (8.199). While negative and significant sca effect were recorded by sixteen cross combinations.

Cross combination was recorded by crosses out of forty-eight crosses, among them three best crosses were HI-1563 x PBW778 (8.626), K-402 x NW-2036 (7.546), K-9006 x PBW-778 (7.208) and cross combination with positive and significant sca effect under sodic soil condition (E_2). While negative and significant sca effect were recorded by Seven cross combinations.

The sca effect of the crosses is an estimate for making selection of superior cross combinations. High specific combining ability denotes, undoubtedly a high heterotic response, however this, does not mean high performance of the hybrids as well.

In general, maximum number of crosses which showed significant sca effects were invariably associated with better per se performance for respective traits. A perusal of data revealed that the good specific combiners involved parents of low x low, average x high, average x low, low x high and high x high general combining ability effects. From these findings, it is obvious that best cross combinations are not always resulted from high x high general combiners, but may also be occurred in other type of parental combinations. However, in majority of cases, the crosses exhibiting high sca effects were found to have both or one of the parents as good general combiner for the characters under study. The results are in agreement with the findings of Singh *et al.* (2002) [17], Sharma *et al.* (2009) [15], Singh *et al.* (2014) [18], Verma *et al.* (2016) [21], Patil (2008) [5], Zalewski, D. (2001) [22].

Table 1: Estimates of General combining ability effects on Number of tillers per plant, Grains per ear and Plant height in wheat Wheat (*Triticum aestivum* L. em. Thell)

S. No.	Lines	Number of tillers per plant		Grains per ear		Plant height	
		E_1	E_1	E_2	E_2	E_1	E_2
1	FLW-15	-1.446	5.790**	4.573**	-0.446	7.842**	4.352**
2	FLW-8	-0.813	3.056**	1.573	-0.846	-14.392**	-3.315**
3	KRL-20	-1.846**	6.323**	3.240**	-1.079**	-9.858**	-3.915**
4	K-402	-1.579**	11.190**	2.906**	-0.646	-9.725**	-7.815**
5	HD-2851	0.821	2.356**	-1.760*	-0.879	-6.325**	-0.548
6	KRL-1-4	1.221**	3.390**	1.906**	0.621	1.608	-6.148**
7	DBW-14	-0.213	-2.277**	3.240**	0.521	3.242**	0.585
8	CHIRYA-1	0.787	-5.944**	-0.760	0.088	4.242**	-7.481**
9	KRL-3-4	-1.213*	-9.610**	-6.094**	-0.379	1.808	3.819**
10	HI-1563	1.821**	6.390**	-7.160**	0.221	3.908**	-0.815
11	FLW-2	0.154	-5.277**	6.373**	1.054**	15.175**	13.819**
12	FLW-11	1.188**	5.056**	-1.927**	0.087	7.742**	7.385**
13	HD-2009	0.921	-1.277	1.973**	1.021	-5.425**	4.252**
14	HI-3118	0.021	-7.944**	-0.360	-0.179	7.342**	-2.148**
15	K-9006	0.121	-5.277**	-1.627	0.454	-0.125	-3.648**
16	DBW-39	0.054	-5.944**	-6.094**	0.387	-7.058**	1.619
	SE(GCA line)	0.153	0.560	0.497	0.110	1.176*	1.081
	SE (gi-gj)	0.216	0.793	0.703	0.155	1.663*	1.528
1	NW-1067	0.152	-2.208**	-2.385**	0.229	-2.883**	-4.308**
2	PBW-778	0.727	-3.577**	2.021**	0.492	2.810**	1.998*
3	NW-2036	-0.879	5.785**	0.365	-0.721	0.073	2.310**
	SE(GCA tester)	0.066	0.243	0.215	0.047	0.509	0.468
	SE(gi-gj)	0.094	0.343	0.304	0.067	0.720	0.662

Table 2: Estimates of General combining ability effects on the Number of tillers per plant, Grains per ear and Plant height in wheat Wheat (*Triticum aestivum* L. em. Thell)

S. No	Lines	Biological yield plant^{-1}		Seed yield plant^{-1}		Harvest index	
		E_1	E_2	E_1	E_2	E_1	E_2
1	FLW-15	22.918**	21.518**	-4.351**	0.914	0.473	-2.142**
2	FLW-8	1.668	19.277**	9.463**	-0.752	0.706	0.992
3	KRL-20	-47.326**	-53.674**	-8.466**	-1.686**	1.906**	0.092
4	K-402	-74.144**	-71.095**	-37.285**	2.914**	0.473	0.458
5	HD-2851	52.552**	54.688**	28.290**	-0.386	1.373**	2.358**
6	KRL-1-4	51.792**	30.388**	26.801**	-0.586	2.106**	3.492**
7	DBW-14	82.900**	79.995**	15.856**	-0.286	1.073**	-0.975
8	CHIRYA-1	3.685**	17.707**	13.679**	0.614	1.040**	0.358
9	KRL-3-4	-58.034**	-54.733**	-24.912**	-1.234**	-0.160	-0.342
10	HI-1563	-29.086**	-7.880**	-3.482**	-0.636	-4.960**	-5.742**
11	FLW-2	3.828**	-9.507**	-11.384**	-1.086**	8.940**	6.725**
12	FLW-11	44.935**	25.624**	14.755**	1.114**	-1.994**	-1.175**
13	HD-2009	50.195**	37.317**	31.614**	-0.152	-0.827	3.025**
14	HI-3118	-48.648**	-56.542**	-21.271**	-0.519	-2.994**	-1.975**
15	K-9006	-24.545**	-0.192**	-19.459**	1.914**	-5.094**	-3.475**
16	DBW-39	-32.691**	-32.891**	-9.847**	-0.152	-2.060**	-1.675**
	SE(GCA line)	7.148	6.378	2.600	0.246	0.351	0.343
	SE(gi-gj)	10.108	9.019	3.677	0.348	0.497	0.485
1	NW-1067	29.847**	20.675**	20.352**	-1.282**	-0.719	-0.210
2	PBW-778	29.104**	31.372**	10.986**	1.687**	-1.063**	-1.660**
3	NW-2036	-58.951**	-52.047**	-31.338**	-0.404	1.781**	1.871**
	SE (GCA tester)	3.095	2.762	1.126	0.107	0.152	0.149
	SE(gi-gj)	4.377	3.905	1.592	0.151	0.215	0.210

Table 3: Estimates of Specific combining ability effects on Plant height, Number of tillers per plant and Grains per ear and in wheat (*Triticum aestivum* L. em. Thell)

Crosses	Plant height		Number of tillers plant^{-1}		Number of grain ear^{-1}	
	E_1	E_1	E_1	E_2	E_2	E_2
FLW-15 X NW-1067	-0.617	0.115	2.742**	2.052**	0.071	-0.958
FLW-15 X PBW-778	-1.810	-0.160	1.510	-0.354	0.108	-1.465
FLW-15 X NW-2036	2.427**	0.046	-4.252**	-1.698	-0.179	2.423**
FLW-8X NW-1067	2.417**	-0.019	-3.325**	-0.948	-0.029	-0.692
FLW-8 X PBW-778	0.923	0.006	-1.556	-0.354	0.008	2.402**
FLW-8 X NW-2036	-3.340**	0.012	4.881**	1.302	0.021	-1.710*
KRL-20 X NW-1067	3.083**	-0.385	0.608	-2.615**	-0.096	-2.092**
KRL-20 X PBW-778	-2.310**	0.040	-3.423**	-0.021	0.142	3.402**
KRL-20 X NW-2036	-0.773	0.346	2.815**	2.635	-0.046	-1.310
K-402 X NW-1067	-2.050**	0.348	2.742**	-1.281	0.071	3.808**
K-402 X PBW-778	4.256**	0.273	-6.490**	0.313	0.008	-3.398
K-402 X NW-2036	-2.206**	-0.621	3.748**	0.969	-0.079	-0.410
HD-2851 X NW-1067	-1.050	-0.052	-0.525	1.385	0.404	0.742
HD-2851 X PBW-778	1.256	0.073	1.944**	-1.021	-0.158	-1.065
HD-2851 X NW-2036	-0.206	-0.021	-1.419	-0.365	-0.246	0.323
KRL-1-4X NW-1067	-0.983	0.048	-0.458	-0.281	0.004	0.342
KRL-1-4X PBW-778	1.323	-0.027	2.910**	0.313	-0.158	0.735
KRL-1-4X NW-2036	-0.340	-0.021	-2.452**	-0.031	0.154	-1.077
DBW-14X NW-1067	-0.317	0.181	1.208	-1.615	0.004	0.308
DBW-14X PBW-778	0.790	-0.094	-0.423	0.979	-0.058	-0.098
DBW-14X NW-2036	-0.473	-0.088	-0.785	0.635	0.054	-0.210
CHIRYA-1X NW-1067	-0.517	-0.019	-1.125	-0.615	0.337	-0.125
CHIRYA-1X PBW-778	-0.710	0.006	2.244**	-0.021	-0.425	-1.231
CHIRYA-1X NW-2036	1.227	0.012	-1.119	0.635	0.088	1.356
KRL-3-4 X NW-1067	0.817	-0.019	-2.458**	-0.281	0.004	-0.225
KRL-3-4 X PBW-778	0.923	0.006	1.910**	0.312	-0.058	-0.531
KRL-3-4 X NW-2036	-1.740**	0.012	0.548	-0.031	0.054	0.756
HI-1563 X NW-1067	-0.183	-0.752	-0.658	2.585**	-0.196	0.008
HI-1563 X PBW-778	-2.177**	0.373	-0.090	-0.621	-0.058	-0.098
HI-1563 X NW-2036	2.360**	0.379	0.748	-1.965**	0.254	0.090
FLW-2 X NW-1067	0.550	0.315	1.208	-0.348	-0.029	1.475
FLW-2 X PBW-778	0.356	-0.160	0.577	0.846	0.108	3.069**
FLW-2 X NW-2036	-0.906	-0.154	-1.785*	-0.498	-0.079	-4.544**
FLW-11 X NW-1067	1.483	0.181	-0.125	0.552	-0.062	-1.192
FLW-11 X PBW-778	-4.010	-0.294	0.244	-0.354	0.175	1.002
FLW-11 X NW-2036	2.527	0.112	-0.119	-0.198	-0.112	0.190
HD-2009 X NW-1067	-2.350	0.048	1.208	-0.148	-0.196	-0.358
HD-2009X PBW-778	-0.044	0.073	-1.423	0.246	0.042	-2.265
HD-2009X NW-2036	2.394	-0.121	0.215	-0.098	0.154	2.623
HI-3118X NW-1067	-0.117	0.248	1.875*	-0.815	-0.296	-0.658
HI-3118 X PBW-778	-0.810	-0.227	-0.756	1.579	0.342	0.735
HI-3118 X NW-2036	0.927	-0.021	-1.119	-0.765	-0.046	-0.077
K-9006 X NW-1067	-2.450	-0.352	-1.792*	0.652	-0.029	-0.158
K-9006 X PBW-778	2.656	0.173	1.577	-1.154	0.008	-0.265
K-9006 X NW-2036	-0.206	0.179	0.215	0.502	0.021	0.423
DBW-39 X NW-1067	2.283	0.115	-1.125	1.719*	0.038	-0.225
DBW-39 X PBW-778	-0.610	-0.060	1.244	-0.688	-0.025	-0.931
DBW-39 X NW-2036	-1.673	-0.054	-0.119	-1.031	-0.012	1.156
SE(sca effect)	2.037	0.265	0.971	0.861	0.190	1.872
SE(sij-skl)	2.880	0.375	1.373	1.217	0.269	2.647

Table 4: Estimates of Specific combining ability effects on Biological yield plant^{-1}, Seed yield plant^{-1} and Harvest index in wheat (*Triticum aestivum* L. em. Thell)

Crosses	Biological yield plant^{-1}		Seed yield plant^{-1}		Harvest index	
	E_1	E_2	E_1	E_2	E_1	E_2
FLW-15 X NW-1067	20.954**	7.009**	2.258**	3.200**	-1.072	0.225
FLW-15 X PBW-778	-9.728**	-3.768**	-3.526**	-0.365	0.175	0.541
FLW-15 X NW-2036	-11.226**	-3.241**	1.268	-2.835**	0.896	-0.766
FLW-8X NW-1067	-12.607**	5.817**	1.110	3.635**	1.092	0.170
FLW-8 X PBW-778	9.431**	-4.439**	-3.387**	-6.286**	-1.667*	-1.227
FLW-8 X NW-2036	3.177**	-1.378	2.277**	2.651**	0.575	1.058
KRL-20 X NW-1067	13.661**	5.547**	2.648**	5.955**	-0.661	1.184
KRL-20 X PBW-778	-6.069**	-6.190**	-3.091**	-3.729**	-0.309	-0.630
KRL-20 X NW-2036	-7.593**	0.642	0.443	-2.226**	0.970	-0.554
K-402 X NW-1067	15.979**	7.708**	2.733**	-6.089**	0.001	-1.977**
K-402 X PBW-778	-6.563**	-5.873**	-2.295**	-1.118	0.401	0.645
K-402 X NW-2036	-9.416**	-1.835*	-0.438	7.208**	-0.401	1.332
HD-2851 X NW-1067	-17.686**	-33.917**	-10.674**	-3.129**	-1.245	2.104**
HD-2851 X PBW-778	18.085**	23.054**	8.014**	4.765**	0.040	-1.255
HD-2851 X NW-2036	-0.400	10.863**	2.661**	-1.636	1.205	-0.848
KRL-1-4X NW-1067	-16.944**	7.318**	-6.500**	2.205**	-0.393	-0.395
KRL-1-4X PBW-778	33.344**	-3.712**	12.191**	-0.652	-0.176	0.031
KRL-1-4X NW-2036	-16.400**	-3.605**	-5.691**	-1.554	0.569	0.364
DBW-14X NW-1067	7.372**	7.697**	3.401**	1.850*	-0.130	-0.362
DBW-14X PBW-778	3.751**	-4.251**	-3.016**	-0.905	-0.671	0.283
DBW-14X NW-2036	-11.122**	-3.446**	-0.385	-0.945	0.801	0.080
CHIRYA-1X NW-1067	-1.914*	8.241**	4.784**	2.571**	1.005	-0.331
CHIRYA-1X PBW-778	-18.112**	-6.190**	-1.664	-1.596	1.110	0.051
CHIRYA-1X NW-2036	20.026**	-2.052**	-3.120**	-0.975	-2.115	0.280
KRL-3-4 X NW-1067	-12.789**	8.465**	1.711*	2.377**	2.055	0.174
KRL-3-4 X PBW-778	8.167**	-5.873**	-2.313**	-1.512	-1.089	0.317
KRL-3-4 X NW-2036	4.622**	-2.593**	0.603	-0.866	-0.966	-0.492
HI-1563 X NW-1067	-7.565**	-29.904**	1.193	-12.043**	0.820	-0.173
HI-1563 X PBW-778	7.499**	19.405**	-7.453**	8.626**	-2.583**	-0.029
HI-1563 X NW-2036	0.066	10.498**	6.260**	3.417**	1.763*	0.202
FLW-2 X NW-1067	-22.131**	5.929**	2.558**	1.127	2.444	-0.053
FLW-2 X PBW-778	-9.509**	-3.965**	-3.100**	-0.848	0.204	0.356
FLW-2 X NW-2036	31.640**	-1.964**	0.543	-0.278	-2.648**	-0.303
FLW-11 X NW-1067	7.630**	6.013**	4.827**	1.809*	0.164	-0.342
FLW-11 X PBW-778	-31.846**	-4.419**	-1.650	-0.909	2.112**	0.044
FLW-11 X NW-2036	24.217**	-1.594	-3.177**	-0.899	-2.275**	0.298
HD-2009 X NW-1067	-10.853**	8.981**	-10.840**	2.909**	-1.796*	-0.414
HD-2009X PBW-778	-5.469**	-6.190**	8.199**	-1.596	1.866**	0.022
HD-2009X NW-2036	16.321**	-2.792**	2.641**	-1.313	-0.070	0.393
HI-3118X NW-1067	-9.170**	8.382**	-5.352**	2.344**	-0.249	0.187
HI-3118 X PBW-778	32.930**	-5.873**	8.173**	-1.512	-0.657	0.323
HI-3118 X NW-2036	-23.759**	-2.509**	-2.821**	-0.832	0.906	-0.510
K-9006 X NW-1067	23.172**	-30.397**	2.308**	-10.855**	-1.035	0.064
K-9006 X PBW-778	-13.156**	19.854**	-3.125**	7.546**	0.542	0.411
K-9006 X NW-2036	-10.016**	10.543**	0.818	3.309**	0.493	-0.475
DBW-39 X NW-1067	22.892**	7.111**	3.837**	2.135**	-1.000	-0.061
DBW-39 X PBW-778	-12.755**	-1.572	-1.955**	0.091	0.701	0.119
DBW-39 X NW-2036	-10.137**	-5.539**	-1.882*	-2.226**	0.299	-0.057
SE(sca effect)	12.380	11.046	4.503	4.158	0.259	0.318
SE(sij-skl)	17.508	15.622	6.368	5.880	0.366	0.450

Conclusion

It is obvious that best cross combinations are not always result from high x high general combiners, but may also be occurred in other types of parental combinations. However, in a majority of cases, the crosses exhibiting high sca effects were found to have both or one of the parents as a good general combiner for the characters under study.

Acknowledgement

The work on combining the ability of wheat has been supported by the All India Coordinated research project on wheat (Karnal) Haryana. The authors are thankful to Director ICAR.

Conflict of Interest

None

References

1. Anonymous. All India Coordinated Wheat & Barley Improvement Project, Directorate of Wheat Research, Karnal (ICAR), Project Director's Report; c2021. p. 1.
2. Bhatti MS, Bajwa MA, Noor-ul. Islam, Asi AG.

Combining ability analysis of five wheat varieties. Pak. J. of Agril. Res. 1984;5(2):88-91.
3. Baric M, Jercic IH, Keresa S, Sarcevic H. Evaluation of heterosis for important quantitative traits in crosses of winter wheat (*Triticum aestivum* L.). Sjemenarstvo. 2008;25(1):5-12.
4. Bhardwaj SL. Genetic Variability and Heritability Studies in Wheat Genotypes under Late Sown Condition in Chhattisgarh Plains. Int. J Pure App. Biosci. 2018;6(3):513-517.
5. Patil RV, Viswanath, Chinnusamy, Sakti, Chahan, Ruwali KN, *et al.* Evaluation of heat stress tolerance in *T. aestivum* and *T. durum* wheat genotype under continual and terminal heat stress environment. J of Plant. Biology. 2008;35(1):1-16.
6. Panse VG, Shukhatme PV. Statistical methods for agricultural workers, IInd Ed., ICAR, New Delhi; c1967. p. 381.
7. Payal, Saxena, Rawat RS, Verma JS, Meena BK. Variability and association analysis for yield and quality traits in wheat. Pant. J of Res. 2007;5(2):85-92.
8. Pooja, Veena Chawla, Vikram Singh, Satender Yadav. Path coefficient and correlation studies of yield and yield associated traits in diverse genotypes of bread wheat (*Triticum aestivum* L.) International Journal of Chemical Studies. 2018;6(3):73-76.
9. Prasad J, Kerketta V, Prasad KD, Verma AK. Study of genetic parameters under different environment conditions in wheat (*Triticum aestivum* L.). J of Res. Birsa Agril. Uni. 2006;18(1):135-140.
10. Rajput RS, Kandalkar VS. Combining ability and heterosis for grain yield and its attributing traits in bread wheat (*Triticum aestivum* L.) Journal of Pharmacognosy and Phytochemistry. 2018;7(2):113-119.
11. Redden RJ, Jensen NF. Mass selection and mating system in cereals. Crop Sci. 1974;14:345-350.
12. Riaz-ud-Din Subhani GM, Naeem, Ahmad. Makhdoom, Hussain, Aziz-ur-Rehman. Effect of temperature on development and grain formation in spring wheat. Pak. J. of Botany. 2010;42(2):899-906.
13. Sattar A, Chaudhry MH, Shah KN, Khan SB. Combining ability estimates in five wheat varieties. Pak. J. of Agril. Res. 1992;13(4):301-305.
14. Sarkar KK, Ghimiray TS, Maji A, Das S. Heterotic breeding lines for yield and quality traits in wheat (*Triticum aestivum* L.). Adv. in Pl. Sci. 2010;23(1):245-248.
15. Sharma S, Chaudhary HK. Combining ability and gene action studies for yield-contributing traits in crosses involving winter and spring wheat genotypes. Acta-Agronomica Hungarica. 2009;57(4):417-423.
16. Shull. What is heterosis? Genetics. 1914;33:439-446.
17. Singh KN, Ravish, Chatrath. Combining ability studies in bread wheat (*Triticum aestivum* L.) under salt stress environment. Indian J. Genet. 2002;57(2):127-132.
18. Singh, Piyusha, Jaiswal JP, Thakur CL. Analysis of combining ability for yield and its attributing traits in bread wheat (*Triticum aestivum* L.). Annals of Biol. 2014;30(1):58-61.
19. Sprague GF, Tatum LA. General *vs.* specific combining ability in single crosses of corn. J Amer. Soc. Agron. 1942;34:923-932.
20. Tabassum, Anil Kumar, Birendra Prasad. Study of combining ability and nature of gene action for yield and its contributing traits in bread wheat (*Triticum aestivum* L. em Thell). Int. J Curr. Microbiol. App. Sci. 2017;6(10):3562-3573.
21. Verma S, Maurya R, Maurya S. Prediction of gene action and combining ability for yield and quality traits in F1 and F2 generations of wheat (*Triticum aestivum* L.). Tropical Plant Res. 2016;3(2):449-459.
22. Zalewski D. Estimation of general and specific combining ability of quantitative traits of winter wheat. Biuletyn Instytutu Hodowli-i-Aklimatyzacji Roslin. 2001;216(2):267-272.