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Research Article

Combining ability for yield and yield components characters of bhendi (*Abelmoschus esculentus* L. Moench)

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Abstract
An investigation was carried out to study the genetics of fruit yield and its components characters. The present study was made with eight genotypes selected based on D^2 Analysis and the parents were crossed to develop fifty six hybrids to estimate mean, general and specific combining ability effect for identifying the best combiners for eight traits, v*iz.*,days to first flowering, plant height, number of branch per plant, number of fruits per plant, fruit length, fruit girth, fruit weight and fruit yield per plant. The general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant for all the studied characters.The parents P7, Parbhani Kranti and Girijavikas were adjudged as superior for fruit yield per plant and most of the characters. Among the fifty six hybrids. Three hybrids *viz*,. Parbhani Kranti X Naveena, Naveena X Girijavikas and Arka Abhay X P7 required significant *sca* effects for six others traits. In the cross revealed combination based on *gca* and *sca* effects four crosses namely Parbhani Kranti X P7 (high X high *gca* parents), Arka Abhay X P7 (low X high *gca* parents), Parbhani Kranti X Naveena (high X low *gca* parents) and Naveena X Girijavikas (low X low *gca* parents) are suggested to improve the fruit yield per plant through heterosis breeding and their use in commercial cultivation.

Key words
gca, *sca*, bhendi, yield and diallel

Introduction

Bhendi (*Abelmoschus esculentus.* L. Moench) is one of the most important vegetable crops in the tropical and sub tropical region of the world. Bhendi has wide popularity in terms of cultivation and acceptability all over the world. Bhendi belongs to the family *Malvaceae* and the genus *Abelmoschus*. It is originated from tropical Africa. It is called lady's finger in England, gumbo in United States of America and Bhendi in India. Bhendi is often cross pollinated crop. Yield is most important character of bhendicultivars and hybrids. Great efforts have been directed to improve yield production and quality properties in bhendi. Combining ability analysis helps in the identification of parents with high general combining ability (GCA) effect and cross combinations with high specific combining ability (SCA) effect Additive and non additive gene actions in the parents estimated through combining ability analysis may be useful in determining the possibility for commercial exploitation of heterosis and isolation of purelines among the progenies of the heterotic F_1. Diallel mating design has been used extensively by several researchers to measure combining ability and the nature of gene action. The present study was conducted to obtain the information on combining ability of 8 genotypes of bhendi (*Abelmoschus esculentus*. L.) for fruit yield and its components.

Materials and Methods

The present investigation was carried out at the Genetics and Plant Breeding farm of Department of Genetics and Plant Breeding,Faculty of Agriculture, Annamalai University, Annamalai Nagar. Eight different parents *viz*., PSR-3, RNBR-1, P7, Girijavikas, Parbhani Kranti, Naveena, Ankur-40 and Arka Abhay. Were 56 selected and were crossed in full diallel fashion to analyse the combining ability and heterosis for yield and yield component traits. Fifty six hybrids and eight parents were evaluated in two replications in Randomized Block Design during the year 2010-2011. Data were recorded for the following eight traits: Days to first flowering, Plant height, Number of branches per plant, Number of fruits per plant, Fruit length, Fruit girth, Fruit weight and Fruit yield per plant. The data were subjected to the analysis the variance in order to test of significance of differences among the 8 genotypes and their 56 hybrids. As the data were obtained chosen set of parents along with direct and reciprocal crosses, method I and model 1 of Griffing (1956a) was employed for the analysis.

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Analysis of variance for RBD

Source of variation	Degrees of freedom	M.S.S.	Expectations of mean squares
Replication	r-1	Mr	σ2e + gσ2r
Genotype	g-1	Mr	σ2e + rσ2g
Error	(r-1)(g-1)	Mrg	σ2e

The statistical analysis was made for full diallel analysis based on Griffing (1956b) Model I (fixed), Method 1 procedures. The table representing the expectation of variance follows.

where, r = number of replications and g = number of genotypes

Combining ability analysis

The procedure outlined by Griffing (1956b) for Model I (fixed), Method 1 was considered appropriate for this study since it involved the parents & F1s of both direct and reciprocal crosses.

Analysis of variance for combining ability

Source	Degrees of freedom	Sum of squares	Mean squares	Expectation of mean squares
GCA	P-1	Sg	Mg	σ2e + 2P [1/(P-1)] Σgi2
SCA	[P(P-1)] / 2	Ss	Ms	σ2e + [2/P(P-1)] ΣΣs2ij
Reciprocal	[P (P-1)] / 2	Sr	Mr	σ2e + [2/P(P-1)] ΣΣr2ij
Error	M	S'e	M'e	σ2e

where, P = Number of parents

Sum of squares due to gca (Sg) =

$$\frac{1}{2P}\sum_i (Xi. + X.j)^2 - \frac{2}{P^2} X^2 ... \quad ...$$

Sum of squares due to sca (Ss) =

$$\frac{1}{2}\sum_i \sum_{<j} Xij\,(Xij + Xji) - \frac{1}{2p}\sum(Xi. + X.j)^2 + \frac{1}{p^2} X^2 ... .$$

Sum of squares due to reciprocals (Sr) =

$$\frac{1}{2}\sum_i \sum_{<j} (Xij - Xji)^2$$

Test of significance

M'e = Me / r, where, Me is the EMS from ANOVA for RBD.

Fgca = Mg/M'e, Fsca = Ms/M'e, Fr = Mr/M'e

General combining ability effects, specific combining ability effects and reciprocal effects were estimated as follows.

gca effects (gi) = (1/2P) (xi. + x.i) – (1/P2) x….

sca effects (sij) = (1/2) (xij +xji) – (1/2P) (xi. + x.j + xj. + x.i) + (1/P2) x….

reciprocal effects (rij) = (1/2) (xij-xji)

Standard error of estimates

The square root of the variance gives the standard error of that estimate. For this, the variances of different effects were calculated as follows.

Variance (Xij) = σ2e = M'e

Variance (gi) = $\frac{P-1}{2P^2}\sigma^2$

Variance (sij) = $\frac{1}{2P^2}(P^2 - 2P + 2)\,\sigma_e^2$

Variance (rij) = $\frac{1}{2}\sigma_e^2$

Critical difference of estimates

The critical difference to compare any two similar estimates was obtained as a product of ‘t’ value against error degrees of freedom and standard error of difference. The square root of the variance gives the standard error of differences.

Variance (gi - gj) = (1 / P) σ2e for two gca estimates

Variance (sij - sik) = [(P-1)/P] σ2e for two sca estimates having one parent in common

Variance (sij - skl) = [(P-2) / P] σ2e for two sca estimates with no parent in common

Variance (rij - rkl) = σ2e for a pair of reciprocal effects

Result and Discussion

The analysis of variance revealed the parents and direct as well as their reciprocal hybrids differed significantly among themselves for all the entire characters studied (Table 1). This indicated the presence of high genetic variability in the reference population. Therefore, further analysis of combining ability and gene action is appropriate.

The mean sum of square for combining ability revealed that the GCA variance was significant for all the characters studied. This indicated the presence of additive genetic variance for these characters. The SCA and RCA variances were also significant for all the characters studied except number of branches per plant and fruit girth. This implied the presence of non-additive genetic variance in the inheritance of these traits. The ratio of GCA/SCA and GCA/RCA were more than unity, which indicated the preponderance of additive genetic variance of the improvement of the traits of interest. The results revealed the presence of both additive and non additive genetic variance in the inheritance of the characters of interest in okra (Table 2). Similar results were previously obtained by Senthilkumar and Sree Parvathy (2010); Ramya, (2010); Shiv Prakash Singh (2011); John Paul Sharma and AK Singh (2012); Prashant Kumar *et al*. (2012); Amaranath Reddy *et al*. (2013); Anithavasline (2013); Aswanikumar*et al.* (2013); Laxman *et al.* (2013) and Medagam Thirupathi Reddy *et al.* (2013) for the most of the characters studied in bhendi. The available additive genetic variance could well be exploited by resorting to simple pure line selection or pedigree selection, whereas the non additive genetic variance could well be exploited in later generations. Both the variances could be simultaneously exploited resorting to population improvement programme.

The selection of parents is based on general combining ability (Table 3). It was observed that the parent P7 (58.93) and Parbhani Kranti (10.50)exhibited significant and positive *gca* effect for fruit yield per plant(figure 2(a)), plant height, number of fruits per plant, fruit length, and fruit weight (figure 1(a). The same parents P7 (-1.01) and Parbhani Kranti (-0.98)observed negative significant *gca* effect for days to first flower. The Girijavikas recorded significant and positive *gca* effect for number of branches per plant. Thus P7 and Parbhani Kranti were considered as superior parents based on general combining ability effects as they recorded highly significant *gca* effects for most of the economic characters.

In the present investigation, the hybrids were evaluated based on specific combining ability effects (Table 4).The hybrids RNBR-1 X P7 and P7 XParbhani Kranti (7 traits); Girijavikas X P7 and Naveena XGirijavikas (6 traits); P7 X Girijavikas, Girijavikas XParbhani Kranti, Naveena X P7 and P7 X PSR-3 (5 traits) observed significant fruit yield and its component traits.

It is interesting to note that among these ten hybrids, had at least one parent (P7, Parbhani Kranti and Girijavikas) which was already identified as superior as parent. With regard to selection of hybrids based on *sca* effects, the crosses Arka Abhay X P7 (28.79), P7 X PSR-3 (26.32), Parbhani Kranti X P7 (23.35), Arka Abhay XParbhani Kranti (21.85) and RNBR-1 X PSR-3(14.40) recorded positive and highly significant for fruit yield per plant (figure 2(b). For days to first flower the crosses PSR-3 XGirijavikas (-1.75), Parbhani Kranti XNaveena (-1.67), P7 XGirijavikas (-1.39), RNBR-1 X P7 (-1.35) and Ankur-40XArka Abhay (-1.04)exhibited maximum and negative significant *sca* effects. The highly positive significant *sca* effects were observed the hybrids namely, P7 X RNBR-1 (4.02),Naveena X Girijavikas (3.79), Arka Abhay X RNBR-1 (3.76)and Arka Abhay XNaveena(3.02)for plant height;Arka Abhay X Girijavikas (0.49), Arka Abhay X P7 (0.38),Naveena X Girijavikas (0.31)and Parbhani Kranti X P7 (0.71) for number of branches per plant; P7 X RNBR-1 (2.75), Parbhani Kranti XGirijavikas (2.25), RNBR-1 XParbhani Kranti (2.11), Parbhani Kranti XNaveena (1.89)and Arka Abhay X P7 (1.75) for number of fruits per plant; Parbhani Kranti X Girijavikas (1.82), Arka Abhay X P7 (1.40),Parbhani Kranti X P7 (1.11) and Naveena X Ankur-40 (1.07) for fruit length; Girijavikas XParbhani Kranti (0.39)and P7 XArka Abhay (0.32)for fruit girth; Naveena XGirijavikas (3.01), Arka Abhay XNaveena (2.88)and Arka Abhay XParbhani Kranti (2.29)for fruit weight (figure 1(b)).

Among the eight characters, the hybrid Parbhani Kranti X P7 recorded favorable significant *sca* effects for seven characters namely days to first flower, plant height, number of branches per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant. The hybrids Parbhani Kranti X Naveena, Naveena XGirijavikas and Arka Abhay X P7 showed favorable *sca* effects for six different characters. Whereas, the hybrid RNBR-1 X P7 recorded significant *sca* effects for days to first flower, plant height, fruit length, fruit weight and fruit yield per plant.

Thus, the hybrids Parbhani Kranti X P7, Parbhani Kranti X Naveena, Naveena X Girijavikas, Arka Abhay X P7 and RNBR-1 X P7 were considered as superior hybrids as they recorded highly significant *sca* effects for most of the economic characters.

The specific combining ability is the deviation from the performance predicted on the basis of general combining ability (Allard, 1960). According to Sprague and Tatum (1942), the specific combining ability is controlled by non-additive gene action. The *sca* effect is an important criterion for the evaluation of the hybrids. The hybrids selected should high *sca* effects.

In the present investigation seventeen hybrids recorded positive significant *sca* effects for fruit yield per plant. Among them the hybrids *viz*., Arka Abhay X P7, P7 X PSR-3 and Parbhani Kranti X P7, had recorded highly significant and positive *sca* for fruit yield per plant. PSR-3 XGirijavikas recorded significant and negative *sca* effect for days to first flower.

Among the fifty six hybrids, three hybrids *viz*., Parbhani Kranti X Naveena, Naveena X Girijavikas and Arka Abhay X P7 registered significant *sca* effects for six other traits.

So, from the foregoing discussion it may be concluded that, the hybrid Parbhani Kranti X P7 could be used as the best for exploitation of heterosis. The hybrids Parbhani Kranti X Naveena, Naveena X Girijavikas and Arka Abhay X P7 were the better hybrids for exploitation of heterosis.

The crosses involving high *gca* parents generally give high *sca* effects (AtanuK Pal and Sabesan, 2009; Ramya, 2010); Shiv Prakash Singh (2011); Laxman Malakannavar *et al.* (2012) Anithavasline (2013); Aswanikumar *et al.* (2013); Medagam Thirupathi Reddy *et al.* (2013) and Mohamed Yassouf Saleem *et al.* (2013). In the present study, the hybrid Parbhani Kranti X P7 showed high *sca* effect with the combination of superior *gca* effect parents for fruit yield per plant.

From the perusal of *sca* effects of the hybrids, it was evident that all types (significantly positive or negative or non- significant) of *sca* effects could be obtained in hybrids with different types (high x high, high x low, low x high and low x low) of parental *gca* combinations. For example, high *sca* effect was produced by high x low or low x high combinations of parental *gca* effects for days to first flower Parbhani Kranti X Naveena; for plant height P7 X RNBR-1; number of branches per plant Arka Abhay X Girijavikas; number of fruits per plant P7 X RNBR-1, Parbhani Kranti X Girijavikas and RNBR-1 X Parbhani Kranti; fruit length Parbhani Kranti X Girijavikas; fruit girth Girijavikas X Parbhani Kranti and P7 XArka Abhay; fruit weight Arka Abhay X Parbhani Kranti; fruit yield per plant Arka Abhay X P7, P7 X PSR-3 and Arka Abhay XParbhani Kranti. The interaction between recessive alleles from poor combiners and dominant alleles from good combiner could have resulted in such potential crosses from good x poor parental combiners (Dubey, 1975).

There were instances in which involvement of both poor combiners produced superior specific combining hybrids as evidenced from the combinations of Naveena X Girijavikas and Arka Abhay X Naveena for fruit weight similar result were obtained by Hazam. Obiadaila Ali *et al.* (2013).

According to Medagam Thirupathi Reddy *et al.* (2013), a combination of two good general combiners need not necessarily be the best combination and low x low was a poor one. In the present investigation also, hybrids P7 X PSR-3 and Girijavikas XParbhani Kranti for days to first flower, showed poor performance even when both the parents involved were good general combiners. The inconsistency between *gca* and *sca* effects might be due to complex interaction of genes as suggested by Matzinger and Kempthorne (1956). Therefore, the specific combining ability of the hybrids evaluated was not always dependent on the general combining ability of their parents.

The perusal of the estimate of *gca* effects of the parents elucidated that P7, Parbhani Kranti was found to be the best combiner for most of the traits. Selection of parents based on the *gca* effects together resulted in the identification of the following parents *viz*., P7, Parbhani Kranti and Girijavikas. Based on the *sca* effects of hybrids, RNBR-1 X P7 and P7 XParbhani Kranti excelled others with significant *sca* effects for seven out of eight characters followed by Girijavikas X P7 and Naveena X Girijavikas for six out of eight characters and P7 X Girijavikas, Girijavikas X Parbhani Kranti, Naveena X P7 and P7 X PSR-3 was five out of eight characters including fruit yield per plant. Based on *gca* and *sca* effects three crosses namely, Parbhani Kranti X P7 (high x high *gca* parents), Arka AbhayX P7 (low x high *gca* parents), Parbhani Kranti XNaveena (high x low *gca* parents), NaveenaX Girijavikas (low x low *gca* parents) were selected for studying gene action through generation mean analysis.It may be concluded that the hybrids Parbhani Kranti X P7, Arka AbhayX P7, Parbhani Kranti X Naveena and Naveena X Girijavikas are suggested to improve the fruit yield per plant through heterosis breeding and their use in commercial cultivation.

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Table 1. Analysis of variance (Mean sum of square) for eight characters in bhendi for diallel analysis

Source	df	Mean Sum of Square							
		Days to first flowering	Plant height (cm)	Number of branches per plant	Number of fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield per plant (g)
Replication	1	0.03	7.68	0.03	0.07	0.17	0.77	2.17	29.00
Genotypes	63	7.06**	45.38**	0.49**	14.09**	5.28**	0.60**	20.53**	3243.41**
Error	63	0.95	4.24	0.21	1.14	0.51	0.13	0.32	51.36

** - Significant at 1 per cent level

Table 2. Estimates of variances for general and specific combining ability for eight characters in bhendi

Source	df	Days to first flowering	Plant height	Number of branches per plant	Number of fruits per plant	Fruit length	Fruit girth	Fruit weight	Fruit yield per plant
GCA	7	10.71**	136.07**	1.71**	42.80**	10.24**	2.17**	65.88**	11812.14**
SCA	7	1.94**	6.93**	0.01	2.79**	1.89**	0.07	1.44**	470.60**
RCA	7	3.32**	10.16**	0.11	2.36**	1.48**	0.05	5.18**	225.28**
Errror	63	0.47	2.12	0.10	0.57	0.25	0.06	0.16	17.68
GCA/SCA		5.5	19.63	122.42	15.30	5.39	28.04	45.56	25.09
GCA/RCA		3.2	13.38	14.54	18.12	6.89	39.69	12.71	52.43

** - Significant at 1 per cent level

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Table 3. Estimation of general combining ability effects of parents for yield and yield component characters in bhendi

Parents	Days to first flowering	Plant height	Number of branches per plant	Number of fruits per plant	Fruit length	Fruit girth	Fruit weight	Fruit yield per plant
PSR-3	-0.17	-3.5	-0.13	-0.27	-0.22	0.08	-1.47**	-20.57**
RNBR-1	-0.20	-0.58	-0.08	-1.74**	-0.54**	-0.13*	-0.60**	-13.53**
P7	-1.01**	2.96**	0.59**	2.75**	1.39**	0.72**	3.62**	58.93**
Girijavikas	-0.17	-0.53	0.33**	-0.24	-0.26*	-0.04	-0.13*	-10.77**
Parbhani Kranti	-0.98**	5.47**	0.09	2.52**	1.35**	0.03	2.59**	10.50**
Naveena	0.32	-0.51	-0.14	-2.02**	-0.20	-0.17**	-1.42**	-7.74**
Ankur-40	1.01**	-0.95**	-0.31**	-0.64**	-1.14**	-0.42**	0.11	-13.48**
Arka Abhay	1.20**	-2.32**	0.36**	-0.35**	-0.35**	-0.23**	-2.40**	-24.87**

* - Significant at 5 per cent level
** - Significant at 1 per cent level

Table 4. Estimation of specific combining ability effects of hybrids for yield and yield component characters in bhendi

Crosses	Days to first flowering	Plant height	Number of branches per plant	Number of fruits per plant	Fruit length	Fruit girth	Fruit weight	Fruit yield per plant
PSR-3 X RNBR-1	0.79	0.34	-0.05	-1.03*	0.66*	-0.07	-0.40	-8.36**
PSR-3 X P7	0.60	0.03	0.01	0.21	0.28	0.07	-0.19	3.49
PSR-3 X GV	-1.73**	-0.74	-0.01	-0.28	0.39	-0.01	0.03	1.58
PSR-3 X PK	-0.17	0.47	0.07	-0.10	0.72*	0.01	0.56*	12.70**
PSR-3 X NV	-0.48	-1.42	0.01	-1.50**	-0.91**	0.01	-0.01	0.93
PSR-3 X A-40	-0.42	0.93	-0.05	-0.75	-0.03	-0.11	-0.36	-9.59**
PSR-3 X AA	0.64	1.61	-0.04	036	-0.81*	0.27	-0.20	-8.82**
RNBR-1 X PSR-3	0.01	0.11	0.09	0.50	0.37	-0.09	-0.75**	14.40**
RNBR-1 X P7	-1.35**	1.98*	0.07	-0.32	0.90**	0.19	0.56*	9.44**
RNBR-1 X GV	-0.95*	-1.81*	0.02	-0.32	-0.34	0.03	0.22	4.12
RNBR-1 X PK	-0.39	-1.67	0.05	2.11**	0.39	-0.05	0.48	9.22**
RNBR-1 X NV	0.29	0.01	-0.03	-0.28	0.20	0.03	-0.34	-4.50
RNBR-1 X A-40	0.85*	0.30	-0.01	0.33	-0.45	-0.08	-0.19	-2.65
RNBR-1 X AA	0.92*	-1.33	-0.05	-0.41	-0.51	0.14	-0.02	-2.22
P7 X PSR-3	1.50**	1.19	-0.04	-1.25*	0.25	0.21	-0.90**	26.32**
P7 X RNBR-1	1.00**	4.02**	-0.23	2.75**	-0.81*	0.19	-0.31	1.03
P7 X GV	-1.39**	1.69	0.02	-0.07	0.24	0.01	-0.39	-6.46*
P7 X PK	-0.07	0.11	0.01	0.61	0.17	-0.04	-0.11	-2.58
P7 X NV	1.10*	1.79	0.06	0.71	0.16	0.08	1.12**	12.17*
P7 X A-40	0.17	-1.04	0.09	1.33**	-0.43	0.17	1.42**	-6.01*

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P7 X AA	-0.51	0.58	0.12	0.08	0.96**	0.32*	1.16**	-18.62**
GV X PSR-3	0.50	-0.03	-0.20	0.25	-0.07	0.01	-0.66*	8.29**
GV X RNBR-1	-0.75	-0.34	-0.28	0.25	0.30	-0.01	0.46	-2.11
GV X P7	0.50	0.95	-0.09	-1.50**	-0.31	-0.01	0.90**	-2.79
GV X PK	1.57**	1.74	-0.03	0.61	0.24	0.39*	-0.44	-7.42**
GV X NV	0.76	0.34	0.06	0.46	-0.03	-0.02	0.78**	11.34**
GV X A-40	1.32**	-0.29	0.04	0.83	0.81*	-0.04	0.68**	12.14**
GV X AA	0.14	0.58	0.02	0.83	0.58	-0.35*	0.28	6.45*
PK X PSR-3	0.25	2.94**	-0.01	-0.50	-0.07	0.24	-1.50**	1.14
PK X RNBR-1	-1.00*	-0.59	-0.03	-0.25	-0.55	0.14	0.10	-0.42
PK X P7	-1.35**	2.69*	0.17*	1.36**	1.11**	-0.31*	1.87**	23.35**
PK X GV	0.50	2.03	0.25	2.25**	1.82**	-0.41*	-0.43	0.59
PK X NV	-1.67**	2.68**	0.06	1.89**	0.75*	-0.02*	0.80**	12.16**
PK X A-40	0.50	1.63	0.01	-1.47**	0.22	0.09	0.31	5.84*
PK X AA	0.20	1.73	-0.04	-0.97*	0.32	-0.03	-0.31	-6.49*
NV X PSR-3	0.50	-4.17**	0.09	0.75	-0.73*	0.11	-3.13**	0.48
NV X RNBR-1	1.00*	0.18	0.09	0.50	-0.30	0.18	-1.53**	1.55
NV X P7	0.50	-3.71**	0.30	0.01	0.33	0.05	-2.16**	-7.73*
NV X GV	1.25**	3.79**	0.31*	1.25*	1.00**	-0.05	3.01**	10.13**
NV X PK	2.25**	-0.70	0.07	-2.25**	-1.92**	0.32	-2.47**	-8.68**
NV X A-40	0.57	-0.71	0.02	-0.13	1.07**	0.09	0.10	4.12
NV X AA	-0.35	0.59	-0.02	1.36**	0.68	-0.09	-0.37	-5.00
A-40 X PSR-3	1.00*	-3.08**	0.11	0.01	-1.52**	0.09	-2.69**	-16.15**
A-40 X RNBR-1	1.25*	-1.13	0.23	-1.00	-1.15**	0.12	-0.28	2.72
A-40 X P7	2.25**	-0.97	0.43	-1.00	0.63	-0.25	-1.07**	-15.62**
A-40 X GV	0.25	0.02	0.42	-0.50	0.54	0.17	-1.83**	-13.95**
A-40 X PK	2.25**	-0.49	0.20	-0.25	-1.39**	-0.07	-1.13**	-9.58**
A-40 X NV	0.50	0.37	0.07	1.25*	0.29	0.02	0.60*	-10.08**
A-40 X AA	-1.04*	-2.64**	-0.03	0.49	0.73*	-0.09	-0.60*	-11.01
AA X PSR-3	0.75	-3.05**	0.17	0.50	-0.44	-0.09	-0.30	-1.72
AA X RNBR-1	0.50	3.76**	0.26	-0.75	-0.40	0.03	0.19	12.55**
AA X P7	3.25**	2.80**	0.38*	1.75**	1.40**	-0.02*	1.07**	28.79**
AA X GV	1.25*	1.47	0.49*	0.01	-0.06	-0.17	0.90**	1.89
AA X PK	1.50**	-1.50	0.36	-0.25	0.57	-0.03	2.29**	21.85**
AA X NV	1.25*	3.02**	0.12	-0.25	0.19	0.06	2.88**	1.03
AA X A-40	1.75**	0.14	-0.01	0.25	-1.06**	0.01	1.53**	-1.62

* - Significant at 5 per cent level

** - Significant at 1 per cent level

GV- Girijavikas, PK- Parbhani Kranti, NV- Naveena, A-40- Anku-40, AA- Arka Abhay, PSR-3, RNBR-1 and P7

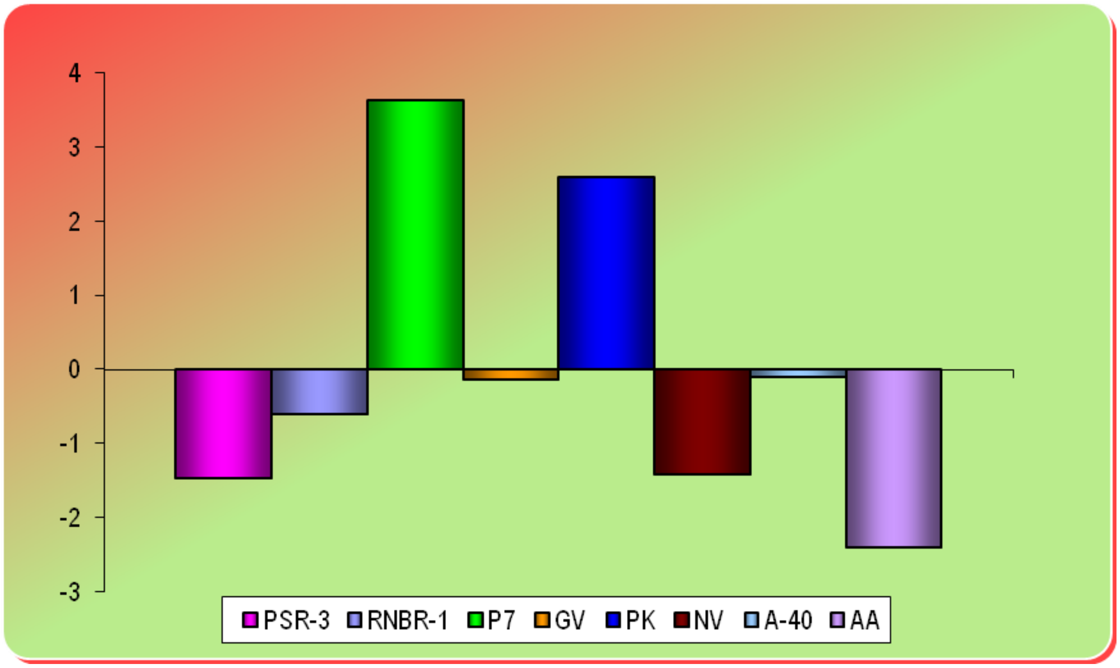

Fig. 1(a) Estimation of general combining ability effects for fruit weight

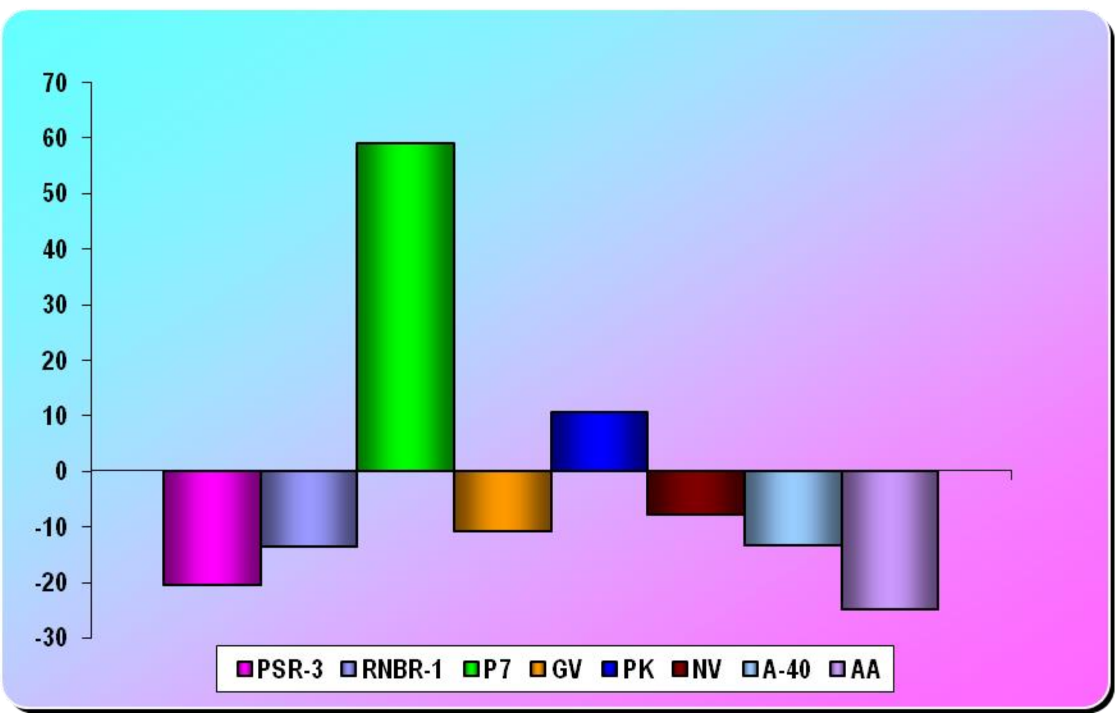

Fig. 2(a) Estimation of general combining ability effects for fruit yield per plant

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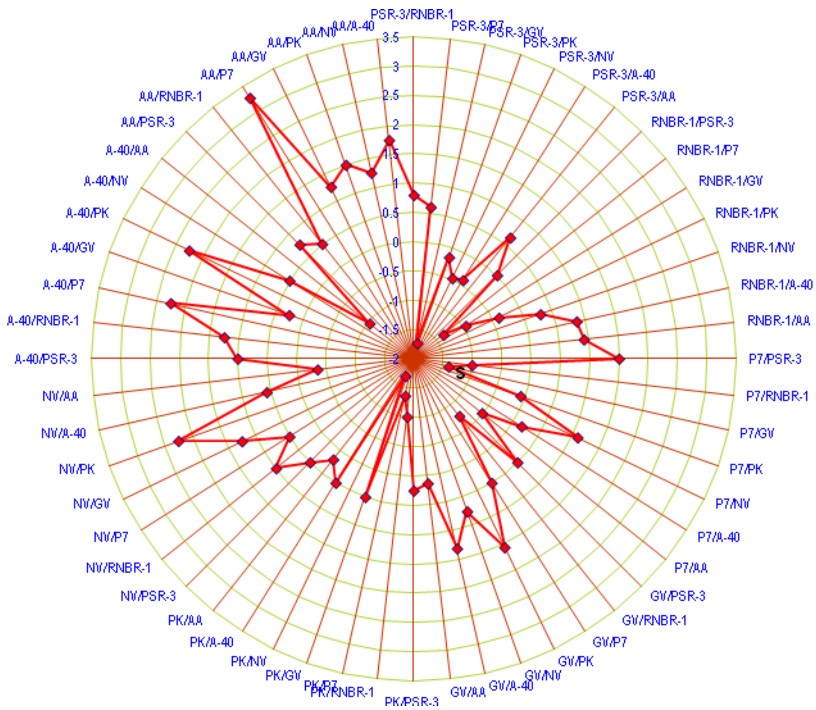

Fig. 1(b) Estimation of specific combining ability effects for fruit weight

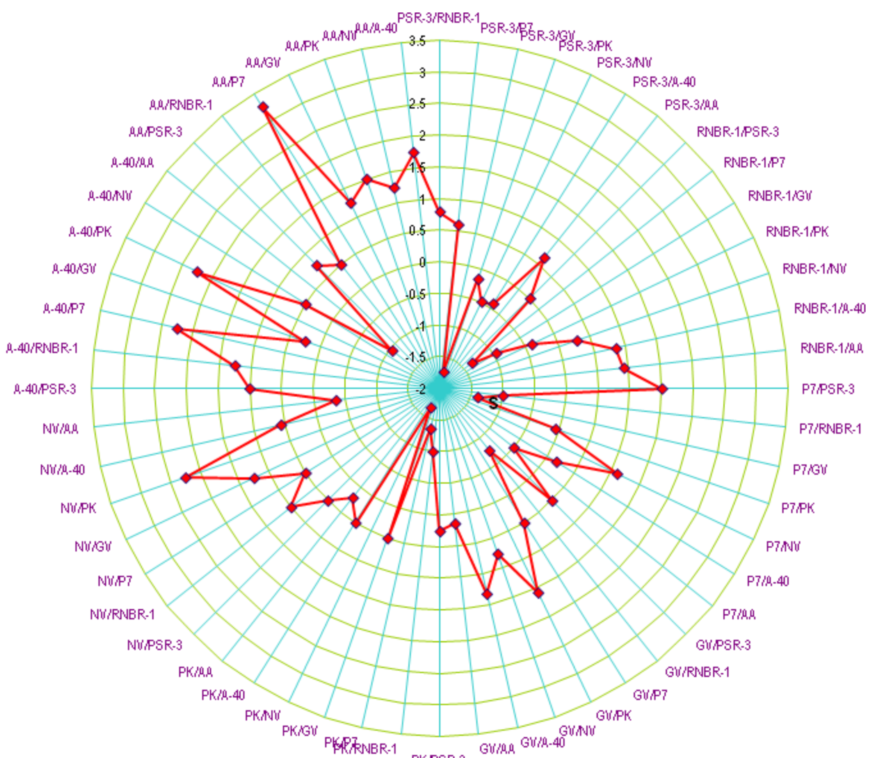

Fig. 2(b) Estimation of specific combining ability effects for fruit yield per plant