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A Comparative Genetic Analysis of Seed Yield and its Attributes in two Crosses of Green Gram (*Vigna radiata* (L.)Wilczek)

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ABSTRACT

Genetic analysis of two crosses of green gram studied LM192 × MDU3465 and BL865 × Chinamung along with their F_2 to F_3 generations was conducted to understand the genetic variability, correlation of yield and yield components along with their direct and indirect effects on seed yield so as to enable to make effective selections for increased yield. Higher magnitudes of variability was recorded for plant height, primary branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, pod yield per plant(g), seed yield per plant (g) and threshing percentage in F_2 and F_3 generation. High heritability and genetic advance as per cent of mean was recorded for all the traits studied except for days to first flowering in both F_2 and F_3 generation that indicate the role of additive gene action in inheritance of these traits and hence, phenotypic selection would be effective in yield improvement. In the cross LM192 × MDU3465, Phenotypic coefficient of variation was slightly higher in magnitude than the genotypic coefficient of variation for number of pods per plant (PCV: 94.19 F_2 and 53.73 F_3 and GCV 89.85 F_2 and 46.14 F_3, respectively). Number of pods per plant (0.783) F_2 and (0.884) F_3, pod yield per plant (0.976) F_2 and (0.985) F_3 and threshing percentage (0.452) F_2 and (0.607) F_3 had shown positive and significant correlation along with their high positive direct effect with seed yield, suggesting that these parameters may be considered as prime traits during the course of selection to obtain increased yield potentials of green gram. In F_2 generation, of the cross BL865 × Chinamung showed high mean performance for seed yield (3.30g), pod yield (4.95) and threshing percentage (63.01), however, least mean performance was observed for yield (1.62g) in F_3 generation, indicating that there was a greater environmental effect on seed yield in F_2 generation. Family performance in the cross LM-192×MDU-3465 for seed yield was comparatively superior over the check KKM-3 and Chinamung.

GREEN GRAM (*Vigna radiata* (L.) Wilczek), popularly known as mung bean is an essential dhal of vegetarian diets, nutritionally valued food legume for its low flatulence protein. It is a self-pollinating, short duration legume that belongs to family *Leguminaceae* with a chromosome number of 2n=22. Among the wide array of pulse crops cultivated in India, green gram occupies an area of 34.4 lakh ha production of 14 lakh tons and productivity of 638 kg/ha (Anon., 2013). Green gram occupies an area of 5.28 lakh ha with a production of 1.08 lakh tones and the average productivity of 205 kg/ha in Karnataka (Anon., 2013).

Enchancement of Green gram productivity is the quintessential need of the country to obtain increased production of mung. It is regularly grown under low fertility lands and low rainfall conditions, with frequent drought spells as one of major stress which adversely affects the yield and its component traits. The genes for agronomic characteristics responsible for high yield has been eroded resulting in narrow genetic base, with relatively lesser tolerance under competitive and stress conditions of agriculture.

In order to improve yield through breeding techniques, a thorough understanding of variability is a prerequisite for a plant breeder. Estimates of genetic parameters do provide an indication of the relative importance of the various types of gene effects affecting the total variation of a plant character. Genotypic and phenotypic coefficients of variation and heritability accompanied with genetic advance are very important parameters in improving traits (Nwosu, *et al*., 2013). In any breeding programme, selection and evaluation of breeding materials for quantitative and yield ability is imperative to facilitate development of cultivars. Owing to this, an experiment was conducted to study variability, heritability and genetic advance in addition to correlation and path analysis among yield and yield parameters of F_2 and F_3 generations in two crosses of green gram *viz.,* LM192 × MDU3465 and BL865 × Chinamung.

Material and Methods

The present study was carried out at K-block, UAS, GKVK, Bangalore during *kharif* 2013 and *summer* 2014. The best performing two crosses *viz.*, LM192×MDU3465 and BL-865 × Chinamung were evaluated along with parents and check varieties (KKM-3, Chinamung) for seed yield and yield attributing traits. Selections were made from F_2 to F_3 based on mean yield performance of traits *viz.,* number of pods per plant, pod yield per plant (g), seed yield per plant (g) and threshing percentage and F_3 generation was raised on plant-to-row progeny basis using augmented design with 10 compact blocks. Each block was comprised of genotypes, parental lines and check varieties. Each progeny was sown in single row of 3m length with a spacing of 30cm between the rows and plant to plant distance of 10cm. All recommended agronomic practices and plant protection measures were followed during the crop growth period to ensure better growth and yield.

Since F_2 and F_3 populations are highly segregating for the genes at each loci for which they differ, the observations were recorded on all F_2 and F_3 populations on individual plant basis on the following traits *viz.,*days to first flowering, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, pod length (cm), number of seeds per pod, pod yield per plant (g), seed yield per plant (g) and threshing percentage. Genetic parameters like mean, range, genotypic and phenotypic coefficient of variation, heritability and genetic advance as *per cent* mean, correlation coefficient and path coefficient analysis were calculated as per the standard procedures Johnson *et al*.(1955).

Results and Discussion

ANOVA of the cross LM 192 × MDU 3465 : Analysis of variance between F_3 families exhibited highly significant differences for all traits among the F_3 progenies, which indicated the existence of sufficient genetic variability within families and between families and scope for improvement (Table I).

Genetic variability parameters in F_2 & F_3 generation of the cross LM 192 × MDU 3465 : Variability parameters *viz.,* mean, range, genotypic co-efficient variation (GCV), phenotypic co-efficient of variation (PCV), broad sense heritability (h^2) and genetic advance expressed as *per cent* mean (GAM) with respect to all the characters in the cross LM192×MDU3465 is presented in Table II.

Growth parameters : Days to first flowering exhibited considerably lesser extent of genetic variation in both F_2 and F_3 population indicating the presence of non-additive gene action and hence limited scope of selection for this character. High GCV and PCV was observed for pod yield per plant (g), seed yield per plant (g), number of **c**lusters per plant, number of pods per plant, number of pods per cluster and plant height (cm), number of branches per plant, respectively in both F_2 and F_3 generations. Genotypic coefficient of variation measures the amount of variation present in a particular character. However, it does not determine the proportion of heritable variation present in the total variation. Therefore, heritable variation existing in the character can be find out with greater degree of accuracy when heritability in combination with genetic advance (Narasimhulu *et al*., 2013). High heritability and genetic advance as percentage of mean was observed for the same characters pod yield per plant (g), seed yield per plant (g), number of clusters per plant, number of pods per plant, number of pods per cluster and plant height (cm), number of branches per plant, respectively in both F_2 and F_3 generations.

However, the characters plant height, branches per plant, clusters per plant, pods per plant, pods per cluster and threshing percentage showed considerable variation in both F_2 and F_3 population and hence these traits may be considered for direct selections. These characters indicated the predominance of additive gene action suggesting that these parameters may be considered as major traits during the course of selection that will be rewarding to obtain higher yield potential in green gram.

TABLE I

Analysis of variance for growth and yield parameters in F_3 generation of the cross LM92×MDU3465 in green gram

Source of variation	df	Mean sum of squares										
		Flowering	Plant height (cm)	Branches / plant	Clusters / plant	Pods / plant	Pods / cluster	Pod length (cm)	Seeds / pod	Pod Yield / pl (g)	Seed Yield / pl (g)	Threshing (%)
Blocks	1	0.01	4.27	0.02	0.64 *	0.49	0.02	0.001	0.02	1.10	0.98	0.58
F_3 progenies + Checks	31	5.39 **	45.38 *	0.65 **	1.56 **	20.33 **	0.64 *	1.89 *	2.63 *	8.01 *	8.73 *	319.72 **
Checks	3	7.75 **	31.24 *	0.76 **	1.52 **	36.51 **	1.17 *	5.65 **	16.23 **	9.91 *	7.81 *	69.54 *
F_3 progenies	27	5.11 **	25.92 *	0.65 **	1.45 **	15.41 **	0.45 *	1.20 **	1.18 *	7.41 *	7.67 *	275.02 **
Checks vs F_3 progenies	1	5.81 **	613.47 **	0.49 *	4.68 **	104.40 **	4.06 **	9.12 **	1.05 *	18.55 **	40.20 **	277.23 **
Error	3	0.08	1.84	0.02	0.03	0.48	0.04	0.02	0.06	0.36	0.39	4.15

* Significant @ P=0.05 ** Significant @ P=0.01

TABLE II

Estimates of genetic parameters for growth and yield characters in F_2 & F_3 generations of the cross LM92×MDU3465 in green gram.

Traits Generation	Mean		Range Min		Range Max		GCV (%)		PCV (%)		Heeritability (%)		GAM (%)	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
X1	32.97	32.99	30.00	30.00	50.00	40.00	4.99	3.81	5.99	4.77	69.27	64.02	8.51	6.29
X2	21.11	22.08	13.00	15.00	64.20	55.00	49.90	26.75	54.31	33.69	84.44	63.04	94.47	43.75
X3	1.37	1.17	1.00	1.00	4.00	3.00	37.36	29.21	46.90	36.94	63.46	62.53	61.31	47.59
X4	5.11	4.20	1.00	1.00	29.00	14.00	81.69	35.60	85.13	43.47	92.08	67.05	161.49	60.04
X5	11.18	9.75	1.00	2.00	55.00	40.00	89.85	46.14	94.19	53.73	90.99	73.75	176.55	81.63
X6	2.21	2.35	1.00	1.00	16.00	8.00	65.61	27.64	67.97	32.30	93.18	73.21	130.48	48.72
X7	5.75	5.80	2.70	3.20	7.50	7.50	11.43	9.65	14.63	13.23	61.03	53.16	18.39	14.49
X8	10.29	10.24	3.00	3.00	14.40	14.40	11.84	14.97	20.00	20.60	35.05	52.79	14.44	22.41
X9	4.65	3.02	0.20	0.80	21.00	18.00	105.50	61.72	107.75	69.26	95.87	79.40	212.92	113.28
X10	3.23	2.35	0.10	0.30	16.40	17.32	117.22	81.44	121.17	90.62	93.59	80.77	233.84	150.77
X11	63.26	71.72	20.00	26.09	94.00	93.84	26.35	22.33	27.97	20.26	88.79	77.07	52.92	40.39

X1 : Days to first flowering, X2 : Plant height (cm), X3 : Branches per plant, X4: Clusters per plant,
X5 : Pods per plant, X6 : Pods per cluster, X7 : Pod length (cm), X8: Seeds per pod,
X9 : Pod yield per plant(g), X10 : Seed yield per plant (g), X11 : Threshing percentage.

Lesser extent of variation was observed for the traits pod length and seeds per pod in both F_2 and F_3 populations. The studies indicated that the trait was under the control of both additive as well as non-additive genes, hence selection for these traits may not be effective. This was on par with the findings of Mallikarjuna Rao *et al.* (2006), Sheela Mary and Gopalan (2006), Rozina gul *et al.* (2008), and Kamleshwar Kumar *et al.* (2013).

Yield parameters

Pod yield per plant : Considerable variation was observed for pod yield per plant in both F_2 and F_3 population with a mean value of 4.65 and 3.02 g, ranging from 0.20 and 0.80 to 21 and 18 g. The estimates of GCV (105.50 and 61.72) and PCV (107.75 and 69.26) were high with least difference between them. The variability could be of genetic cause, which is a pre requisite for effectiveness of selection for this trait. High heritability (95.87 and 79.40) coupled with high genetic advance as per cent of mean (212.92 and 113.28) was observed for this character. Suggesting that this character was under the control of additive genes and scope for phenotypic selection for this character might be effective. These results are in agreement with the results obtained by Mallikarjuna Rao *et al.* (2006) and Kamleshwar Kumar *et al.* (2013).

Seed yield per plant : Seed yield per plant in F_2 and F_3 population had a mean a value of 3.23 and 2.35 g, ranging from 0.10 and 0.30 to 16.40 and 17.32 g, respectively. This trait exhibited high GCV (117.22 and 81.44) and PCV (121.17 and 90.62) value. Hence, this trait offers scope for direct selection. The estimates of the both the broad sense heritability (93.59 and 80.77) and genetic advance expressed as per cent of mean (233.84 and 150.77) were high. Indicating that this character was under the control of additive gene action and phenotypic selection for this character might be effective. Similar results were reported by Mallikarjuna Rao *et al.* (2006), Aqsa tabasum *et al.* (2010) and Kamleshwar Kumar *et al.* (2013).

A*NOVA of the cross BL 865 × Chinamung* : The analysis of variance in F_3 progenies of the cross BL 865 × Chinamung revealed highly significant ($p<0.01$) to significant ($p<0.05$) differences for all characters observed among the F_3 progenies. This suggested the presence of adequate amount of genetic variability among F_3 progenies, desirable to the breeder for identification of suitable high yielding segregants to be used in crop improvement programme to enhance the seed yield of green gram (Table III).

Genetic variability parameters in F_2 & F_3 generation of the cross BL 865 × Chinamung : Variability parameters *viz.*, mean, range, genotypic co-efficient variation (GCV), phenotypic co-efficient of variation (PCV), broad sense heritability (h^2) and genetic advance expressed as per cent mean (GAM) with respect to all the characters in the cross BL 865 × Chinamung is presented in Table IV.

Growth parameters : Very high GCV and PCV values was observed for pod yield per plant, seed yield per plant followed by number of clusters per plant, number of pods per plant, number of branches per plant, moderate for plant height and threshing percentage and low for days to 50 per cent flowering in both F_2 and F_3 generations. Generally, higher PCV values than GCV values are indications of some environmental implication alongside genotypic reasons for variations observed among genotypes used in this study. Heritability combined with genetic advance is a more reliable index for selections of traits. A high heritability and high genetic advance as per cent of mean (GAM) attributable to highly additive gene effect was observed for number of clusters per plant, number of pods per plant, pod yield per plant, plant height, number of branches per plant, number of pods per cluster, number of seeds per pod and threshing percentage in both F_2 and F_3 generation of the cross BL 865 × Chinamung. Thus, suggesting the influence of fixable additive gene effects for inheritance of these traits and therefore, selection for these traits would lead to fast genetic improvement (Nwosu, *et al*., 2013)

A wide range of variability, ranging from 29 to 50 days for days to first flowering in both F_2 and F_3 observed was on par with the findings reported by earlier workers Mallikarjuna Rao *et al.* (2006). Large amount of variation was also observed for plant height, number of branches per plant, number of clusters per plant, number of pods per plant, number of pods per

TABLE III

Analysis of variance for growth and yield parameters in F3 generation of the cross BL 865 X Chinamung in green gram

Source of variation	df	Mean sum of squares										
		Flowering	Plant height (cm)	Branches / plant	Clusters / plant	Pods / plant	Pods / cluster	Pod length (cm)	Seeds / pod	Pod Yield / pl (g)	Seed Yield / pl (g)	Threshing (%)
Blocks	1	0.002	5.54	0.001	0.15 *	0.02	0.001	0.02	0.03	0.80 *	525*	0.25
F_3 progenies + Checks	29	7.39 *	102.06 *	0.41 *	1.67 **	14.59 *	0.78 *	2.78 *	3.19 **	3.72 **	2.77 **	466.57 **
Checks	3	15.52 **	11.14	0.17	1.76 **	24.13 **	1.26 *	3.45 *	0.98 *	8.52*	7.77 **	30.99
F_3 progenies	25	6.69 *	114.01 *	0.45 *	1.65 **	11.14 *	0.68 *	2.77 *	3.31 **	3.21 **	1.94 **	455.54 **
Checks vs F_3 progenies	1	0.30	76.18 *	0.001	1.78 **	72.18 **	1.80 **	1.17	6.73 **	1.98 *	8.69 **	2048.84 **
Error	3	0.43	4.69	0.02	0.01	0.76	0.04	0.15	0.08	0.06	0.03	6.70

* Significant @ P=0.05 ** Significant @ P=0.01

TABLE IV

Estimates of genetic parameters for growth and yield characters in F_2 and F_3 generations of the cross BL865 X Chinamung in green gram

Traits Generation	Mean		Range Min		Range Max		GCV (%)		PCV (%)		Heeritability (%)		GAM (%)	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
X1	32.74	32.78	29.00	29.00	50.00	50.00	4.8	3.85	5.89	5.15	66.35	56.08	8.02	5.95
X2	24.67	21.60	19.00	18.00	46.20	48.00	27.1	20.93	30.04	25.64	81.39	66.68	50.23	35.21
X3	1.48	1.10	1.00	1.00	4.00	3.00	36.54	24.42	51.99	29.04	49.39	70.69	52.59	42.29
X4	6.17	3.49	1.00	1.00	35.00	15.00	76.29	32.78	80.89	40.70	88.96	64.88	147.88	54.40
X5	11.92	7.19	1.00	3.00	49.00	41.00	76.27	43.64	80.88	50.24	88.92	75.45	147.8	78.08
X6	2.01	2.10	0.29	0.63	6.13	8.20	35.94	28.73	45.3	32.44	62.95	78.41	58.5	52.41
X7	5.91	6.00	4.06	4.06	7.60	8.10	10.33	9.22	10.99	11.26	88.50	67.07	19.98	15.55
X8	10.13	10.22	3.00	3.00	14.56	15.80	20.78	17.01	21.91	20.99	89.90	65.68	40.49	28.39
X9	4.95	2.19	0.49	0.60	27.00	20.37	83.63	66.36	100.09	74.66	69.81	78.99	143.43	121.50
X10	3.30	1.62	0.20	0.30	20.57	18.47	60.24	79.54	64.28	86.41	66.35	84.73	104.59	150.83
X11	63.01	71.07	14.33	8.24	93.90	94.75	27.1	20.80	30.04	23.49	81.39	78.37	50.23	37.93

X1: Days to first flowering, X2: Plant height (cm), X3: Branches per plant, X4: Clusters per plant,
X5: Pods per plant, X6: Pods per cluster, X7: Pod length (cm), X8: Seeds per pod,
X9: Pod yield per plant(g), X10: Seed yield per plant(g), X11: Threshing percentage.

cluster and threshing percentage in both between F_2 and F_3, suggesting that these characters was under the control of additive genes and scope for improving this character through simple phenotypic selection could be effective. This finding also get corroborate with Sheela Mary and Gopalan (2006), Rozina gul *et al.* (2008) Imdad Ullah Zaid (2012) and Kamleshwar Kumar *et al.* (2013).

Yield parameters

Pod yield per plant (g) : Considerable variation existed for pod yield per plant in both F_2 and F_3 with a mean value of 4.95 and 2.19 g, ranging from 0.49 and 0.60 to 27 and 20.37 g. The estimates of GCV (83.63, 66.36) and PCV (100.09, 74.66) were high with broad difference between them. Indicates the existence of greater amount environmental effects for this trait. Heritability combined with genetic advance is a more reliable index for selections of traits. A high heritability and high genetic advance as per cent of mean (GAM) attributable to highly additive gene effect was observed for pod yield per plant (69.81, 78.99) genetic advance as per cent of mean (143.43, 121.50) in both F_2 and $F_{3,}$ respectively. Suggesting that this character was under the control of additive genes and scope for phenotypic selection for this character might be effective, reported by Mallikarjuna Rao *et al.* (2006) and Kamleshwar Kumar *et al.* (2013).

Seed yield per plant (g) : Seed yield per plant between F_2 and F_3 with a mean value of 3.30 and 1.62g, varied from 0.20 and 0.30 to 20.57and 18.47 g. This trait exhibited high GCV (60.24, 79.54) and PCV (64.28, 86.41) value, indicated that the higher magnitude of variability was recorded. The estimates of the both the broad sense heritability (66.35, 84.73) and genetic advance (104.59, 150.83) expressed as per cent of mean were high. The trait was under the control of additive genes, scope for simple selection may be effective. This finding also get collaborated with Aqsa tabasum *et al*. (2010), Kamleshwar Kumar *et al.* (2013) and Narasimhulu *et al.* (2013).

Correlation of yield with its component traits in F_2 and F_3 generation : Information regarding the nature and extent of association of morphological characters would be helpful in developing imitable plant type, in addition to the improvement of yield a complex character for which, direct selection is not effective.

1. The cross LM 192 × MDU 3465

Seed yield per plant : Exhibited positive and highly significant association with plant height, number of branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, pod yield per plant and threshing percentage. Indicate the possibility of simultaneous improvement of these traits by single selection programme (Table V). These results are in agreement with the results of Mallikarjuna Rao *et al.* (2006).

Plant height : Plant hight registered positive and significant association with number of branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, pod yield per plant and threshing percentage. Suggesting that this trait is directly/indirectly responsible to enhance magnitude of these aforesaid traits. Similar results were reported by Kamleshwar Kumar *et al.* (2013). Thus, selection for plant height would result in higher yields. Number of primary branches per plant showed positive and significant association with number of clusters per plant, number of pods per plant, pod yield per plant and threshing percentage. Thus, this trait can be considered as a use full trait in improvement of seed yield per plant. Same results were reported by Kamleshwar kumar *et al.* (2013). Number of clusters per plant were found to have positive and significant relationship with number of pods per plant, pod yield per plant and threshing percentage. Indicating that direct selection of number of clusters per plant would improve the yield. Similar kind of observations were reported Imdad Ullah Zaid (2012). Number of pods per plant exhibited positive and significant association with number of pods per cluster, pod length, pod yield per plant and threshing percentage. Indicating that this trait may be considered as prime trait during the course of selection for enhancing seed yield. These results are in confirmation with results obtained by Kamleshwar Kumar *et al.* (2013). Number of pods per cluster exhibited positive and significant association with pod yield per plant. The similar results were reported by Tejbir Singh and Alie Fayaz Ahmad (2009). Pod length recorded positively significant relationship with seeds

TABLE V

Estimates of phenotypic correlation coefficients for seed yield and its contributing characters in F_2 & F_3 generation of the cross LM 192 × MDU 3465 in green gram

Traits	G	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
X1	F_2	1.000	0.360 **	0.708 **	0.744 **	0.190 **	0.436 **	0.438 **	0.683 **	0.325 **	0.700 **
	F_3	1.000	0.326 **	0.567 **	0.620 **	0.270 **	-0.065	-0.011	0.487 **	0.437 **	0.503 **
X2	F_2		1.000	0.662 **	0.540 **	-0.060	0.202 **	0.182 **	0.460 **	0.184 **	0.446 **
	F_3		1.000	0.417 **	0.356 **	0.002	-0.048	0.019	0.402 **	0.227 **	0.408 **
X3	F_2			1.000	0.894 **	-0.017	0.339 **	0.323 **	0.726 **	0.307 **	0.725 **
	F_3			1.000	0.800 **	-0.077	-0.045	0.034	0.692 **	0.519 **	0.706 **
X4	F_2				1.000	0.341 **	0.410 **	0.403 **	0.782 **	0.316 **	0.783 **
	F_3				1.000	0.455 **	-0.080 *	-0.013	0.869 **	0.600 **	0.884 **
X5	F_2					1.000	0.181 **	0.226 **	0.200 **	0.014	0.186 **
	F_3					1.000	-0.063	-0.067	0.345 **	0.250 **	0.354 **
X6	F_2						1.000	0.597 **	0.389 **	0.203 **	0.382 **
	F_3						1.000	0.627 **	-0.073	-0.022	-0.069
X7	F_2							1.000	0.378 **	0.087	0.356 **
	F_3							1.000	-0.002	0.032	0.001
X8	F_2								1.000	0.326 **	0.976 **
	F_3								1.000	0.479 **	0.985 **
X9	F_2									1.000	0.452 **
	F_3									1.000	0.607 **
X10	F_2										1.000
	F_3										1.000

X1 : Plant height (cm), X2 : Branches per plant, X3 : Clusters per plant, X4: Pods per plant,
X5 : Pods per cluster, X6 : Pod length (cm), X7 : Seeds per pod, X8 : Pod yield per plant (g),
X9 : Threshing percentage, X10 : Seed yield per plant (g). G : Generation.

per pod. Pod yield per plant registered positively significant relationship with threshing percentage. Indicating that this trait may be considered as prime trait during the course of selection for enhancing seed yield. These results are in confirmation with results obtained by Mallikarjuna Rao *et al.* (2006), Imdad Ullah Zaid (2012) and Kamleshwar Kumar *et al.* (2013).

2. The cross BL 865 × Chinamung

Seed yield per plant : Between F_2 and F_3 population exhibited positive and significant association with plant height, number of primary branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, pod yield per plant, threshing percentage. Pod length and seeds per pod in F_2 population alone exhibited positive and significant association with seed yield (Table VI) . Similar results were also observed by Mallikarjuna Rao *et al.* (2006), Kamleshwar Kumar *et al.* (2013) and Narasimhulu *et al.* (2013).

Plant height between F_2 and F_3 population registered positive and significant association with number of branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, pod yield per plant and threshing percentage. Which may be responsible to enhance the yield of green gram. This finding is collaborated with Kamleshwar Kumar *et al.* (2013). Number of primary branches per plant between F_2 and F_3 population showed positive and significant association with number of clusters per plant, number of pods per plant and pod yield per plant. These finding was in agreement with the observations of Mallikarjuna Rao *et al.,* (2006). Number of clusters per plant between F_2 and F_3 population showed positive and significant association with number of pods per plant, pod yield per plant and threshing percentage. Indicating that this character may be responsible to enhance the yield. Similar results were also observed by Mallikarjuna Rao *et al.* (2006). Number of pods per plant between F_2 and F_3 population exhibited positive and significant association with number of pods per cluster, number of seeds per pod, pod yield per plant and threshing percentage. Indicating that this character may be considered as prime trait during the course of selection for enhancing the yield of green gram. This finding is in conformity with the results of Mallikarjuna Rao *et al.* (2006), Kamleshwar Kumar *et al.* (2013). Number of pods per cluster between F_2 and F_3 population exhibited positive and significant association with pod yield per plant, threshing percentage. Pod length between F_2 and F_3 population recorded positively significant relationship with number of seeds per pod. Number of seeds per pod between F_2 and F_3 population exhibited positive and significant association with pod yield and threshing percentage. This finding is in agreement with the observations of pod yield per plant between F_2 and F_3 population registered positively significant relationship with and threshing percentage. Indicating that this character may be responsible to enhance the yield. Similar results were also observed by Aqsa tabasum *et al.* (2010), Kamleshwar Kumar *et al.* (2013) and Narasimhulu *et al.* (2013).

Path analysis of seed yield per plant in F_2 and F_3 generation

1. The cross LM 192 × MDU 3465

In order to understand the true significance of the correlation studies the highly correlated traits were subjected to Path coefficient analysis. The path co-efficient analysis of seed yield per plant and its contributing characters were calculated and presented in Table VII.

Pod yield per plant exhibited highest positive direct effect on seed yield followed by threshing percentage and number of pods per plant. Plant height and number of primary branches per plant showed highest indirect effect on seed yield per plant *via* pod yield per plant followed by threshing percentage and number of pods per plant. Number of clusters per plant and number of pods per plant exhibited highest indirect effect on seed yield per plant *via* pod yield per plant followed by threshing percentage. Number of pods per cluster had highest indirect effect on seed yield per plant through pod yield per plant followed by number of pods per plant. Pod yield per plant exhibited highest indirect effect on seed yield per plant *via* number of pods per plant followed by threshing percentage. Threshing percentage showed indirect effect on seed yield per plant *via* pod yield per plant followed by number of pods per plant. Similar results were also observed by

TABLE VI

Estimates of phenotypic correlation coefficients for seed yield and its contributing characters in F_2 & F_3 generation of the cross BL 865 x in green gram

Traits	G	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
X1	F_2	1.000	0.318 **	0.495 **	0.552 **	0.227 **	0.401 **	0.374 **	0.455 **	0.138 *	0.429 * *
	F_3	1.000	0.108 **	0.517 **	0.618 **	0.259 **	0.018	-0.040	0.387 **	0.266 **	0.445 **
X2	F_2		1.000	0.747 **	0.569 **	-0.152 *	0.291 **	0.267 **	0.440 **	0.099	0.422 * *
	F_3		1.000	0.256 **	0.210 **	0.022	-0.072	0.018	0.130 **	0.150 **	0.156 **
X3	F_2			1.000	0.782 **	-0.104	0.379 **	0.328 **	0.631 **	0.171 * *	0.616 * *
	F_3			1.000	0.715 **	-0.164 **	0.011	-0.079 *	0.444 **	0.350 **	0.517 **
X4	F_2				1.000	0.411 **	0.368 **	0.347 **	0.700 **	0.241 **	0.698 **
	F_3				1.000	0.505 **	0.003	-0.078 *	0.684 **	0.395 **	0.766 **
X5	F_2					1.000	0.081	0.133 *	0.199 **	0.141 *	0.212 **
	F_3					1.000	0.005	- 0.018	0.351 **	0.140 **	0.377 **
X6	F_2						1.000	0.716 **	0.443 **	0.259 **	0.443 **
	F_3						1.000	0.327 **	0.017	-0.027	0.004
X7	F_2							1.000	0.421 **	0.213 **	0.425 **
	F_3							1.000	-0.020	-0.095 *	-0.072
X8	F_2								1.000	0.204 **	0.957 **
	F_3								1.000	0.256 **	0.886 **
X9	F_2									1.000	0.401 **
	F_3									1.000	0.540 **
X10	F_2										1.000
	F_3										1.000

X1: Plant height (cm), X2: Branches per plant, X3: Clusters per plant, X4: Pods per plant, X5: Pods per cluster,
X6: Pod length (cm), X7: Seeds per pod, X8: Pod yield per plant (g), X9: Threshing percentage, X10: Seed yield per plant (g). G : Generation.

* Significant @ P=0.05 probability level ** Significant @ P=0.01 Probability level

TABLE VII

Estimates of direct effects (diagonal) and indirect effects of different characters on seed yield per plant in F_2 & F_3 generations of the cross LM 192 × MDU 3465 in green gram

Traits	G	Plant hieght (cm)	Branches / plant	Clusters / plant	Pods / plant	Pods / cluster	Pod yield / pl. (g)	Threshing (%)	Seed Yield / Pl.(g) (r)
Plant height (cm)	F_2	0.038	-0.003	-0.058	0.078	-0.007	0.616	0.046	0.700 **
	F_3	-0.013	0.003	-0.026	0.026	-0.006	0.439	0.080	0.503 **
Branches / Plant	F_2	0.013	-0.008	-0.054	0.057	0.002	0.414	0.026	0.446 **
	F_3	-0.004	0.012	-0.019	0.015	-0.001	0.363	0.041	0.408 **
Clusters / plant	F_2	0.027	-0.005	-0.082	0.094	0.001	0.655	0.044	0.725 **
	F_3	-0.007	0.005	-0.046	0.033	0.001	0.624	0.095	0.706 **
Pods / plant	F_2	0.028	-0.004	-0.073	0.105	-0.012	0.705	0.045	0.783 **
	F_3	-0.008	0.004	-0.037	0.042	-0.010	0.784	0.109	0.884 **
Pods / cluster	F_2	0.007	0.001	0.001	0.036	-0.036	0.181	0.002	0.186 **
	F_3	-0.003	0.001	0.003	0.019	0.022	0.311	0.045	0.354 **
Pod yield / plant (g)	F_2	0.026	-0.003	-0.060	0.082	-0.007	0.901	0.047	0.976 **
	F_3	-0.006	0.004	-0.032	0.036	-0.007	0.902	0.087	0.985 **
Threshing percentage	F_2	0.012	-0.001	-0.025	0.033	-0.001	0.294	0.144	0.452 **
	F_3	-0.006	0.002	-0.024	0.025	-0.005	0.432	0.182	0.607 **

Residual effect **(F_2)** = 0.1589 Residual effect**(F_3)** = 0.0728 **G** : Generation

the findings of Mallikarjuna Rao *et al.* (2006), Kousar Makeen *et al.* (2007) and Kamleshwar Kumar *et al.* (2013).

2. The cross BL 865 × Chinamung

Pod yield per plant between F_2 and F_3 population exhibited highest positive direct effect followed by number of pods per plant and threshing percentage (Table VIII). This result is in agreement with the results obtained by Mallikarjuna Rao *et al.* (2006). Hence, selection for these traits would greatly contribute towards enhancing seed yield per plant in green gram breeding.

Plant height had highest indirect effect on seed yield per plant *via* pod yield per plant followed by pods per plant. Number of primary branches per plant showed highest indirect effect on seed yield per plant *via* pod yield per plant followed by number of pods per plant. Number of clusters per plant showed highest indirect effect on seed yield per plant *via* pod yield per plant followed by number of pods per plant. Number of pods per plant had highest indirect effect on seed yield per plant through pod yield per plant followed by threshing percentage. Number of pods per cluster showed indirect effect on seed yield per plant *via* pod yield per plant followed by number of pods per plant. Hence, priority should be given to these traits in indirect selection for seed yield improvement. Pod yield per plant exhibited highest indirect effect on seed yield per plant *via* number of pods per plant followed by threshing percentage. Threshing percentage showed indirect effect on seed yield per plant *via* pod yield per plant followed by number of pods per plant. Indicating that these characters may be considered as prime traits during the course of selection for enhancing the yield of green gram. Similar results were also observed by the findings of Mallikarjuna Rao *et al.* (2006), Kousar Makeen *et al.* (2007), Kamleshwar Kumar *et al.* (2013) and Narasimhulu *et al.* (2013).

The present variability studies was conducted involving two crosses of green gram *viz.*, LM192 × MDU3465 and BL865 × Chinamung, and their F_2 to F_3 generations. There is an increase in mean values

TABLE VIII

Estimates of direct effects (diagonal) and indirect effects of different characters on seed yield per plant in F_2 & F_3 generations of the cross BL 865 × Chinamung in green gram

Traits	G	Plant hieght (cm)	Branches / plant	Clusters / plant	Pods / plant	Pods / cluster	Pod yield / pl. (g)	Threshing (%)	Seed Yield / Pl.(g) (r)
Plant height(cm)	F_2	-0.024	-0.003	-0.001	0.021	-0.002	0.415	0.030	0.429 **
	F_3	-0.010	-0.001	-0.073	0.212	-0.025	0.262	0.079	0.445 **
Branches/Plant	F_2	-0.007	-0.011	-0.001	0.021	0.001	0.401	0.021	0.422 **
	F_3	-0.001	-0.010	-0.036	0.072	-0.002	0.088	0.045	0.156 **
Clusters/ plant	F_2	-0.011	-0.008	-0.001	0.029	0.001	0.575	0.037	0.616 **
	F_3	-0.005	-0.002	-0.141	0.245	0.015	0.300	0.104	0.517 **
Pods /plant	F_2	-0.013	-0.006	-0.001	0.038	-0.005	0.638	0.052	0.698 **
	F_3	-0.006	-0.002	-0.101	0.343	-0.048	0.462	0.118	0.766 **
Pods/cluster	F_2	-0.005	0.001	0.001	0.015	-0.012	0.181	0.030	0.212 **
	F_3	-0.002	-0.001	0.023	0.173	-0.096	0.237	0.042	0.377 **
Pod yield/pl.(g)	F_2	-0.011	-0.005	-0.001	0.026	-0.002	0.911	0.044	0.957 **
	F_3	-0.004	-0.001	-0.062	0.235	-0.033	0.676	0.066	0.886 **
Threshing percentage	F_2	-0.003	-0.001	-0.001	0.009	-0.001	0.186	0.216	0.401 **
	F_3	-0.002	-0.001	-0.049	0.136	-0.013	0.173	0.298	0.540 **

Residual effect **(F_2)** = 0.1589 Residual effect**(F_3)** = 0.0728 **G** : Generation

from F_2 to F_3 generation, indicating relatively higher mean performance for some of the characters in some of the progenies. In F_2 generation, the cross BL865×Chinamung showed high mean performance for seed yield, pod yield and threshing percentage, However, in F_3 generation, least mean performance for yield was observed in the cross BL865×Chinamung. Indicating that there was a greater environmental effect on seed yield in F_2 generation of the cross BL865×Chinamung there by recording least mean performance for yield. Among the crosses studied, best families that performed superior to check and their respective parents were selected based on pods per plant, pod yield per plant, seed yield per plant and threshing percentage. Family performance in the cross LM-192×MDU-3465 for seed yield was comparatively superior over the check KKM-3 and Chinamung. Similar trend was also observed for pod yield per plant and pods per plant.

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