

Original Research Article

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Generation Mean Analysis for Metric Traits in Urdbean (*Vigna mungo* [L.] Hepper)

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ABSTRACT

Keywords

Generation mean analysis, Scaling tests, Epistatic interactions and Urdbean

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The nature and magnitude of gene action was analyzed using six generation mean for seed yield and its attributes in three inter-varietal crosses of urdbean. A perusal of generation mean analysis (GMA) indicated that a simple additive-dominance model was inadequate and an epistatic model had to be assumed as seen from the significance of scaling tests. Further the GMA revealed that seed yield and its component traits were influenced by different types of gene action *viz.*, additive, dominance and epistatic interactions, chiefly of dominance x dominance and duplicate dominant types. Hence, improvement of these traits is impossible with simple selection techniques, as they are unable to fix in superior lines. Therefore, deferment in selection of superior lines to later generations is practised in pedigree method of breeding to make it effective. However to harness epistatic interactions, one or two cycles of recurrent selection followed by pedigree breeding method would be effective and useful to identify superior lines with high yield and yield components.

Introduction

Urdbean ($2n=2x=22$), a premier short duration food legume with photo-thermo insensitive nature and soil fertility ameliorator capacity, serves as an ideal option for crop intensification and diversification. Besides, it is an excellent source of high quality easily digestible dietary protein (25-28%), oil (1.0-1.5%), fiber (3.5%-4.5%), ash (4.5-5.5%), carbohydrates (62-65%), low flatulence and fair supplier of lysine, vitamins, iron and phosphorus. To evolve high yielding promising genotypes in urdbean, studies on nature and magnitude of gene effects of

metric traits is imperative to unravel their complex inheritance for designing and formulation of efficient breeding strategies.

In self-pollinated crops like urdbean, an approach based on generation mean analysis has particular suitability as in addition to additive and dominance gene effect, as it also estimates the type of epistasis present. Hence in the current study, an attempt has been made to estimate gene effects operative for control of seed yield and its attributes by using six generation means in three inter varietal crosses of urdbean.

Materials and Methods

The experimental material in present investigation comprises of three inter-varietal crosses of urdbean *viz.*, Co 5 x PU 31 (C₁), Co 5 x VBN (Bg) 4 (C₂) and Co 5 x VBN (Bg) 6 (C₃). Six generations *viz.*, P₁, P₂, F₁, F₂, B₁ and B₂ of these three crosses (C₁, C₂ and C₃) were sown in compact family block design with two replications, raised on ridges of two

metre length spaced at 30 cm between ridges and 10 cm between plants for evaluation during *kharif*, 2014 at National Pulses Research Centre, Vamban. Recommended agronomic packages of practices were followed to raise the healthy crop. The number of plants studied in each of the six generations in each of the three inter-varietal crosses are given below.

S. No.	Generation	No. of rows / replication	No. of plants studied in each replication	Total No. of plants studied
1	P ₁	1	20	40
2	P ₂	1	20	40
3	F ₁	1	20	40
4	F ₂	8	160	320
5	B ₁	3	60	120
6	B ₂	3	60	120

Data were recorded on selected plants in each replication for nine quantitative traits *viz.*, days to 50% flowering, plant height, number of branches / plant, number of clusters / plant, number of pods / plant, number of seeds / pod, hundred seed weight and seed yield / plant. Simple scaling test A, B, and C of Mather (1949) was used to detect presence of the epistasis. Six parameter model advocated by Hayman (1958) was used to obtain estimate of m, d, h, i, j and l parameters.

Results and Discussion

The estimates of mean for six generations *viz.*, P₁, P₂, F₁, F₂, B₁ and B₂; scaling test (A, B and C scales) and the gene effects *viz.*, additive, dominance and epistatic interaction for the three inter-varietal crosses of urdbean are presented for seed yield and its attributes in Tables 1 and 2.

Days to 50 % flowering

In parents, the P₁ mean was higher than P₂ in all the three crosses studied. The F₁ mean was

found to be intermediate when compared to their parents in all the crosses. The F₂ mean was higher than F₁ mean in all the three crosses. The B₁ mean exceeded the F₁ mean in crosses C₁ and C₂ and lesser in cross C₃. In B₂, the mean was less than F₁ in all the crosses and it was more pronounced in cross C₂.

The scaling test revealed that the (i) scale B was significant in the crosses C₂ and C₃(ii) scale C was significant in crosses C₁ and C₃. Hence, a simple additive-dominance model was inadequate for all the crosses studied. The natural origin m was positive and significant in all the crosses and also the m effect was greater than all other effects. The additive effect (d) was positive and significant in all the crosses, except in cross C₃ where it was non-significant. A positively significant dominance effect (h) was noticed in cross C₁. The additive x additive interaction (i) was negatively significant in crosses C₁ and C₃ and positively significant in cross C₁. The additive x dominance interaction (j) was negatively significant in cross C₃ only whereas it was

positive in crosses C_2 and C_1 with significance and non-significance respectively. Positive and significant dominance x dominance (l) interaction effect was registered in the cross C_2 only while it was positive non-significant in cross C_3 and negatively significant in cross C_1 .

Thus additive, dominance and all the three types of epistatic interactions govern this trait. Jahagiridar (2001) and Rahecha *et al.*, (2006) reported additive gene action for this trait. Kute and Deshmukh (2002), Vasline *et al.*, (2007), Anbu Selvam and Elangaimannan (2010), Supriyo Chakraborty *et al.*, (2010), Isha Parveen *et al.*, (2012), Selvam (2012), Gill *et al.*, (2014) and Vijay Kumar *et al.*, (2014) reported the predominance of dominance effect for this trait. Murugan (2005) and Ram *et al.*, (2013) noticed that both additive and dominance variance contribute for this trait. All the three types of epistatic interactions were reported by Kute and Deshmukh (2002), Murugan (2005), Singh *et al.*, (2007) and Ramakant and Srivastava (2012) to govern this trait.

Plant height

In all the crosses, the P_1 mean was greater than P_2 mean. The F_1 was found to be intermediate in all the crosses. In all the three crosses, the F_2 mean was greater than that of respective F_1 mean. The B_1 mean exceeded the F_1 mean in all the crosses. Compared to F_1 mean, the B_2 mean was found to be more in crosses C_2 and C_3 while it was less in cross C_1 .

An epistatic model had to be assumed for all the crosses as indicated by the scaling test. The scale A was found to be positive and non-significant in all the crosses. The scale B showed significance positive in cross C_3 . The scale C showed positive significance in all the crosses.

The 'm' was positive and significant in all the crosses and also the 'm' effect was also greater than all other effects. The additive effect (d) was positive and significant in all the crosses. The dominance effect (h) was negatively significant in the crosses C_1 and C_2 while it was positively non-significant in the cross C_3 . The additive x additive (i) effect was negative with significance in crosses C_1 and C_3 and non-significant in cross C_2 . The additive x dominance effect (j) was negative with significance in cross C_3 and non-significant in cross C_1 while positive non-significant in cross C_2 . The dominance x dominance (l) interaction effect was non-significant in crosses C_1 and C_2 whereas it was negative with significance, non-significant in cross C_3 only.

Thus additive, dominance and all the three types of epistasis had governed this trait. Several workers like Jiji Joseph and Santhosh Kumar *et al.*, (2000 a), Manivannan (2002), Vaithiyalingam *et al.*, (2002), Singh and Dikshit (2003), Anbumalarmathi *et al.*, (2004), Murugan (2005), Vasline *et al.*, (2007), Anbu Selvam and Elangaimannan (2010), Supriyo Chakraborty *et al.*, (2010), Selvam (2012), Gill *et al.*, (2014) and Vijay Kumar *et al.*, (2014) had observed greater dominance variance for this trait. However, additive gene action was also reported by few workers like Rahecha *et al.*, (2006) and Isha Parveen *et al.*, (2012). All the three types of epistasis was registered by Khattak *et al.*, (2002), Murugan (2005), Singh *et al.*, (2007) and Ramakant and Srivastava (2012).

Number of branches / plant

In all the crosses, the P_1 mean was higher than P_2 mean in all the crosses. The F_1 mean was greater than the parental means in all the crosses. The F_2 mean was found to be drastically lesser than the F_1 mean in all the crosses. The B_1 mean was on par or lesser

than the respective recurrent parent in all the crosses. In B₂, the mean was higher than the respective recurrent parent for all the crosses.

The scale A was negative and non-significant in all the crosses. The scale B was non-significant in cross C₂ whereas positively non-significant in the crosses C₁ and C₃. The scale C was negatively significant in all the crosses. Hence, a simple additive-dominance model was inadequate for all the three crosses.

The m effect was positively significant and greater than other effects in all the crosses. The additive effect (d) was positively non-significant in all the crosses. The dominance effect (h) was positively non-significant in all the crosses. The additive x additive (i) effect was positively significant in cross C₃ only and non-significant in the remaining crosses. The additive x dominance effect (j) and dominance x dominance (l) interaction effect were negatively non-significant for all the crosses.

Table.1 Estimates of scaling test for seed yield and its attributes in urdbean

Character	Scaling test	Cross		
		C ₁	C ₂	C ₃
Days to 50% flowering	A	1.23±0.45	-0.47± 0.44	-0.43 ± 0.38
	B	1.03±0.41	-2.47**± 0.45	1.10** ± 0.43
	C	-7.40*± 0.65	1.12± 0.70	-2.24** ± 0.74
Plant height	A	0.37± 2.28	2.33± 1.98	1.87 ± 1.92
	B	1.13 ± 1.70	0.97 ± 1.49	19.00**± 1.30
	C	12.50**± 3.81	13.10**± 3.01	31.68**± 3.00
Number of branches/plant	A	-0.30 ± 0.34	-0.30 ± 0.31	-0.33 ± 0.28
	B	0.17 ± 0.30	-0.07 ± 0.30	0.07 ± 0.28
	C	-0.56* ± 0.45	-0.82* ± 0.45	-1.16**± 0.44
Number of clusters/plant	A	-1.00 ± 0.90	-1.50 ± 0.81	-1.97 ± 0.77
	B	-2.70**± 0.90	-2.27**± 0.86	-2.27**± 0.80
	C	-6.42**± 1.43	-5.78**± 1.33	-6.46**± 1.28
Number of pods/plant	A	-1.37 ± 1.09	-1.77 ± 1.06	-1.60 ± 0.99
	B	0.37 ± 1.04	-0.03 ± 1.03	0.97 ± 0.87
	C	-11.60**± 1.79	-11.32**± 3.09	-10.82**± 1.66
Pod length	A	-0.23**± 0.09	-0.14 ± 0.08	-0.27** ± 0.10
	B	0.05 ± 0.08	0.07 ± 0.07	-0.16 ± 0.09
	C	-0.35* ± 0.14	-0.22* ± 0.11	-0.57** ± 0.15
Number of seeds/pod	A	-0.63* ± 0.31	-0.73**± 0.26	-0.20 ± 0.27
	B	-0.60* ± 0.30	-0.50 ± 0.27	-0.23 ± 0.25
	C	-0.98* ± 0.49	-0.90* ± 0.39	-0.50 ± 0.40
Hundred seed weight	A	-0.20**± 0.06	-0.16** ± 0.06	-0.17** ± 0.06
	B	-0.65**± 0.07	-0.57** ± 0.07	-0.54** ± 0.07
	C	-0.64**± 0.11	-0.53** ± 0.11	-0.51** ± 0.11
Seed yield/plant	A	-1.27**± 0.33	-1.40** ± 0.40	-0.96* ± 0.41
	B	-1.88**± 0.37	-1.75** ± 0.29	-1.13**± 0.38
	C	-4.82**± 0.59	-4.55** ± 0.49	-4.57**± 0.61

*Significance at 5% level of probability

**Significance at 1% level of probability

Table.2 Estimates of gene action for seed yield and its attributes in urdbean

Character	Cross	Gene action					
		m	d	H	i	J	l
Days to 50% flowering	C ₁	23.13**± 0.54	3.00**± 0.16	21.70**± 1.44	9.67**± 0.52	0.10 ± 0.26	-11.93**± 1.03
	C ₂	39.75**± 0.66	0.30*± 0.15	-12.14**± 1.70	-4.05**± 0.64	1.00**± 0.27	6.99**± 1.15
	C ₃	37.07**± 0.68	0.100 ± 0.14	-2.68 ± 1.65	-1.57* ± 0.66	-0.77**± 0.24	0.91 ± 1.08
Plant height	C ₁	57.15**± 3.19	9.95**± 0.94	-28.65**± 7.57	-11.00**± 3.05	-0.38 ± 1.22	9.50 ± 4.94
	C ₂	56.15**± 3.25	7.25**± 0.65	-25.65**± 7.99	-9.80 ± 3.18	0.68 ± 1.18	6.50 ± 4.97
	C ₃	46.91**± 2.94	17.40**± 0.66	0.44 ± 7.11	-10.81**± 2.87	-8.57**± 1.06	-10.05* ± 4.47
Number of branches/plant	C ₁	2.27**± 0.39	0.20 ± 0.14	1.22 ± 1.07	0.43 ± 0.37	-0.23 ± 0.21	-0.29 ± 0.74
	C ₂	2.40**± 0.35	0.15 ± 0.13	0.99 ± 0.96	0.45 ± 0.33	-0.12 ± 0.19	-0.09 ± 0.69
	C ₃	2.01**± 0.34	0.20 ± 0.12	1.92* ± 0.90	0.90**± 0.32	-0.20 ± 0.17	-0.63 ± 0.65
Number of clusters/plant	C ₁	16.13**± 1.10	-0.85**± 0.33	1.69 ± 2.92	2.72**± 1.05	0.85 ± 0.51	0.98 ± 2.14
	C ₂	16.84**± 1.06	-0.55 ± 0.32	0.41 ± 2.77	2.01* ± 1.01	0.38 ± 0.49	1.75 ± 1.98
	C ₃	16.42**± 1.01	-0.25 ± 0.30	1.27 ± 2.62	2.23* ± 0.96	0.15 ± 0.46	2.01 ± 1.87
Number of pods/plant	C ₁	19.40**± 1.50	-3.50**± 0.46	26.20**± 3.76	10.60**± 1.42	-0.87 ± 0.65	-9.60**± 2.55
	C ₂	20.88**± 1.48	-3.40**± 0.38	22.74**± 3.73	9.52**± 1.43	-0.87 ± 0.61	-7.72** ± 2.58
	C ₃	19.96**± 1.46	-2.75**± 0.38	25.19**± 3.57	10.19**± 1.41	-1.28* ± 0.57	-9.55**± 2.36
Pod length	C ₁	4.70**± 0.11	0.34**± 0.03	0.10 ± 0.28	0.17 ± 0.10	-0.14**± 0.05	0.01 ± 0.21
	C ₂	4.73**± 0.11	0.29**± 0.03	0.11 ± 0.28	0.15 ± 0.10	-0.11* ± 0.05	-0.08 ± 0.19
	C ₃	4.77** ± 0.11	0.23**± 0.03	-0.13 ± 0.28	0.14 ± 0.10	-0.05 ± 0.05	0.29 ± 0.21
Number of seeds/pod	C ₁	6.00**± 0.34	-0.05 ± 0.10	-1.29 ± 0.90	-0.25 ± 0.32	-0.02 ± 0.16	1.49* ± 0.70
	C ₂	6.08**± 0.33	0.05 ± 0.10	-1.45 ± 0.90	-0.33 ± 0.32	-0.12 ± 0.16	1.57* ± 0.63
	C ₃	5.48**± 0.32	-0.15 ± 0.11	0.35 ± 0.84	0.07 ± 0.30	0.02 ± 0.16	0.37 ± 0.60
Hundred seed weight	C ₁	4.59**± 0.09	-0.17**± 0.03	-0.88**± 0.23	-0.21* ± 0.09	0.23**± 0.04	1.06**± 0.15
	C ₂	4.57**± 0.09	-0.15**± 0.03	-0.78**± 0.22	-0.20* ± 0.08	0.21**± 0.04	0.94**± 0.15
	C ₃	4.58**± 0.09	-0.15**± 0.03	-0.76**± 0.21	-0.21* ± 0.08	0.18**± 0.04	0.91**± 0.15
Seed yield/plant	C ₁	4.77**± 0.51	-1.44**± 0.11	2.77* ± 1.29	1.67**± 0.50	0.30 ± 0.20	1.49 ± 0.90
	C ₂	5.32**± 0.56	-1.16**± 0.10	1.95 ± 1.47	1.40* ± 0.55	0.18 ± 0.23	1.74 ± 0.96
	C ₃	3.90**± 0.59	-1.05**± 0.14	5.78**± 1.52	2.48**± 0.57	0.08 ± 0.25	-0.40 ± 1.02

*Significance at 5% level of probability

**Significance at 1% level of probability

Thus the presence of additive and dominant gene actions followed by all the three types of interaction and duplicate dominant interaction appeared to govern this trait. The results were in consonance with the findings by earlier workers for this trait. Dominant gene action was reported by Jiji Joseph and Santhosh Kumar (2000), Manivannan (2002), Vaithiyalingam *et al.*, (2002), Anbumalarmathi *et al.*, (2004) and Murugan (2005). All the three types of epistasis were noted by Murugan (2005).

Number of clusters / plant

The P_2 mean was higher than the P_1 mean in all the crosses. Compared to the parental means, the F_1 mean was greater in cross C_3 while it was intermediate in the remaining crosses. The F_2 mean was less than the F_1 mean in all the crosses. The B_1 mean were lesser than the respective recurrent parent in all the crosses. In case of B_2 also the similar trend was observed.

In the scaling test, the scale B and scale C were significant in all the crosses. Hence, a simple additive model was inadequate for all the crosses. The natural origin m was positively significant and greater than other effects in all the crosses. The additive effect (d) was negative with significant in crosses C_1 and non-significant in crosses C_2 and C_3 . The dominance effect (h) was non-significant positively in all the crosses. The additive x additive (i) effect was positive and significant in all the crosses. The additive x dominance effect (j) was positive and non-significant in all the crosses. Positive non-significance of dominance x dominance (l) interaction effect was noticed in all the crosses.

Thus as a whole, the dominance effect was predominant followed by additive effect. In the epistatic interactions, the dominance x dominance (l) and additive x additive (i) were

important for this trait. Jiji Joseph and Santhosh Kumar (2000), Singh and Dikshit (2003) and Murugan (2005) reported dominance gene effect governing this trait. Both additive and dominance was attributed by Jahagiridar (2001) and Murugan (2005). The epistatic interaction was reported by various workers *viz.*, Murugan (2005). Especially, Kute and Desmukh (2002) reported additive x additive interaction effect for this trait.

Number of pods / plant

In all the crosses, the P_2 mean was higher than P_1 mean. Compared to the parental means, it was observed the mean of F_1 was drastically higher in all the crosses. The F_2 mean was comparatively much lesser than the F_1 mean in all the crosses. Higher mean value was registered in B_1 when compared to the respective recurrent parent in all the crosses. Compared to P_2 mean, the B_2 mean was found to be more in all the crosses.

In the scaling test, scale C was significant in all the crosses. The scale B was non-significant in all the crosses. Hence, a simple additive-dominance model was inadequate in all the three crosses. The natural origin m was positively significant in all the crosses and was found lesser than dominance effect (h) in all the crosses. The additive effect (d) was negatively significant in all the crosses. The dominance effect (h) and additive x additive (i) effect were positively significant in all the crosses. The additive x dominance effect (j) was negatively non-significant in crosses C_1 and C_2 , significant in cross C_3 alone. Negative significance of dominance x dominance (l) interaction effect was noticed in all the crosses.

Thus, over all dominance followed additive and epistatic interactions mainly of dominance x dominance and additive x

additive type with duplicate dominant type of gene action appear to govern this trait. Jiji Joseph and Santhosh Kumar (2000), Manivannan (2002), Singh and Dikshit (2003), Anbumalarmathi *et al.*, (2004) and Murugan (2005) attributed the presence of dominant type of gene action governing this trait. Ganesamurthy and Seshadri (2002) and Murugan (2005) revealed the presence of epistatic interaction for this trait.

Pod length

In parents the mean pod length of P_1 was higher than P_2 in all the crosses. It was observed that the F_1 mean was intermediate in all the crosses compared to the parental means. In general, the F_2 mean was lesser than the F_1 mean in all the crosses except in cross C_2 where it was on par. In B_1 , the mean was found to be lower than P_1 in all the crosses. Contrary trend was observed in B_2 where its mean was found to be higher than the respective recurrent parent.

In the scaling test, the scale C was negatively significant in all the crosses while the same trend was observed in the crosses C_1 and C_3 for scale A. The scale B was non-significant and negative in the cross C_3 but positive in crosses C_1 and C_2 .

The residual effect m was positively significant and greater than other effects in all the crosses. The additive effect (d) was positively significant in all the crosses. However the dominance effect (h) was positive but non-significant in all the crosses. The additive x additive (i) effect was non-significant in all the crosses. The additive x dominance effect (j) was negatively significant in crosses C_1 and C_2 . The dominance x dominance (l) interaction effect exhibited non-significant positive sign in the crosses C_1 and C_3 while negative sign in the remaining cross, C_2 .

Thus additive, dominance and epistatic interactions mainly of additive x additive type governed this trait. Both additive and dominance effect was reported by Vaithiyalingam *et al.*, (2002) for this trait. Murugan (2005) revealed the presence of all the three types of epistatic interaction for this trait.

Number of seeds / pod

The mean of P_2 was higher than P_1 in all the crosses except in the cross C_2 . The F_1 mean was higher than both the parents in all the crosses. The F_2 mean was drastically lower than the corresponding F_1 in all the crosses. The B_1 mean was lower than the respective recurrent parent in all the crosses except in cross C_3 . Comparing the P_2 mean, the B_2 mean was superior in cross C_3 only whereas it was on par in cross C_2 and inferior in the rest of the crosses.

In the scaling test, the scale A was negative and significant in the crosses C_1 and C_3 . Similar trend was noticed for scale B where the cross C_1 exhibited negative significance with the rest being non-significant. The scale C showed negative significance for all the crosses except in cross C_3 where non-significance was observed.

The natural origin m was found to be positively significant and greater than other effects in all the crosses. The additive effect (d) was negatively significant in the cross C_1 while it was non-significant in the remaining crosses. The dominance effect (h) was non-significant and negative in all the crosses except in cross C_2 where it was positive. The additive x additive effect (i) was non-significant and negative sign in the crosses C_1 and C_2 . The additive x dominance effect (j) and dominance x dominance (l) interaction effect exhibited non-significance and negative in the crosses C_1 and C_2 .

Thus additive, dominance and epistatic interactions mainly of dominance x dominance and duplicate dominant interaction governed this trait. The predominance of additive effect was reported by Aher *et al.*, (2001). Singh and Dikshit (2003), Anbumalarmathi *et al.*, (2004) and Murgan (2005) reported the presence of non-additive gene action governing this trait. The dominance x dominance effect was earlier reported by Murugan (2005) for this trait.

Hundred Seed weight

The mean of P₂ was higher than P₁ in all the crosses. In F₁, the mean was higher than the corresponding parental means. The F₂ mean was less than the respective F₁ mean in all the crosses. When comparing B₁ mean with their respective recurrent parent, all the crosses showed greater mean values while vice-versa was observed in B₂, where its mean was lower than their corresponding recurrent parent.

The scaling test revealed that all the three scales were negatively significant in all the crosses. The natural origin m was positively significant and greater than other effects in all the crosses. The additive effect (d) was negatively significant in all the crosses. The dominance effect (h) and additive x additive effect (i) exhibited significant negatively in all the crosses. The additive x dominance effect (j) was significantly positive in all the crosses. Positive significance for dominance x dominance (l) interaction effect was observed in all the crosses. The signs of (h) and (l) effects were opposite in all the three crosses.

Thus overall, additive, dominance, epistatic interactions and duplicate dominant interaction appear to govern this trait. Several workers had earlier reported for the nature of gene action governing hundred seed weight. Additive gene action was observed by Indrani Dana and Das Gupta (2001) and Aher *et al.*,

(2001). The non-additive gene action was registered by Jehagiridar (2001), Vaithiyalingam *et al.*, (2002), Singh and Dikshit (2003) and Anbumalarmathi *et al.*, (2004). Contrary, duplicate dominant epistasis was registered by Murugan (2005).

Seed yield / plant

In all the crosses, the P₂ mean was greater than the P₁ mean. The F₁ mean was greater than both the parents in all the crosses. In F₂, there was a marked reduction in the mean values when compared to the respective F₁ mean for all the crosses. The mean of B₁ was far superior to their respective recurrent parent in all the crosses. The B₂ mean was found inferior to their corresponding recurrent parent except in cross C₃ where it was found superior.

In scaling test, all the three scales were found to be negatively significant in the crosses. The natural origin m was found to be positively significant and greater than other effects in all the crosses. The additive effect (d) was negatively significant in all the crosses. The dominance effect (h) was positive and significant in all the crosses except in cross C₂. The additive x additive effect (i) was positively significant in all the crosses. The additive x dominance effect (j) was non-significant in all the crosses. Positive non-significance for dominance x dominance (l) interaction effect was observed in all the crosses.

As a whole, additive, dominance and epistatic interactions especially of dominance x dominance and duplicate dominant interaction appear to govern this trait. The manifestation of additive gene action was reported by Aher *et al.*, (2001). Earlier workers like Jiji Joseph and Santhosh Kumar (2000), Pooran Chand and Raghunadha Rao (2002), Manivannan (2002), Vaithiyalingam *et al.*, (2002 a),

Anbumalarmathi *et al.*, (2004) and Murugan (2005) reported the preponderance of dominance effect. Both additive and dominance gene action was reported by Indrani Dana and Das Gupta (2001). The additive x additive interaction effect (i) was reported by Kute and Desmukh (2002) and Ganesamurthy and Seshadri for this trait. The preponderance of dominance x dominance interaction effect (I) was noted by Murugan (2005) for this trait. All the three types of epistatic interaction were reported by Murugan (2005) for this trait.

In conclusion the generation mean analysis revealed that all the nine yield and yield contributing traits were influenced by different types of gene action *viz.*, additive, dominance and epistatic interactions chiefly of dominance x dominance and duplicate dominant types. Hence, improvement of these traits is impossible with simple selection techniques as they are unable to fix in superior lines. Therefore, deferment in selection of superior lines to later generations is practised in pedigree method of breeding to make it effective. However to harness epistatic interactions, one or two cycles of recurrent selection followed by pedigree breeding method would be effective and useful to identify superior lines with high yield and yield components.

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