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Variability for Growth, Yield and Yield Attributing Characters in M_3 Generation Mutants of Butter Beans (*Phaseolus lunatus* L) var. KKL-1

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ABSTRACT: Butter beans or Lima beans (*Phaseolus lunatus* L.), is an herbaceous plant of the leguminaceae family rich in protein, vitamins B and C, and various minerals including iron, magnesium, phosphorus, and potassium. Owing to its cleistogamous nature, mutation breeding was effectively utilized for creation of variability and to improve the yield and other polygenic characters. The experimental material comprised of 35 M_3 mutants along with the check variety KKL-1. The M_3 mutant lines were grown in RBD with three replications at Horticultural Research Station, Tamil Nadu Agricultural University, Kodaikanal. The data collected from individual mutants along with check were subjected to statistical analysis to calculate mean significance of mutants and genetic parameters using TNAUSTAT. Among 35 mutants, 20 mutants showed significant mean values for plant height compared to local check variety KKL 1. Eight mutants recorded the highest leaves per plant (26.00). The mutant BBM18 and BBM34 recorded the highest number of pods per plant (40.00). BBM1, BBM5, BBM18 and BM25 recorded the highest pod girth. Whereas BBM 7 was identified as early flowering and early maturity mutant.

Keywords: Butter beans, mutants, variability, genetic parameters.

INTRODUCTION

Butter beans or Lima beans (*Phaseolus lunatus* L.), is an herbaceous plant of the leguminaceae family rich in protein, vitamins B and C, and various minerals including iron, magnesium, phosphorus, and potassium. A large seeded butter bean is considered to be a high value crop in the hilly regions of Tamil Nadu *viz.*, Kodaikanal and The Nilgiris. Owing to its cleistogamous nature, mutation breeding has been effectively utilized for creation of variability and to improve the yield and other polygenic characters (Deepalakshmi and Anandakumar 2004).

Mutation induction has become an established tool in plant breeding to supplement existing germplasm and to improve cultivars in certain specific traits (Kumar and Ramesh 2004). Gamma rays in particular are known to influence the plant growth and development by inducing cytological, genetical, biochemical, physiological and morphogenetic characters in cells and tissues (Gunckel and Sparrow 1961). By the mutation work conducted at Horticultural Research Station, Kodaikanal, genetic variation was induced through gamma rays in butter beans var. KKL-1. The mutant lines identified in the M_2 generation were forwarded to M_3 generation and evaluated for the segregating characters in terms of quantitative and qualitative traits.

MATERIALS AND METHODS

Experiment trials were conducted at Horticultural Research Station, Kodaikanal, which is geographically situated between 10°24' N latitude and 77°48' E longitude at an altitude of 2225 m above mean sea level. The origin of experimental materials was KKL-1 butter beans released by Horticultural Research Station at Kodaikanal during 1991. A total of 2734 M_2 mutant lines were evaluated which included 808, 1096 and 530 mutant from 50Gy, 100Gy and 150Gy treatments respectively. Stringent selection was made based on yield and plant habit and a total of 35 mutant lines were identified and forwarded to M_3 generation. The details of 35 mutant lines raised are given in the Table 1.

The selected 35 M_2 mutant lines were raised as M_3 families with the check variety KKL -1. The M_2: M_3 families (2734 nos.) raised were analyzed for its variability of traits by way of phenotypic observations. The data collected from individual mutants along with check were subjected to statistical analysis to calculate mean significance of mutants and genetic parameters using TNAUSTAT.

RESULTS AND DISCUSSION

The mean performance of the 12, 15 and 8 mutants treated with 50Gy, 100Gy and 150Gy respectively for growth, yield and yield attributing characters were studied (Table 2 & 3). The consolidated mean and range of mutants compared with the check variety KKL-1 as given in Table 4 for plant height ranged between 60.00 cm to 250.00 cm and among 35 mutants studied in the M_3 generation, twenty mutants *viz.*, BBM1, BBM3, BBM6, BBM7, BBM9, BBM10, BBM11, BBM12, BBM13, BBM 15, BBM17, BBM18, BBM23, BBM26, BBM27, BBM28, BBM31, BBM32, BBM33, BBM35 registered lesser mean values for plant height compared to the local check butter beans var. KKL-1 (200.10 cm). Whereas the remaining 15 mutants registered higher values for plant height compared to the local check var. KKL -1. The highest plant height was registered in the mutant line BBM34 (250.00 cm) and the lowest plant height was recorded in the mutant line BBM35 (60.00 cm). Likewise, the range for number of leaves per plant was from 8.00 to 26.00. Eight mutants *viz.*, BBM 20, BBM 21, BBM22, BBM23, BBM24, BBM25, BBM26, and BBM27 recorded the highest leaves per plant (26.00). While the lowest number of leaves per plant (8.00) was registered in the mutant line BBM35.

Plant growth habit mainly depends on the plant height and the leaf number. This parameter is a major determining factor for yield as the nodes and internodes are the places of flowering axils. In the present investigation, a dwarf (M_3) mutant line BBMG 35 was identified which recorded a plant height of 60.00 cm possessing only eight leaves. This mutant line can be considered as an useful mutant as it does not requires pole due to its dwarf bushy nature. It was also found that a drastic reduction in plant height was observed in higher doses of gamma irradiation. This is in accordance with the earlier finding of Quastler and Bair (1950) who reported that the reduction of plant height observed at higher doses was due to growth aberration and caused by cytological, morphological and physiological factors.

Earliness in flowering ranged between 30 to 45 days among the 35 mutant lines studies for days taken for first flowering. Early mutants *viz*., BBM-7 (50 Gy) and BBM15 (100 Gy) were identified in M_3 generation which took only 30 days for first flowering as against the mutant lines *viz*., BBM29, BBM31 and BBM34 (150 Gy) which took 45 days for first flowering. The result indicated positive changes at higher doses and negative changes at lower doses of gamma rays which is in conformity with the results of Hanafy and Akladious (2018).

Among the 35 mutants lines evaluated in the M_3 generation, the mutants *viz.*, BBM1, BBM4, BBM5, BBM6, BBM8, BBM9, BBM11, BBM13, BBM18, BBM21, BBM25, BBM26 BBM27, BBM 29, BBM30, BBM31 and BBM34 recorded the highest significant number of pods per plant compared to the local check, butter beans var. KKL-1 (31.45). Among the significant mutants, BBM18 and BBM34 recorded the highest number of pods per plant (40.00). Besides, the value for number of pods per plant ranged between 40.00 and 14.00, wherein the lowest number of pods per plant was registered in the dwarf mutant line BBM35 (14.00).

The pod length among the 35 mutants lines M_3 generation ranged from 8.20 cm to 15.89 cm and among them, fifteen mutants *viz.*, BBM4, BBM5, BBM6, BBM8, BBM9, BBM11, BBM13, BBM16, BBM18, BBM22, BBM24, BBM25, BBM29, BBM30 and BBM34 recorded significantly higher mean values for pod length when compared to the local check butter beans var. KKL-1 (13.46 cm). The highest mean value for pod length was registered in the mutant line BBM34 915.89 cm) and the lowest mean value for pod length was observed in the mutant line BBM3 (8.20 cm). Among the 35 mutants of M_3 generation the mutants *viz.*, BBM1, BBM5, BBM18, BBM25 recorded the highest pod girth and showed significantly higher mean values when compared to the local check butter beans var. KKL-1(6.13cm).

The significant mean values for the fresh ovules per pod was recorded in the mutants BBM1, BBM4, BBM5, BBM6, BBM13, BBM14, BBM16, BBM18, BBM21, BBM22, BBM24, BBM25, BBM27, BBM30, BBM34 when compared to the local check butter beans var. KKL-1 (5.50). The mean values for fresh ovules per pod ranged between 3.00 and 7.00 wherein the lowest number of fresh ovules per pod (3.00) was registered in BBM35 and the highest number of fresh ovules per pod (7.00) was registered in six mutant lines *viz*., BBM5, BBM13, BBM18, BBM21, BBM25 and BBM34

Seven mutants *viz.*, BBM1, BBM5, BBM9, BBM13, BBM18, BBM21, BBM25 and BBM34 recorded highest significant mean values for 100 seed weight when compared to the local check butter beans var. KKL-1 (66.30g) in the M_3 generation. Significant mean values were not registered in the mutants in M_3 progenies for shelling percentage (%) when compared to the local check butter beans var. KKL-1(75.36%). The values for pod yield per plant ranged between 65.04 g and BBM18 (318.96 g). The highest significant pod yield per plant was recorded in BBM5, BBM9, BBM18, BBM25, BBM34 compared to the local check variety butter beans var. KKL-1 (285.85g). The highest pod yield per plant was registered in the mutant line BBM18 (318.96 g).

According to the mutagen derived variability for a quantitative trait in crop plants is heritable and response to selection is good. In a highly self-pollinated crop like butter beans the variability available in the mutant population assumes much greater importance. In the present investigation on the genetic variability in the M_3 generation mutants of Butter beans, number of leaves

per plant, number of pods per plant, pod girth, fresh ovules per pod and pod yield per plant registered the highest PCV and GCV (Table 4). Similar observations on high PCV and GCV for seed yield per plant, pods per plant and plant height in mung bean was reported by Mathew and Palmer (2005); Kalaichelvi (2007) indicating greater role for environment interacting with genetic factors in the expression of these characters. Singh *et al.* (2000) also reported highest magnitude of variability for pods per plant in black gram due to induced mutagenesis. The reason for high level of PCV and GCV observed for morphological traits could be because of the expression of limited mutant loci, as a single mutation can have marked influence on the plant traits (Gaur and Guar 2007).

M_3 generation mutants of butter beans exhibited low PCV and GCV for days to first flowering and expressed low to medium PCV and GCV for plant height, pod length, pod weight, 100 seed weight and shelling percentage (Table 4). The low values indicated very narrow range of variation for these characters and provided very least scope for selection (Roychowdhury and Tah 2013). The low values also revealed that genetic factors were predominantly responsible for expression of these attributes and selection could be made effectively on the basis of phenotypic performance (Roychowdhury *et al.*, 2011).

Estimation of heritability and genetic advance in the M_3 generation butter beans mutants revealed high heritability coupled with high genetic advance for traits *viz.*, leaves per plant, pods per plant, pod length, pod weight and fresh ovules per pod (Table 4). Similar results were reported by Kalaichelvi (2007) in green gram and Sri Devi & Mullainathan (2012) in black gram for various quantitative traits. Johnson *et al.* (1955) stated that high heritability and genetic advance for a character would indicate the predominance of additive gene action for that trait and as such, that trait is likely to respond effectively to phenotypic selection. For the improvement of seed yield, selection may be based directly on these attributes (Sarwar and Haq 2006). The findings clearly indicated the least influence of environment in the expression of these characters and prevalence of additive gene action in their inheritance.

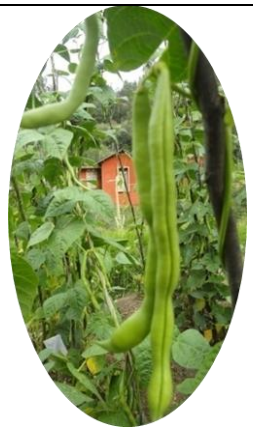
High heritability and low GA as percentage of mean were recorded for plant height and pod yield per plant in M3 generation which revealed high heritability and less stability of the mutant population. This finding was similar to the reports of Govindarasu *et al.* (1997). Combination of high heritability with low genetic advance is indicative of non-additive gene action (Manimaran and Raveendran 2004).

High heritability and moderate GA as percentage of mean were recorded for days to first flowering, 100 seed weight, shelling percentage in M3 generation. Similar findings on high heritability with moderate to high genetic advance for days to first flowering, 100 seed weight and shelling percentage were observed by Awnindra and Kumar (2009) in mung bean.

From the present investigation, it is evident that the wide range of variability existed for different traits coupled with high heritability and high genetic advance for important yield traits *viz.*, leaves per plant, pods per plant, pod length, pod weight and fresh ovules per pod in M_3 generation. Hence, the selection is effective for these traits while advancing to next generation without genetic loss of these traits.

Fig. 1. Butter Beans var. KKL-1.

Variation in pod colour and shape



Variation for pod colour and size

Variation in plant stature – Dwarf and spreading type

Fig. 2. M_3 generation Mutants of KKL -1 Butter Beans.

Fig. 3. M_3 generation Mutants of KKL -1 Butter Beans for varying seed size.

Table 1: Details of 35 mutant lines raised.

Sr. No.	Treatment dose	No of mutants	Desirable mutants identified from M_2 generation to be forwarded to M_3 generation.
1.	T1-50Gy	12	BBM1, BBM2, BBM3, BBM4, BBM5, BBM6, BBM7, BBM8, BBM9, BBM10, BBM11, BBM12.
2.	T2-100Gy	15	BBM13, BBM14, BBM15, BBM16, BBM17, BBM18, BBM19, BBM20, BBM21, BBM22, BBM23, BBM24, BBM25, BBM26, BBM27.
3.	T3-150Gy	8	BBM28, BBM29, BBM30, BBM31, BBM32, BBM33, BBM34, BBM35.
Total number of mutants		**35**	

Table 2: Mean performance of M_3 generation mutants of butter beans var. KKL-1 for yield and yield attributing traits.

Traits	PH	LPP	DFF	PPP	PL	PG	PW	FOPP	100 SW	SP	PYPP
BBM 1	200.00*	25.00	42.00	38.00*	14.00	6.56*	7.97	6.00*	73.00*	70.00	303.08
BBM 2	220.00	24.00	41.00	28.00	12.25	3.90	6.77	5.00	50.00	72.00	189.78
BBM 3	120.50*	15.00	40.00	18.00	8.20	3.88	6.50	5.00	57.80	50.85	117.00
BBM 4	204.00*	25.00	41.00	36.00*	14.22*	4.20	6.77	6.00*	50.00	73.74	244.00
BBM 5	206.40	24.00	42.00	37.00*	14.17*	6.87*	8.46	7.00*	74.00*	73.74	313.24*
BBM 6	190.90*	23.00	39.00	38.00*	14.20*	4.10	6.84	6.00*	51.10	73.74	260.07
BBM 7	150.80*	16.00	30.00	20.00	9.02	3.12	7.98	5.00	53.40	68.70	159.64
BBM 8	207.50	25.00	41.00	35.00*	14.14*	4.16	6.97	5.00	59.10	73.74	244.26
BBM 9	199.20*	24.00	42.00	38.00*	14.17*	6.27	8.07	5.00	78.00*	73.74	307.00*
BBM 10	190.90*	23.00	42.00	30.00	13.53	4.20	7.65	4.00	58.00	73.74	229.74
BBM 11	182.60*	22.00	41.00	34.00*	14.31*	4.22	6.44	5.00	54.50	65.43	219.23
BBM 12	150.50*	25.00	42.00	20.00	9.87	3.11	6.17	5.00	53.00	73.74	123.48
BBM 13	199.20*	24.00	43.00	39.00*	14.89*	6.00	7.70	7.00*	73.00*	73.75	300.30
BBM 14	215.80	26.00	41.00	28.00	11.06	5.83	7.08	6.00*	51.10	60.00	198.21
BBM 15	150.90	18.00	30.00	25.00	9.32	3.12	5.65	4.00	57.80	58.40	141.15
BBM 16	207.50	25.00	41.00	31.00	14.34*	4.23	7.90	6.00*	57.60	73.75	245.02
BBM 17	199.20*	24.00	40.00	23.00	9.52	3.39	5.66	4.00	58.10	60.00	130.27
BBM 18	182.60*	22.00	40.00	40.00*	14.40*	6.95*	7.97	7.00*	72.00*	73.75	318.96*
BBM 19	207.50	25.00	40.00	25.00	9.32	2.32	4.08	4.00	51.20	73.75	102.10
BBM 20	215.80	26.00	42.00	30.00	9.35	3.93	4.87	5.00	56.90	73.75	146.07
BBM 21	222.00	26.00	42.00	38.00*	14.00	6.26	7.98	7.00*	74.00*	70.00	303.09
BBM 22	230.00	26.00	41.00	30.00	14.25*	4.90	7.78	6.00*	50.00	72.00	233.34
BBM 23	160.50*	26.00	40.00*	20.00	9.20	3.18	5.50	4.00	57.80	62.00	110.00
BBM 24	210.00	26.00	41.00	30.00	14.22*	4.89	6.78	6.00*	50.00	73.75	203.34
BBM 25	208.40	26.00	42.00	37.00*	14.17*	6.87*	8.47	7.00*	76.00*	73.75	313.24*
BBM 26	195.90*	26.00	39.00	38.00*	9.20	3.88	4.84	5.00	51.10	60.00	184.07
BBM 27	195.90*	26.00	39.00	34.00*	14.03	5.82	7.98	6.00*	53.40	68.70	271.39
BBM 28	150.00*	16.00	36.00	28.00	10.14	3.86	5.98	5.00	59.10	63.50	167.41
BBM 29	230.00	23.00	45.00	32.00	14.17*	5.87	8.08	5.00	62.00	68.50	258.53
BBM 30	240.00	20.00	42.00	33.00*	14.53*	4.65	7.66	6.00*	63.00	66.40	252.71
BBM 31	190.00*	18.00	42.00	34.00*	10.32	2.92	4.45	5.00	54.50	55.40	151.23
BBM 32	150.00*	16.00	45.00	28.00	10.87	2.93	4.50	4.50	53.00	53.40	126.00
BBM 33	180.00*	16.00	43.00	29.00	14.06	3.83	7.08	5.00	51.10	68.40	205.29
BBM 34	250.00	24.00	45.00	40.00*	15.89*	6.12	7.70	7.00*	74.30*	73.75	308.00*
BBM 35	60.00*	8.00	38.00	14.00	8.32	1.50	4.65	3.00	47.80	54.50	65.04
Grand mean	190.70	22.40	40.57	30.80	12.33	4.51	6.77	5.39	59.05	67.84	212.72
Check-KKL-1	200.10	25.40	35.35	31.45	13.46	6.13	9.06	5.50	66.30	75.36	285.85
2SE	5.6	0.8	0.59	0.96	0.6	0.42	0.39	0.34	1.77	1.22	18.59

(**PH**- Plant height (cm), **LPP**- Leaves per plant, **DFF**- Days to first flowering, **PPP**- Pods per plant, **PL**- Pod length(cm)**, PG**- Pod girth(cm), **PW**- Pod weight(g), **FOPP**- Fresh ovules per pod, **100SW**- 100 seed weight(g), **SP** – shelling percentage (%)**, PYPP**- pod yield per plant(g))

Table 3: Range, mean in M_3 generation mutants of butter beans var. KKL-1.

Traits	Maximum	Minimum	Range	Mean
Plant height (cm)	250.00	60.00	190.00	190.70
Leaves per plant	26.00	8.00	18.00	22.40
Days taken for first flowering	45.00	30.00	15.00	40.57
Pods per plant	40.00	14.00	26.00	30.80
Pod length (cm)	15.89	8.20	7.69	12.33
Pod girth (cm)	6.95	1.50	5.45	4.51
Pod weight (g)	8.47	4.08	4.39	6.77
Fresh ovules per pod	7.00	3.00	4.00	5.39
100 seed weight (g)	78.00	47.80	30.20	59.05
Shelling percentage	73.75	50.85	22.90	67.84
Pod yield per plant (g)	318.96	65.04	253.92	212.72

Table 4: Genetic parameters in M_3 generation mutants of butter beans var. KKL-1.

Traits	PCV	GCV	h^2	GA	GA as per cent of mean
Plant height (cm)	19.65	18.52	88.83	8.61	4.52
Leaves per plant	20.18	18.53	84.36	8.50	37.91
Days to first flowering	8.93	8.33	87.00	5.74	14.13
Pods per plant	23.14	22.08	91.03	9.45	30.63
Pod length(cm)	19.69	16.46	69.90	7.64	61.79
Pod girth(cm)	31.89	24.27	57.93	8.85	196.50
Pod weight(g)	19.69	17.94	83.04	8.33	123.30
Fresh ovules per pod	24.74	20.31	67.38	8.41	156.23
Hundred seed weight (g)	15.96	14.48	82.34	7.47	12.64
Shelling percentage	12.31	11.63	89.35	6.83	10.07
Pod yield per plant (g)	34.15	28.03	67.35	9.88	4.64

CONCLUSIONS

From the above observations, it is evident that the physical mutagen has created variation in chromosome level in the M_3 progenies which lead to the evolution of new beneficial mutant mutants. The mean value observed for different traits in M_3 generation led to identification of a dwarf mutant line BBM35 recorded a very low plant height, BBM25 exhibited taller plant, an early mutant line BBM7 and a high yielding mutant line BBM18 were forwarded to M_4 generation.

FUTURE SCOPE

The present investigation resulted in identification of dwarf, early and high yielding mutants in M3 generation which should be studied for their stability in future generation and can be utilized in crop improvement programme of butter beans

Conflict of Interest. Authors have declared that no competing interests exist.

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