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Generation mean analysis in yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) for vegetative and yield characters

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Abstract
Generation mean analysis in yard long bean was undertaken to estimate to estimate gene action operating in the inheritance of vegetative and yield characters. Six basic generations, *viz*., P_1, P_2, F_1, F_2, BC_1 and BC_2 of the cross VS 50 (Kakkamoola Local) x VS 34 (Githika) was studied. Significance of scaling test revealed the presence of epistasis for characters under investigation. The type of gene action involved in the expression of a trait is helpful in deciding the appropriate breeding procedures to be used for the improvement of the trait. Earliest flowering was observed in F_1 in the cross (50.00 days) while P_1 (53.50) was late. Yield plant^{-1} was highest for F_1 (1210.51 g) and lowest was recorded by P_2 (642.61 g) in the cross. The predominance of dominance component for the characters under study indicates the improvement of traits through heterosis breeding.

Keywords: Duplicate gene action, gene action, generation mean analysis, heterosis breeding, yard long bean

Introduction

Yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt; 2n=24), a distinct form of cowpea, is one of the most important leguminous vegetable crops originated from Central Africa and widely distributed in India, Indonesia, Philippines and Srilanka. It is an annual food legume belonging to the family Fabaceae and the genus *Vigna*, which comprises of about 80 species. Trailing type of vegetable cowpea or yard long bean, vernacularly known as 'Achingapayar', 'Kurutholapayar', 'Vallipayar', 'Pathinettumaniyan' etc., is one of the most popular and remunerative vegetable crop traditionally grown in Kerala, evenly distributed and preferred in all the 14 districts. It is cultivated mainly for crisp and tender pods which are consumed in cooked form. It is one of the most favourite vegetable crop as it ensures a stable market throughout the year.

Prerequisite for the effective choice of breeding methodology for developing elite varieties is the understanding of the mode of inheritance of the vegetative and yield components. Appropriate breeding procedure can be used for the improvement of the trait based on the gene action involved in the expression of the trait. The present project was undertaken to study the inheritance of vegetative and yield characters to understand the gene action controlling these traits in order to suggest the proper breeding method for improving these traits. Mean performance and gene action were studied for the vegetative characters *viz.*, vine length at final harvest (cm), primary branches plant^{-1} and days to first flowering, yield characters like pod length (cm), pod weight (g), pods plant^{-1}, yield (g plant^{-1}) and days to harvest.

Materials and Methods

The present investigation was carried out at Department of vegetable science, College of Agriculture, Vellayani, Kerala from 2017 to 2018. The experiment was carried out in three parts. The superior F_1 hybrid of yard long bean with high yield and quality characters *viz.* VS 50 x VS 34 (Kakkamoola Local x Githika) was selected and selfed to produce F_2 progeny. Simultaneously, the F_1 hybrid was backcrossed with female parent to produce BC_1 generation and male parent to produce BC_2 generation. The six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) from the cross combination was raised in Randomized Block Design with spacing 1m x 1m. One replication consisted of one row of parents, F_1, two rows of the back cross generations BC_1 and BC_2 and four rows of F_2. Each row consisted of 10 plants and subjected to generation mean analysis Hayman (1958) [1] followed by scaling test (Mather, 1949) [2].

The type of epistasis is revealed by the significance of specific scale as given in Table 1.

Table 1: Significance of specific scales

Sl. No	Scales	Significance
1	A, B or both scales	Presence of all three types of epistasis, *viz.* A x A, A x D and D x D
2	C scale	Dominance x Dominance type of epistasis (*l*)
3	D scale	Additive x Additive type of epistasis (*i*)
4	C and D scales	Additive x Additive (*i*) and Dominance x Dominance (*l*)

Results and Discussion

The observations were analyzed statistically and the result obtained from the present study are given below (Table 2). Analysis of variance showed significant differences among the generations of the cross VS 50 x VS 34 (Kakkamoola Local x Githika) for most of the characters studied.

Vine Length at Final Harvest (cm): No significant variation was observed among the generations for vine length at final harvest in the cross. Mean value of F_1 was higher than that of F_2 and significance of all the scales except scale B suggested the inadequacy of additive-dominance model and presence of non-allelic interaction. Dominance, additive x additive and dominance x dominance effects were significant, in which dominance effect was positive and greater than all other genetic components while dominance x dominance type of interaction was negative. Hence heterosis breeding can be suggested for improving the trait. The predominance of dominance gene action suggested the usefulness of heterosis breeding for improving this trait. Sawant (1994) [3], Nagaraj *et al.* (2002) [4], Subbiah *et al.* (2013) [5] and Jithesh (2009) [6] reported the presence of dominance effect in controlling the trait in cowpea. Duplicate nature of epistasis was present in the cross as indicated by opposite signs of dominance (h) effect and dominance x dominance (l) type of interaction.

Primary Branches Plant^{-1}: Significant 'm' denoted wide variation for primary branches plant^{-1} among the generations. Highest number of primary branches plant^{-1} was observed in BC_2 (5.22) and BC_1 (3.22) recorded the lowest. Mean value of F_1 was higher than that of F_2 and during scaling test, significance was observed for all the scales of which scale B was positive which implies that F_1 is better than the second parent. All the genetic components were significant of which dominance and additive x additive were in the favourable positive direction. Predominance of dominance effect suggested that heterosis breeding would improve the trait primary branches plant^{-1}. These results are in agreement with the findings of Sawant (1994) [3] and Lakshmi (2016) [7]. Duplicate nature of epistasis was predominant in which was indicated by opposite signs of dominance (h) effect and dominance x dominance (l) type of interaction.

Days to First Flowering: 'm' was significant and greater than all other effects, denoting the significant variation between the treatments for days to first flowering. F_1 was earlier to flower (50.00) while P_1 (53.50) was late. Significance was observed for scales A, B and C and all were acting in the favourable negative direction. Superiority of F_2 over the parents was denoted by the significance with highest value of scale C over all other scales. Significance was observed for additive, dominance and dominance x dominance. Dominance effect was acting in the favourable negative direction and had the highest magnitude. Hence heterosis breeding would improve the trait days to first flowering and restore early flowering types. Predominance of dominance gene effect was reported by Sawant (1994) [3], Jithesh (2009) [6] and Gupta *et al.* (2017) [8].

Pod Length (cm): Significant variation was observed among the generations for pod length as shown by the significant value of 'm'. Pod length was highest for P_1 (65.99 cm) and lowest pod length was recorded for P_2 (47.86 cm). Significance was observed for scales B and C in favourable positive direction among which scale B had the highest magnitude, which implies that F_1 is better than the second parent. All the genetic components except additive x additive were significant among which additive x dominance and dominance x dominance were in negative direction and dominance gene action possessed the highest positive value. The predominance of dominance gene action revealed that reliance should be placed on heterosis breeding for the improvement of pod length. The findings are in concurrence with Sawant (1994) [3], Nagaraj (2002) [4], Aliyu (2007) [9] and Khodambashi *et al.* (2012) [10] in cowpea. Opposite signs of dominance (h) effect and dominance x dominance (l) type of interaction indicated the presence of duplicate type of epistasis.

Pod Weight (g): Significance of 'm' denoted wide variation for pod weight among the generations. The highest mean values for pod weight was recorded by BC_1 (47.22 g) and the lowest values by P_2 (27.33 g). Significance was observed for all the scales A, B, C and D in favourable positive direction except D, which was negative. The highest magnitude of scale C denotes the betterment of F_2 over the parents. Significance was observed for all the genetic components, among which additive, dominance, and additive x additive were positive while additive x dominance and dominance x dominance were in negative direction. Dominance gene action had the highest magnitude. Since dominance effect was predominant, heterosis breeding could be used for the improvement of the trait in accordance with Adeyanju (2009) [11] and Jithesh (2009) [6]. Duplicate type of epistasis was seen for the trait which was observed from the opposite signs of dominance (h) effect and dominance x dominance (l) type of interaction.

Pods Plant^{-}: The generations differed significantly for pods plant^{-1} in the cross as given by significant 'm' value. F_1 produced highest number of pods plant^{-1} (84.00), while P_1 (32.67) the lowest. All the scales were significant in the cross among which scale C had the highest magnitude in positive direction indicating that F_2 is better than the parents. Though all the genetic components displayed significance, additive and dominance x dominance effect were negative while dominance, additive x additive and additive x dominance were positive of which dominance effect had the highest value. Predominance of dominance effect suggested that heterosis breeding would improve the trait. Epistasis was revealed to be duplicate due to opposite signs of dominance (h) effect and dominance x dominance (l) interactions. These results are in agreement with the findings of Smitha (1995) [12], Valarmathi *et al.* (2007) [13], Ushakumari *et al.* (2010) [14], Yadav *et al.* (2010) [15], Chaudhari *et al.* (2013) [16], Lakshmi (2016) [7] and Gupta *et al.* (2017) [8]. Epistasis was revealed to be duplicate due to opposite signs of dominance (h) effect and dominance x dominance (l) interactions.

Yield (g plant^{-1}): Significant difference was observed among the six generations for pod yield plant^{-1}, since 'm' value was significant and greater than all other effects. Among the treatments, yield plant^{-1} was highest for F_1 (1210.51 g) and lowest yield plant^{-1} was recorded by P_2 (642.61 g). Positive significance was noticed for scales A, C and D, of which scale C had the highest magnitude, which implies the superiority of F_2 over both the parents. Further analysis of genetic components showed the significance of additive, dominance, additive x additive and additive x dominance of which dominance had the highest positive value. The predominance of dominance effect underlines the suitability of exploiting heterosis breeding for the improvement of the character, as observed in earlier studies of Adeyanju (2009) [11], Patel *et al*. (2009) [17], Kumar and Kumar (2013) [18] and Behra (2015) [19]. Duplicate type of epistasis was seen for the trait which was observed from the opposite signs of dominance (h) effect and dominance x dominance (l) type of interaction.

Days to Harvest: The treatments differed significantly for days to harvest as given by significant 'm' value. The generations F_1 and BC_2 (61.00) were found earlier to harvest. P_1 and P_2 (64.00) took maximum number of days to harvest. Non-significance was noticed in all the scales A, B, C and D which indicates the absence of non-allelic interaction and adequacy of additive-dominance model to study the trait. Among the genetic components, predominance of dominance gene action was observed in favourable negative direction, which implies the suitability of using heterosis breeding for the improvement of the character. The absence of epistasis for days to harvest was earlier observed by Singh *et al*. (1988) [20], Rana and Gupta (1994) [21], Nagaraj *et al*. (2002) [4] and Lovely (2005) [22].

Table 2: Generation means (±SE), Scale values (±SE), and estimates of genetic component (±SE) in yard long bean

	Vine Length at Final Harvest (cm)	**Primary Branches Plant^{-1}**	**Days to First Flowering**	**Pod Length (cm)**	**Pod Weight (g)**	**Pods Plant^{-1}**	**Yield (g plant^{-1})**	**Days to harvest**
Generation means								
P_1	508.67 ± 4.84	4.00 ± 0.10	53.50 ± 0.17	65.99 ± 0.04	35.33 ± 0.17	32.67 ± 0.73	707.95 ± 2.62	64.00 ± 0.87
P_2	481.67 ± 26.31	5.00 ± 0.17	53.00 ± 0.10	47.86 ± 0.39	27.33 ± 0.26	45.67 ± 1.45	642.61 ± 14.22	64.00 ± 0.00
F_1	386.33 ± 4.38	4.55 ± 0.15	50.00 ± 0.19	62.16 ± 0.48	37.89 ± 0.15	84.00 ± 0.87	1210.51 ± 24.55	61.00 ± 0.00
F_2	310.67 ± 11.00	3.55 ± 0.10	50.17 ± 0.21	62.50 ± 0.30	42.22 ± 0.14	75.67 ± 0.70	1018.46 ± 5.99	62.00 ± 0.34
BC_1	463.67 ± 7.25	3.22 ± 0.08	50.60 ± 0.21	63.91 ± 0.45	47.22 ± 0.14	80.67 ± 0.41	1071.52 ± 11.52	62.00 ± 0.34
BC_2	414.67 ± 14.89	5.22 ± 0.14	50.03 ± 0.21	61.22 ± 0.21	45.66 ± 0.17	78.67 ± 0.30	913.87 ± 1.48	61.00 ± 0.00
Scale values								
A	32.33* ± 15.91	-2.11* ± 0.23	-2.29* ± 0.50	-0.34 ± 1.01	21.22* ± 0.35	44.67* ± 1.40	224.57* ± 33.77	-1.00 ± 1.11
B	-38.67 ± 39.38	0.89* ± 0.35	-2.94* ± 0.47	12.42* ± 0.75	26.11* ± 0.46	27.67* ± 1.80	-25.39 ± 28.53	-3.00 ± 0.00
C	-520.33* ± 52.23	-3.88* ± 0.53	-5.82* ± 0.93	11.82* ± 1.58	30.44* ± 0.70	56.33* ± 3.66	302.27* ± 56.52	-2.00 ± 1.62
D	-257.00* ± 27.32	-1.33* ± 0.26	-2.93 ± 0.51	-0.13 ± 0.77	-8.44* ± 0.35	-8.00* ± 1.49	51.54* ± 16.69	1.00 ± 0.77
Genetic components								
m	-18.83 ± 56.25	1.83* ± 0.52	52.66* ± 1.02	56.66* ± 1.56	14.45* ± 0.72	23.17* ± 3.07	778.36* ± 34.15	66.00* ± 1.59
d	13.50 ± 13.38	-0.50* ± 0.10	0.25* ± 0.10	9.07* ± 0.20	4.00* ± 0.15	-6.50* ± 0.81	32.67* ± 7.23	0.00 ± 0.00
h	912.83* ±137.18	4.18* ± 1.28	-7.31* ± 2.44	17.85* ± 3.87	87.66* ± 1.80	149.17* ± 6.86	528.25* ± 90.71	-11.00* ± 3.67
i	514.00* ± 54.64	2.67* ± 0.51	0.59 ± 1.01	0.27 ± 1.55	16.89* ± 0.71	16.00* ± 2.96	-103.08* ± 33.37	
j	71.00 ± 42.02	-3.00* ± 0.37	0.65 ± 0.62	-12.76* ± 1.06	-4.89* ± 0.54	17.00* ± 1.92	249.96* ± 27.37	
l	-507.67* ± 83.23	-1.45 ± 0.82	4.65* ± 1.50	-12.35* ± 2.53	-64.22* ± 1.13	-88.33* ± 4.19	-96.11 ± 73.17	
E	D	D	D	D	D	D	D	

E: Epistasis D: Duplicate type of epistasis *Significant at 5% level

Conclusion

Predominance of dominance gene action was observed for most of the characters studied in the cross VS 50 x VS 34. Predominance of dominance gene action pointed out the suitability of resorting to heterosis breeding for the improvement of the trait.

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