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Research Article

Genetic analysis of seed yield and component characters over environments in castor (*Ricinus communis* L.)

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Abstract
Thirty six castor hybrids developed by half diallel mating design along with nine pistillate parents were studied for combining ability effects. The genotypes, parents and hybrids significantly differed among themselves for all the characters, parents and hybrids also differed among themselves for all the characters except shelling out turn. Significance of both σ^2gca and σ^2sca for most of the characters suggested importance of both additive and non-additive genetic variances for inheritance of traits. The estimates of potence ratio and predictability ratio revealed preponderance of additive genetic variance for number of nodes up to primary raceme, plant height up to primary raceme, total length of primary raceme, effective length of primary raceme, number of secondary spikes per plant, 100 seed weight, volume weight and shelling out turn. The parents JP-65 and DPC-9 were good general combiners and SKP-84, ANDCP-06-07-1 and ANDCP-06-07 were average general combiners for seed yield and important yield contributing characters. Crosses SKP-84 x JP-65, ANDCP-06-07 x JP-65 and JP-65 x ANDCP-06-07-1 were good specific combiners for seed yield and good / average specific combiners for rest of the characters. The crosses which involved at least one good general combiner parent would produce transgressive segregants. However, for full exploitation of existing genetic variance in these crosses intermating of elite plants in the early segregating generations would be profitable to built up elite population for early and dwarf pistillate lines with high seed yield.

Key words:
Castor, diallel, combining ability, GCA, SCA, potence ratio, predictability ratio.

Introduction

The genus *Ricinus* is monotypic and *R. communis* is the only species with the most polymorphic forms known. Several of these forms were designated as species (*R. communis, R. macrocarpus, R. microcarpus*) (Weiss, 2000) but they are inter-crossable and fertile and are not true species. All the varieties investigated cytologically are diploids and it is presumed to be a secondary-balanced polyploid with a basic number of x=5 (Singh, 1976). Sexually is considered as polymorphic species with different sex forms *viz*., monoecious, pistillate, hermaphrodite and pistillate with interspersed staminate flowers (ISF). A variant of pistillate form with male flowers interspersed throughout the female flowers on the spike is termed as ISF. Cross pollinating nature and availability of pistillate lines facilitated an exploitation of hybrid vigour in castor. Inspite of number of hybrids released, the crop productivity has stagnated and reached plateau. This might be because of lack of variability for pistillate lines and their sources. It is equally important to plan breeding work to improve pistillate lines through conversion work or population improvement programme. In general, the available information on gene effects governing inheritance of various quantitative characters including seed yield is for single environment. Gene effects estimated for single environment are biased, as castor crop has wide sowing duration (Late *kharif* to *Rabi*) and largely influenced by environment. Therefore, under present investigation, nine pistillate lines having considerable variation for morphological and yield attributing characters were studied through half diallel analysis over three environments of a year at single location.

Material and methods

The experimental material consisted of nine genetically diverse pistillate lines *viz*. ANDCP-08-01, ANDCP-06-07, ACP-1-06-07, SKP-84, VP-1, DPC-9, JP-65, ANDCP-06-07-1 and ANDCP-06-07-2 were crossed in half diallel mating fashion. The resulting 46 genotypes (36 hybrids + 9 parents + GCH-7 as check) were grown in Randomized Complete Block Design with three replications. The investigation was carried out at Regional Research Station, Anand Agricultural University, Anand during 2012-13. Each genotype was grown in a single row of 7.2 meter length with 0.90 x 0.60 m^2 spacing. The observations were recorded for sixteen yield and yield contributing characters (Table 1). Mean value of each experimental unit was subjected to analysis of variance given by Tai (1971) and pooled analysis of variance used for combining ability with expectation of mean squares reviewed by Singh(1973).

Results and discussion

Pooled analysis of variance for experimental design (Table1) revealed that mean squares due to environments were significant for all the characters except volume weight which indicated that created environments differed from each other. Mean square values due to genotypes, parents and hybrids were significant for all the characters suggesting existence of sufficient amount of variability among material studied, parents and hybrids also differed among themselves for all the characters except shelling out turn. Significance of mean square due to genotype x environment interaction for all the characters except volume weight and shelling out turn suggested that genotypes behaved differently to array of environments.

Combining ability analysis (Table 2) indicated significance of mean squares due to both general and specific combining ability for all the characters; whereas, mean squares due to environments were significant for all the characters except volume weight, which also revealed existence of differences among parents, hybrids and environments. The interaction variances resulted from GCA x environments and SCA x environments were significant for all the characters except for volume weight, oil content and shelling out turn in SCA x environments, which revealed that both σ^2gca and σ^2sca were influenced by environments, while for these three characters additive genetic variance was variable across the environments. The results were in conformity with report of Solanki and Joshi (2000).

Significance of both σ^2gca and σ^2sca for most of the characters suggested importance of both additive and non-additive genetic variances for inheritance of traits. While, non-significance of σ^2gca was observed for total number of capsules per plant and seed yield per plant which revealed importance of only non-additive genetic variance for these characters and the findings confirmed the reports of Manivel *et al*. (1998) and Tank *et al*. (2003).

The estimates of potence ratio (genetic variance >1) and predictability ratio (genetic variance >0.5) revealed preponderance of additive genetic variance for number of nodes up to primary raceme, plant height up to primary raceme, total length of primary raceme, effective length of primary raceme, number of secondary spikes per plant, 100 seed weight, volume weight and shelling out turn. The results were in accordance with the findings of Manivel *et al*.(1998), Solanki and Joshi (2000), Tank *et al*. (2003) and Patel *et al*. (2012). Preponderance of non-additive variance was realized for number of tertiary spikes per plant, total number of capsules per plant and seed yield per plant.

The characters days to 50 % maturity of primary raceme, number of effective branches per plant, number of tertiary spikes per plant, total number of capsules per plant, seed yield per plant and oil content had above one value of average degree of dominance, which revealed over dominance behaviour of interacting alleles. The complete dominance behaviour of interacting alleles was observed for the characters days to 50 % flowering of primary raceme (1.13), total length of primary raceme (0.90) and number of capsules per primary raceme (1.16) as the ratio of average degree of dominance was equal to one. The said value was less than one for rest of the characters revealing existence of partial dominance. Since over dominance gene action was involved for an inheritance of seed yield per plant, heterosis breeding would be most effective approach to improve the character. However, for development of superior genotypes with high seed yield, selection should be postponed to later generations, thereby dominance would be diluted (Narayanan and Gunasekaran, 2008).

General combining ability effect of parents and specific combining ability effect of crosses were calculated in case of significance of combining ability variances of respective source. The results pertaining to *per se* performance and gca effect of the parents for various characters are presented in Table 3. The parents JP-65 as well as DPC-9 were good general combiners and SKP-84, ANDCP-06-07-1 and ANDCP-06-07 were average general combiners for seed yield per plant across the environments; whereas, parent ANDCP-06-07-2 was poor general combiner for most of the characters across the environments. Most of the parents had relatively high degree of correspondence between *per se* performance and their gca effects for majority of the characters, which could be because of existence of genes showing additivity and *pseudo* additive gene effects. Therefore, in selection of parents for hybridization work, equal importance should be given to their *per se* performance along with gca effects.

The information pertaining to different aspects of sca effect is presented in Table 4. The magnitude of sca effect for different characters was in both the directions. In general, the crosses which showed high desirable sca effect also had a high *per se* performance and involved at least one parent as good general combiner for all the characters. For seed yield per plant, crosses SKP-84 x JP-65, ANDCP-06-07 x JP-65 and JP-65 x ANDCP-06-07-1 had higher sca estimates, all these crosses were good / average specific combiners for rest of the characters. Therefore, these crosses may be given due weightage in crop improvement work. In most of the crosses, the involvement of either one or both the parents with significant gca effect, contributed to significant sca effect for the crosses, indicating the occurrence of additive gene action in such crosses. The crosses which involved at least one good general combiner parent would produce transgressive segregants. However, for full exploitation of existing genetic variance in these crosses, intermating of elite plants in the early segregating generations would be profitable to built up elite population for early and dwarf pistillate lines with high seed yield.

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Table 1. Analysis of variance for experimental design pooled over the environments

Source of variation	df	Days to 50 % flowering of primary raceme	No. of nodes up to primary raceme	Plant height up to primary raceme (cm)	Days to 50 % maturity of primary raceme	Total length of primary raceme (cm)	Effective length of primary raceme (cm)	Number of effective branches per plant	Number of secondary spikes per plant
Environments	2	16845.9 **	336.52 **	1510.06 **	13583.00 **	981.50 **	741.62 **	1983.11 **	65.72 **
Genotypes	45	176.1 **	24.69 **	5895.71 **	401.89 **	687.33 **	681.08 **	33.21 **	6.59 **
Geno. x Envi.	90	10.90 **	1.69 **	53.58 **	20.00 **	53.96 **	52.24 **	3.36 **	0.74 **
Parents (P)	8	328.56 **	45.15 **	5535.89 **	760.34 **	1379.80 **	1433.35 **	12.11 **	4.46 **
Hybrids (H)	35	127.56 **	20.68 **	6014.85 **	284.12 **	429.65 **	460.46 **	27.02 **	5.49 **
P *vs* H	1	816.35 **	25.73 **	5326.12 **	1991.12 **	4852.65 **	2958.66 **	178.88 **	7.36 **
Check *vs* Hybrids	1	2.88 NS	0.81 NS	4404.69 **	25.05 NS	16.90 NS	40.07 NS	239.85 **	57.68 **
Error	90 (270)	13.93	1.63	36.68	19.68	47.70	47.51	1.28	0.66

Table 1. Contd..

Source of variation	df	Number of tertiary spikes per plant	Number of capsules per primary raceme	Total number of capsules per plant	100 Seed weight (g)	Volume weight (g/100ml)	Seed yield per plant (g)	Oil content (%)	Shelling out turn (%)
Environments	2	165.48 **	2394.87 **	1132956.00 **	52.36 **	0.13 NS	659905.00 **	467.81 **	107.56 **
Genotypes	45	11.06 **	1502.30 **	62608.53 **	51.28 **	28.91 **	48962.44 **	23.66 **	72.23 **
		1.18 **	107.75 **	7224.68 **	2.54 **	2.08 NS	4846.68 **	0.75 **	3.58 NS
Parents (P)	8	9.50 **	1645.15 **	16179.80 **	33.39 **	44.55 **	8234.64 **	34.62 **	147.06 **
Hybrids (H)	35	7.89 **	1313.01 **	55343.79 **	49.27 **	23.78 **	41815.39 **	17.52 **	45.48 **
P *vs* H	1	45.60 **	7430.94 **	593470.89 **	291.12 **	103.65 **	544881.99 **	165.14 **	13.07 NS
Check *vs* Hybrids	1	89.28 **	679.64 NS	114960.69 **	13.93 NS	13.51 NS	92380.18 **	4.22 NS	454.61 **
Error	90 (270)	0.31	147.66	2331.15	3.47	4.98	1371.45	1.31	11.42

*, ** Significant at 0.05 and 0.01 levels of probability, respectively; figure in parenthesis is pooled error df

Table 2. Estimates of components of gene effect pooled over the environments

Source of variation	df	Days to 50 % flowering of primary raceme	No. of nodes up to primary raceme	Plant height up to primary raceme (cm)	Days to 50 % maturity of primary raceme	Total length of primary raceme (cm)	Effective length of primary raceme (cm)	Number of effective branches per plant	Number of secondary spikes per plant
Environments	2	5549.76 **	109.76 **	453.68 **	4425.37 **	322.18 **	239.50 **	640.53 **	21.33 **
GCA	8	169.60 **	33.71 **	9097.39 **	348.91 **	779.10 **	801.54 **	23.52 **	6.27 **
SCA	36	35.55 **	2.79 **	387.00 **	89.30 **	113.25 **	104.67 **	6.08 **	0.78 **
GCA x Environment	16	21.57 **	4.96 **	65.76 **	29.78 **	98.29 **	83.76 **	3.97 **	0.88 **
SCA x Environment	72	8.59 **	0.99 **	50.88 **	17.84 **	45.26 **	46.42 **	3.14 **	0.73 **
Pooled error	264	4.62	0.55	12.05	6.55	16.10	15.98	0.43	0.22
Estimates of components of genetic variance and related parameters									
□^{2}GCA ($\sum gi^2$)		12.19 *	2.81 *	791.85 *	23.60 *	60.53 *	63.35 *	1.59 *	0.50 *
□^{2}SCA ($\sum\sum sij^2$)		30.93 *	2.24 *	374.95 *	82.75 *	97.14 *	88.69 *	5.66 *	0.56 *
Potence ratio $\frac{1}{df}\sigma^2 gca \Big/ \frac{1}{df}\sigma^2 sca$		1.77	5.65	9.50	1.28	2.80	3.21	1.26	3.99
Predictability ratio $2\sigma^2 gca \Big/ 2\sigma^2 gca + 2\sigma^2 sca$		0.44	0.72	0.81	0.36	0.55	0.59	0.36	0.64
σ^2A		24.37	5.62	1583.71	47.20	121.06	126.70	3.17	1.00
σ^2D		30.93	2.24	374.95	82.75	97.14	88.69	5.66	0.56
(□^{2}D/□^{2}A)$^{0.5}$		1.13	0.63	0.49	1.32	0.90	0.84	1.34	0.75

Table 2. Contd..

Source of variation	df	Number of tertiary spikes per plant	Number of capsules per primary raceme	Total number of capsules per plant	100 Seed weight (g)	Volume weight (g/100ml)	Seed yield per plant (g)	Oil content (%)	Shelling out turn (%)
Environments	2	56.81 **	816.04 **	341829.61 **	17.29 **	0.10 NS	194997.43 **	157.67 **	34.67 **
GCA	8	5.65 **	1375.67 **	26260.31 **	59.88 **	35.02 **	19462.05 **	19.63 **	73.46 **
SCA	36	2.43 **	310.48 **	18793.47 **	7.83 **	4.19 **	14881.56 **	5.41 **	9.43 **
GCA x Environment	16	1.44 **	155.65 **	8673.54 **	4.96 **	3.94 **	5287.18 **	2.22 **	7.41 *
SCA x Environment	72	1.09 **	99.30 **	6349.53 **	2.04 **	1.68 NS	4237.79 **	0.40 NS	2.83 NS
Pooled error	264	0.11	50.00	788.35	1.18	1.66	453.04	0.44	3.87
Estimates of components of genetic variance and related parameters									
□^{2}GCA ($\sum gi^2$)		0.29 *	96.84 *	678.80	4.73 *	2.80 *	416.41 NS	1.29 *	5.82 *
□^{2}SCA ($\sum\sum sij^2$)		2.33 *	260.48 *	18005.12 *	6.65 *	2.52 *	14428.53 *	4.97 *	5.57 *
Potence ratio $\frac{1}{df}\sigma^2 gca \Big/ \frac{1}{df}\sigma^2 sca$		0.57	1.67	0.17	3.20	5.00	0.13	1.17	4.71
Predictability ratio $2\sigma^2 gca \Big/ 2\sigma^2 gca + 2\sigma^2 sca$		0.20	0.43	0.07	0.59	0.69	0.05	0.34	0.68
σ^2A		0.58	193.67	1357.61	9.46	5.61	832.82	2.58	11.64
σ^2D		2.33	260.48	18005.12	6.65	2.52	14428.53	4.97	5.57
(□^{2}D/□^{2}A)$^{0.5}$		1.99	1.16	3.64	0.84	0.67	4.16	1.39	0.69

***, ** significant at 0.5 and 0.01 probability level, respectively.**

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Table 3. Estimates of general combining ability effect and *per se* performance of parents over environments

Parents		Days to 50 % flowering of primary raceme		No. of nodes up to primary raceme		Plant height up to primary raceme (cm)		Days to 50 % maturity of primary raceme		Total length of primary raceme (cm)		Effective length of primary raceme (cm)		Number of effective branches per plant		Number of secondary spikes per plant	
		Per se	GCA	*Per se*	GCA	*Per se*	GCA	*Per se*	GCA	*Per se*	GCA	*Per se*	GCA	*Per se*	GCA	*Per se*	GCA
ANDCP-08-01		64.0	-2.22 **	15.0	-1.01 **	26.7	-16.82 **	141.4	-0.71	61.5	-3.11 **	56.8	-2.73 **	9.1	-0.26 *	4.8	-0.07
ANDCP-06-07		65.6	-1.36 **	16.0	-0.33 **	44.3	-9.11 **	136.7	-0.35	70.0	-2.50 **	62.9	-2.97 **	8.4	-0.84 **	5.0	-0.50 **
ACP-1-06-07		78.3	4.48 **	20.3	1.86 **	57.4	1.82 **	148.8	4.66 **	99.7	11.07 **	94.5	10.66 **	7.3	-1.14 **	4.2	-0.46 **
SKP-84		67.0	1.16 **	18.0	0.99 **	46.2	-6.86 **	138.1	-1.02 *	78.5	2.76 **	73.9	2.99 **	8.9	0.11	4.4	0.00
VP-1		60.6	-2.58 **	12.8	-1.27 **	35.3	-12.04 **	128.4	-3.78 **	70.8	-2.92 **	63.7	-2.90 **	10.4	0.67 **	5.0	0.10
DPC-9		70.4	-0.13	14.8	-0.81 **	73.9	19.48 **	134.6	-1.62 **	55.5	-4.59 **	49.2	-4.77 **	9.9	0.63 **	5.6	0.35 **
JP-65		73.2	1.56 **	18.0	0.45 **	109.5	34.65 **	156.4	5.74 **	67.8	2.65 **	65.3	3.91 **	10.9	1.56 **	6.4	0.91 **
ANDCP-06-07-1		59.3	-1.76 **	15.2	-0.18	45.7	-4.46 **	128.0	-3.35 **	74.6	-1.14	65.4	-1.86 **	9.0	-0.22 *	4.7	-0.04
ANDCP-06-07-2		65.7	0.85 *	16.6	0.30 *	43.0	-6.65 **	142.7	0.43	69.3	-2.22 **	61.9	-2.34 **	8.1	-0.51 **	4.4	-0.30 **
Mean		**67.1**	-	**16.3**	-	**53.6**	-	**139.5**	-	**72.0**	-	**65.9**	-	**9.1**	-	**4.9**	-
Range	**Min.**	59.3	-2.58	12.8	-1.27	26.7	-16.82	128.0	-3.78	55.5	-4.59	49.2	-4.77	7.3	-1.14	4.2	-0.50
	Max.	78.3	4.48	20.3	1.86	109.5	34.65	156.4	5.74	99.7	11.07	94.5	10.66	10.9	1.56	6.4	0.91
SE (g_i)±		-	0.35	-	0.12	-	0.57	-	0.42	-	0.66	-	0.66	-	0.11	-	0.08
SE (g_i-g_j)±		-	0.53	-	0.18	-	0.85	-	0.63	-	0.99	-	0.98	-	0.16	-	0.12
C.D. 5 % (g_i-g_j)		-	1.04	-	0.36	-	1.68	-	1.24	-	1.95	-	1.94	-	0.32	-	0.23

Table 3 Contd..

Parents	Number of tertiary spikes per plant		Number of capsules per primary raceme		Total number of capsules per plant		100 Seed weight (g)		Volume weight (g/100ml)		Seed yield per plant (g)		Oil content (%)		Shelling out turn (%)	
	Per se	**GCA**	***Per se***	**GCA**	***Per se***	**GCA**	***Per se***	**GCA**	***Per se***	**GCA**	***Per se***	**GCA**	***Per se***	**GCA**	***Per se***	**GCA**
ANDCP-08-01	3.9	-0.17 **	58.8	-2.18	138.2	***-38.98*** **	**31.1**	**1.79** **	55.2	0.20	116.8	***-22.39*** **	**47.0**	0.14	60.2	-0.07
ANDCP-06-07	2.9	***-0.24*** **	68.8	***-3.48*** **	233.6	-14.27 **	27.4	***-0.90*** **	56.8	**1.17** **	175.0	***-16.91*** **	45.9	**0.42** **	**68.7**	**2.04** **
ACP-1-06-07	2.6	***-0.59*** **	**93.4**	**6.70** **	215.4	***-17.62*** **	28.8	**0.65** **	52.3	***-0.46*** *	169.6	-9.31 **	45.0	-0.26 *	61.8	-0.53
SKP-84	4.0	0.07	79.4	4.64 **	242.1	6.15	28.9	-0.04	54.0	0.24	195.2	**7.38** *	45.0	***-0.46*** **	66.8	**2.05** **
VP-1	4.3	**0.35** **	45.1	***-13.03*** **	242.4	***-17.32*** **	30.0	0.14	**56.9**	**0.71** **	**196.2**	-15.23 **	45.5	***-0.32*** **	62.1	***-1.18*** **
DPC-9	3.6	**0.17** **	66.5	**5.49** **	168.5	**10.41** *	28.4	**1.72** **	51.5	***-1.75*** **	128.7	**21.25** **	45.7	**1.26** **	60.5	***-2.00*** **
JP-65	**6.1**	**0.83** **	61.3	**6.34** **	182.2	**59.63** **	27.4	0.36 *	51.7	***-1.50*** **	135.5	**52.79** **	40.6	***-1.49*** **	55.3	***-1.68*** **
ANDCP-06-07-1	3.9	-0.19 **	63.2	-2.20	**271.1**	**17.37** **	25.4	***-1.90*** **	56.3	**0.86** **	193.3	0.27	46.9	**0.61** **	64.6	0.59
ANDCP-06-07-2	3.1	***-0.23*** **	62.8	***-2.28***	231.9	-5.37	25.5	***-1.82*** **	56.0	0.51 *	167.7	***-17.86*** **	46.8	0.10	65.2	**0.78** *
Mean	**3.8**	-	**66.6**	-	**213.9**	-	**28.1**	-	**54.5**	-	**164.2**	-	**45.4**	-	**62.8**	-
Range Min.	2.6	-0.59	45.1	-13.03	138.2	-38.98	25.4	-1.90	51.5	-1.75	116.8	-22.39	40.6	-1.49	55.3	-2.00
Range Max.	6.1	0.83	93.4	6.70	271.1	59.63	31.1	1.79	56.9	1.17	196.2	52.79	47.0	1.26	68.7	2.05
SE (g_i)±	-	0.05	-	1.16	-	4.61	-	0.18	-	0.21	-	3.49	-	0.11	-	0.32
SE (g_i-g_j)±	-	0.08	-	1.74	-	6.91	-	0.27	-	0.32	-	5.24	-	0.16	-	0.48
C.D. 5 % (g_i-g_j)	-	0.16	-	3.43	-	13.61	-	0.53	-	0.63	-	10.32	-	0.32	-	0.95

Table 4. Estimates of specific combining ability effect and *per se* performance of castor hybrids over environments

Characters	Range of SCA effect	Range of crosses for their *per se* performance	Top ranking three crosses	*Per se* performance	SCA effect of the crosses	GCA effect of parents involved with a cross	Number of crosses with significant +ve and –ve SCA effect +ve	–ve
Days to 50 % flowering of primary raceme	-6.75 to 5.29	55.6 to 74.3	VP-1 x ANDCP-06-07-1	55.6	-4.38**	G x G	6	13
			ANDCP-08-01 x ANDCP-06-07	56.7	-4.04**	G x G		
			ANDCP-08-01 x JP-65	58.8	-4.85**	G x P		
Number of nodes up to base of primary raceme	-1.98 to 1.95	13.1 to 19.8	VP-1 x ANDCP-06-07-1	13.1	-1.24**	G x A	5	9
			ANDCP-06-07 x VP-1	13.5	-0.68	G x G		
			ANDCP-08-01 x DPC-9	13.5	-0.47	G x G		
Plant height up to base of primary raceme	-16.86 to 25.44	31.4 to 122.7	ANDCP-06-07 x VP-1	31.4	-8.30**	G x G	11	10
			ANDCP-08-01 x ANDCP-06-07	33.2	-1.72	G x G		
			VP-1 x ANDCP-06-07-2	34.8	-7.31**	G x G		
Days to 50 % maturity of primary raceme	-10.95 to 9.50	122.7 to 144.8	VP-1 x ANDCP-06-07-1	122.7	-5.22**	G x G	8	16
			ANDCP-08-01 x ANDCP-06-07-1	126.9	-4.07**	A x G		
			DPC-9 x ANDCP-06-07-2	126.9	-6.95**	G x A		
Total length of primary raceme	-6.07 to 9.16	68.8 to 99.1	ACP-1-06-07 x SKP-84	99.1	6.40**	G x G	11	4
			ACP-1-06-07 x JP-65	93.0	-1.69	G x G		
			SKP-84 x DPC-9	91.6	2.61	G x P		
Effective length of primary raceme	-8.97 to 10.31	60.9 to 94.4	ACP_1-06-07 x SKP-84	94.4	9.42**	G x G	10	3
			ACP_1-06-07 x JP-65	84.7	-1.24	G x G		
			ACP-1-06-07 x ANDCP-06-07-1	83.0	2.86	G x P		
Number of effective branches per plant	-2.01 to 3.48	8.0 to 15.6	SKP-84 x JP-65	15.6	3.48**	A x G	11	6
			ANDCP-06-07 x JP-65	13.8	2.63**	P x G		
			JP-65 x ANDCP-06-07-1	13.0	1.19**	G x P		
Number of secondary spikes per plant	-0.87 to 1.29	3.8 to 7.4	SKP-84 x JP-65	7.4	1.29**	A x G	5	3
			ANDCP-06-07 x JP-65	6.4	0.73**	P x G		
			SKP-84 x DPC-9	6.4	0.81**	A x P		
			VP-1 x DPC-9	6.4	0.72**	A x G		
			JP-65 x ANDCP-06-07-1	6.4	0.32	G x A		
Number of tertiary spikes per plant	-1.31 to 2.09	3.1 to 6.5	DPC-9 x ANDCP-06-07-2	6.5	2.09**	G x P	14	9
			SKP-84 x JP-65	6.4	0.98**	A x G		
			ANDCP-06-07 x JP-65	6.3	1.26**	P x G		
Number of capsules per primary raceme	-14.32 to 19.67	52.1 to 97.0	DPC-9 x JP-65	97.0	10.06**	G x G	9	5
			ACP-1-06-07 x ANDCP-06-07-1	93.6	13.92**	G x A		
			DPC-9 x ANDCP-06-07-2	93.2	14.79**	G x A		
Total number of capsules per plant	-109.26 to 138.10	187.3 to 494.4	SKP-84 x JP-65	494.4	138.10**	A x G	14	6
			JP-65 x ANDCP-06-07-1	463.7	96.15**	G x G		
			JP-65 x ANDCP-06-07-2	410.4	65.70**	G x A		
100 Seed weight	-1.99 to 3.08	25.0 to 35.0	ANDCP-08-01 x JP-65	35.0	3.08**	G x G	8	3
			VP-1 x DPC-9	34.2	2.52**	A x G		
			ANDCP-08-01 x DPC-9	33.8	0.43	G x G		
Volume weight	-1.60 to 1.97	50.7 to 57.8	ANDCP-08-01 x ANDCP-06-07	57.8	0.90	A x G	5	2
			VP-1 x ANDCP-06-07-2	57.8	1.03	G x A		
			SKP-84 x ANDCP-06-07-2	57.7	1.38*	A x A		
Seed yield per plant	-92.30 to 112.59	128.6 to 410.3	SKP-84 x JP-65	410.3	112.59**	G x G	15	8
			ANDCP-06-07 x JP-65	371.2	97.70**	P x G		
			JP-65 x ANDCP-06-07-1	368.7	78.10**	G x A		
Oil content	-2.48 to 2.03	43.9 to 50.2	DPC-9 x ANDCP-06-07-1	50.2	1.65**	G x G	12	3
			ANDCP-06-07 x DPC-9	49.9	1.61**	G x G		
			ACP-1-06-07 x DPC-9	49.5	1.81**	P x G		
Shelling out turn	-4.08 to 2.44	58.2 to 67.2	ANDCP-08-01 x SKP-84	67.2	2.08*	A x G	5	2
			SKP-84 x ANDCP-06-07-1	66.9	1.09	G x A		
			ANDCP-06-07 x SKP-84	66.4	-0.87	G x G		