LR-4525
[1-6]

RESEARCH ARTICLE Legume Research- An International Journal, Volume Issue : ()

Genetic Variability Studies in Short Statured Early Maturing M_3 Generation Cluster Bean [*Cyamopsis tetragonoloba* (L.) Taub.] Mutants

P. Balasubramanian, C. Vanniarajan, V. Swaminathan,
J. Souframanien, Devi Suresh, M. Ananthan

10.18805/LR-4525

ABSTRACT

Background: The present germplasm of cluster bean lack the needed natural variability for developing early maturing short statured lines. Therefore, an attempt was made to study the magnitude of heritable variability stimulated through induced mutation in M_3 generation.

Methods: M_3 generation seeds of cluster bean variety MDU1 treated with gamma rays, electron beam and combination of gamma ray with EMS were used in the present investigation. The biometric observations were recorded on ten selected M_3 plants from each family of every treatments for six traits *viz*., plant height, days to first flowering, number of clusters per plant, number of pods per plant, pod length and pod yield per plant. The same method was followed for recording observations on untreated parental materials also.

Result: Studies on the variability parameters indicated that the phenotypic variance, genotypic variance, heritability and genetic advance were higher in combination treatment for all the traits. The shortest mutant and the earliest flowering (3M11) was observed in combination of 100 Gy of gamma ray+20 mM EMS. Mutant for the highest number of clusters (3M3) was observed in combination treatment of 300 Gy gamma ray with 20 mM EMS. The mutants for the highest number of pods per plant (3M1 and 3M2) and the highest pod yield (3M1) were identified at 400 Gy of gamma ray treatment. Fifteen desirable mutants were selected and forwarded to next generation for testing the stability in different environments.

Key words: Cluster bean, Electron beam, EMS, Gamma rays, Genetic variability, Induced mutation.

INTRODUCTION

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] (Syn. *C. psoraliodies* D.C.) is a traditional underexploited vegetable crop grown mainly in the north western dry zones of India. Apart from being used as a vegetable cum fodder crop, it is getting industrial importance due to the galactomannan content. One of the major setbacks to the cluster bean production is the plant lodging due to adverse environmental conditions like downpour and strong winds. Hence, it is essential to develop short-statured crops with enhanced productivity.

The present germplasm of cluster bean lack the needed natural variability for developing superior short-statured high yielding lines. Generally, hybridization is the most common breeding method used to create the needed genetic variability in majority of the vegetable crops. The manual hybridization in cluster bean is a tedious process due to the tiny floral structure which makes it highly uneconomical to produce hybrid seeds. In such a scenario, induced mutagenesis can be efficiently used as an alternative source to create the desirable variability in physiological and morphological characters. Dahiya (1973) and Ram *et al.,* (1982) stated theoretically some genetic gain would be expected from selection for quantitative traits, assuming that the variability observed in the treated population is largely genetic and most of the genetic variance is additive in nature from mutagenic treatments is given by means and components of variance.

Selection of mutants for synchronization with determinate type suitable for mechanical harvesting is a major concern. Since genetic variability is a prerequisite for any successful breeding, the creation and management of such induced variability becomes a central base for the improvement of any crop. Creation of genetic variability followed by screening and selection of the best mutants is important. Mutation is considered as one of the effective tools for crop improvement. Spontaneous mutation cannot be expected to serve the cause of crop improvement effectively. Therefore, the present investigation was

Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.

Corresponding Author: P. Balasubramanian, Krishi Vigyan Kendra, Kuyavankudi Farm, Sathankulam-623 536, Tamil Nadu, India. Email: pbalasubramanian@tnau.ac.in

How to cite this article: Balasubramanian, P., Vanniarajan, C., Swaminathan, V., Souframanien, J., Suresh, D. and Ananthan, M. (2021). Genetic Variability Studies in Short Statured Early Maturing M_3 Generation Cluster Bean [*Cyamopsis tetragonoloba* (L.) Taub.] Mutants. Legume Research. DOI: 10.18805/LR-4525.

Submitted: 08-10-2020 **Accepted:** 02-06-2021 **Online:** 28-08-2021

undertaken to study the magnitude of heritable variability induced through induced mutation in M^3 generation of cluster bean variety MDU 1.

MATERIAL AND METHODS

The experiment was conducted from March (2019) to May (2019) at the College Orchard, Department of Vegetable Science, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai. MDU 1 mutant was used in this work taking into consideration of its higher yielding potential (250 to 300 g/plant) and other desirable attributing characters. It is a variety developed from Agricultural College and Research Institute, Madurai (TNAU) by selection from IC 432117 in 2015.

The seeds of cluster bean cv. MDU 1 were mutagenized using gamma rays, electron beam and combination of gamma ray with EMS to raise M_1 and M_2 generation. In M_2 generation, the shortest mutant was observed in combination treatment of 100Gy+20mM of EMS and earliest flowering in combination treatment of 300 Gy+20mM EMS. The highest number of clusters, number of pods per plant and pod yield per plant was observed at 300 Gy of gamma ray treatment. So a total of ninety mutants were selected for terminal flowering with yield in M_2 generation and forwarded to M_3 generation for the further variability studies. (Table 1).

Observations were recorded on ten selected M_3 plants from each family (Table 2) of treatments for six polygenically controlled traits *viz.*, plant height, days to first flowering, number of clusters per plant, number of pods per plant, pod length and pod yield per plant. The same method was followed for recording observation on untreated parental materials also. Throughout the growth period, recommended cultivation practices and protection measures were followed. The genetic variability parameters like per se performance, Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV) were estimated according to Burton (1952), heritability (Lush, 1940); genetic advance (GA) and genetic advance as percentage of mean by Johnson *et al*. (1955). Correlations between the traits were estimated using SPSS software and skewness and kurtosis have been estimated as per the statistical procedure given by Panse and Sukhatme (1978).

RESULTS AND DISCUSSIONS

Estimation of genotypic variability in irradiated population would reveal the heritable portion of total variation created. The GCV provided a mean to study the genetic variability generated in quantitative characters Johnson *et al*., (1955). The GCV alone is not sufficient to account the heritable variability. In addition, assessment of heritability and genetic advance as percentage of mean is also required to assess the heritable portion of total variation and extent of genetic gain anticipated for effective selection. As heritability in broad sense includes both additive and epistatic gene effects, it will be reliable, if accompanied by high genetic advance Burton (1952). Johnson *et al*. (1955) suggested that heritability estimates coupled with genetic advance are more helpful than the heritability values alone. This is because the heritability estimates are subjected to genotype–environment interactions Kaul and Kumar (1983). Moreover, genetic advance gives the extent of stability and genetic progress for a particular trait under a suitable selection system.

Here, six polygenically controlled traits *viz*., plant height, days to first flowering, number of clusters per plant, number of pods per plant, pod length and plant yield per plant were recorded in the progenies raised in M_3 generation. (Table 3)

Studies on the variability parameters in M_3 generation indicated that the phenotypic variance, genotypic variance, heritability and genetic advance were higher in combination treatment for all the traits. For plant height, the highest PCV (30.72%), GCV (30.17%) and GAM (61.04%) were recorded in combination treatment (300Gy of gamma ray with 20 mM EMS) and the highest h2 (98.24 %) was recorded in 200 Gy of electron beam. For pod yield per plant, the highest PCV (42.11%), GCV (41.78%), h2 (98.42%) and GA as percentage of mean (85.38%) were observed in combination treatment of 300Gy of gamma ray with 20 mM EMS.The high value of heritability accompanied with high value of genetic advance indicated that heritability is most likely due to additive gene effect and selection would be effective

Table 1: Lethal dose fixed treatments.

Mutagens	Gamma rays	Electron beam	Gamma rays+ EMS
	300Gy (T1)	200Gy (T4)	100Gy+20mM (T7)
Concentrations	400Gy (T2)	300Gy (T5)	200Gy+20mM(T8)
	500Gy (T3)	400Gy (T6)	300Gy+20mM (T9)

Non-treated dried seeds - control (T0) LD50 dose: gamma rays - 406.69 Gy, electron beam - 302.46 Gy, EMS+ gamma rays - 202.45 Gy.

Table 2: Number of plants from each family studied in M_3 generation.

Gamma rays		Electron beam		Combination of gamma rays + EMS	
Treatments	Number of plants	Treatments	Number of plants	Treatments	Number of plants
T1	10	T4	10	T7	10
T2	10	T5	10	T8	10
T3	10	T6	10	T9	10

Total number of plants studied = 90,T0 – control treatment.

method for forwarding these traits to next generation. The interrelation of various yield components showed that the plant height exhibited high positive and significant association with number of clusters per plant and number of pods per plant. Similar results were reported by Jukanti *et al*. (2015) in cluster bean, Usharani and Kumar (2015a) in black gram, Baisakh *et al*. (2014) in blackgram and Lavanya *et al*. (2014) in green gram.

Table 3.1: Mean and components of variance for plant height in M_3 generation.

Treatments	Mean	PCV (%)	GCV (%)	h2 (%)	GA as % of mean
Control (T0)	112.90	-	-	-	-
Gamma rays					
300 Gy (T1)	134.23	18.24	18.02	97.65	36.68
400 Gy (T2)	121.96	21.47	21.25	97.94	43.31
500 Gy (T 3)	86.92	29.90	29.59	97.91	60.31
Electron beam					
200 Gy (T4)	124.20	22.76	22.56	98.24	46.07
300 Gy (T5)	96.89	13.47	12.91	91.73	25.46
400 Gy (T6)	88.34	14.34	13.70	91.22	26.95
Combination of gamma rays + EMS					
100 Gy + 20 mM (T 7)	85.60	23.31	22.89	96.46	46.31
200 Gy + 20 mM (T 8)	86.76	24.28	23.89	96.83	48.44
300 Gy + 20 mM (T 9)	64.95	30.72	30.17	96.46	61.04

Table 3.2: Mean and components of variance for days to first flowering in M3 generation.

Treatments	Mean	PCV (%)	GCV (%)	h2 (%)	GA as % of mean
Control (T0)	24.09	-	-	-	-
Gamma rays					
300 Gy (T1)	24.18	7.14	5.04	49.93	7.34
400 Gy (T2)	24.35	9.56	8.14	72.50	14.28
500 Gy (T 3)	21.05	10.42	8.66	69.04	14.83
Electron beam					
200 Gy (T4)	22.98	7.63	5.47	51.44	8.08
300 Gy (T5)	23.49	8.76	7.05	64.77	11.69
400 Gy (T6)	23.42	9.03	7.37	66.63	12.39
Combination of gamma rays + EMS					
100 Gy + 20 mM (T 7)	22.93	12.65	11.47	82.27	21.43
200 Gy + 20 mM (T 8)	22.11	11.48	10.06	76.86	18.18
300 Gy + 20 mM (T 9)	20.36	9.61	7.51	61.06	12.09

Table 3.3: Mean and components of variance for number of clusters per plant in M3 generation.

Treatments	Mean	PCV (%)	GCV (%)	h2 (%)	GA as % of mean
Control (T0)	28.36	-	-	-	-
Gamma rays					
300 Gy (T1)	29.29	13.56	12.46	84.45	23.60
400 Gy (T2)	26.40	16.02	14.88	86.27	28.46
500 Gy (T 3)	19.96	38.68	37.88	95.88	76.41
Electron beam					
200 Gy (T4)	25.92	23.23	22.43	93.23	44.61
300 Gy (T5)	17.80	13.81	10.64	59.36	16.89
400 Gy (T6)	15.96	12.34	7.47	36.69	9.33
Combination of gamma rays + EMS					
100 Gy + 20 mM (T 7)	18.46	26.35	24.95	89.63	48.66
200 Gy + 20 mM (T 8)	16.60	27.68	26.02	88.37	50.39
300 Gy + 20 mM (T 9)	11.84	29.32	26.17	79.64	48.11

Mean performance for quantitative characters for selected dwarf mutants in M_3 generation

Observations were recorded based on mean performance and fifteen best performing mutants were selected for terminal flowering with high yield *viz.* 3M1, 3M2, 3M3, 3M4, 3M5, 3M6, 3M7, 3M8, 3M9, 3M10, 3M11, 3M12, 3M13, 3M14 and 3M15. The tallest mutants were 3M1 (77.5 cm followed by 3M4 (76 cm) and the shortest mutants were 3M11 (53.9 cm) followed by 3M14 (55.7 cm) and 3M12 (56.5 cm). The earliest flowering was observed 3M11 and 3M12 at 21st day

Table 3.4: Mean and components of variance for number of pods per plant in M3 generation.

Treatments	Mean	PCV (%)	GCV (%)	h2 (%)	GA as % of mean
Control (T0)	116.90	-	-	-	-
Gamma rays					
300 Gy (T1)	112.87	10.54	10.16	92.87	20.16
400 Gy (T2)	106.09	10.44	10.00	91.78	19.74
500 Gy (T 3)	77.62	29.01	28.72	98.01	58.57
Electron beam					
200 Gy (T4)	103.48	15.60	15.30	96.13	30.90
300 Gy (T5)	84.15	11.05	10.39	88.34	20.12
400 Gy (T6)	79.54	11.24	10.51	87.38	20.24
Combination of gamma rays + EMS					
100 Gy + 20 mM (T 7)	78.69	24.24	23.90	97.23	48.54
200 Gy + 20 mM (T 8)	78.72	20.20	19.80	96.01	39.96
300 Gy + 20 mM (T 9)	54.68	37.99	37.54	97.66	76.43

Table 3.5: Mean and components of variance for pod length in M3 generation.

Treatments	Mean	PCV (%)	GCV (%)	h2 (%)	GA as % of mean
Control (T0)	12.66	-	-	-	-
Gamma rays					
300 Gy (T1)	12.75	5.05	4.96	96.49	10.04
400 Gy (T2)	12.45	4.86	4.76	96.02	9.60
500 Gy (T 3)	12.49	3.80	3.68	93.55	7.33
Electron beam					
200 Gy (T4)	12.82	4.51	4.41	95.65	8.88
300 Gy (T5)	12.98	2.43	2.25	85.40	4.28
400 Gy (T6)	12.73	3.76	3.63	93.63	7.24
Combination of gamma rays + EMS					
100 Gy + 20 mM (T 7)	12.63	5.07	4.98	96.45	10.07
200 Gy + 20 mM (T 8)	12.77	2.89	2.73	89.29	5.31
300 Gy + 20 mM (T 9)	12.48	4.63	4.53	95.64	9.12

Table 3.6: Mean and components of variance for pod yield in M3 generation.

Treatments	Mean	PCV (%)	GCV (%)	h2 (%)	GA as % of mean
Control (T0)	256.03	-	-	-	-
Gamma rays					
300 Gy (T1)	244.93	10.54	10.15	92.73	20.13
400 Gy (T2)	236.58	10.44	10.02	92.07	19.81
500 Gy (T 3)	174.63	29.54	29.27	98.18	59.76
Electron beam					
200 Gy (T4)	231.54	12.45	12.09	94.18	24.16
300 Gy (T5)	201.19	9.96	9.34	87.95	18.05
400 Gy (T6)	191.13	9.39	8.65	84.96	16.43
Combination of gamma rays + EMS					
100 Gy + 20 mM (T 7)	187.56	20.10	19.76	96.60	40.00
200 Gy + 20 mM (T 8)	189.04	17.55	17.16	95.60	34.56
300 Gy + 20 mM (T 9)	131.56	42.11	41.78	98.42	85.38

Table 4: Data of selected mutants of cluster bean in M_3 generation.

Mutants	PH	DFF	NOC/P	NOH	TNP/P	PL	PY
3M1	77.50	27.00	14.00	12.00	74.00	13.10	174.64
3M2	74.50	26.00	14.00	12.00	71.00	13.00	167.56
3M3	65.80	25.00	15.00	13.00	67.00	12.60	158.12
3M4	76.00	25.00	14.00	12.00	69.00	13.20	162.84
3M5	62.50	24.00	13.00	11.00	58.00	13.00	136.88
3M6	68.40	24.00	12.00	12.00	63.00	13.10	148.68
3M7	72.60	25.00	12.00	12.00	66.00	12.80	155.76
3M8	70.00	25.00	12.00	12.00	65.00	12.60	153.40
3M9	59.80	23.00	11.00	11.00	57.00	12.90	134.52
3M10	62.70	24.00	10.00	10.00	59.00	12.50	139.24
3M11	53.90	21.00	9.00	10.00	48.00	12.60	113.28
3M12	56.50	21.00	10.00	10.00	52.00	13.10	122.72
3M13	59.80	21.00	10.00	10.00	54.00	13.00	127.44
3M14	55.70	21.00	10.00	10.00	49.00	13.00	115.64
3M15	57.50	21.00	11.00	11.00	51.00	12.00	120.36

PH- Plant height (cm), DFF-Days to first flowering, NOC/P- Number of clusters per plant, TNP/P-Total number of pods per plant, PL-Pod length (cm), PY-Pod yield per plant (g), NOH-Number of harvests per plant.

3M1, 3M2, 3M3, 3M4 - 400 Gy, 3M5, 3M6 - 500Gy (Gamma rays).

3M7 - 300 Gy, 3M8,3M9 - 400 Gy (Electron beam).

(Gamma rays + EMS).

3M10,3M11 – 100 Gy + 20 mM,

3M12,3M13 – 200 Gy + 20 mM,

3M14,3M15 – 300Gy + 20mM

and highest number of clusters was in 3M3 (15) and 3M1 had 14 clusters. The highest number of pods per cluster was recorded in 3M1 and 3M2 with 6.4 pods. The highest number of pods per plant was observed in 3M1 (74) and 3M2 (71). The longest pods were observed in 3M4 (13.20 cm) and 3M1 had 13.10 cm. The maximum number of harvest was observed in 3M3 (13) followed by 3M1,3M2 and 3M4 had 12 harvest. The highest pod yield was obtained in 3M1 (174.64 g) followed by 3M2 (167.56g) and 3M4 (162.84 g). (Table 4). The findings for morphological characters are similar to findings of Jagtap and More (2016) in lablab, Sultan *et al.,* (2012) in cluster bean and Shinde *et al.* (2017) in cluster bean.

The shortest mutant 3M11 and earliest flowering mutant 3M11 were found at combination of 100Gy of gamma ray+ 20mM EMS. Whereas mutant 3M3 with the highest number of clusters was observed at combination of 300 Gy gamma ray with 20 mM EMS. Also the highest number of pods per plant in 3M1 and 3M2 and highest pod yield in 3M1 were observed at 400 Gy of gamma ray treatment. The selected mutants have to be tested for stability in different environments.

CONCLUSION

The macro mutants *viz.*, tall, dwarf, early maturity, late maturity, synchronized maturity, determinate type, terminal flowering and high yielding mutants were isolated from the M_3 generation of cluster bean. The determinate mutants with synchronized maturity were selected based on suitability for mechanical harvesting and were forwarded to next generation for testing the stability in different environments.

REFERENCES

Baisakh, B., Das, T.R. and Panigrahi, K.K. (2014). Genetic variability and correlation analysis for yield and yield contributing traits in advanced mutant lines of blackgram. Food Legumes. 27(3): 202-205.

Burton and Glenn, W. (1952). Quantitative inheritance in grasses. Pro VI Int Grassl Cong, 1952: 277-283.

Dahiya, B.S. (1973). Improvement of mung bean through induced mutations. Indian Journal of Genetics and Plant Breeding (The). 33(3): 460-468.

Jagtap, S.S. and More, A.D. (2016). Induction of Morphological Leaf Mutations in *Lablab purpureus* (L.) Sweet through Chemical and Physical Mutagens. International Journal of Current Microbiology and Applied Sciences. 5(10): 592 - 597.

Johnson, Herbert, W., Robinson, H.F and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybeans 1. Agronomy Journal. 47(7): 314-318.

Jukanti, Kumar, A., Bhatt, R., Sharma, R. and Kalia, R.K. (2015). Morphological, agronomic and yield characterization of cluster bean (*Cyamopsis tetragonoloba* L.) germplasm accessions. Journal of Crop Science and Biotechnology. 18(2): 83-88.

Kaul, M.L.H. and Kumar, V. (1983). Mutation genetic-studies in rice. 4. Variability components and genetic-parameters. Biologisches Zentralblatt. 102(5): 559-566.

Lavanya, A.S. and Vanniarajan, C. (2014). Clustering of Greengram [*Vigna radiata* (L.) Wilczek] Genotypes Based on Qualitative Characters. Vegetos-An International Journal of Plant Research. 27(2): 389-393.

Lush and Jay, L. (1940a). Intra-sire correlations or regressions of offspring on dam as a method of estimating heritability of characteristics. Journal of Animal Science. (1): 293-301.

Panse, V.G. and Sukhatme, P.V. (1978) Statistical methods for Agricultural Workers. ICAR, New Delhi.

Ram, H.H, Verma, V.D. and Singh, K. (1982). Note on the effect of selection for quantitative traits in the M progenies of soybean. Indian Journal of Agricultural Sciences.

Shinde, Rao, M.S. and More, A.D. (2017). Induction of Macromutations in Cluster Bean (*Cyamopsis tetragonoloba*) through mutagens. International Journal of Scientific Research.6 11(179 - 181).

Sultan, Maria, Rabbani, M.A., Shinwari, Z.K. and Masood, M.S. (2012). Phenotypic divergence in guar (*Cyamopsis tetragonoloba*) landrace genotypes of Pakistan. Pak. J. Bot. 44(S1): 203-210.

Usharani, K.S. and Kumar, C.R.A. (2015). Induced polygenic variability using combination treatment of gamma rays and ethyl methane sulphonate in Blackgram [*Vigna mungo* (L.) Hepper]. African Journal of Biotechnology. 14(20): 1702-1709.