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HETEROSIS AND COMBINING ABILITY IN SOYBEAN FOR THE TRAITS OF VEGETABLE IMPORTANCE

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Summary

Fifteen cross combinations along with their parents were studied for combining ability heterosis and gene action for 12 traits of vegetable importance in soybean. All the traits were found under the control of additive gene action. From the results it was also concluded that DS 9501(P3), TNAU S 55 (P2) and TNAU S 7 (P1) were found to be good general combiners. On the basis of *per se* performance, heterosis and specific combining ability of the cross combinations and general combining ability of the parents involved four cross combinations *viz*., TNAU S 55 / DS 9501 (P2 / P3), TNAU S 55 / TS 82 (P2 / P4), DS 9501 / TS 82 (P3 / P4) and DS 9501 / CO 2 (P3 / P6) were assessed as the best material for further breeding work to obtain superior segregants.

सारांश

सब्जी सोयाबीन के 15 संकर एवं उनके प्रभेदों के साथ 12 गुणों के लिये संकर ओज एवं संयोजन क्षमता का अध्ययन किया गया। सभी गुणों के लिये प्रभावी ओज महत्वपूर्ण पाया गया। प्रभेद डीएस 9501, टीएनएयू 55 तथा टीएनएयू 7 में सामान्य संयोजन क्षमता अधिक पायी गयी। संकर प्रभेदों TNAU S 55 / DS 9501 (P2 / P3), TNAU S 55 / TS 82 (P2 / P4), DS 9501 / TS 82 (P3 / P4) and DS 9501 / CO 2 (P3 / P6) में विशिष्ट संयोजन क्षमता तथा संकर ओज अधिक पाया गया।

Introduction

An improvement in yield and quality of self-pollinated crops like soybean is effected mainly through selection of genotypes with desirable characters from the variation through recombination followed by selection. Since metric traits are governed by many genetic factors it is necessary to plan and adopt an appropriate selection strategy, which warrant sound knowledge of the genetic make up of the characters and their expression in different genetic backgrounds. Some information on additive and non-additive effects associated with yield and yield-contributing traits in grain soybean is available. However that on vegetable soybean on Indian context is very meager. On the other hand popularity of soybean as vegetable is on increasing trend. Realizing the importance of the above facts, the present study was carried out with the following objectives of studying the nature of gene action, assessing the combining ability and finding out heterotic cross combinations for traits of vegetable importance in soybean.

Materials and Methods

Six genotypes of soybean *viz*, TNAU S 7 (P1), TNAU S 55 (P2), DS 9501 (P3), TS 82 (P4), Himso 1563 (P5) and CO 2 (P6) were crossed in a diallel crossing pattern according to the method proposed by Agrawal *et al*. (2000) resulting in fifteen crosses without reciprocals. The cross combinations along with their parents were planted in randomized block design with three replications during Rabi 2003-04. Each genotype was sown in a row of four-meter length with a spacing of 45 X 20 cm and the crop was raised following optimal agronomic practices. Data were recorded on 12 quantitative traits *viz*., days to fifty per cent flowering (DFF), days to maturity (DM), plant height (PHT), number of branches per plant (NBP), number of cluster per plant (NCP), number of pods per cluster (NPC), number of two seeded pods per plant (N2SP), number of three seeded pods per plant (N3SP), total number of pods per plant (TPP), standard pod length (SPL), standard pod width (SPW) and pod yield per plant (PYP) on five randomly selected competitive plants. The mean data over the sample plants obtained for twelve characters were subjected to analysis of variance (Panse and Sukhatme, 1961). The significance test was carried out by referring to the F table given by Snedecor (1961). Combining ability including the parents and F_1 straight cross derivatives was estimated using method II model 1 as suggested by Griffing

(1956). The magnitude of heterosis in hybrid (F_1) was estimated following the formula of Hayes *et al*. (1955) and Briggle (1963) presented as percentage of increase or decrease in expression of a character over better parent (BP). The significance was tested as per the method suggested by Turner, (1956).

Results and Discussion

Assessment of gene action: The differences among the genotypes were significant for all the characters studied. A perusal of the table 1 revealed that both GCA and SCA variances were significant and GCA variance was greater than SCA variance indicating the significance of both additive and non-additive gene action with preponderance of additive genes in inheritance of all the traits. Similarly, Sharma and Phul (1994) observed high GCA variance for DFF, NBP and TPP. In contrary to this, Ganesamurthy and Seshadhri (2002) reported importance of non-additive gene action in inheritance of all the traits except for plant height. The significance of both GCA and SCA as in

Table 1.Analysis of variance for twelve traits of vegetable importance in soybean for combining ability analysis

Trait	GCA	SCA	GCA / SCA
DFF	40.20**	0.95**	42.32
DM	76.16**	15.17**	5.02
PHT	338.00**	85.28**	3.96
NBP	1.72**	0.58**	2.97
NCP	176.20**	44.33**	1.85
NPC	1.52**	0.48**	3.17
N2PP	2061.56**	250.02**	8.25
N3PP	739.10**	66.17**	11.17
TPP	3108.83**	707.01**	4.40
SPL	0.27**	0.06**	4.50
SPW	0.015**	0.003**	5.00
PYP	891.52**	188.24**	4.74

*significant at five per cent level ; ** significant at one per cent level

the present study was also reported by Menon (1980) for DFF, DM, PHT and NBP and Sharma and Phul (1994) for DFF, PHT, NBP and TPP. The present results were also found in concurrent with reports of Harer and Deshmukh (1993) and Halvankar and Patil (1993) for DFF, PHT, NBP and TPP. Rahangdale and Raut (2002) reported additive gene effects for DFF, DM and NCP, dominance gene action for yield and duplicate epistasis gene interaction for NBP and TPP. In the present case, as all the traits are under the control of additive gene action, it is suggested that selection in early generation may be fruitful either following mass selection or progeny selection or hybridization and selection with pedigree breeding.

Identification best general combiners: In any breeding programme, the choice of parent is the secret of success in developing high yielding varieties / hybrids. The broad principles governing the choice of the parents are their *per se* performance and general combining ability (*gca*) effects in desired magnitude and direction. In the parent study, P3, P2 and P1 recorded significantly superior *per se* performance of PYP, TPP, NCP, NBP, NCP and PHT than other parents. Besides, P1 and P2 showed the superiority for N2SP, DFF and DM, P3 and P4 for SPL and SPW and P2 and P3 for NPC and P3 for N3SP (Table 2).

The parent with high mean values may not necessarily be able to transmit the superior trait into their progenies (Simmonds, 1979). In that case, the second criterion became valid. Among the parents, P3 and P2 recorded significant and *gca* effects for PYP. With respect to their expression for yield component traits while P2 expressed desirable *gca* for TPP, N2SP, NPC, NCP, PHT, NBP, DFF and DM, P3 was a good general combiner for the above traits except for DFF and DM.

Table 2. Estimates of GCA effects of parents for twelve characters of vegetable importance in soybean

Characters	P1	P2	P3	P4	P5	P6	SE
DFF	3.85**(39.33**)	1.26**(35.67**)	-0.19(33.67)	-1.07(29.67)	-1.07(30..33)	*-2.19***(28.67)	0.15
DM	4.24**(89.33**)	3.24**(94.00**)	-1.85(86.67)	*-2.93***(81.67)	-0.01(87.00)	-2.68**(86.33)	0.17
PHT	6.08**(43.40**)	6.28**(44.38**)	5.29**(40.24**)	-6.05**(22.73)	-4.55**(26.74)	*-7.04***(23.48)	0.29
NBP	0.27**(3.93**)	0.48**(3.53**)	0.48**(3.42**)	*-0.58***(2.00)	-0.37**(2.50)	-0.27**(2.73)	0.025
NCP	0.39(30.00**)	4.32**(25.93**)	6.61**(32.30**)	-1.99**(17.24)	-4.45**(11.76)	*-4.89***(14.46)	0.22
NPC	0.21**(3.43)	0.63**(5.00**)	0.28**(4.57**)	*-0.42***(3.43)	-0.31**(3.57)	-0.39**(3.93)	0.03
N2SP	14.37**(77.85**)	22.75**(86.33**)	3.23**(54.20)	*-10.56***(26.58)	-15.57**(21.37)	-14.19**(25.27)	0.40
N3SP	-7.50**(16.40)	-1.93**(17.36)	19.22**(64.62**)	*-3.85***(10.27)	-3.32**(11.23)	-2.62**(19.89)	0.21
TPP	8.15**(101.69**)	22.78**(114.61**)	21.09**(121.67**)	*-19.64***(49.88)	-14.97**(54.99)	-17.41**(54.38)	0.40
SPL	-0.29(3.53)	-0.02(3.79)	0.27(4.36**)	0.11(4.15**)	-0.04(3.37)	-0.03(3.80)	0.02
SPW	-0.03**(0.97)	-0.05**(0.93)	0.02*(1.01**)	0.07**(1.15**)	-0.01*(0.97)	0.01(0.99)	0.01
PYP	-1.88**(63.57**)	9.92**(56.69**)	15.64**(71.54**)	-4.19**(24.39)	*-10.97***(29.19)	-8.53**(29.15)	0.32

* Significant at five per cent level; ** Significant at one per cent level; values in parentheses indicate the *per se* performance

Table 3. Superior specific combiners identified for economic traits of vegetable soybean

Character	Superior crosses
DFF	P1/ P4 (h X m), P1/ P5 (h X m), P2/ P6 (h X l)
DM	P1/ P3 (h X m), P1/ P4 h X l), P1/ P5 (h X m), P1/ P6 (h X l), P2 / P5 (h X m), P3 / P4 (m X l)
PHT	P1/ P4 (h X l), P1/ P5 (h X l), P1/ P6 (h X l), P2 / P4 (h X l), P2 / P5 (h X l), P2 / P6 (h X l), P3 / P4 (h X l), P3 / P5 (h X l), P3 / P6 (h X l)
NBP	P1/ P3 (h X h), P1 / P4 (h X l), P1 / P6 (h X l), P2 / P4 (h X l), P2 / P5 (h X l), P3 / P4 (h X l), P3 / P5 (h X l), P3 / P6 (h X l)
NCP	P1/ P4 (m X l), P1/ P5 (m X l), P2 / P4 (h X l), P2 / P5 (h X l), P2 / P6 (h X l), P3 / P4 (h X l), P3 / P5 (h X l), P3 / P6 (h X l)
NPC	P1/ P3 (h X l), P1/ P4 (h X l), P1 / P5 (h X l), P1 / P6 (h X l), P2 / P3 (h X h), P2 / P4 (h X l), P2 / P5 (h X l), P3 / P4 (h X l)
N2PP	P1 / P3 (h X h), P1 / P4 (h X l), P2 / P5 (h X l), P3 / P4 (h X l), P1 / P5 (h X l), P2 / P5 (h X l), P3 / P5 (h X l), P1 / P6 (h X l), P2 / P6 (h X l), P3 / P6 (h X l)
N3PP	P1 / P4 (l X l), P2 / P4 (l X l), P3 / P4 (h X l), P2 / P5 (l X l), P3 / P5 (h X l), P1 / P6 (l X l), P5 / P6 (l X l)
TPP	P1/ P4 (h X l), P1/ P5 (h X l), P1 / P6 (h X l), P2 / P4 (h X l), P2 / P5 (h x l), P2 / P6 (h X l), P3 / P4 (h X l), P3 / P5 (h X l), P3 / P6 (h X l)
SPL	P1 / P2 (m X m), P3 / P5 (m X m), P4 / P5 (m X m), P2 / P6 (m X m), P4 / P6 (m X m), P5 / P6 (m X m)
SPW	P1/ P2 (l X l), P2 / P5 (l X l), P4 / P5 (h X l), P3 / P6 (h X m), P4 / P6 (h X m)
PYP	P2 / P3 (h X h), P2 / P4 (h X l), P3 / P4 (h X l), P2 / P5 (h x l), P3 / P6 (h X l), P4 / P6 (l X l)

Instead, it showed significant *gca* effects for SPW and N3SP.Among the parents, there was close agreement between *per se* performance and *gca* effects for PYP and six other characters *viz.,* TPP, NPC, N2SP, NCP, NBP and PHT with respect to P2 and P3. However theparent, P1, a superior general combiner for PYP did not exhibit higher *per se* performance for this trait (Table 2). Hence, close agreement between *per se* performance and *gca* effect of the parents, reported by earlier workers Kaw and Menon (1981), Harer and Deshmukh (1993), Ponnusamy and Harer (1999) and Ganesamurthy and Seshadri (2002) was not fully concurrent in this study. In this present study based on the per se performance and *gca* effects of the parents studied, two parents *viz*, P2 and P3 were selected as best general combiners for important economic traits of vegetable soybean.

Identification of best specific combiners: Choice of the cross combinations is effected based on the *per se* performance, heterosis and specific combining ability (*sca*) of the cross combinations and also the gca effects of parents involved. A detailed perusal of the *per se* performance of 15 cross combinations revealed that six showed significantly increased PYP over the general mean. Among these, four involved P3 (P1 / P3, P2 / P3, P3 / P4 and P3 / P6) and three cross combinations involved P2 (P2 / P3, P2 / P4 and P2 / P5) as one of the parents in combination with other. All the cross combinations exhibiting significantly increased pod yield per plant also recorded higher number of TPP which showed the close association of these traits. The cross combinations, P1 / P3, P2 / P3 and P2 / P5 exhibited superior *per se* performance for the four traits *viz*, N2SP, PHT, NBP, and NPC. They exhibited superior *per se* performance for some other traits also i.e., P1 / P3 for SPW, DFF and DM, P2 / P3 for SPL, N3SP and NCP and P2 / P5 for N3SP, DM, and NCP. Similarly, P2 / P4 showed superiority for six traits *viz.,* N3SP, N2SP, PHT, NBP, NCP and NCP, P3 / P4 for SPL, N3SP, SPW and PHT and P3 / P6 for SPL, N3SP and NBP.

Table 4. Level of heterobeltiosis in fifteen cross combinations for nineteen characters of vegetable importance in soybean

	DFF	DM	PHT	NBP	NCP	NPC	N2PP	N3PP	TPP	SPL	SPW	PYP
P1 × P2	-0.85	-0.71	11.95**	1.67	-21.56**	5.33*	-4.25*	-24.88**	0.90	-6.67*	-3.33	-24.81**
P1 × P3	-7.69**	**5.62****	15.43**	12.50**	-19.92**	15.33**	9.66	-74.21**	4.14**	-9.18**	0.00	-26.78**
P1 × P4	-4.27*	3.00**	21.08**	-11.67**	-18.22**	56.31**	-3.25	-7.13	-0.17	-16.40**	-16.18**	-32.64**
P1 × P5	-5.13**	**5.62****	9.97**	-16.50**	-24.44**	34.58**	-12.82**	-38.67**	24.92**	-9.17**	-6.00	-36.81**
P1 × P6	-9.40**	3.75**	6.92*	0.83	-29.78**	21.19**	-5.24*	-27.71**	6.11**	-21.33**	-0.67	-42.44**
P2 × P3	-8.33**	-9.57**	8.36**	11.08**	4.44	11.40**	-0.39	-47.90**	13.36**	-6.66*	-5.30	27.24**
P2 × P4	-10.19**	-6.74**	4.92	19.17**	46.68**	3.53	28.29**	66.67**	31.74**	-5.87*	-15.61**	45.31**
P2 × P5	-6.48**	0.00	13.69**	20.92**	12.62**	0.53	-10.50**	22.86**	9.96**	-4.17	-2.00	3.64
P2 × P6	-7.41**	-6.38**	15.29**	-5.00	25.22**	-6.67*	-7.16**	-21.94**	21.32**	0.50	-5.67*	-15.71**
P3 × P4	-7.84**	-3.45**	24.11**	26.67**	8.91**	-12.00	7.63*	-25.14**	6.28**	-2.41	-2.89	5.07*
P3 × P5	-3.92	-6.13**	33.36**	50.00**	13.13 **	-14.00**	4.14	-28.65**	1.48	13.33**	-1.33	-32.44
P3 × P6	*-10.78***	-11.11**	10.83**	63.33**	0.31	-15.33**	*7.79**	-37.38**	2.70	3.33	11.67**	*7.54***
P4 × P5	-1.10	-3.45**	-16.05**	*-16.67***	-2.55	-9.81*	-3.15	4.69	-16.54**	6.67*	16.67**	*26.39***
P4 × P6	-4.44	*-11.97***	-20.60**	-14.27**	*-40.78* **	*-42.63***	-30.86**	*-66.98***	*-40.70***	4.17	14.00**	45.17**
P5 × P6	-1.11	-5.36**	*-26.60***	-9.76*	-26.14 **	-7.25*	*25.37***	*19.18***	17.58**	4.56	-3.33	9.50
SE	0.668	0.761	1.283	0.110	0.955	0.131	1.76	0.93	1.768	0.11	0.02	1.42

* Significant at one per cent level; ** Significant at one per cent level

For the second criterion of selecting the best hybrids, in the present discussion, significant better parent heterosis in positive direction has been taken in to consideration for all the traits except for DFF and DM (Table 3). For pod yield per plant, the maximum heterotic expression of 45.31 per cent over the standard parent was exhibited by P2 / P4 followed by P4 / P6 (45.17), P2 / P3 (27.24), P4 / P5 (26.39), P5 / P6 (9.10) and P3 / P6 (7.54 per cent). Besides PYP, P2 / P4 recorded significant better parent heterosis for PHT, NBP, NCP, TPP, N2SP and N3SP. Similarly, P2 / P3 exhibited significant better parent heterosis for PHT, NPC and TPP. Among the characters studied, greatest heterosis was observed for N2SP (66.67). However Kunto *et al*. (1997) reported greatest heterotic response for TPP.

Two other cross combinations *viz.,* P4 / P5 and P4 / P6 exhibiting significant positive heterosis for PYP recorded insignificant or negative better parent heterosis for all other traits except for SPL and SPW and SPW respectively that showed the importance of these traits for the improvement of vegetable soybean. Similarly Bravo *et al*. (1980) noted that pod size especially the pod width seemed to be positively associated with seed weight.

Among the 15 cross combinations studied, significant positive *sca* effects for PYP were shown by P2 / P3, P2 / P4, P3 / P4, P2 / P5 P3 / P6 and P4 / P6 (Table 4). With respect to their *sca* performance for other traits, P2 / P5 recorded superior *sca* effects for seven characters *viz*., PHT, NCP, NPC, N2SP, N3SP, TPP and SPW, P3 / P4 and P3 / P6 for six characters each *viz*., DM, NBP, NPC, N2SP, N3SP and TPP and PHT, NBP, NCP, N2SP, TPP and SPW respectively and P2 / P4 for five characters *viz.,* NBP, NCP, NPC, N3SP and TPP. Other two crosses *viz.,* P2 / P3 and P4 / P6 expressed superior *sca* effects respectively for NPC and SPL and SPW.

For the improvement of self pollinated crop like soybean, high *sca* effects of the particular cross combination combined with high *gca* effects of the parents involved will be of much useful unlike the *sca* effect alone in case of cross pollinated crop (Raghavaiah and Joshi, 1986). The *gca* effects of the parents of the superior cross combinations with high *sca* effects revealed that the best hybrids for the pod yield per plant involved combinations between high x high (P2 / P3), high x low (P2 / P4, P3 / P4, P2 / P5 and P3 / P6) and low x low (P4 / P6). In the present study, superior cross combinations for economic traits were obtained in all the combinations. However, Ganesamurthy and Seshadri (2002) did not report superior cross combinations involving low x low combinations. Considering the *per se* performance, standard heterosis and *sca* effects of the hybrids and the *gca* of the parents involved, four hybrids *viz.,* P2 / P3, P2 / P4, P3 / P4 and P3 / P6 were assessed as the best material for further breeding work to obtain superior segregants for economically important traits of vegetable importance in soybean

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