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Induced Polygenic Variability in Soybean

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ABSTRACT

The magnitude of induced genetic variability for different quantitative characters was estimated in the M_3 generation of soybean varieties Bragg and Type 49 treated with 10, 15, 20, 25 and 30 Krad gamma rays; 0.2, 0.4, 0.5 and 0.6 per cent EMS and three combined treatments of gamma rays and EMS. The treatments with 15 Krad gamma rays, 0.2, 0.4, and 0.6 per cent EMS increased the yield/plant while 0.2 per cent EMS increased the yield/plot significantly as compared to the controls. The total variances within treated populations were significantly higher than the variances in control populations for most of the characters indicating induced polygenic variability. The magnitude of differences in variances for seeds/pod was highest between Bragg 0.6 per cent EMS and control. For yield/plant heritability in broad sense was estimated to be 66.5 per cent.

Key words : Polygenic, gamma rays, EMS, Krad

Efficiency of mutation breeding has been demonstrated in several crop species and a number of varieties with high yield potential, better standability and nutritional quality have been evolved[1]. However, this technique has remained practically unexploited for soybean improvement. Soybean is ideally suited for inducing useful mutations because the cultivated varieties of soybean (*Glycine max* L. Merrill) possess a very narrow genetic base[2] and its progenitor *G. ussuriensis*[3] is not much different. The persent investigation has been undertaken to ascertain extent of genetic variability induced by gamma rays and ethylmethanesulphonate (EMS) for different quantitative traits in soybean.

Materials and Methods

Samples of 200 seeds of Bragg and Type-49 soybean varieties were treated with 10, 15, 20, 25 and 30 Krad doses of gamma rays and 0.2, 0.4, 0.5 and 0.6 per cent EMS. The gamma irradiated seeds with 10 Krad were treated with 0.2 and 0.4 per cent EMS and those of 15 Krad with 0.2 per cent EMS. Treated seeds along with controls were planted in a single row plot in the split plot design with varieties as main plots and doses as sub-plots using three replications.

All the non-segregating M_2 progenies for qualitative characters, were bulked treatmentwise. A trial consisting of 26 treatments using the M_3 seeds was planted in split plot design with two replications. Varieties were kept as main plots and treatments as sub-plots. Each plot consisted of 5 rows which were 6 m long and 60 cm apart. Necessary agronomic practices were followed to raise a good crop. Twenty five plants from the middle 3 rows of each plot were tagged immediately after germination for taking observations on various quantitative characters. Yield was also recorded on plot basis. At maturity, 5 m strips of the middle 3 rows were

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harvested for estimating yield per plot to which the yield of separately harvested 25 plants was also added.

Analysis of variance was conducted to test the significance of differences among different treatments for different quantitative characters in M_3 generation. In order to test whether treated populations had significantly more variability for different quantitative characters as compared to their respective control populations in M_3 generation, 'F' test was used. It was assumed that the control population could provide an estimate of environmental variability and the treated populations would include environmental as well as induced genetic variability. The variance for particular character in control population was taken as an estimate of environmental variance and the broad sense heritability was calculated.

In view of the similarities between two set of results from the two varieties, data for variety Bragg only are presented in Table 1 and 2. The significant results from variety Type-49 are mentioned in the text.

Results

Days to flowering

Bragg took 40 days to flower whereas Type-49 flowered in 60 days. Within population variances were significantly higher in case of 25 Krad gamma rays, 0.4, 0.5 and 0.6 per cent EMS treatments of Bragg and Type-49 0.6 per cent EMS than their controls. Broad sense heritability ranged from 0 to 62 per cent.

Days to maturity

The populations which received 15, 20, 25 and 30 Krad gamma rays and 15 Krad gamma rays + 0.2 per cent EMS treatments showed delayed maturity, compared to their respective controls. The intrapopulation variances of the treated populations were significantly higher in many cases. The heritability estimates in broad sense ranged from 0 per cent to 73 per cent.

Plant height

All the treatments, single as well as combined reduced the plant height to a varying extent in both the varieties. Thus in Bragg the maximum reduction in plant height was noticed in the treatment with 15 Krad gamma rays + 0.2 per cent EMS, whereas in Type-49 the treatment with 0.6 per cent EMS resulted in maximum reduction in plant height. Similarly, 0.2 per cent EMS treatment had no effect on Type-49 but reduced the plant height of Bragg by 18 cm. Treatments with 15 and 20 Krad gamma rays and 0.4, 0.5, 0.6 per cent EMS and 15 Krad gamma rays + 0.2 per cent EMS in Bragg increased the intrapopulation variances significantly. In Type-49 irradiation with 15, 20 and 25 Krad gamma rays and EMS treatments of 0.5 and 0.6 per cent and 10 Krad gamma rays + 0.2 per cent EMS as well as 10 Krad gamma rays + 0.4 per cent EMS increased the within population variances significantly. Heritability estimates ranged from 0 to 89 per cent.

Primary branches per plant

All the four EMS treatments in Bragg increased the number of branches per plant whereas in Type-49 the treatments with 15 Krad gamma rays, 0.6 per cent EMS and all the combination treatments with gamma rays and EMS reduced the number of branches pei plant. The variabilily in different treated populations was greater than that of control. However, significant increase in variability was observed in Bragg 20 Krad and Bragg 0.6 per cent EMS treatments only. All the treated populations of Type-49 showed little or no increase in variance as compared to the untreated control. The heritability estimates in broad sense ranged upto 44 per cent.

Pods per plant

Data presented as Table 1 indicate the increase in mean number of pods per plant of Bragg treated with 15 Krad gamma rays, 0.2, 0.4, 0.5 and 0.6 per cent EMS, whereas treatment with 30 Krad gamma rays reduced the pods as compared to that in the control. Type-49 15 and 20 Krad gamma rays and 0.4, 0.5 and 0.6 per cent EMS treatments had more number of pods per plant as compared to the control. All the combination treatments with gamma rays and EMS reduced the mean number of pods per plant in Type-49. The variance of most of the treated populations of Bragg and Type-49 were higher than their respective controls. However, only 15 and 20 Krad doses of gamma rays, all the four EMS treatments and one combination treatment (10 Krad gamma rays + 0.2 per cent EMS) increased the variability significantly in both the varieties. The maximum broad sense heritability estimate was 79 per cent.

Seeds per pod

The two varieties used in the experiment did not differ much with respect to number of seeds per pod. Although the mean number of seeds per pod was not altered in most of the treatments, the variances of the treated populations were generally higher. In case of Bragg 0.6 per cent EMS, the variance was approximately 15 times more than the control population of Bragg. Similarly, 20 Krad treatment in Type-49 resulted in approximately 14 times as much variability as in the control. The heritability estimates were also found to be very high and up to 94 per cent broad sense heritability was recorded in 0.6 per cent EMS treated population of Bragg.

Seed weight

The inter-varietal differences between Bragg and Type-49 for 100-seed weight were quite marked. Seed size increased with the single as well as combined treatments with gamma rays and EMS. Significant increase in variences of treated populations was observed in 25 and 30 Krad gamma rays and 0.4, 0.5 and 0.6 per cent EMS treatments in Bragg and 20 Krad gamma rays, 0.6 per cent EMS and 10 Krad gamma rays + 0.2 per cent EMS and 10 Krad gamma rays + 0.4 per cent EMS treatments in Type-39. The heritability estimates were 85 per cent in case of Bragg 0.5 per cent EMS, 73 per cent for Bragg 0.6 per cent EMS, 51 per cent for Type-49 20 Krad and 54 per cent Type-49 0.6 per cent EMS.

Seed yield per plant and per plot

Bragg yielded more than Type-49. The treatments with gamma rays and EMS affected the yielding ability of soybean. However, significant differences were observed only in few cases. In Bragg the 15 Krad gamma rays and 0.2, 0.4 and 0.5 per cent EMS treatments caused significant increment in per plant yield, whereas the treatments with 25 Krad gamma rays, 10 Krad gamma rays + 0.4 per cent EMS and

Table 1. Effect of mutagen treatments on Bragg variety of soybean

Treatments	Days to flower	Days to maturity	Plant height (cm)	Primary branches	Pods per plant	Seeds per pod	100 seed weight (g)	Yield per plant (g)	Yield per plot (q/ha)
0 Krad	40	111	81.6	4.9	64.3	2.10	15.3	19.6	22.8
10 Krad	39	110	73.9	4.9	65.1	2.04	15.7	23.3	26.6
15 Krad	39	115*	74.3	5.5	84.8*	2.05	15.9	29.1*	25.1
20 Krad	42	116*	72.7*	4.1*	66.3	2.50*	17.8	17.1	19.3
25 Krad	42	120*	70.3*	4.2	60.8	2.05	17.8*	14.0*	18.2
30 Krad	42	118*	69.8*	4.6	51.7*	2.06	17.3*	17.9	18.9
0.2% EMS	40	110	63.7*	6.3*	105.5*	2.13	17.3*	29.2*	28.3*
0.4% EMS	40	108	61.0*	6.5*	101.7*	2.03	16.3	32.0*	27.0
0.5% EMS	39	111	61.4*	6.3*	104.3*	2.04	17.4*	26.4*	17.6*
0.6% EMS	39	111	59.8*	6.3*	101.1*	1.98	15.3	14.9	11.8*
10 Krad + 0.2% EMS	39	111	59.7*	5.1	64.4	2.00	17.7*	14.7	18.0*
10 Krad + 0.4% EMS	41	113	62.8*	4.0*	64.5	2.06	18.6*	13.1*	14.4*
15 Krad + 0.2% EMS	41	120*	59.3*	4.0*	58.9	2.20	16.4	13.5*	19.2
C. D.	3.0	4.0	8.3	0.8	12.8	0.25	1.2	5.6	4.6

*Significant at 5% level

Table 2 : The extent of variability for different quantitative characters in Bragg variety of soybean

Treatments	Days to flower	Days to maturity	Plant height (cm)	Primary branches	Pods per plant	Seed per pod	100 seed weight (g)	Yield per plant (g)
0 Krad	0.91	1.71	22.3	2.01	379.8	0.011	3.21	127.9
10 Krad	1.19	1.39	26.5	2.05	380.9	0.019*	2.88	129.1
15 Krad	1.21	1.91	82.5**	2.00	798.0**	0.025**	3.09	199.9
20 Krad	1.41	2.81*	87.0**	3.50*	780.1**	0.019*	3.74	285.9**
25 Krad	1.60*	3.42**	28.0	3.01	447.5	0.009	5.76*	201.3
30 Krad	0.98	4.00**	30.5	2.98	401.5	0.009	6.28**	210.3*
0.2% EMS	1.26	3.85**	31.9	2.93	944.9**	0.045**	4.24	265.8**
0.4% EMS	1.57*	3.04**	39.4	2.91	1150.3**	0.027**	6.26**	199.8
0.5% EMS	2.30**	4.03**	120.3**	2.99	911.3**	0.123**	21.10**	331.9**
0.6% EMS	2.39**	4.11**	49.7	3.58*	1160.0**	0.173**	11.59**	357.9**
10 Krad + 0.2% EMS	1.11	3.00**	21.0	2.07	860.3**	0.085**	3.84	139.8
10 Krad + 0.4% EMS	1.20	1.99	28.7	1.98	459.2	0.021*	4.01	148.8
15 Krad + 0.2% EMS	1.12	2.00	37.7*	1.89	402.1	0.017	4.55	252.8**

*Significant at 5% level
**Significant at 1% level

15 Krad gamma rays + 0.2 per cent EMS reduced the plant yield significantly as compared to control. The treatment with 0.2 per cent EMS caused increment in yield of Type-49 and per plant yield was 12.5 g as against 7.8 g for control. Per plot yields were significantly greater than control only in Bragg 0.2 per cent EMS and Type-49 0.2 per cent EMS populations. The per plot yields of Bragg 0.5, 0.6 per cent EMS, 10 Krad gamma rays + 0.2 per cent EMS, 10 Krad gamma rays + 0.4 per cent EMS were significantly lower than the control.

Most of the treated populations showed significantly higher variability than the respective control. The heritability estimates in broad sense were up to 66.5 per cent. The analysis of variance for split plot design indicated significant differences between Bragg and Type-49 for almost all the characters. The dose effect was mainfested only for plant height, number of primary branches, pods per plant, 100 seed weight, seed yield per plant and per plot yield. The variety × dose interaction was also significant for height, branches per plant, pods per plant, 100 seed weight and seed yield per plant and per plot yield.

Discussion

The utility of induced mutations in crop plants depends upon the specific or general superiority of the mutants with respect to yield, quality, disease and lodging *etc.* However, due to undesirable pleiotropic effect of mutant genes, multiple mutations of linked genes and chromosomal disorders, most of the mutants do not possess agronomic superiority and are therefore, often discarded[5,6]. This is particularly true for macromutations[4,5]. The ratio of desirable mutants to undesirable ones may range from 1 : 1000 to 1 : 100 depending upon crop species and breeding objectives. The mutations for genes affecting metric traits are often not visible on individual plant basis and their effect must be assessed by appropriate biometrical techniques. The increase in variance of treated populations over untreated control is the first definite indication of the occurrence of micromutations.

The yielding ability of crop plants is a complex quantitative character showing continuous variation and highly influenced by environmental factors. In spite of the difficulty of detecting yield mutants, there is no doubt about their existance and a number of mutant cultivars with improved yield have been released[1,7]. In the present investigation many of the M_3 populations had higher yield than controls. The frequency of induced as well as spontaneous positive yield mutants which may surpass the mother strain is very much low[8,9]. Therefore, large populations are required in order to raise the probability of finding such mutants.

Significant increase in variances of the treated populations over controls, for most of the quantitative characters and fairly high heritability for yield components in M_3 generation offer a definite possibility of improving these characters by further selection. In most of the cases, the mean of the treated population was either slightly better or similar to untreated control which indicated that micromutations were both in positive as well as negative direction. In the present investigation, the relative superiority of the mean of some of the treated populations further indicate that the frequency of positive micromutants was more than the negative ones. Therefore, it should be possible to extract true breeding homozygous lines from these populations through selection. The increase in variance of treated populations have been reported in peanuts[9], soybean[10] and green gram[11-13]. The doses of 20 Krad gamma rays and 0.2 per cent EMS were found to be effective and the effects of the mutagens were not additive with respect to mean or variance. Thus, mutagenic treatments with gamma rays and EMS may be used as a method of breeding, in addition to the existing conventional methods, to generate the genetic variability for improvement of soybean as in other crops.

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