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Hybrid Specific Combining Ability in Relation to Parental General Combining Ability in Dolichos Bean (*Lablab purpureus* L.)

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A B S T R A C T

The choice of parents in a breeding programme for hybridization is one of the most critical considerations, since the selection on the basis of performance does not provide clear information. Combining ability, play a significant role in crop improvement, since they help in characterizing the nature and magnitude of genetic effects governing yield and component traits, besides pinpointing the promising parents to be used in the creation of genetic variability for eventual use in development of suitable varieties in self-pollinated crops. Hence, a study was undertaken to assess combining ability of crosses and their relationship with their parental general combining ability and elicit mode of action of genes controlling pod yield and its component traits in Dolichos bean using 12 lines and 4 testers. The 48 crosses (developed through Line × Tester combination) and their parents were evaluated for seed yield and its component traits during 2013 and 2014 kharif seasons at experimental plots of University of Agricultural Sciences, Bengaluru. Significant differences were found among the lines for all the traits and among testers for all the characters except for racemes plant^{-1}, justifying the selection of parents. Further, greater magnitude of *sca* variance for most of the traits studied in both years indicates greater importance of non-additive gene action for the inheritance of these traits. The lines RIL 185, HA 10-8 and tester RIL 60 were considered as best general combiners for most of the traits studied irrespective of the years. While, the crosses involving the line RIL 185 followed by RIL 332 and tester RIL 60 exhibited desirable *sca* effects in both years for most of the traits.

Introduction

Dolichos bean (*Lablab purpureus* L. Sweet) commonly known as field bean, hyacinth bean, Indian bean, sem, butter bean, Egyptian kidney bean and lubia bean etc., belongs to the family Fabaceae and is one of the most ancient crops among the cultivated plants. The crop is documented by archaeo-botanical finds in India from 2000 to 1700 BC at Hallur, the earliest Iron Age site in Karnataka, to 1200-300 BC at the Veerapuram excavation site in Andhra Pradesh (Fuller, 2003). In India, Dolichos bean is primarily cultivated in

Karnataka and adjoining districts of Tamil Nadu, Andhra Pradesh and Maharashtra (Mahadevu and Byre Gowda, 2005) for use as vegetable (immature pods and immature grains) and forage (NRC, 2006). It is cultivated either as a pure crop or intercropped with finger millet, groundnut, castor, corn, pearl millet or sorghum. Despite its importance as a multi-purpose crop and ability to withstand drought better than common bean and cowpea (Maass *et al.*, 2010), and adapt to acidic (Mugwira and Haque, 1993) and saline soils (Murphy and Colucci, 1999), Dolichos bean truly qualifies as 'underutilized' crop as evidenced by limited efforts for its genetic improvement.

Pure-limes are the only cultivar option in Dolichos bean as it is predominantly self-fertilizing species (Shivashankar and Kulkarni, 1989). Pedigree breeding is the most preferred method of developing pure-line cultivars in Dolichos bean. Pedigree breeding is a method of combining several desirable traits in a single genotype (pure-line) through selection from segregating generations derived from two/three/four/multi parent crosses involving parents harbouring desired traits.

Very often plant breeders are controlled with the task of selecting suitable parents for effecting crosses and choosing only a few highly productive crosses from a large number of crosses to maximise the probability of isolating desirable pure-lines. Combining ability (CA) is one of the widely accepted criteria for choosing the parents for effecting crosses. Apart from providing an objective criterion for choosing parents, CA also provides useful clues about mode of action of genes controlling economically important traits. The greatest advantage of CA approach for genetic analysis is that it is statistically robust and genetically neutral (Arunachalam, 1981). Precise knowledge on the nature of genetic control of target traits in working germplasm is a pre-requisite for designing suitable selection strategy.

Under these premises, the present investigation was carried out to assess combining ability of crosses and their relationship with their parental general combining ability and elicit mode of action of genes controlling pod yield and its component traits in Dolichos bean.

Materials and Methods

Plant material and experimental design

The base material for the study consisted of four inbred lines such as RIL 21, RIL 25, RIL 60 and RIL 180 designated as testers; 12 phenotypically diverse inbred lines which include two released varieties (HA 3 and HA 4), six advanced breeding lines (HA 11-3, HA 10-8, FPB 3, FPB 8, FPB 15 and FPB 21) and four recombinant inbred lines (RIL 11, RIL 162, RIL 185 and RIL 332) designated as lines (Table 1). The 12 inbred lines were crossed to four testers during 2012 rainy season. The 48 F_1's and their parents (12 lines and 4 testers) along with two check varieties such as HA 3 and HA 4 were evaluated in a randomised block design with two replications during 2013 and 2014 rainy seasons at the experimental plots of Department of Genetics and Plant Breeding, University of Agricultural Sciences (UAS), Bengaluru, India.

The experimental plotsare located at 12°58' latitude North, 77°35' longitude East and an altitude of 930 meters above sea level. The annual rainfall ranges from 679.1 mm to 888.9 mm. The data on average monthly minimum and maximum temperature, bright sunshine hrs and relative humidity are furnished in Table 2. The 48 F_1'sand 12 inbred lines were planted in a single row of 3 m length with a spacing of 0.6 m between rows and 0.3 m between plants within a row. A total of 12 plants were maintained in each row. Recommended production practices were followed for raising a good crop.

Collection of data

The data were collected on five randomly selected plants (avoiding border plants) in each of the 48 F_1's, parents and check varieties and in each replication on days to flowering, racemes plant^{-1}, pods plant^{-1}, dry pod weight plant^{-1}, dry seed weight plant^{-1}and fresh pod weight plant^{-1}.

Statistical analysis

The mean of two replications were used for thecombining ability analyses [9] Kempthorne (1957). Analysis of variance for CA, CA effects and components of genotypic variance were computed by using computer software program Windowstat 8.0 (developed by Indostat services 18.0, Ameerpet, Hyderabad, India).

Results and Discussion

Pooled analysis of variance

From the pooled analysis of variance (Table 1), indicated significant differences among the lines for all the traits and among testers for all the characters except for racemes plant^{-1}, justifying the selection of parents for CA analysis. Dethe *et al.*, (2008) in mungbean, Iqbal *et al.*, (2010) in common bean and Das *et al.*, (2014) in Dolichos bean reported significant difference among parents and crosses for days to flowering, racemes plant^{-1}, pods plant^{-1}, pod and seed yield plant^{-1}. Significant mean sum of squares due to genotypes × years ($P<0.01$) indicated differential performance of parents and crosses across twoyears. On the other hand, non-significant mean sum of squares due parents ×years interaction for most of the traits suggested comparable per se performance of parents. However, crosses interacted significantly over the years for most of the traits.

Significant mean sum of squares due to line effect (for days to flowering, dry seed weight and fresh pod weight plant^{-1}), tester effect and line × tester (L × T) effect for all the traits suggested importance of both general and specific combining ability for these traits. The significance of the interaction arising from line effect with season for days to flowering and L × T effect with the years for all the traits except for days to flowering and fresh pod weight plant^{-1} revealed that the alleles controlling the gca and sca behaved differently in the different years. The presence of significant line effect, tester effect or L × T effect × years interaction have been reported by Matzinger *et al.*, (1959) in maize, Kunkaew *et al.*, (2006) in azukibean and Iqbal *et al.*, (2010) in rajmesh for seed weight plant^{-1}, with contradictory reports revealing non-significant interaction of line effect, tester effect or L × T effect× years for pods plant^{-1}. Comparison of relative magnitude of *gca* and *sca* variances indicated greater magnitude of *sca* variance for most of the traits studied in both years, thereby indicating greater importance of non-additive gene action for the inheritance of these traits.

Importance of non-additive gene action forpod and seed weight plant^{-1} have been reported by Sofi *et al.*, (2006) field pea, Barelli *et al.*, (2000) in common bean, Saleem (2009) in faba bean and Iqbal *et al.*, (2010) in rajmesh and for racemes plant^{-1} have been reported by Singh and Singh (1981), Singh *et al.*,(1980, 1986) in lablab bean. However, the average degree of dominance was in the range of partial to over-dominance for all the traits studied (Table 2), which was revealed by Sofi *et al.*, (2006) in field pea and Iqbal *et al.*, (2010) in rajmesh.

Practical utility of CA lies in the prediction of performance of yet untested F_1 hybrids. Prediction power of gca is fairly high provided sca is absent or of very low magnitude. When both gca and sca are important gca serves the purpose of only short-listing parents further testing in specific combination. An important principle repeatedly overlooked frequently, is that estimates of gca and sca are relative to and dependent on the particular set of inbred lines included in the experiment.

Sprague and Tatum (1985) interpreted CA in terms of mode of action of genes. The differences in gca of lines are due to σ^2_A and σ^2_{AA}. The differences in sca of crosses assemble due to non-additive σ^2_g. In selected set of maternal, gca is less important than that of sca, whereas reverse is true for unselected maternal (Alam and Newaz, 2005).

General combining ability (*gca*) effects

The parental combining ability of parents (Table 3) revealed that among lines, HA 3 and FPB 21 and among testers, RIL 25 were good general combiners for early flowering in both years. The line, FPB 15 and RIL 332 exhibiting good combining ability for racemes plant^{-1} in 2013 rainy season only.

The lines RIL 185 and HA 10-8 were good general combiners as it exhibited significant positive *gca* effects for racemes plant^{-1} (in 2014 rainy season), pods plant^{-1}, dry pod and seed weight plant^{-1} and fresh pod weight plant^{-1} in both years. However, line HA 10-8 showed itself as a good general combiner for dry pod and seed weight plant^{-1} in 2014 rainy season only.

Among testers, RIL 60 showed good general combiner for racemes plant^{-1} (in 2014 rainy season only), pods plant^{-1}, fresh pod weight plant^{-1}, dry pod and seed weight plant^{-1} in both years.

Though none of the parents showed good general combining ability for all the traits, the lines RIL 185, HA 10-8 and tester RIL 60 were considered as best general combiners for most of the traits studied irrespective of the years.

Different types of combining ability in different years were also found for most of the genotypes. These differential results may be due to genotype-environment interaction. The similar results of differential types of combining ability in different sowing dates were also noticed by Alam and Newaz (2005) in lablab bean.

Specific combining ability (*sca*) effects

The estimates of *sca* effect revealed the importance of gene interaction for the characters studied. The cross combination RIL 332 × RIL 180 in 2013 rainy season and cross combination involved RIL 60 as a tester parent with lines RIL 11, FPB 21 and RIL 332 in 2014 rainy season had the highest significant *sca* effect in desirable direction for early flowering. The crosses HA 10-8 × RIL 60, RIL 332 × RIL 180 and FPB 3 × RIL 60 showed significant positive *sca* effect for pods plant^{-1}, fresh pod weight plant^{-1}, dry pod and seed weight plant^{-1} in 2013 rainy season. On the other hand, crosses such as RIL 185 × RIL 25 and RIL 162 × RIL 60 exhibited high *sca* effect for pods plant^{-1}, fresh pod weight plant^{-1}, dry pod and seed weight plant^{-1} in 2014 rainy season.

However, some other crosses gave significant positive *sca* effects in 2013 rainy season but non-significant or significant negative *sca* effects in 2014 rainy season for same traits and vice versa (Table 4). Alam and Newaz (2005) in lablab bean and Sofi *et al.,* (2006) in field pea also reported the crosses having differential response of *sca* effects in different environments/sowing dates.

Table.1 Pooled analysis of variance for quantitative traits in Dolichos bean

Source of variation	df	Days to flowering	Racemes plant^{-1}	Pods plant^{-1}	Dry pod weight plant^{-1}	Dry seed weight plant^{-1}	Fresh pod weight plant^{-1}
Replications	1	10.041	0.42	149.71	0.68	98.68	46.25
Years	1	500.08**	0.44	3568.05**	4484.65**	218.93*	5673.95**
Replication × Years	1	58.43 *	3.22	176.51	64.62	320.45**	310.88*
Genotypes	63	154.47**	16.49**	1572.26**	1466.57**	558.39**	2225.49**
Parents (P)	15	99.62**	4.83**	600.19**	1271.11**	553.93**	2783.70**
Lines (L)	11	86.85**	4.73**	289.01**	795.51**	361.91**	1519.39**
Testers (T)	3	175.91**	2.41	1356.05**	2418.98**	1036.35**	5471.46**
Lvs T	1	11.21	13.20**	1755.71**	3059.13**	1218.92**	8627.86**
P vs C	1	401.65**	196.21**	13686.05**	19577.64**	8123.05**	26600.32**
Crosses (C)	47	166.72**	16.38**	1624.76**	1143.61**	398.87**	1528.72**
Line effect	11	415.85**	15.80	1181.71	1066.03	471.00*	1805.05*
Tester effect	3	267.28*	48.40*	10722.46**	6558.73**	2150.36**	7909.15**
Line × Tester effect	33	74.53**	13.67**	945.37**	677.18**	215.61**	856.57**
Years× Genotypes	63	30.27**	8.15**	149.06**	217.99**	89.31**	307.92**
Years× Parents	15	35.91**	0.74	48.40	142.39	43.38	75.61
Years× Lines	11	41.54**	0.83	50.84	131.54	44.16	93.12
Years× Testers	3	10.57	0.27	21.84	33.87	4.53	1.36
Years×Lvs T	1	50.02	1.18	101.21	587.26*	151.32	105.72*
Years× Pvs C	1	21.00	0.01	7.53	1040.86**	436.72**	352.91**
Years× Crosses	47	28.67**	10.69**	184.20**	224.61**	96.56**	381.11
Years× Line effect	11	47.90*	6.28	152.71	181.10	50.65	245.54
Years× Tester effect	3	39.01	18.53	315.36	284.33	182.06	273.62
Years×(L × T) effect	33	21.31	11.45**	182.78**	233.68**	104.09**	436.07**
Pooled error	126	13.98	1.44	51.75	111.47	45.22	74.64

*Significant at P = 0.05 **Significant at P = 0.01

Table.2 Estimates of combining ability effects, components of variance and narrow-sense heritability (h^2 – ns) for quantitative traits in Dolichos bean

Parameters	Days to flowering		Racemes plant^{-1}		Pods plant^{-1}		Dry pod weight plant^{-1}		Dry seed weight plant^{-1}		Fresh pod weight plant^{-1}	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
σ^2 **GCA**	10.73	11.59	0.97	1.63	188.09	192.07	162.07	76.82	56.78	26.76	119.37	191.10
σ^2**SCA**	8.96	24.99	7.29	3.83	239.20	273.13	147.80	196.16	45.92	68.70	137.42	434.26
GCA / SCA	1.20	0.46	0.13	0.43	0.79	0.70	1.10	0.39	1.24	0.39	0.87	0.44
σ^2_A	21.46	23.17	1.94	3.26	376.18	384.15	324.13	153.64	113.56	53.52	238.73	382.20
σ^2_D	8.96	24.99	7.29	3.83	239.20	273.13	147.80	196.16	45.92	68.70	137.42	434.26
σ^2_E	11.42	2.56	0.69	0.75	22.92	28.83	53.40	58.06	21.89	23.34	39.41	35.23
σ^2_P	41.84	50.72	9.93	7.83	638.30	686.11	525.34	407.86	181.36	145.56	415.56	851.68
$\sqrt{\sigma^2_D / \sigma^2_A}$	0.65	1.04	1.94	1.08	0.80	0.84	0.68	1.13	0.64	1.13	0.76	1.06
h^2 **– ns (%)**	51.29	45.69	19.57	41.64	58.94	55.99	61.70	37.67	62.61	36.77	57.45	44.87

Table.3 Estimates of general combining ability effects of lines and testers for quantitative traits in Dolichos bean

Genotypes	Days to flowering		Racemes plant^{-1}		Pods plant^{-1}		Dry pod weight plant^{-1}		Dry seed weight plant^{-1}		Fresh pod weight plant^{-1}	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Lines												
HA 3	-7.50**	-3.41**	-1.08*	-1.76**	-8.51**	-4.96	-6.32	-1.67	-4.22	-1.51	3.47	-6.91*
HA 4	-6.05**	-2.66**	-0.46	-0.41	0.84	-6.23*	-5.32	-3.42	-4.72*	-4.43	-6.28	-2.00
HA 11-3	-5.55**	-3.01**	-0.04	-0.63	-3.41	5.28	-2.32	-0.03	-2.05	-0.31	4.80	8.54**
RIL 11	-0.70	2.44**	-1.04*	-0.87*	-15.18**	-8.67**	-5.02	-3.22	-1.48	-0.37	-4.53	-12.87**
RIL 185	13.35**	11.89**	0.42	2.99**	19.32**	7.78**	27.76**	12.83**	16.64**	9.97**	21.00**	13.06**
FPB 8	-1.82	-0.24	-1.29**	-0.56	-9.16**	-6.43*	-6.98	-8.80*	-5.28*	-6.01*	-14.14**	-11.08**
FPB 15	-0.70	-1.14	1.67**	0.79	-2.81	-4.41	0.83	-1.63	1.85	-0.20	-9.62**	-9.63**
RIL 332	5.00**	-2.19**	1.69**	-0.09	2.27	2.21	-5.92	-5.97	-4.53	-1.95	-2.88	-9.54**
FPB 3	7.55**	2.51**	-0.69	1.07*	-1.41	-2.61	11.63**	1.22	8.16**	1.63	6.32*	0.00
RIL 162	2.23	0.51	-0.77	-1.12*	15.47**	8.67**	-5.63	-0.41	-3.35	-3.23	-13.64**	-2.92
HA 10-8	0.20	-0.19	0.67	1.06*	9.17**	16.14**	5.73	13.35**	4.04	6.90**	14.15**	27.21**
FPB 21	-6.02**	-4.51**	0.92*	-0.49	-6.58**	-6.77*	-8.46*	-2.25	-5.06*	-0.49	1.34	6.16*
C.D @ 95%	**3.40**	**1.61**	**0.84**	**0.87**	**4.82**	**5.40**	**7.35**	**7.66**	**4.71**	**4.86**	**6.31**	**5.97**
C.D @ 99%	**4.54**	**2.15**	**1.12**	**1.16**	**6.43**	**7.21**	**9.81**	**10.23**	**6.28**	**6.48**	**8.43**	**7.97**
Testers												
RIL 21	-0.03	-2.40**	0.48	-0.26	-4.91**	-10.72**	-6.29**	-7.13**	-3.71**	-5.66**	-5.11**	-5.65**
RIL 25	-1.84	-1.80**	-1.53**	-0.81**	-8.88**	-10.02**	-9.04**	-6.69**	-4.02**	-2.41	-7.76**	-14.31**
RIL 60	2.43*	4.43**	0.59*	1.94**	22.07**	22.42**	20.41**	14.01***	12.03**	7.78**	16.75**	20.10**
RIL 180	-0.56	-0.22	0.45	-0.87**	-8.28**	-1.68	-5.076*	-0.19	-4.30**	0.30	-3.88*	-0.13
C.D @ 95%	**1.96**	**0.93**	**0.48**	**0.50**	**2.78**	**3.12**	**4.24**	**4.43**	**2.72**	**2.81**	**3.64**	**3.44**
C.D @ 99%	**2.62**	**1.24**	**0.65**	**0.67**	**3.71**	**4.16**	**5.66**	**5.91**	**3.63**	**3.74**	**4.86**	**4.60**

*Significant at P = 0.05 **Significant at P = 0.01

Table.4 Top ranking specific cross combinations on the basis of *sca* effects, their *per se* performance and their parental *gca* status

Traits	2013				2014			
	Crosses	sca effect	*Per se* value	gca status	Crosses	sca effect	*Per se* value	gca status
Days to flowering	RIL 332 × RIL 180	-8.07*	48.40	H × L	RIL 11 × RIL 60	-8.25**	53.10	H × L
	RIL 185 × RIL 21	-6.24	59.10	L × H	FPB 21 × RIL 60	-6.60**	47.80	L × L
	RIL 162 × RIL 60	-5.78	50.90	H × L	RIL 332 × RIL 60	-5.23**	51.50	H × L
	RIL 11 × RIL 60	-5.65	48.10	H × L	RIL 185 × RIL 21	-5.07**	58.90	L × H
	FPB 3 × RIL 180	-4.32	54.70	L × L	FPB 3 × RIL 180	-4.78**	52.00	L × L
Racemes plant^{-1}	HA 11-3 × RIL 180	8.75**	17.42	L × L	RIL 162 × RIL 60	3.95**	13.10	H × L
	HA 3 × RIL 60	4.57**	12.33	H × L	HA 10-8 × RIL 60	3.46**	14.80	L × L
	RIL 11 × RIL 180	2.84**	10.50	H × L	RIL 11 × RIL 21	3.40**	10.60	H × H
	RIL 185 × RIL 21	2.60**	11.75	L × H	HA 11-3 × RIL 25	3.36**	10.25	L × H
	FPB 3 × RIL 21	2.29**	10.33	L × H	FPB 15 × RIL 60	3.03**	14.10	L × L
Pods plant^{-1}	HA 10-8 × RIL 60	33.60**	111.80	L × L	RIL 162 × RIL 60	41.16**	126.88	H × L
	HA 4 × RIL 21	25.31**	68.20	H × H	RIL 185 × RIL 25	32.62**	85.00	L × H
	RIL 185 × RIL 21	-6.27	55.10	L × H	HA 10-8 × RIL 60	23.89**	117.07	L × L
	RIL 332 × RIL 180	20.16**	61.10	H × L	FPB 3 × RIL 60	21.51**	95.93	L × L
	FPB 3 × RIL 60	19.97**	87.60	L × L	RIL 332 × RIL 21	20.19**	66.30	H × H
Dry pod weight plant^{-1}	HA 10-8 × RIL 60	37.02**	124.10	L × L	RIL 185 × RIL 25	44.29**	117.42	L × H
	RIL 185 × RIL 25	19.44*	99.10	L × H	RIL 162 × RIL 60	25.59**	106.17	H × L
	RIL 332 × RIL 180	17.55*	67.50	H × L	FPB 8 × RIL 180	19.09*	77.08	H × L
	FPB 21 × RIL 180	17.49*	64.90	L × L	FPB 21 × RIL 21	16.76*	74.38	L × H
	FPB 3 × RIL 60	17.42*	110.40	L × L	FPB 15 × RIL 25	16.25*	74.92	L × H
Dry seed weight plant^{-1}	HA 10-8 × RIL 60	22.25**	78.74	L × L	RIL 185 × RIL 25	31.10**	79.42	L × H
	FPB 3 × RIL 60	14.83**	75.44	L × L	RIL 162 × RIL 60	13.10**	58.42	H × L
	FPB 21 × RIL 180	12.17*	43.23	L × L	RIL 11 × RIL 180	9.81*	50.50	H × L
	RIL 185 × RIL 25	11.00*	64.04	L × H	FPB 15 × RIL 25	9.69	47.83	L × H
	RIL 332 × RIL 180	6.97	38.56	H × L	FPB 8 × RIL 180	9.20	44.25	H × L
Fresh pod weight plant^{-1}	HA 10-8 × RIL 60	27.85**	146.82	L × L	RIL 185 × RIL 25	44.17**	141.75	L × H
	RIL 332 × RIL 180	21.46**	102.77	H × L	FPB 21 × RIL 180	29.46**	134.33	L × L
	FPB 21 × RIL 180	17.62**	103.15	L × L	HA 4 × RIL 180	25.63**	122.33	H × L
	FPB 3 × RIL 60	16.01*	127.15	L × L	FPB 3 × RIL 60	23.07**	142.00	L × L
	HA 4 × RIL 21	13.70*	90.37	H × H	FPB 15 × RIL 25	23.60**	98.50	L × H

*Significant at P = 0.05 **Significant at P = 0.01
H = High overall gca status L = Low overall gca status

The best five cross combinations for yield and its attributing traits on the basis of *sca* revealed that line RIL 185 was involved in maximum number of cross combination (10) followed by RIL 332 and FPB 3 (6) and tester RIL 60 (22) followed by RIL 180 (17) revealing desirable *sca* effects in both years. While assessing the performance of parents on the basis of general combining ability, it was observed that most of the desirable cross combinations involved high × high, high × low/low × high and low× low general combiners, which have also been reported by several workers in most of the crop species (Ram and Rajput (1999) in French bean; Ganesamurthy and Seshadri (2002) in soybean; Alam and Newaz (2005) in lablab bean; Iqbal *et al.*, (2010) in rajmesh). These results suggested the involvement of both additive and non-additive gene actions in the expression of the characters of Dolichos bean.

These parents are expected to give heterotic combinations resulting from the non-additive gene action and also results in the evolution of transgressive segregants for high yielding genotypes ensuing from complementary epitasis, additive type of gene action and recombination of latent genetic variability hidden in the heterogenetic blocks of such crosses. Normally, *sca* alone would not contribute tangibly in the improvement of self-pollinated crops, except where commercial heterosis is feasible. However, *sca* resulting from the heterozygosity of polygenes governing yield and yield components may result in the evolution of recombinants possessing desirable gene aggregates in a homozygous line.

Early elimination of a less productive crosses helps in efficient utilization of resources and allows handling of a reasonably large segregating populations of only a few crosses for maximise isolated purelines. Hybridization between chosen parents is only the beginning of a long process of selection and isolation of desirable recombinant inbred lines.

Rawlings and Cockerham (1962) suggested that a variety having best gca should be used as a third parent for a triple cross hybrid. Such triple cross hybrids have an element of gamete selection, since the superior performance of triple cross F_1 reflects the combination of a superior gamete from the segregating single cross with the genotype of non-segregating variety used as third parent. Stadler (1939) argued that frequency of superior gametes is much higher (q^2) than the frequency of superior zygotes (q). Therefore triple cross hybrids provide a more efficient mating system for obtaining lines with higher performance.

The dissimilarities between *per se* performance of the crosses and their *sca* effects suggested that both parameters such as *per se* performance and *sca* effects should be considered simultaneously in selecting suitable hybrids and their advanced generations. Genotypic expressions of the hybrids were also found to be different in different years indicating the presence of genotype-years interaction. Thus, plant breeders should also think about stable genotypes in different years before going on with selection of suitable advanced generation.

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