Received: 22 Jul 2020 | Revised: 13 Feb 2021 | Accepted: 15 Feb 2021

Electronic Journal of Plant Breeding

Research Article

Gene action and combining ability of yield and yield related characters in genetically diverse lines in yard long bean [*Vigna unguiculata* ssp. *sesquipedalis* (L.) Verdc.]

B. Lovely* and V. Kumar

Onattukara Regional Agricultural Research Station, Kayamkulam, Alappuzha 690502, Kerala Agricultural University, Thrissur, Kerala, India.
***E-Mail**:lovelybethel@yahoo.co.in

Abstract
Ten parents were mated in partial diallel fashion to develop twenty five crosses and were evaluated along with parents in Randomised block design. All the characters studied had non-additive and additive gene action as indicated by the significant differences of analysis of variances due to specific combining ability and general combining ability. The parents VS41, VS43 and VS47 were having significant general combining ability. The crosses VS-44 x VS-47, VS-9 x VS-43 and VS-43 x VS-47 exhibited the high SCA effect for pod yield per plant. Positive *sca* effects combined with negative *gca* effects of the respective parents were noticed for days to 50 per cent flowering in many hybrids suggesting the preponderance of dominance gene action.

Key words
Yard long bean, Combining ability, Partial diallel, Gene action

INTRODUCTION

Yard long bean [*Vigna unguiculata* ssp. *sesquipedalis* (L.) Verdc.] is a unique form of cowpea grown as a vegetable crop in southern Asia and the Far East for its immature pods. It is considered to be a very important vegetable crop in parts of Indonesia, Thailand, the Philippines, Taiwan and China. The crop is grown throughout India and is extensively cultivated in Kerala. The identification of suitable parental genotypes which can potentially generate superior crosses with high yield and yield contributing traits is an important step in the development of improved varieties. The assessment of combining ability and determination of gene action is a prerequisite for the selection of ideal parental genotypes. Combining ability studies are regarded as an elementary tool to select good combining parents, which on crossing would produce more desirable segregants. The present study was carried out to assess combining ability based on mean performance and gene action for yield and other biometric characters in the yard long bean.

MATERIALS AND METHODS

Partial diallel crosses with ten genetically divergent genotypes of yard long bean as parents were done to develop 25 hybrids. Hybridisation was done by the technique suggested by Krishnaswamy (1970). Twenty-five hybrids along with their parents and a standard check were evaluated in randomised block design with three replications. The package of practices- recommendations of Kerala Agricultural University was followed to raise the crop. The biometric observations - days to 50% flowering, pod length (cm), pod breadth (cm), pod weight (g), pods per cluster, pods per plant, pod yield per plant (g), seeds per pod and length of harvest period were recorded from five randomly selected plants per genotype. The general combining ability of the parents and the specific combining ability as estimated by adjusting mean values of the hybrids were computed using a partial diallel method (Kempthorne and Curnow, 1961). The mean squares due to various sources of variation and their genetic expectations were determined.

RESULTS AND DISCUSSION

Significant variation among the hybrids and parents for all the characters was revealed by the results obtained from a partial diallel analysis of variance (**Table 1**). General combining ability (*gca*) and specific combining ability (*sca*) variances were highly significant for all the traits which suggested 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. The value of *gca* variance was higher than the *sca* variance for the characters days to 50 per cent flowering, pod weight, pods per cluster, pod yield per plant and length of the harvest period. Recombination breeding can be suggested as the best strategy for the improvement of these characters indicated by the presence of additive gene action (Kwaye *et al.,* 2008). Prevalence of additive gene action for days to maturity and pod length (Owusu *et al.,* 2018), the number of pods per plant, ten pod weight and hundred fresh seed weight (Jivani *et al.,* 2016) was reported earlier.

Table 1. ANOVA (mean square) and variance components for combining ability for various traits studied in yard long bean

Source	Replication	Crosses	*gca*	*gca* variance	*sca*	*sca* or dominance variance	Additive variance	Error
Df	2	24	9	-	15	-	-	48
Days to 50% flowering	1.012	78.374**	183.928**	12.666	15.042**	4.459	25.333	1.666
Pod length	2.460	86.327**	161.206**	8.986	41.400**	11.707	17.971	6.279
Pod breadth	0.023	0.138**	0.260**	0.015	0.064**	0.015	0.030	0.018
Pod weight	2.609	26.524**	61.257**	4.168	5.684**	1.082	8.336	2.438
Pods per cluster	0.014	0.562**	1.198**	0.076	0.180**	0.054	0.153	0.020
Pods per plant	0.752	54.093**	114.525**	7.252	17.834**	4.619	14.396	3.976
Pod yield per plant	604.360	5911.951**	12079.815**	740.144	2211.233**	577.467	1480.287	478.832
Seeds per pod	0.573	4.124**	9.605**	0.658	0.836**	0.078	1.315	0.601
Length of harvest period	0.973	17.892**	40.454**	2.707	4.355**	0.900	5.415	1.654

**Significant at 1% level

The characters length and breadth of pods and seeds per pod had higher *sca* variance, designating predominance of dominant gene action. A significant role of non-additive gene action in inheritance of yield and most of the characters was observed in cowpea by Kumari and Chauhan (2018), Mwale *et al*. (2017) and Pampaniya, (2017).

Table 2. General combining ability effects of parents for yield parameters in yard long bean

Parents	Days to 50% flowering	Pod length	Pod breadth	Pod weight	Pods per cluster	Pods per plant	Pod yield per plant	Seeds per pod	Length of harvest period
VS-2	1.99	6.10*	-0.16*	1.81*	0.00	0.14	-10.34	-0.54	0.53
VS-9	-2.41*	-2.22	-0.14	-2.30*	-0.08	4.69*	18.75	-0.15	1.31*
VS-24	0.54	2.72	-0.12	1.57*	0.21	1.09	-19.62	-0.49	1.36*
VS-41	0.96	-2.61	0.08	-0.87	0.54*	2.39	38.72*	0.07	-0.19
VS-43	-1.79	2.06	-0.06	2.44*	0.32*	0.34	43.98*	1.07*	0.31
VS-44	-3.56*	0.66	0.19*	1.35	-0.13	-0.82	-3.26	-0.75*	-0.88
VS-21	6.50*	2.01	0.22*	2.01*	-0.57*	-7.21	-34.23*	-0.81*	-0.86
VS-22	4.02*	-5.95*	-0.12	-4.35*	-0.46*	-4.41*	-51.38*	-0.61*	-1.57*
VS-45	-2.40*	-3.02	-0.01	-1.15	-0.09	1.39	-112.95	0.77*	-3.42*
VS-47	-3.85*	0.25	0.13	-0.50	0.25	2.41	30.34*	1.44*	3.41*
SE	1.18	1.96	0.08	0.73	0.13	1.29	14.32	0.28	0.64
CD	3.36	5.57	0.22	2.06	0.37	3.66	40.71	0.79	1.81

*Significant at 1% level

Assessment of combining ability effects is done to estimate the relative ability of a genotype to transmit its desirable performance to its hybrids. Combining ability analysis facilitates the appraisal of inbreds in terms of their genetic value and the selection of appropriate parents for hybridisation.

Table 2 represents the general combining ability (*gca*) of the parents. The *gca* effect was significant for pod yield per plant for VS-41, VS-43, VS-21, VS-22 and VS-47. The highest *gca* was observed for VS-43 (43.98). Significant positive *gca* effects for pod weight was recorded for the parents VS-24 and VS-43. Substantial positive *gca* effect for pods per plant was recorded for VS-9 only. The parent VS-43 had significant *gca* effects for pod weight, pods per cluster and pod yield per plant. The parent VS-43 can be considered as the best general combiner as it exhibited significant *gca* effects for pod yield per plant, pod weight, and pods per cluster. Among the other parents, VS-41 also had significant *gca* effects for pods per cluster and pod yield per plant. Significant *gca* effects for the characters days to 50% flowering, plant height, clusters per plant, pods per plant, length of the pod and the number of seeds per plant was obtained by Ushakumari *et al.*(2010), Kumar *et al.*(2017) and Owusu *et al.* (2018).

The success of hybridisation depends on securing parents to attain improved genotypic combination, which cannot be ensured from parental values. Estimation of *sca* effects for 25 crosses has resulted in the identification of good specific combiners for various traits as given in **Table 3**. The adjusted mean values (*sca*) of the hybrids showed that VS-9 x VS-43, VS-43 x VS-47 and VS-44 x VS-47 had desirable significant negative *sca* effects for days to 50 per cent flowering and significant positive *sca* effects for pods per cluster, pods per plant, pod yield per plant and length of the harvest period. VS-2 x VS-43 for pod length, VS-44 x VS-47 for pod breadth, VS-2 x VS-21 for pod weight, VS-41 x VS-47 for pods per cluster, VS-2 x VS-41 for pods per plant, VS-44 x VS-47 for pod yield per plant, VS-43 x VS-47 for seeds per pod and VS-24 x VS-47 for the length of harvest period were recognised as the best specific combinations for the respective characters. Excellent specific combiners for seed yield per plant (Pandey and Singh, 2010; Pampaniya, 2017 and Owusu, 2018) and earliness (Patil and Navale, 2006; Patel *et al.,* 2013; Ogunwale and Salami, 2017 and Kumar, 2017) were obtained in cowpea. The earliness of the crop will reduce the duration of the crop which will help to fit the crop into a cropping system and also to evade drought stress.

Table 3. Estimates of specific combining ability (*sca*) effect of hybrids for different yield related characters in yard long bean.

Crosses	X1	X2	X3	X4	X5	X6	X7	X8	X9
VS-2 x VS-41	1.68*	6.93*	-0.15	1.70	0.68*	6.89**	37.13**	-0.01	0.16
VS-2 x VS-43	2.35**	4.53*	-0.29**	3.14*	0.30*	-3.29*	26.73*	0.65	0.83
VS-2 x VS-44	-4.99**	5.76*	0.01	2.44*	-0.38*	-1.04	-13.48	-1.35**	-0.51
VS-2 x VS-21	10.35**	8.43*	0.08	3.92*	-0.39**	-7.56**	-58.78**	-1.68**	-0.51
VS-2 x VS-22	6.68**	1.00	-0.15	-1.58	-0.47**	-4.01**	-49.49*	-1.35**	-0.51
VS-9 x VS-43	-5.65**	0.20	-0.12	2.28*	0.50*	5.70**	70.99*	0.99*	2.16**
VS-9 x VS-44	-1.99*	2.37	0.15	-0.97	-0.43**	3.63**	12.79	-0.68	0.83
VS-9 x VS-21	2.68**	3.87	0.11	-0.38	-0.56*	-2.70	3.29	-1.01*	-0.51
VS-9 x VS-22	1.35	-12.56**	-0.39**	-8.46**	-0.49*	1.52	-33.87	-1.01*	-1.84*
VS-9 x VS-45	-5.65**	-4.45**	-0.22**	-3.67**	-0.32*	4.57**	-17.30	0.65	-0.51
VS-24 x VS-44	-4.99**	2.54	0.01	2.12*	0.13	-0.21	-47.57**	-1.35**	1.16
VS-24 x VS-21	8.35**	2.40	0.05	2.96*	-0.53*	-5.84**	-50.35*	-1.68**	-0.17
VS-24 x VS-22	6.01**	0.50	-0.35**	-3.30*	-0.26**	-4.67*	-81.56**	-1.35**	-0.51
VS-24 x VS-45	-4.32**	3.63	0.18*	2.55*	0.48**	5.49**	11.77	0.65	-1.17
VS-24 x VS-47	-1.65*	-1.53	-0.09	0.87	0.25	2.06	-1.88	1.32**	4.06**
VS-41 x VS-21	7.68**	-0.23	0.31**	1.48	-0.04	-4.63*	13.57	-0.68	-0.51
VS-41 x VS-22	3.01**	-11.80**	0.15	-4.12*	0.13	-0.74	-0.38	-1.01*	-1.17
VS-41 x VS-45	0.01	-10.27**	-0.19*	-3.30*	0.36**	0.44	19.81	0.99*	-4.84**
VS-41 x VS-47	-1.32	1.70	0.31**	-2.30	0.72**	2.31	44.90**	1.32**	3.50**
VS-43 x VS-22	2.35**	-0.80	-0.25**	-1.62	-0.19*	-5.50**	-20.13	1.65**	-0.51
VS-43 x VS-45	-3.99**	0.43	0.01	1.36	0.25**	4.66**	50.31**	1.32**	-2.51**
VS-43 x VS-47	-6.65**	1.10	0.05	0.55	0.35	4.32**	66.42*	1.65**	1.83*
VS-44 x VS-45	-4.32**	-3.82*	0.11	-0.52	-0.34**	-0.52	-50.78**	-0.01	-6.17**
VS-44 x VS-47	-7.65**	5.03*	0.35**	3.08**	0.70**	3.76**	88.91**	0.65	3.50**
VS-21 x VS-47	0.68	-0.20	0.31**	1.78	-0.41*	-4.62**	-21.06*	1.32**	3.83**
CD	2.13	4.13	0.22	2.58	0.23	3.29	36.09	1.28	2.12

** significant at 1 per cent level

*significant at 5 per cent level

X1-Days to 50% flowering; X2- pod length; X3- pod breadth; X4- pod weight; X5- pods per cluster; X6- pods per plant; X7- pod yield per plant; X8- seeds per pod; X9- length of harvest period

Positive *sca* effects in combination with negative *gca* effects of the corresponding parents were observed for days to 50 per cent flowering in many hybrids which indicates the preponderance of dominance gene action. Similar results for days to 50 per cent flowering in hybrids of soybean were reported by Ojo (2003). The appearance of dominance gene action advocates heterosis breeding as the best approach for enhancing these traits. The characters length and weight of pods, pods per plant and per cluster, pod yield per plant, the number of seeds per pod and length of the harvest period revealed positive *sca* effects combined with positive *gca* effects for both or either one of the parents. Refinement of these characters can be achieved by adopting recombination breeding.

The present study suggests the presence of additive gene action controlling several yield related traits. As far as quantitative traits are concerned, the presence of additive gene action is an expedient phenomenon crucial for crop improvement. This investigation indicates that combining ability studies helps in identifying the best combiners and cross combinations for hybridisation and to exploit heterosis. Out of the 10 parents, VS-43 and VS-41 were observed to be the best general combiners. The hybrids VS-9 x VS-43, VS-43 x VS-47 and VS-44 x VS-47 exhibited high *sca* effects for pods per cluster, pods per plant, pod yield per plant and length of the harvest period. The parents with significant *gca* effects can be utilised in the upcoming breeding programme since they possess an additive component which is fixable. The best performing specific combiners can be utilised as hybrids possessing early maturity and higher yield, which can be included in a multiple cropping system patterns.

ACKNOWLEDGEMENT

The first author is obliged to the Council of Scientific and Industrial Research for granting the Junior Research Fellowship for Ph D programme.

REFERENCES

Jivani, L.L., Khanpara, S.V., Vachhani, J.H. and Kachhadia, V.H. 2016. Genetic variability, heritability and genetic advance studies in vegetable cowpea [*Vigna unguiculata* (L.) Walp.]. *Electronic Journal of Plant Breeding*, 7(2): 408-413. [Cross Ref]

Kempthorne, O. and Curnow R.N. 1961. The partial diallel cross. *Biometrics*, **17:** 229-250. [Cross Ref]

Krishnaswamy, N. 1970. Cowpea. Pulse crops of India (ed. P. Kachroo) Indian Council of Agricultural Research, Krishi Bhavan, New Delhi, India.

Kumar, S., Sridhar, K., Kumar, V. and Kulkarni, N.S. 2017. Combining ability analysis in dual purpose in cowpea (*Vigna unguiculata* (L.) Walp). *Plant Archives,* 17(2): 919-923.

Kumari, J. and Chauhan, D.A. 2018. Estimation of heterosis for green pod yield and attributing characters in cowpea (*Vigna unguiculata* (L.) Walp). *International Journal of Current Microbiology and Applied Sciences,* 7(7): 3400-3413. [Cross Ref]

Kwaye, G.R., Shimelis, H. and William, P.M. 2008. Combining ability analysis and association of yield and yield components among selected cowpea lines. *Euphytica*, **162**(2): 205–210. [Cross Ref]

Mwale, S.E., Ssemakula, M.O., Sadik, K., Alladassi, B., Rubaihayo, P., Gibson, P., Singini, W. and Edema, R. 2017. Estimates of combining ability and heritability in cowpea genotypes under drought stress and non-stress conditions in Uganda. *Journal of Plant Breeding and Crop Science*, **9**(2): 10-18. [Cross Ref]

Ogunwale, G.I. and Salami, A.E. 2017. Combining ability for days to flowering and grain yield among cowpea (*Vigna unguiculata*) of different maturity periods. *Journal of Agriculture, Forestry and Social Sciences*, 13(1): 1-9. [Cross Ref]

Ojo, D.K. 2003. Heritability and combining ability of seedling emergence, grain yield and related characteristics in six tropical Soyabean (*Glycine max* (L.) Merr.) cultivars. *Nigerian Journal of Genetics.* **18:** 22-8. [Cross Ref]

Owusu, E.Y., Amegbor, I.K., Darkwa, K., Oteng-Frimpong, R. and Sie, E.K. 2018. Gene action and combining ability studies for grain yield and its related traits in cowpea (*Vigna unguiculata*). *Cogent Food and Agriculture*, **4**: 1-17. [Cross Ref]

Pandey, B. and Singh Y.V. 2010. Combining ability for yield over environment in cowpea [*Vigna unguiculata* (L.) Walp.] *Legume Research,* 33(3): 190-195.

Pampaniya, A.G. 2017. Combining ability analysis for yield and its components in cowpea [*Vigna unguiculata* (L.) Walp.]. M.Sc. thesis. Navsari Agricultural University, Gujarat.

Patel, M.D., Ravindrababu, Y., Sharma, S.C. and Patel, A.M. 2013. Combining ability studies in cowpea [*Vigna unguiculata* (L.) Walp.]. *Environment and Ecology*, **31**(2C): 1054-1056.

Patil, H.E. and Navale, P.A. 2006. Combining ability in cowpea (*Vigna unguiculata* (L.)Walp.) *Legume Research,* **29**(4): 270-273.

Ushakumari, R., Vairam, N., Anandakumar C.R. and Malini, N. 2010. Studies on hybrid vigour and combining ability for seed yield and contributing characters in cowpea (*Vigna unguiculata*). *Electronic Journal of Plant Breeding*, **1**(4): 940-947.