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MUTATION STUDIES IN MUNG BEAN (*PHASEOLUS AUREUS* ROXB.)[1]

VI. Estimates of Genetic Variability

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Abstract

Studies were undertaken to explore the possibility of inducing micro-mutations in quantitative characters of mung bean, ***Phaseolus aureus*** Roxb., after treatment with hydrazine hydrate (HZ) and gamma rays in single and in combination treatments. Induced variation was studied for plant height, days to maturity and plant yield in the M2 generation. A shift in the mean values of treated populations occurred towards the positive direction for the two characters: days to maturity and plant yield. However, there was no particular shift in case of plant height. The coefficient of variability and heritability (b. s.) increased considerably in these characters, indicating the effectiveness of mutagenic treatments in inducing the polygenic mutations. The range of variability shifted both in negative and positive directions, more so in the positive direction. The genetic variance induced in single and in combination treatments can be exploited for the further improvement of plant yield of this pulse.

Introduction

The practical role of induced mutations in the improvement of crop plants can best be assessed on the basis of quantitatively inherited characters. Depending upon the crop plant, character to be improved and the availability of mass screening technique, mutation breeding is not only useful but also the most appropriate one in self-fertilizing species. Mung bean, *Phaseolus aureus* Roxb., being a self-pollinated crop, offers many opportunities of exploitation of mutations, recombinations and of increasing genetic variability in quantitative characters

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(Khan, 1982).

The purpose of the present investigation was to study the nature and direction of induced mutations for the quantitative characters. The characters studied were: plant height, days to maturity and plant yield in the M2 generation following treatment with hydrazine hydrate (HZ) and gamma rays used either singly or in combinations.

Materials and Methods

Dry seeds of uniform size of *Phaseolus aureus* Roxb. var. PS-16 were pre-soaked in distilled water for 9 h prior to treatment with four concentrations of hydrazine hydrate (HZ) ranging from 0.01% to 0.04%. The HZ solution was prepared using phosphate buffer of pH 7. The pre-soaked seeds were soaked in freshly prepared solution of HZ of each concentration for 6 h at a constant room temperature of 27±1°C. Control was maintained by treating the seeds with buffer solution.

For post-irradiation treatment, the dry seeds were irradiated with 20 kR of gamma rays and then soaked in distilled water for 9 h at the same temperature. The pre-soaked seeds were treated separately with the four concentrations of HZ for 6 h. The treated seed material was washed thoroughly in running tap water for half an hour. The control and treated seed material was sown directly in the field to study the three quantitative characters such as plant height, days to maturity and plant yield in the M2 generation. The details of sowing have been given earlier by Khan (1981).

Data on individual M2 plants were collected and statistically analysed. Mean, standard error of mean and coefficient of variation were calculated treatmentwise on population basis as per the standard procedures. The different treatments were compared with their respective controls. Since the samples were of unequal size, a correction had to be applied which was originally derived by Snedecor and Cochran (1968) and modified by Khan (1979). The expected mean squares for progeny rows are:

(a) Lines mean square = $\delta_e^2 + \lambda\,\delta_L^2$

(b) Error mean square = δ_e^2

where

$$\lambda = \frac{1}{k-1}\left(\Sigma\, n_i - \frac{\Sigma\, n_i^2}{\Sigma\, n_i}\right) \quad \text{or} \quad \frac{1}{k-1}\left(\mathrm{N} - \frac{\Sigma\, n_i^2}{\mathrm{N}}\right)$$

λ = Unequal size of the sample

k = Number of lines

$\Sigma\, n_i(\mathrm{N})$ = Size of the sample

n_i = The size of the sample for the ith line which varies from line to line.

Analysis of variance was computed to find out the variation between and within-families. The components of variance considered were:

(a) Within-family variation in the control and in the treated material which was an estimate of environmental variation.

(b) Between-family variation which was an estimate of between-family genetic variation.

The estimates of genetic variance due to difference between-families were obtained by substracting the error mean square from the lines mean square and then dividing the difference by Lamda (λ).

The broad sense heritability (h^2) of a character was estimated as follows:

$$h^2 = \frac{\delta_g^2}{\delta_t^2}$$

Where δ_g^2 = induced genetic variance and δ_t^2 = total phenotypic variance ($\delta_t^2 = \delta_g^2 + \delta_e^2$) calculated from the treated populations.

Results

The estimated range, mean, phenotypic and genotypic coefficients of variation and heritability for plant height, days to maturity and plant yield are shown in Tables 1 to 3 for treated and control populations.

Table 1. *Estimates of range* (R), *mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$), *shift in mean, coefficient of variation and heritability* (h^2) *for PLANT HEIGHT* (*cm*) *in the M2 generation*

Treatments	N	R	$\bar{X} \pm S\bar{x}$	Shift in $\bar{X}$	CV(p) (%)	CV(g) (%)	h^2 (b. s.)
Buffer control	247	23-46	36.96±0.5331	—	18.37	0.00	0.00
0.01% HZ	235	23-51	34.15±0.4727	−2.81	26.31	7.47	0.31
0.02% HZ	227	30-50	39.09±0.7338	+2.13	21.89	3.82	0.08
0.03% HZ	211	28-46	35.90±0.3954	−1.06	20.20	4.53	0.16
0.04% HZ	217	23-49	35.51±0.3363	−1.45	28.90	6.24	0.16
20 kR	243	25-47	34.88±0.6194	−2.08	21.64	1.74	0.01
20 kR+0.01% HZ	220	29-50	37.22±0.5344	+0.26	22.51	5.80	0.20
20 kR+0.02% HZ	206	29-50	37.73±0.6364	+0.77	24.75	6.89	0.26
20 kR+0.03% HZ	182	23-50	35.50±0.4523	−1.46	21.71	5.43	0.18
20 kR+0.04% HZ	181	27-47	37.73±0.4861	+0.77	20.70	3.95	0.09

CV(p) Phenotypic coefficient of variation.
CV(g) Genotypic coefficient of variation.

Plant Height

Date recorded for plant height (cm) showed that HZ and gamma rays used either singly or in combinations were capable of inducing much variation for this character. The range was much wider as compared to the control. It shifted only in positive direction. The mean plant height varied in the individual treatments of HZ and gamma rays (Table 1).

Phenotypic and genotypic coefficients of variation had increased in all the treatments as compared to their respective controls. Phenotypic coefficient of variation did not show much difference in single as well as in combination treatments. However, the genotypic coefficient of variance was high at the lowest treatment 0.01% HZ (7.47%), followed by 20 kR +0.02% HZ (6.89%) and then 0.04% HZ (6.24%). Highest values for heritability were recorded for 0.01% HZ and the lowest for 20 kR of gamma rays.

Days to Maturity

Days to maturity did not show appreciable difference in the range of variability. However, mean days to maturity increased almost in all the single and combinaion treatments. The mean values were significantly greater as compared to the control, with the exception of 0.01% HZ (Table 2).

Table 2. *Estimates of range* (R), *mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$), *shift in mean, coefficient of variation and heritability* (h^2) *for DAYS TO MATURITY in the M2 generation*

Treatments	N	R	$\bar{X} \pm S\bar{x}$	Shift in $\bar{X}$	CV(p) (%)	CV(g) (%)	h^2 (b. s.)
Buffer control	247	59-72	64.39±0.6817	—	18.60	0.00	0.00
0.01% HZ	235	59-72	65.11±0.6330	+0.73	29.07	8.75	0.71
0.02% HZ	227	59-76	68.57±0.8271	+4.18	31.75	8.67	0.37
0.03% HZ	211	59-72	66.10±0.5640	+1.72	28.18	8.48	0.68
0.04% HZ	217	59-73	65.95±0.5992	+1.56	30.50	0.09	0.75
20 kR	243	59-76	66.91±0.8117	+2.52	37.88	6.88	0.19
20 kR+0.01% HZ	220	62-76	70.20±0.6303	+5.81	20.17	7.29	0.73
20 kR+0.02% HZ	206	60-70	65.87±0.5026	+1.48	17.07	6.04	0.73
20 kR+0.03% HZ	182	61-70	66.44±0.4349	+2.05	17.66	5.99	0.24
20 kR+0.04% HZ	181	62-71	69.39±0.5269	+4.99	25.45	5.61	0.13

CV(p) Phenotypic coefficient of variation.
CV(g) Genotypic coefficient of variation.

Genetic parameters showed much variation in the treated populations. Highest coefficient of variability (37.88%) was recorded for 20 kR of gamma rays. Where genotypic coefficient of variation and estimates of heritability were concerned, the values were highest for 0.04% of HZ. There was much genetic variability in single treatments as compared to combination treatments. However, it is very interesting to note that the values of heritability were decreasing with the simultaneous increase in the concentration of HZ in the combination treatments.

Plant Yield

It is clear from the data recorded for plant yield (g) that all the single and combination treatments showed a great variation for this character (Table 3). The range shifted in positive direction for the individual treatments and it was on either side of the control in the combination treatments of 20 kR+0.01% and 20 kR+0.04% HZ. The mean values increased both in single and combination treatments. But the yield was recorded more in the single treatment of HZ.

Table 3. *Estimates of range* (R), *mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$), *shift in mean, coefficient of variation and heritability* (h^2) *for PLANT YIELD* (*g*) *in the M2 generation*

Treatments	N	R	$\bar{X} \pm S\bar{x}$	Shift in $\bar{X}$	CV(p) (%)	CV(g) (%)	h^2 (b.s.)
Buffer control	247	5.00-24.30	12.70±0.4760	—	44.44	00.00	0.00
0.01% HZ	235	6.20-26.60	15.15±0.4010	+2.45	50.33	10.03	0.11
0.02% HZ	227	5.60-27.50	15.80±0.4376	+3.09	77.73	22.51	0.34
0.03% HZ	211	6.20-24.70	13.96±0.3753	+1.26	61.30	11.30	0.10
0.04% HZ	217	5.50-28.00	14.56±0.4328	+1.85	61.07	16.48	0.26
20 kR	243	5.40-28.80	12.84±0.5081	+0.14	87.02	22.06	0.35
20 kR+0.01% HZ	220	3.00-32.10	13.26±0.5143	+0.56	166.79	39.21	0.42
20 kR+0.02% HZ	206	7.20-26.40	13.49±0.3730	+0.78	178.15	37.46	0.40
20 kR+0.03% HZ	182	5.50-27.80	13.70±0.4645	+0.99	93.86	18.79	0.25
20 kR+0.04% HZ	181	3.00-25.40	12.77±0.4702	+0.06	78.14	22.79	0.35

CV(p) Phenotypic coefficient of variation.
CV(g) Genotypic coefficient of variation.

The phenotypic and genotypic coefficients of variabilty increased more in the combination treatments than in the individual ones. The lower combinations (20 kR+0.01% and 0.02% HZ) gave the highest values for these parameters. The same situation was observed for the values of heritability. Highest phenotypic coefficient of variability (166.79%), genotypic coefficient of variation (39.21%) and heritability (0.42) were given by the combination treatment, 20 kR+0.01% HZ.

Discussion

From the study of range, mean, coefficient of variation and heritability of M2 populations, it appears that considerable variation has been induced in the quantitative characters like plant height, days to maturity and plant yield after treatment with HZ and gamma rays used either singly or in combinations. The range increased in both positive and negative directions. However, it increased more in the positive direction. Induced increased range in plant yield indicates scope for selection.

As might be expected, the variation in M2 generation of the treated population was consistently higher than the control population in all these characters. This is in general agreement with the observations of other workers (Matsuo and Onozawa, 1961; Yamaguchi, 1964; Borojevic and Borojevic, 1972; Rajput, 1974; Larik, 1975, 1978; Khan, 1978, 1979, 1982; Siddiqui *et al.*, 1979). Plant height increased and decreased in the single treatments of HZ and gamma rays. No significant increase was observed in the combination treatments. The reduced plant height has also been reported by Goud (1967), Bajaj *et al.* (1970), Rajput (1974) and Chakrabarti (1975). On the other hand, increased plant height has been reported by Sakai and Suzuki (1964) and Ismail *et al.* (1977). Days to maturity increase in all the treatments. Plant yield showed considerable increase in the single treatments of HZ. However, there was only a slight improvement in combination treatments. Increase in plant yield may be due to the increase in the number of fertile branches, number of pods and 100-seed weight (Khan, 1980). In this case, if the plants from the positive extremity can be fixed, there may be improvement in the yield. Borojevic (1965) suggested that the increase in the mean plant yield might have resulted from the purposeful elimination of all the mutants which produce abnormal spike morphology. In the present study, the increase in mean yield may be due to elimination of aberrant plants. The self-improvement in the treated stocks was mainly the result of natural selection.

Highest phenotypic coefficient of variation was recorded in plant yield followed by days to maturity and then plant height. The same was true in the case of genotypic coefficient of variation. The values of heritability were higher in the case of days to maturity and plant yield. Plant height showed comparatively low values. The genetic parameters did not increase consistently with the increase of the concentrations of HZ. It may be due to an uncontrolled environmental variation. Yamaguchi (1964) also reported that the relationship between dose and variance in rice was not linear. Heritability estimates showed considerable increase, indicating that the characters could be transmitted to future generations and significant gain could possibily be achieved through selection in early generations. From practical breeding point of view, increased variation assumes greater significance. Frey (1969) reported that mutagen-derived variability for quantitative characters in crop plants is heritable and that the response to selection is good. The relative value of this source of variability for use in crop improvement, therefore, depends almost entirely upon the nature of phenotypic expression caused by the mutations induced at polygenic loci (Larik *et al.*, 1980). It can be concluded from this induced mutation study that there is a scope for further improvement of this variety of mung bean with regard to the quantitative character like yield per plant by using micro-mutation technique.

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綠豆突變之研究

VI. 遺傳變異性的估算

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本試驗探討以水化聯氨（HZ）和伽瑪射線單獨或聯合處理綠豆能誘發其數量性狀微突變之可能性。調查之性狀包括突變第二代（M2）之株高、成熟日數、植物產量。經處理之族羣，其成熟日數和產量二性狀之平均值發生正向平移，株高則無。三種性狀之變異係數及遺傳率均顯著增加，此現象指示出誘變處理能有效誘發微效基因突變。變異性之變域在正負兩方向均有平移，而正向較多。由單獨或聯合處理後誘發之遺傳變異可爲此種豆類日後產量改良之利用。