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Gene Action Studies in Cowpea Inbreds and Hybrids with Varying Levels of Heterosis

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ABSTRACT

Background: Cowpea is an important pulse crop grown worldwide that fits well in a variety of cropping systems. Improvement in yield and related characters along with reduced duration are desirable traits in this crop. The study of heterosis reveals the type of gene action involved which enables the plant breeder to adopt suitable breeding methodology for its improvement.

Methods: The present investigation was carried out with 10 parent partial diallel design to analyse the gene action and estimate of heterosis with respect to nine yield related traits in cowpea.

Result: Highly significant variances observed for all the traits indicated that hybrids and parents were different from each other for the traits under study and that variability in the breeding materials was attributed to additive and non-additive gene effects. Perusal of the data revealed significant positive heterosis for all yield related traits and significant negative heterosis for days to 50% flowering indicating earliness. Among the twenty five crosses studied, VS9 x VS43, VS24 x VS45 and VS44 x VS47 had significant heterosis for maximum number of characters. Both *gca* and *sca* variances were significant for all the characters indicating both additive and non-additive gene actions controlling the various traits. The additive variance was much higher than dominance variance for the characters days to 50% flowering, pod length, pod breadth, pod weight, pods per plant and cluster, pod yield per plant, seeds per plant and length of harvest period suggesting the preponderance of additive gene action.

Key words: Additive and non-additive gene effects, Cowpea, Heterobeltiosis, Relative heterosis.

INTRODUCTION

Cowpea is an important food legume growing in tropical and subtropical regions of Africa, Asia and Central and South America. There is a large morphological diversity found within the crop and the growth conditions and grower preferences for each variety vary from region to region. However, as the plant is primarily self-pollinating its genetic diversity within varieties is comparatively less (Egbadzor, 2014). In a self-pollinating crop like cowpea, variability is often created through hybridization between carefully chosen parents. The superiority of a hybrid in one or more characters over its parents is known as heterosis. Even the expression of small magnitudes of heterosis for a particular character is also very much desirable in breeding. High estimate of heterosis is a result of high genetic diversity among parents indicating the possibility of identifying high yielding transgressive segregants from the hybrid populations (Singh, 2002). The scope for exploitation of hybrid vigour in cowpea depends upon the direction and magnitude of heterosis and the type of gene action involved. Information about the estimates of heterosis will help identify crosses which can lead to superior transgressive segregants in segregating generation. Therefore, the present investigation was undertaken to estimate heterosis for yield and yield component traits in cowpea.

MATERIALS AND METHODS

The experimental material consisted of ten divergent parental lines namely VS 2, VS 9, VS 21, VS 22, VS 24, VS 41, VS 43, VS 44, VS 45 and VS 47 and their crosses in a partial diallel design. The accessions VS 41 and VS 45 had high peroxidase activity, VS 24 exhibited high poly phenol oxidase activity and VS 21 had high phenyl alanine ammonialyase activity indicating significant disease resistance. The parent VS 2 had a pod length of 53.98 cm while VS 21 had a pod weight of 26.49 g. Comparatively high protein content was observed in VS 24, while VS 41 recorded very high pod yield per plant. Number of seeds per pod was 20.98 in VS 47. These parents were selected in order to incorporate yield and yield contributing characters along with disease resistance to the hybrids.

Each parent was involved in five selected crosses. The twenty-five crosses along with their parents and a standard check (Sarika, a variety of vegetable cowpea released in the year 1993 for Kerala) were evaluated in a field experiment in randomised complete block design with three replications. The experiment was conducted in the Instructional Farm of College of Agriculture, Vellayani during

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2004. The normal cultural methods as per the package of practices recommendations of the Kerala Agricultural University for the crop were followed to raise the crop. Five competitive plants per genotype were randomly selected to record the biometric observations on days to 50 per cent flowering, pod length, pod breadth, pod weight, pods per cluster, pods per plant, pod yield per plant, seeds per pod and length of harvest period.

Analysis of variance for partial diallel analysis was conducted for all the characters. The general combining ability (*gca*) of the parents and the specific combining ability (*sca*), as estimated by adjusted mean values of the hybrids were obtained using partial diallel method (Kempthorne and Curnow, 1961). The mean squares due to various sources of variation and their genetic expectations were also computed. The relative heterosis, heterobeltiosis and standard heterosis were estimated and expressed as percentage for all the twenty-five hybrids to calculate the extent of heterosis (Falconer, 1989).

RESULTS AND DISCUSSION

Results obtained from the partial diallel analysis of variance revealed significant variation among the crosses and parents for all the characters studied (Table 1) indicating the importance of additive and non-additive gene action for most of the traits (Katariya *et al*., 2016). Exploitation of heterosis is one of the most important objectives of the plant breeder. The magnitude of useful heterosis is of utmost importance in its commercial exploitation. The mean performances of the hybrids were estimated (Table 2) which revealed a wide variation among the crosses (Patel *et al*., 2009). The highest yield of 365.5 g was observed for the cross VS44 x VS47, which was also the earliest to flower (38 days). Pod weight and pod length was highest for VS2 x VS21.

The range of relative heterosis, heterobeltiosis and standard heterosis for the 25 crosses with respect to the nine characters are presented in Table 2. Table 3 represents the number of crosses with significant heterotic effects over mid parent, better parent and standard check. None of the crosses recorded significant positive relative heterosis for days to 50% flowering. Earliness indicated by significant negative relative heterosis and heterobeltiosis was recorded by VS2 x VS44, VS9 x VS43, VS9 x VS45 and VS24 x VS44. Significant negative heterosis for days to 50 per cent flowering in cowpea was earlier reported by Manggoel *et al*. (2012) and Anita *et al*. (2016).

Heterosis was ranged from -16.6 to 33.9 per cent, -27.1 to 18.1 per cent and -10.0 to 40.5 per cent over mid parent, better parent and standard check respectively for pod length (Okunlola, 2014). For pod breadth, the range of heterosis

Table 1: ANOVA (mean square) for partial diallel analysis for various yield related traits in cowpea.

Source	Replication	Crosses	Parents	Parent vs crosses	Error
Df	2	24	9	15	48
Days to 50% flowering	1.012	78.374**	183.928**	15.042**	1.666
Pod length (cm)	2.460	86.327**	161.206**	41.400**	6.279
Pod breadth (cm)	0.023	0.138**	0.260**	0.064**	0.018
Pod weight (g)	2.609	26.524**	61.257**	5.684**	2.438
Pods per cluster	0.014	0.562**	1.198**	0.180**	0.020
Pods per plant	0.752	54.093**	114.525**	17.834**	3.976
Pod yield per plant (g)	604.360	5911.951**	12079.815**	2211.233**	478.832
Seeds per pod	0.573	4.124**	9.605**	0.836**	0.601
Length of harvest period	0.973	17.892**	40.454**	4.355**	1.654

**Significant at 1% level.

Table 2: Range of mean and the heterosis % over mid parent (Relative heterosis), better parent (Heterobeltiosis) and standard check (Standard heterosis) for yield and yield related characters in cowpea.

Characters	Range of mean		Range of heterosis %		
	Parents	Crosses	RH	HB	SH
Days to 50% flowering	42.5 to 57	38.0 to 56.6	-22.79 to 1.26	-15.5 to 9.6	-23.5 to 8.7
Pod length (cm)	28.4 to 67.6	37.5 to 58.6	-16.6 to 33.9	-27.1 to 18.1	-10.0 to 40.5
Pod breadth (cm)	1.9 to 2.7	2.1 to 2.8	-10.2 to 22.1	-18.1 to 0	-5.8 to 27.1
Pod weight (g)	6.57 to 26.5	10.6 to 22.2	-8.9 to 53.8	-29.7 to 31.6	-28.7 to 49.7
Pods per cluster	0.42 to 2.7	2.1 to 3.4	0.14 to 31.1	-27.4 to 18.4	-9.1 to 47.1
Pods per plant	3.1 to 23.1	9.4 to 23.9	-4.3 to 113.8	-45.1 to 104.6	-29.4 to 78.9
Pod yield per plant (g)	63.9 to 252.8	195.1 to 365.5	4.1 to 112.3	-27.3 to 74.1	11.8 to 109.5
Seeds per pod	17.3 to 21.0	17.7 to 20.7	-1.8 to 9.6	-6.8 to 5.5	-0.02 to 18.9
Length of harvest period	17.5 to 27	19.3 to 29.7	-8.7 to 15.9	-21.6 to 8.1	-15.9 to 29.0

RH- Relative heterosis; HB- Heterobeltiosis; SH- Standard heterosis.

Table 3: Number of hybrids having significant heterotic effects.

Characters	Positive			Negative			Percentage of crosses showing heterosis over	
	RH	HB	SH	RH	HB	SH	Mid parent	Better parent
Days to 50% flowering	-	1	2	17	5	14	68	24
Pod length (cm)	12	3	20	3	8	2	60	44
Pod breadth (cm)	2	-	11	-	-	-	8	0
Pod weight (g)	11	1	19	-	8	1	44	36
Pods per cluster	9	2	13	-	7	-	36	36
Pods per plant	13	7	16	-	4	-	52	44
Pod yield per plant (g)	23	6	23	-	5	-	92	44
Seeds per pod	3	-	14	-	-	-	12	0
Length of harvest period	8	-	16	-	4	2	32	16

RH – Relative hetrosis; HB – Heterobeltiosis; SH – Standard heterosis.

over mid parent, better parent and standard check were from -10.2 to 22.1 per cent, -18.1 to 0 per cent and -5.8 to 27.1 per cent respectively. None of the hybrids exhibited significant negative heterosis for pod breadth. Heterosis for pod weight ranged from -8.9 to 53.8 per cent, -29.7 to 31.6 per cent and -28.7 to 49.7 per cent over mid, better and standard check respectively (Sharma *et al*., 2016). The estimates of heterosis for this trait revealed that 11 and 19 crosses showed significant positive heterosis over mid parent and standard check respectively. High estimates of heterosis for various pod related traits in cowpea were earlier reported by Aremu and Adewale (2010).

For pods per plant, the range of heterosis over mid, better and standard check was from -4.3 to 113.8 per cent, -45.1 to 104.6 per cent and -29.4 to 78.9 per cent respectively. Similar result was also reported by Pandey and Singh (2015). Comparatively the values of heterosis for pods per cluster were less (0.14 to 31.1 per cent, -27.4 to 18.4 per cent and -9.1 to 47.1 per cent respectively) indicating that the number of pods per plant was not dependent on the number of pods per cluster. The percentage of crosses with significant heterosis for pods per plant (52 per cent and 44 per cent) over mid and better parent indicated the equal involvement of additive and non-additive gene action for this trait (Dias *et al*., 2016). The magnitude of heterosis for pod yield per plant ranged from 4.1 to 112.3 per cent, -27.3 to 74.1 per cent and 11.8 to 109.5 per cent over mid, better and standard check respectively (Patil *et al*., 2014). All the crosses exhibited significant positive relative and standard heterosis. Twenty three crosses recorded positive significant heterosis over mid parent and standard check. The per cent of crosses showing significant heterosis over mid and better parent was 92 and 44 respectively, indicating dominant gene action (Bhushana *et al*., 2000). The trait seeds per pod did not exhibit a wide range of heterosis over mid, better and standard check. None of the crosses recorded significant negative heterosis for this trait (Sharma *et al.,* 2010).

Significant positive relative heterosis was highest for VS24 x VS45 for pod length (33.9), pod breadth (22.1), pod weight (53.8), pods per plant (113.8), pod yield per plant (112.3) and length of harvest period (15.9). The hybrid VS9 x VS43 also had high and significant relative heterosis for pod length (12.31), pod weight (27.0), pods per cluster (22.6), pods per plant (24.5) and pod yield per plant (28.2). Significant positive heterosis for various characters in cowpea was earlier reported by Asokbhai (2015) and Sharma (2010).

The *sca* or dominance variance, *gca* variance and additive variance of the various characters are presented in Table 4. Both *gca* and *sca* variances were significant for all the characters indicating both additive and non-additive gene actions controlling the various traits. (Chaudhari *et al*., 2013) The *gca* variance is higher than the *sca* variance for the characters days to 50% flowering, pod weight, pods per cluster, pods per plant, pod yield per plant and length of harvest period. This indicates the presence of additive gene action controlling these characters suggesting recombination

Table 4: Variances for the various characters.

Characters	*Sca* or dominance variance	*Gca* variance	Additive variance
Days to 50% flowering	4.4587	12.6664	25.3328
Pod length (cm)	11.7070	8.9855	17.9709
Pod breadth (cm)	0.01533	0.0147	0.0295
Pod weight (g)	1.0819	4.1679	8.3359
Pods per cluster	0.0536	0.0763	0.1527
Pods per plant	4.6194	7.2518	14.3959
Pod yield per plant (g)	577.4670	740.1436	1480.2871
Seeds per pod	0.0783	0.6577	1.3154
Length of harvest period	0.9004	2.7074	5.4148

breeding as the best strategy for improvement. The additive variance was much higher than dominance variance for the characters days to 50% flowering, pod length, pod breadth, pod weight, pods per plant and cluster, pod yield per plant, seeds per plant and length of harvest period suggesting the preponderance of additive gene action. Predominance of additive gene action for days to maturity and pod length was reported by Owusu *et al.* (2018).

The *sca* variance was higher than *gca* variance for pod length, pod breadth and seeds per pod, indicating predominance of dominant gene action. (Pampaniya, 2017) Significant role of non-additive gene action in inheritance of yield and most of characters was observed by Kumari and Chauhan (2018).

CONCLUSION

Negative heterosis, indicating earliness was observed for days to 50 per cent flowering for all the crosses with respect to standard heterosis. Yield per plant presented positive relative and standard heterosis for all the hybrids. The crosses VS9 x VS43, VS24 x VS45 and VS44 x VS47 had significant heterosis for maximum number of characters. These cross combinations would provide better source population to get superior segregants. The results indicate the possibilities of developing early duration cowpea genotypes, coupled with high yield. A predominance of additive gene action for most of the yield related characters in cowpea suggests recombination breeding as an effective strategy for crop improvement.

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