Indian J. Genet., **59**(2): 193-201 (1999)

MUTAGEN INDUCED POLYGENIC VARIABILITY IN MUNGBEAN (*VIGNA RADIATA* WILCZEK L.)

J. L. TICKOO AND N. CHANDRA

Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012

(Received: December, 1998; accepted: April 28, 1999)

ABSTRACT

Two varieties of mungbean were treated with three chemical mutagens and gamma rays. In M_2 and M_3 observation on six characters were recorded for overall variance, interfamily variance and character means. All mutagen doses induced significant variability. Mean values showed a negative shift for most of the characters in M_2. Plants with desirable attributes were selected from M_2 families showing higher CV and mean values than the highest corresponding values from the respective control group of families. Selection in M_2 was effective as mean values in M_3 shifted in positive directions and in M_3 interfamily variances increased over corresponding M_2 treatments. In M_3 alongwith the positive shift of mean values, both interfamily and overall variances were still significantly higher than the respective control values indicating scope for further selection and improvement of characters governed by polygens. In M_5 yield trial, the selected strains gave yields upto 19.7 q/ha against control yields of 12.2 q/ha. The study reveals that mutagenesis is a potent tool for the improvement of polygenic characters, provided large populations are raised and rigrous selection procedures are followed.

Key words : Mungbean, mutagenesis, polygenes, micromutations.

Mungbean is grown in more than three million hectares in India with the national productivity being around 400 kg/ha only. The limited improvement in the grain yield is partly due to the lack of sufficient genetic variability in this crop. The alleles of higher productivity may have been lost, owing to cultivation of the crop under environments, not very much different from the ones which its wild relatives have been growing for centuries now [1]. Cultivation under rainfed marginal farming conditions, without any inputs fertilizers, pesticides and any serious selection efforts, the plant has maintained wild characteristics like photo and thermosensitivity, indeterminate growth habit, low harvest index and zero dormancy of seeds etc.

Under the emerging intensive cropping systems, with growing awareness and concern among both scientists and farmers for soil health and sustainable crop production, mungbean can emerge as the most important grain legume crop, provided determinate growth early and high yielding varieties are developed. Variability being the essence of selection and varietal development in crop plants, the present study was undertaken to assess and quantify the mutagen induced variability in some agronomically important characters of mungbean.

MATERIALS AND METHODS

Two mungbean varieties, Pusa Baisakhi and Mohini were treated with Ethyle Methane Sulphonate (EMS, 0.1% and 0.2%), Nitrosomethyle Urea (NMU, 0.01% and 0.02%), Hydroxylamine (HA, 0.06% and 0.07%) and gamma rays (30 kR and 40 kR). M_1 single plants, harvested individually were planted as M_2 family rows in three replications. All M_2 family plots consisted of single five meter long rows with spacing of 30 and 10 cms between rows and adjacent plants respectively. Compact family block layout was used in M_2 to M_4 generations with families as main plots and plants selected within these families as subplots. Each of the resultant 18 treatments, including two checks, had 100 to 200 families and the total population of these M_2 generation was about 4,00,000 single plants. Observations on micromutations viz. grain yield per plant, pods per plant, seeds per pod, 100 seed weight, harvest index and days to flower were based on 50 randomly selected families in each of the 18 treatments. Ten random plants from each of the two replications of the above stated 50 families more chosen for observation. Observations in M_3 were limited to 10 randomly selected families in each treatment, each family again consisting of 10 randomly selected plants from each of the two replications. Thus observations in M_2 were based on 18000 single plants and in M_3 on 3600 single plants for estimating the nature and magnitude of the induced micromutations. The selections in M_2 and M_3 families were made on the basis of family means and coefficients of variability. Families with higher means and higher coefficients of variability than the highest corresponding values from 50 families of respective control treatments were selected. From these families the single plants progenies with the desirable attributes were selected and advanced into next generation.

Generations were advanced to multiply the selected M_3 materials to conduct grain yield trial in M_5 generation. M_4 lines, derived from the selected M_3 families, that were uniform in maturity, plant type and seed characteristics were bulked. In M_5, 41 of these selections along with seven other selected high yielding macromutants and the two checks were evaluated in a RBD trial with four replications. Each M_5 plot consisted of three rows, four meter long each with spacings of 30/10 cms.

RESULTS AND DISCUSSIONS

In India, 43 varieties of cereal crops, 38 of grain legumes, 23 of oilseeds, 13 of fibre crops and 10 of millets that were developed by mutagenesis, have been released/approved for cultivation [2]. The polygenic characters viz. high grain yield, early maturity, plant type quality characters, grain quality, abiotic stress and biotic resistance have been improved by mutagenesis [1-5, 7]. These findings are enough evidence that mutagenesis is a potential tool to be employed in the crop improvement.

The response to mutagens, as measured by the magnitude and the nature of the induced variability varied from character to character and between the two varieties. The estimates of overall and interfamily variances showed significant increases in all mutagenic treatments for all the six characters in both M_2 and M_3 [Table 1]. For seeds per pod in Pusa Baisakhi and seed weight in Mohini, the overall variance values though significant in M_3, were comparatively of smaller magnitude. In all characters except pods per plant in Pusa Baisakhi, the overall variances though still significantly higher than the respective control values, decreased in M_3

Table 1. Mutagen induced variability in M_2 and after one cycle of selection in M_3 generation

Character		Pusa Baisakhi		Mohini	
		M_2	M_3	M_2	M_3
Days to flower	(C)	1.00	0.23	1.05	0.33
	(T)	22.16**	10.76**	23.50**	12.22**
Harvest Index	(C)	14.66	9.81	9.59	4.78
	(T)	89.53**	41.54**	84.39**	39.57**
Pods/Plant	(C)	9.25	10.15	7.46	7.06
	(T)	39.96**	44.59**	71.61**	51.14**
Seeds/pod	(C)	0.24	0.22	0.15	0.21
	(T)	2.00**	0.52*	2.46*	0.69**
100 Seed wt.	(C)	0.004	0.003	0.004	0.004
	(T)	0.72**	0.29**	0.57**	0.29**
Yield/plant	(C)	1.64	1.67	1.44	1.17
	(T)	6.08**	5.28**	9.71**	6.67**

(C) = Control; (T) = Treatment average

after one cycle of selection in M_2. The only insignificant interfamily variance was observed for seeds per pod in M_3 for variety Pusa Baisakhi. [Table 2]. Many earlier

Table 2. Mutagen induced interfamily variances in M_2 and after one cycle of selection in M_3 generation

Character		Pusa Baisakhi		Mohini	
		M_2	M_3	M_2	M_3
Days to flower	(C)	1.18	0.15	1.59	0.53
	(T)	36.93**	107.87**	35.43**	124.21**
Harvest Index	(C)	16.30	14.55	10.06	3.95
	(T)	138.49**	103.28*	107.07**	93.69*
Pods/Plant	(C)	13.51	21.50	10.13	12.84
	(T)	66.76*	217.24**	126.98**	161.37**
Seeds/pod	(C)	0.29	0.39	0.13	0.23
	(T)	2.82**	0.62	3.21**	0.89**
100 seed wt.	(C)	0.01	0.009	0.00	0.003
	(T)	1.06**	3.12**	0.75**	3.12**
Yield/plant	(C)	2.26	3.55	2.03	2.14
	(T)	11.98**	17.13**	17.51**	19.68*

(C) = Control; (T) = Treatment average

workers have also observed significant mutagenically induced interfamily and overall variances for all the studied characters, associated with a negative shift of some treatment means in the treated populations against the control means [3-8].

Induced variability though less in magnitude was still prevalent in M_3. In some characters, these workers found that mean values shifted equally in both negative and positive directions.

In M_2, interfamily variances increased significantly by mutagenic treatments for all the six studied characters. In soybean [9] similar results were obtained. In mungbean, increase of overall variance in M_2 was observed. The magnitude varied with mutagen, dose and the variety. Certain treatments were more effective in increasing the overall variance than the interfamily variance and vice versa. In M_3 while the overall variances were lesser than that in M_2 for the corresponding characters and treatments, the interfamily variances registered an increase for most of the characters. This suggests that the selection applied in M_2 families was effective and certain M_3 families were superior than other families. Interfamily variance in M_3 increased as a result of selection in M_2 and due to the correlated response for other characters as a result of selection for any one particular character. For seeds per pod and harvest index, the M_3 interfamily values, though still significantly higher than the respective control values, were lower than the corresponding M_2 values in both the varieties. This indicates that selection for days to flower, pods per plant, 100 seed weight and single plant grain yield has been more effective. The results were on expected line, as during selection in M_2 more weightage was given to the later group of characters. This could also be due to the lack of correlated response of seeds per pod and harvest index to the selection made in the other four characters. Less increase in variance for some characters in some treatments, could also be due to the variance prevalent in the test materials/varieties for such characters having reached the genetic limits, under the natural evolutionary process. So lesser enhancement in variability was obtained when mutagenesis was employed in characters like days to flower and seeds per pod. M_3 treated populations still retained considerable amount of variability owing to the polygenic nature of inheritance of the characters studied. Thus mutagenesis holds great promise in increasing polygenic variation in grain legumes where available variability in the gene pool is limited.

The mean values of all the characters in M_2 and M_3 changed significantly over their respective controls except for days to flower in both varieties, for seeds per pod in Pusa Baisakhi and pods per plant in Mohini, in M_2. Therefore the response, of two varieties and the six characters studied to mutagenic treatment, was not same in respect to their mean values [Table 3].

Table 3. Treatment means in M_2 and after one cycle of selection in M_3 generation

Character		Pusa Baisakhi		Mohini	
		M_2	M_3	M_2	M_3
Days to flower	(C)	36.72	36.25	37.00	36.58
	(T)	36.93	35.88*	37.41	37.16**
Harvest Index	(C)	30.20	30.81	30.87	30.26
	(T)	34.40**	31.50	32.13*	31.56*
Pods/Plant	(C)	17.83	19.18	16.94	18.72
	(T)	12.39**	25.37**	16.08	29.45**
Seeds/pod	(C)	9.65	9.68	9.81	9.72
	(T)	9.10	9.91**	9.05	9.82
100 Seed wt.	(C)	4.38	4.38	4.38	4.38
	(T)	3.97**	4.19**	3.73**	4.05**
Yield/plant	(C)	7.55	8.17	7.27	7.97
	(T)	4.49**	10.25**	5.42**	11.50**

(C) = Control; (T) = Treatment average

Harvest index in both the varieties increased significantly in M_2 by mutagenic treatment. It is because the previous selection history of this character in mungbean has been for vegetatively bigger, taller, bushy and low harvest index plant type.

The mutagenic treatments have brought a change in the opposite direction of the previous selection history. Selection for high harvest index was effective in Mohini but not in Pusa Baisakhi. This is explained owing to already a comparatively compact plant type of Pusa Baisakhi against a tall and bushy and high bio-mass plant type of Mohini. For seeds per pod, the response to selection has been quite opposite to the harvest index. It has increased in Pusa Baisakhi in M_3 but did not increase significantly in Mohini. For yield per plant, pods per plant, seeds per pod and 100 seed weight, the induced variability was mainly in the negative direction, as the population means in M_2 for above characters were lower as compared to the corresponding values in the control. Similar changes in mean values of mutagenically treated materials in M_2 and M_3 have been demonstrated in various crop plants [10, 11]. There are also reports of increase in variance with mean values remaining unchanged [12]. In pea and lentil, along with increased variance, the means values approximated around the control population values, implying that induced variation was in both positive and negative directions and almost in equal proportions [13]. In these crops it was found that variance decreased in the selected material but increased in unselected material in M_3 for almost all the characters that were studied.

The M_2 means for yield per plant, pods per plant and 100 seed weight shifted significantly in negative direction. M_2 mean values for days to flower for both the varieties and for pods per plant in Mohini in both control and treated populations were comparable. Similar observations in chickpea and pigeonpea were observed in M_2 [12]. The analysis of variance and the observations on variety and treatment interactions suggest that the individual treatments differed more in M_3 than in M_2 in generating variability and for overall mean values. In M_3 populations, a shift in mean values in the desired direction is evident for all the characters. For yield per plant and pods per plant notably, the means increased significantly in the mutagenically derived populations and were still associated with a high overall and interfamily variance values. Such associations of increased means with significantly high overall and interfamily variances suggest scope for further selection in the M_3 test populations. This potential was explored as is evident from the results obtained in M_5 generation. Using both chemical mutagens and gamma rays, many other workers have also found mean values decreasing significantly for most of the characters in M_2 generation, suggesting occurrence of more polygenic mutations in negative direction [14, 15]. They attributed the decline to either physiological damage caused chiefly by chemical mutagens or chromosomal aberrations caused mainly by irradiations. These physiological disturbances get eliminated progressively in the subsequent generations.

Grain yield is a complex character and is influenced by many other quantitative characters. Decrease in yield in M_2 in the present work is expected, as most of the yield components get adversely affected by mutagenic treatments. Most of the induced mutations are of deleterious nature and recessive and this explains the reduction in the mean values. Brock [15] observed that random mutations in characters with definite selection history, shift the treatment means away from the control mean, in the direction, opposite to the previous selection history. Contrarily, it is proposed that random mutations bring about unidirectional changes in the mean values of almost all the quantitative characters of interest to the plant breeder [16]. The change is independent of genotype, but is associated with vitality. The present findings showed that induced variability is overwhelmingly in the opposite direction to the previous selection history, but there are exceptions to this rule. The view expressed by Gaul [16] that vitality of the genotype is the probable factor governing the mean behaviour, though partly explains the irregular behaviour of the mean, still is not satisfactory. In the present investigation in five of the six characters studied, the M_2 mean values got significantly reduced. The sixth character harvest index registering an increase in M_2 mean values, also confirms Brock's theory, because the previous selection for the character uptill now has been for bigger leafy plant types and consequently for low harvest index values. It is generally expected that most of the induced mutations are of recessive nature and if a parental character is determined by wild type genes, the induced variation will largely be in the reverse direction. On the other hand, recessive genes if involved in determinating a character in the parent, only a very small fraction of the induced variation in the opposite direction is to be expected. Most quantitative characters however, have a complex genetic determination involving a large number of genes interacting with one another. Consequently variation in both the directions is to be expected, although the two components will not be uniformly generated. it is implied that in this study, for characters days to flower, seeds per pod and pods per plant in Mohini and for days to flower and seeds per pod in Pusa Baisakhi the number of plus and minus effects in the studied quantitative characters were essentially equal.

Yield Evaluation in M_5 generation

The M_5 yield trial included 32 selected strains from M_4 families of variety 'Mohini' (MS) and 12 such strains from M_4 families of variety Pusa Baisakhi (MP). Eleven of the MS and eight of the MP strains gave significantly higher grain yields than their respective checks [Table 4]. The maximum yield increase among MS strains was 61.6% and 49.4% in M.P. strains over their respective checks. MS-41 gave a yield of 19.7 q/ha against the check yield of 12.2 q/ha. MP-33 yielded 14.3 q/ha against 9.5 q/ha by its check variety Pusa Baisakhi. The results support the earlier work that micromutations being least deleterious, useful variations can be induced, and if adequate selection is practiced, improved strains can be obtained [17].

Table 4. Performance of some high yielding M_5 selection

Character	Grain Yield		Percent increase over check
	Per plot kg/ha	q/ha	
Mohini (check)	439.50	12.21	-
MS-1	477.75	13.27	9.5
MS-4	494.25	13.73	12.45
MS-7	509.50	14.15	15.89
MS-15	470.75	13.08	7.12
MS-19	529.75	14.71	20.48
MS-25	488.75	13.58	11.22
MS-27	506.00	14.06	15.15
MS-28	641.50	17.82	45.95
MS-31	496.00	13.78	12.86
MS-22	404.50	14.01	14.74
MS-41	710.25	19.73	61.59
Pusa Baisakhi (Check)	345.00	9.54	-
MP-2	457.50	12.71	32.67
MP-10	465.00	12.92	34.86
MP-21	436.50	12.13	26.62
MP-32	424.74	11.80	23.70
MP-26	476.00	13.22	38.00
MP-33	515.25	14.31	49.37
MP-39	373.50	10.38	8.35
MP-44	414.25	11.51	20.15
MP-48	378.50	10.51	9.71

C.D. at 5% = 30.06; C.D. at 1% = 39.50

Despite getting the above encouraging results, our experience has been that the induced desirable variations in a trait are often associated with many other undesirable changes and it is often necessary to use the same technique of selection and hybridization as in the case of conventional breeding programmes. Clearly a greater control over mutation process is required before this tool can be wider application the desired way. As of today, we may not be able to induce variability useful always unless a very large scale programme is undertaken as was done in the present study. Small experients with limited early generation populations are more likely not to meet up the plant breeders efforts to select more useful crop plants.

REFERENCES

1 H. K. Jain. 1975. Breeding for yield and other attributes in grain legumes. Indian J. Genet., **35**: 169-187.

2. M. C. Kherakwal. 1996. Accomplishments of mutation breeding in crops plants in India. *In* : Isotopes and radiation in agriculture and environmental research. Ed: M. S. Sachdev and D. L. Deb, pp 196-218.

3. K. Virupakshappa, D. M. Mahishi and G. Shivashankar. 1980. Variation in cowpea following hybridization and mutagenesis. Indian J. Genet., **40**: 396-398.

4. A. Sarkar and B. Sharma. 1987. Induction and screening for polygenic variability for multiple characters in lentil (*Lens esculenta Medik*). Indian J. Genet., **47**: 179-182.

5. A Sarkar and B. Sharma. 1988. Efficiency of early generation selection for induced polygenic mutations in lentil (*Lens culinaris* Medik). Indian J. Genet., **48**: 155-159.

6. S. K. Bhadra. 1982. Studies on the genetic improvement of blackgram (*Vigna mungo* L. Hepper) through induced mutations. Unpubld. Ph.D. thesis, IARI, New Delhi.

7. B. K. Verma and D. P. Singh. 1984. Gamma ray induced variability in green gram. Indian J. Agric. Sci., **54**: 277-279.

8. I. A. Khan. 1984. Mutations induced by gamma irradiation, ethyl methane sulphonate and hydrazine hydrate in mungbean. Bot. Bull. Acad. Sinica., **25**: 103-110.

9. S. S. Meheyre, C. R. Mahajan, R. P. Shinde and R. D. Ghatge. 1996. Assessment of gamma rays induced genetic divergence in M_2 generation of soybean. Indian J. Genet., **56**: 186-190.

10. H. Gaul. 1965. The concept of macro and micromutations and results on induced micromutations in barley. *In* : Proc. The FAO/IAEA, Rome : 407-428.

11. R. E. Scossrolli. 1965. Value of induced mutation for quantitative characters in plant breeding. Rad. Bot. (Suppl.), **5**: 443-450.

12. C. H. Rao. 1974. Studies on induced variability in pigeonpea and chickpea. Unpubl. Ph.D. thesis, IARI, New Delhi

13. B. Sharma 1986. Increasing the efficiency of mutagenesis for micromutations by early generation selection. Indian J. Genet., **46** (Suppl.): 88-100.

14. D. S. Virk, S. S. Saini and V. P. Gupta. 1978. Gamma radiation induced polygenic variation in pure breeding and seggregating genotypes of wheat and rice. Env. Expt. Bot., **18**: 185-191.

15. R. D. Brock. 1965. Induced mutations affecting quantitative characters. Rad. Bot., **51** (Suppl.) 451-464.

16. H. Gaul and K. Aastveit. 1966. Induced variability of culm length in different genotypes of hexaploid wheat following X-irradiation and EMS treatment. Proc. of Fifth Yugoslav Symp. on Research in Wheat, Novisad., **12**: 263-276.

17. W. C. Gregory. 1965. Mutation frequency, magnitude of change and the probability of improvement in adaptation. Rad Bol., (Suppl.) **5**: 429-441.