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# Induced Genetic Variability for Quantitative Traits in Pigeonpea

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## ABSTRACT

Seeds of two pigeonpea varieties namely BDN 708 and BSMR 853 were treated with Gamma rays, ethyl methane sulphonate (EMS) and Sodium azide (SA). The treated as well as control plant populations were screened to study the induced variability for quantitative characters. Positive shift in mean values for number of primary branches per plant was observed except 0.10% EMS in variety BSMR 853 and BDN 708 in $M_2$ generation. The effect of all the mutagenic treatments on pods per plant revealed statistically significant negative as well as positive shifts in mean values in BSMR 853 in $M_2$ and $M_3$ generations.


**Key words:** EMS, Gamma rays, Pigeonpea, Sodium azide.

## INTRODUCTION

Mutation breeding has played significant role in improving legumes. The greatest challenge for legume researchers is to enhance the economic competitiveness of legumes by improving their intrinsic yield potential, their adaptation to niches available in various cropping systems, enhancing their end-use quality for diversified uses and reducing their susceptibility to a host of biotic/ abiotic stresses that prevent the full realization of yield potential and cause yield instability (Saxena, 2005). Rakesh Kumar *et al.,* (2017) analysed ratio of gca/sca variance was less than unity which indicated the preponderance of non- additive gene action in pigeon pea. Ramchander *et al.,* (2015) investigated the effects of gamma rays on two quality rice varieties and were found linear reduction with increase in dose or concentration of mutagens. Singh and Sinha (2010) were used mutagen EMS to determine effectiveness in pre-soaking range using $M_1$seedling traits in finger millet. The pigeonpea botanically known as *Cajanus cajan* (L.) Millsp. (2n = 22) belongs to family Fabaceae. Pigeonpea is an important pulse crop of Asia and Africa. It is the fourth most important pulse crop in the world with almost all production coming from the developing countries. Pigeonpea is also commonly known as red gram, arhar, congo red, gandul, gunga pea and no eye pea.

## MATERIALS AND METHODS

Dry and healthy seeds of the two varieties of pigeonpea, namely BDN 708 and BSMR 853 were obtained from the Agricultural Research Station of Marathwada Agriculture University, Parbhani, M.S. India). Three hundred seeds were taken for each replicate from both the varieties for physical as well as chemical mutagenic treatment. The seeds were sealed in polythene bags and exposed to 05kR, 10kR and 15kR doses of Gamma rays were applied from $Co^{60}$, 1000 curie source of the gamma irradiation unit of Government Institute of Science, Aurangabad. (M.S.), India. The dose rate was 24,578 rads per hour.

Healthy and uniform seeds of both the pigeonpea varieties Amol (BDN-708) and Vaishali (BSMR- 853) were presoaked in distilled water for 6 hours. Such presoaked seeds were later immersed in the mutagenic solution for 5 hours with regular shaking. Seeds soaked in distilled water for 12 hours served as control. The different concentrations used for chemical mutagenic treatment were 0.05%, 0.10%, 0.15% for EMS and 0.010%, 0.015%, 0.020% for SA, respectively. Seeds of each treatment were sown in the field following randomized block design (RBD) with three replications along with control for raising the $M_1$ generation. The seeds of all plants from each treatment in $M_1$ generation were harvested separately. They were used for raising $M_2$ generation on plant to a row basis. The seeds of the harvested pods from all treatment and mutants of $M_2$ generation of pigeonpea were sown in the field as $M_3$ generation.

The treated as well as control plant populations were screened to study the induced variability for quantitative characters. From each replication and treatment including control, plants were randomly selected for recording data on different quantitative characters in both the $M_2$ and $M_3$ generations.

## RESULTS AND DISCUSSION

Data obtained on induction of genetic variability in various yield contributing characters like days to flowering, number of primary branches, days to pod maturity, plant height, number of pods per plant, number of seeds per pod and hundred seed weight in both the varieties of pigeonpea was recorded and analysed statistically (Table 1, 2, 3 and 4).

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**Table1:** Effect of different mutagens on various quantitative characters in $M_2$ generation of pigeonpea variety BDN 708.

| Quantitative character | | Days to flowering | | | Number of primary branches per plant | | | Days to pod maturity | | | Plant height | | | Total number of pods per plant | | | Total number of seeds per pod | | | Hundred seeds weight | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muta--gen | Concen--tration (%)/dose | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. |
| Control | — | 99.33 | 0.52 | 0.90 | 16.17 | 0.88 | 9.47 | 162.63 | 1.28 | 1.36 | 205.67 | 2.40 | 2.02 | 384.53 | 39.91 | 17.98 | 99.10 | 0.42 | 0.73 | 11.98 | 0.12 | 1.71 |
| | 0.05 | 99.77 | 0.44 | 0.76 | 17.53* | 0.77 | 7.60 | 158.50** | 1.01 | 1.11 | 151.53 | 2.34 | 2.67 | 379.93 | 16.67 | 7.60 | 109.17** | 1.02 | 1.61 | 11.82 | 0.31 | 4.60 |
| EMS | 0.10 | 98.57 | 0.81 | 1.42 | 16.47 | 0.76 | 8.02 | 160.23** | 0.68 | 0.74 | 153.00 | 0.86 | 0.98 | 302.23 | 7.57 | 4.34 | 98.37 | 0.94 | 1.65 | 12.62** | 0.20 | 2.69 |
| | 0.15 | 98.13* | 0.23 | 0.41 | 18.00* | 0.96 | 9.25 | 161.47 | 0.27 | 0.29 | 162.07 | 1.45 | 1.55 | 386.40 | 29.20 | 13.09 | 101.63 | 2.84 | 4.84 | 12.77** | 0.10 | 1.38 |
| | 0.010 | 97.67* | 0.35 | 0.62 | 18.27** | 0.88 | 8.36 | 160.20* | 0.32 | 0.35 | 162.63 | 2.16 | 2.30 | 418.80 | 23.40 | 9.68 | 102.30 | 3.20 | 5.42 | 11.79 | 0.26 | 3.77 |
| SA | 0.015 | 97.59* | 0.80 | 1.43 | 18.30** | 0.15 | 1.45 | 164.63 | 0.84 | 0.89 | 166.30 | 0.40 | 0.42 | 483.34** | 25.03 | 8.97 | 98.33 | 3.27 | 5.77 | 12.09 | 0.05 | 0.74 |
| | 0.020 | 99.33 | 1.46 | 2.55 | 19.10** | 0.29 | 2.62 | 162.67 | 0.62 | 0.66 | 180.20 | 2.02 | 1.94 | 454.20** | 9.83 | 3.75 | 99.67 | 2.11 | 3.67 | 12.58** | 0.18 | 2.46 |
| Gamma | 05 kR | 95.80** | 0.17 | 0.31 | 20.10** | 0.75 | 6.47 | 160.07** | 0.55 | 0.59 | 181.47 | 0.61 | 0.58 | 466.43** | 5.64 | 2.09 | 104.53* | 1.48 | 2.45 | 12.58** | 0.32 | 4.34 |
| rays | 10kR | 95.83** | 0.45 | 0.81 | 20.67** | 0.41 | 3.43 | 161.10* | 0.26 | 0.28 | 191.90 | 3.44 | 3.10 | 395.10 | 13.79 | 6.04 | 89.30 | 5.80 | 11.26 | 12.71** | 0.12 | 1.64 |
| | 15kR | 97.50* | 0.49 | 0.88 | 18.43** | 0.45 | 4.21 | 162.80 | 1.15 | 1.23 | 184.93 | 3.03 | 2.84 | 412.43 | 13.52 | 5.68 | 98.50 | 2.45 | 4.31 | 12.33* | 0.24 | 3.40 |
| S.E. | | | 0.54355 | | | 0.495 | | | 0.594 | | | 1.707 | | | 17.170 | | | 2.260 | | | 0.164 | |
| C.D.(p=0.05) | | | 1.14145 | | | 1.040 | | | 1.248 | | | 3.585 | | | 36.056 | | | 4.747 | | | 0.345 | |
| C.D.(p=0.01) | | | 1.56542 | | | 1.427 | | | 1.711 | | | 4.917 | | | 49.449 | | | 6.510 | | | 0.473 | |
| F (Replicates) | | | 0.23315 | | | 2.471 | | | 1.381 | | | 0.145 | | | 0.070 | | | 0.099 | | | 0.677 | |
| F (Treatments) | | | 3.84822 | | | 4.913 | | | 5.405 | | | 64.349 | | | 5.545 | | | 3.074 | | | 3.166 | |

*Significant at p=0.05.

**Significant at p=0.01.

**Table2:** Effect of different mutagens on various quantitative characters in $M_2$ generation of pigeonpea variety BSMR 853.

| Quantitative character | | Days to flowering | | | Number of primary branches per plant | | | Days to pod maturity | | | Plant height | | | Total number of pods per plant | | | Total number of seeds per pod | | | Hundred seeds weight | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muta-gen | Concen-tration (%) / dose | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. |
| Control | — | 102.67 | 0.15 | 0.25 | 16.77 | 0.41 | 4.23 | 164.37 | 1.20 | 1.27 | 171.03 | 3.20 | 3.24 | 447.17 | 38.13 | 14.77 | 96.90 | 2.01 | 3.59 | 11.56 | 0.61 | 9.15 |
| | 0.05 | 105.53 | 0.71 | 1.16 | 17.43 | 0.94 | 9.29 | 163.10 | 0.80 | 0.85 | 135.13 | 0.50 | 0.64 | 388.53 | 9.21 | 4.11 | 93.97 | 3.38 | 6.24 | 11.49 | 0.22 | 3.30 |
| EMS | 0.10 | 102.13 | 1.01 | 1.71 | 16.67 | 0.82 | 8.49 | 162.97* | 0.37 | 0.39 | 137.57 | 1.78 | 2.24 | 443.13 | 17.07 | 6.67 | 94.10 | 5.70 | 10.49 | 12.25* | 0.19 | 2.64 |
| | 0.15 | 100.47** | 0.33 | 0.57 | 17.93* | 0.84 | 8.13 | 163.03* | 0.38 | 0.41 | 147.83 | 0.61 | 0.71 | 461.23 | 7.01 | 2.63 | 94.67 | 1.81 | 3.31 | 11.68 | 0.59 | 8.79 |
| | 0.010 | 100.83** | 0.38 | 0.66 | 18.40* | 0.40 | 3.80 | 162.73** | 0.47 | 0.50 | 162.50 | 2.26 | 2.41 | 456.60 | 21.66 | 8.22 | 106.60** | 2.01 | 3.27 | 11.74 | 0.24 | 3.54 |
| SA | 0.015 | 100.93** | 0.07 | 0.11 | 18.97** | 0.43 | 3.96 | 165.13 | 0.91 | 0.95 | 178.23** | 0.72 | 0.70 | 472.07 | 7.40 | 2.71 | 108.07** | 0.43 | 0.69 | 11.90 | 0.08 | 1.17 |
| | 0.020 | 98.83** | 0.23 | 0.41 | 18.67* | 0.26 | 2.42 | 163.37 | 0.70 | 0.74 | 173.60 | 3.44 | 3.43 | 476.77 | 7.04 | 2.56 | 101.23* | 2.48 | 4.25 | 10.47 | 0.14 | 2.35 |
| Gamma | 05 kR | 101.90** | 0.60 | 1.02 | 20.03** | 0.07 | 0.58 | 163.13* | 0.41 | 0.43 | 168.13 | 1.62 | 1.67 | 491.90** | 23.86 | 8.40 | 96.97 | 3.00 | 5.36 | 13.04** | 0.56 | 7.38 |
| rays | 10kR | 103.00 | 1.01 | 1.69 | 19.90** | 0.66 | 5.71 | 161.50** | 0.92 | 0.99 | 165.03 | 2.54 | 2.67 | 531.03** | 32.89 | 10.73 | 93.13 | 0.37 | 0.68 | 11.47 | 0.37 | 5.58 |
| | 15kR | 101.03** | 0.37 | 0.64 | 18.60* | 0.17 | 1.61 | 162.73** | 0.38 | 0.40 | 172.07 | 2.10 | 2.11 | 441.20 | 4.61 | 1.81 | 87.43 | 1.58 | 3.12 | 12.74** | 0.33 | 4.55 |
| S.E. | | | 0.441 | | | 0.459 | | | 0.538 | | | 1.635 | | | 14.991 | | | 1.979 | | | 0.300 | |
| C.D.(p=0.05) | | | 0.925 | | | 0.965 | | | 1.130 | | | 3.433 | | | 31.480 | | | 4.156 | | | 0.631 | |
| C.D.(p=0.01) | | | 1.269 | | | 1.323 | | | 1.550 | | | 4.708 | | | 43.173 | | | 5.700 | | | 0.865 | |
| F (Replicates) | | | 1.410 | | | 0.384 | | | 1.472 | | | 1.088 | | | 2.014 | | | 2.225 | | | 0.630 | |
| F (Treatments) | | | 9.977 | | | 3.833 | | | 1.968 | | | 53.376 | | | 3.680 | | | 6.146 | | | 3.445 | |

*Significant at p=0.05.

**Significant at p=0.01.

A thorough statistical analysis was carried out by computing the mean, standard error and coefficient of variation using standard formulae. The shift in means and variance were also studied to assess the amount of induced variability due to mutagenic treatments.

**Days to flowering**

It was observed that in all the treated plants, the period for days to flowering was slightly earlier than the control. This feature was quite evident at the three mutagens in both the varieties in $M_2$ and $M_3$ generations. In $M_2$ generation the maximum earliness in days to flowering could be seen at 05 kR dose in variety BDN 708 and at 0.020% SA treatment in variety BSMR 853. The negative shift in mean values was observed in majority of the treatments. In $M_3$ generation, the maximum earliness in days to flowering could be seen at 0.010% SA and 0.10% EMS treatment in both the varieties BDN 708 and BSMR 853 of pigeonpea, respectively. Lower concentrations/doses of the mutagens induced early flowering in $M_2$ generation in variety BDN 708. Similar results were also observed by Khan and Veeraswamy (1974), Brij and Pandya (1986) and Micke *et al.* (1990). EMS treatment was found to be most effective in inducing early flowering followed by Gamma rays. Result obtained was in confirmation with results of Rao *et al.* (1984), Biradar (2004), Shinde (2007) in pigeonpea. An early flowering feature has been obtained by Jana (1963) in black gram. Chowta and Dnyansagar (1974) reported delay in flowering in plants raised from irradiated and EMS treated seeds of *Chlorophytum*. The reports of delayed flowering with increasing concentrations of mutagenic treatments have been made by Bhatia and Swaminathan (1962), Chary (1983), Tyagi and Gupta (1991), Gaikwad (2002) and Savant (2008).

**Number of primary branches per plant**

Positive shift in mean values for number of primary branches per plant was observed except 0.10% EMS in BSMR 853 and BDN 708 in $M_2$ generation. Mean value shifted in negative direction in $M_3$ generation except at 05 kR and 15kR Gamma ray doses in variety BDN 708 and a maximum negative shift in mean values was recorded at 0.05% EMS treatment in variety BSMR 853 of pigeonpea.

In the present investigation, treatments of EMS and SA exerted inhibitory effect on branches per plant than lower treatments. The Gamma rays showed promotary effect on branches per plant. Similar results were obtained by Khan and Veeraswamy (1974) in pigeonpea and Tambe (2009) in soybean, Aher *et al.* (2006) and Chandirakala and Subbaraman (2010) reported high magnitude of heterosis for primary branches in pigeonpea.

**Days to pod maturity**

Days to maturity in control were 162.63 (BDN 708) and 164.37 (BSMR 853) in $M_2$ generation. While in $M_3$ generation, the values were 169.07 and 181.80 in BDN 708 and BSMR 853, respectively. In $M_2$ generation all treatments have shown statistically significant negative shift in mean values in BSMR 853 except 0.015% concentration of SA. The 0.015% and 0.020 % concentration of SA treatment and 15 kR dose of Gamma rays showed positive shift in mean in variety BDN 708 in $M_2$ generation. It was observed that, days taken to maturity were shifted in almost negative directions as compared to respective controls. Concentrations of EMS treatments revealed promotary effect on days taken to maturity. Similar significant induced variance for days taken to maturity was reported by Gregory (1961), Brock (1965), Paul and Bajpai (2000) in pigeonpea and Tambe (2009) in soybean. Early maturing feature was recorded by Azam *et al.* (2001) in rice, Ravikesavan *et al.* (2001) in pigeonpea.

**Plant height**

It was observed that all the mutagenic treatments employed in the present study succeeded in affecting the plant height in both the varieties of pigeonpea in $M_2$ and $M_3$ generations. A decline in mean height of plants could be seen in majority of the concentrations/doses of mutagens in both the varieties. The mean values in regard to plant height demonstrated shift towards negative direction in $M_2$ generation in both the varieties except 0.015 % and 0.020% concentrations of SA and 15kR dose in variety BSMR 853. In $M_3$ generation, the negative shift in mean was seen in all the mutagenic treatments in both the varieties except BSMR 853 at 15 kR dose of Gamma rays.

Mutagenic treatments employed in the present study succeeded in affecting the plant height in both varieties of pigeonpea in $M_2$ and $M_3$ generations. Similar increase in mean plant height was reported by Barshile and Apparao (2006) in chickpea at 20mM concentration of Sodium azide. Aher *et al.*(2006), Phad *et al.* (2009) and Chandirakala and Subbaraman (2010) observed good amount of heterosis for this character in pigeonpea. Greater variance for the character was also recorded by Nadarajan *et al.* (1983) in $M_2$ generation. Decrease in plant height as a result of mutagenic treatments was reported by several workers like Khan and Wani (2006) in mungbean, Bolbhat and Dhumal (2009) in Horse gram Evans and Sparrow (1961) correlated the reduction in height with the chromosomal injury, genetic change or both.

**Number of pods per plant**

The number of pods per plant is a significant feature responsible for the high yielding character of plant. It looked evident from the pertinent observation that an increase in the mean number of pods per plant could be observed at all the treatments of SA and Gamma rays in $M_2$ generation of variety BDN 708 except lower concentration of EMS and 15 kR dose of Gamma rays in variety BSMR 853. The highest positive shift in mean value was recorded at 0.015% SA treatment in BDN 708 in $M_2$ generation.

The effect of all the mutagenic treatments on pods per plant revealed negative as well as positive shift in mean values in BSMR 853 in $M_2$ and $M_3$ generations in most of

**Table 3:** Effect of different mutagens on various quantitative characters in $M_3$ generation of pigeonpea variety BDN 708.

| Quantitative character | | Days to flowering | | | Number of primary branches per plant | | | Days to pod maturity | | | Plant height | | | Total number of pods per plant | | | Total number of seeds per pod | | | Hundred seeds weight | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muta-gen | Concentration (%)/dose | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. |
| Control | — | 116.80 | 0.45 | 0.67 | 23.87 | 0.67 | 4.89 | 169.07 | 0.34 | 0.35 | 231.33 | 2.43 | 1.82 | 349.23 | 31.57 | 15.66 | 101.70 | 1.46 | 2.48 | 11.84 | 0.19 | 2.71 |
| EMS | 0.05 | 114.00** | 0.47 | 0.72 | 20.20 | 0.90 | 7.69 | 165.80** | 0.21 | 0.22 | 172.50 | 2.43 | 2.44 | 282.27 | 17.39 | 10.67 | 94.83 | 4.08 | 7.46 | 10.98 | 0.37 | 5.87 |
| | 0.10 | 114.93** | 0.67 | 1.01 | 17.83 | 0.72 | 7.01 | 161.47** | 0.52 | 0.56 | 159.51 | 0.89 | 0.96 | 233.50 | 6.73 | 4.99 | 96.27 | 4.13 | 7.42 | 11.38 | 0.34 | 5.25 |
| | 0.15 | 112.30** | 0.38 | 0.58 | 18.40 | 1.10 | 10.33 | 164.87** | 0.55 | 0.58 | 185.37 | 6.19 | 5.78 | 320.00 | 34.67 | 18.77 | 104.90 | 2.48 | 4.10 | 11.85 | 0.11 | 1.60 |
| SA | 0.010 | 111.90** | 1.50 | 2.33 | 20.90 | 0.55 | 4.56 | 163.93** | 0.48 | 0.51 | 180.70 | 1.46 | 1.40 | 386.33 | 33.40 | 14.98 | 101.40 | 1.15 | 1.97 | 11.43 | 0.26 | 3.99 |
| | 0.015 | 115.27** | 0.59 | 0.89 | 17.20 | 0.59 | 5.90 | 164.80** | 0.32 | 0.34 | 169.00 | 4.96 | 5.08 | 298.37 | 34.14 | 19.82 | 98.03 | 1.65 | 2.91 | 11.72 | 0.29 | 4.29 |
| | 0.020 | 114.83** | 0.95 | 1.44 | 22.87 | 0.12 | 0.91 | 163.87** | 0.44 | 0.46 | 190.70 | 4.16 | 3.78 | 400.83* | 49.04 | 21.19 | 106.93* | 0.87 | 1.42 | 11.83 | 0.14 | 2.02 |
| Gamma rays | 05 kR | 116.00 | 0.86 | 1.29 | 24.13 | 1.15 | 8.23 | 168.47 | 0.43 | 0.44 | 207.37 | 2.59 | 2.16 | 411.87* | 43.58 | 18.33 | 99.77 | 2.72 | 4.72 | 11.74 | 0.02 | 0.34 |
| | 10kR | 114.60** | 0.44 | 0.66 | 21.97 | 0.72 | 5.69 | 163.00** | 0.26 | 0.28 | 210.70 | 2.83 | 2.33 | 325.97 | 21.73 | 11.55 | 99.10 | 3.16 | 5.52 | 11.89 | 0.10 | 1.45 |
| | 15kR | 114.30** | 0.40 | 0.61 | 24.30 | 0.82 | 5.83 | 166.07** | 0.43 | 0.44 | 223.10 | 4.29 | 3.33 | 325.40 | 16.58 | 8.82 | 109.53 | 2.19 | 3.47 | 11.59 | 0.08 | 1.18 |
| S.E. | | | 0.559 | | | 0.619 | | | 0.333 | | | 2.395 | | | 24.564 | | | 1.961 | | | 0.178 | |
| C.D.(p=0.05) | | | 1.173 | | | 1.301 | | | 0.700 | | | 5.029 | | | 51.585 | | | 4.117 | | | 0.374 | |
| C.D.(p=0.01) | | | 1.609 | | | 1.784 | | | 0.959 | | | 6.897 | | | 70.745 | | | 5.647 | | | 0.513 | |
| F (Replicates) | | | 1.827 | | | 0.616 | | | 0.127 | | | 4.395 | | | 0.824 | | | 1.766 | | | 0.308 | |
| F (Treatments) | | | 4.341 | | | 11.285 | | | 29.513 | | | 60.772 | | | 3.080 | | | 3.427 | | | 1.570 | |

*Significant at p=0.05.

**Significant at p=0.01.

**Table 4:** Effect of different mutagens on various quantitative characters in $M_3$ generation of pigeonpea variety BSMR 853.

| Quantitative character | | Days to flowering | | | Number of primary branches per plant | | | Days to pod maturity | | | Plant height | | | Total number of pods per plant | | | Total number of seeds per pod | | | Hundred seeds weight | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muta-gen | Concentration(%) / dose | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. | Mean | S.E. | C.V. |
| Control | — | 122.80 | 0.45 | 0.64 | 21.43 | 0.92 | 7.47 | 181.80 | 0.06 | 0.06 | 197.87 | 2.32 | 2.03 | 415.43 | 28.18 | 11.75 | 100.63 | 1.50 | 2.58 | 11.31 | 0.11 | 1.71 |
| | 0.05 | 120.50** | 0.36 | 0.52 | 16.33 | 0.99 | 10.54 | 175.07** | 0.15 | 0.14 | 167.37 | 1.03 | 1.07 | 298.10 | 34.98 | 20.32 | 96.17 | 1.10 | 1.98 | 10.30 | 0.15 | 2.55 |
| EMS | 0.10 | 118.40** | 0.32 | 0.47 | 19.20 | 0.10 | 0.90 | 173.47** | 1.79 | 1.79 | 174.03 | 0.71 | 0.70 | 358.33 | 1.75 | 0.85 | 95.67 | 3.87 | 7.00 | 10.59 | 0.21 | 3.51 |
| | 0.15 | 121.23* | 0.74 | 1.06 | 17.50 | 0.80 | 7.94 | 176.23** | 0.52 | 0.51 | 166.50 | 2.76 | 2.87 | 337.90 | 29.08 | 14.91 | 99.17 | 2.87 | 5.01 | 11.65* | 0.07 | 0.99 |
| | 0.010 | 122.07 | 1.04 | 1.48 | 22.03 | 0.88 | 6.89 | 177.07** | 0.59 | 0.58 | 186.70 | 6.63 | 6.15 | 416.20 | 33.88 | 14.10 | 97.63 | 4.04 | 7.16 | 11.46 | 0.13 | 2.02 |
| SA | 0.015 | 121.77 | 0.58 | 0.82 | 20.50 | 0.38 | 3.20 | 175.53** | 0.15 | 0.14 | 174.87 | 2.38 | 2.36 | 421.83 | 30.57 | 12.55 | 100.27 | 3.36 | 5.80 | 11.51 | 0.22 | 3.35 |
| | 0.020 | 123.07 | 0.35 | 0.50 | 21.57 | 0.98 | 7.90 | 175.93** | 0.43 | 0.43 | 188.63 | 3.45 | 3.17 | 351.90 | 13.25 | 6.52 | 97.87 | 3.30 | 5.84 | 10.58 | 0.27 | 4.35 |
| Gamma | 05 kR | 121.90 | 0.32 | 0.46 | 21.03 | 1.50 | 12.37 | 174.43** | 0.68 | 0.68 | 194.23 | 1.02 | 0.91 | 465.07* | 71.26 | 26.54 | 91.93 | 0.96 | 1.80 | 11.20 | 0.15 | 2.34 |
| rays | 10kR | 123.93 | 1.63 | 2.28 | 21.97 | 0.90 | 7.12 | 178.23** | 0.12 | 0.12 | 194.83 | 2.70 | 2.40 | 426.53 | 25.23 | 10.25 | 90.83 | 2.92 | 5.56 | 11.22 | 0.35 | 5.38 |
| | 15kR | 123.37 | 0.32 | 0.45 | 23.13* | 0.46 | 3.47 | 177.00** | 0.21 | 0.20 | 210.90** | 1.06 | 0.87 | 472.33* | 13.13 | 4.81 | 106.57* | 3.35 | 5.44 | 11.49 | 0.12 | 1.88 |
| S.E. | | | 0.600 | | | 0.713 | | | 0.517 | | | 2.320 | | | 21.322 | | | 2.187 | | | 0.154 | |
| C.D.(p=0.05) | | | 1.260 | | | 1.498 | | | 1.086 | | | 4.872 | | | 44.776 | | | 4.592 | | | 0.323 | |
| C.D.(p=0.01) | | | 1.728 | | | 2.055 | | | 1.489 | | | 6.682 | | | 61.407 | | | 6.298 | | | 0.443 | |
| F (Replicates) | | | 0.007 | | | 0.030 | | | 1.290 | | | 0.529 | | | 5.533 | | | 1.757 | | | 0.703 | |
| F (Treatments) | | | 4.289 | | | 5.471 | | | 12.096 | | | 23.616 | | | 4.297 | | | 2.550 | | | 5.590 | |

*Significant at p=0.05.

**Significant at p=0.01.

the mutagenic treatments. In the present study, EMS and Gamma ray treatments produced more number of pods per plant over control except their highest concentration /doses. Singh (1973) also noticed increased performance of number of pods in 5kR and 10kR doses. However, Chary and Bhalla (1988) and Nadarajan *et al.,* (1983) recorded reduced number of pods per plant in $M_2$ of treated seeds with mutagen. Decrease in heterosis was recorded earlier by Chandirakala and Subbaraman (2010). However, increased heterosis was observed by Aher *et al.* (2006). Similar decrease in pod number was also observed by Rao *et al.,* (1983), Barshile *et al.,* (2009), Chaudhary and Sharma (1984) and Singh and Yadav (1991). The observed decrease in number of pods in $M_2$ population has been attributed to the increased pollen sterility (Shivraj *et al.,* 1962). There was an increase in the number of pods per plant with some exceptions. This was supported by Hakande (1992) in winged bean and Savant (2008) in sesame.

**Number of seeds per pod**

It is evident from the pertinent observations that statistically significant increase in mean values for number of seeds per plant could be observed in all mutagenic treatments at lower concentration /dose in variety BDN 708 in $M_2$ generation. 0.05 % concentration of EMS treatment recorded highest positive shift in mean in variety BDN 708 of pigeonpea in $M_2$ generation. While variety BSMR 853 showed flexible trend in seeds per pod in $M_2$ and $M_3$ generations.

**Hundred seeds weight**

The treatments of EMS, SA and Gamma rays succeeded in inducing variability regarding weight of hundred seeds. The range of shift in mean values was mostly positive for all the mutagenic treatments in both the varieties in $M_2$ generation. In control the mean of hundred seed weight was 11.98 gm and 11.56 gm in variety BDN 708 and BSMR-853 in $M_2$ generation, while the same was 11.84 gm and 11.31 gm in variety BDN 708 and BSMR 853 in $M_3$ generation, respectively. In $M_3$ generation, all the mutagenic treatments have shown negative shift in mean values except for 0.15% EMS and 10 kR Gamma rays in variety BDN 708 and also in variety BSMR 853 with lower concentrations of SA, respectively.

Results obtained for number of seeds per pod and hundred seed weight indicated positive as well as negative shift in mean for all mutagenic treatments in both the varieties in $M_2$ and $M_3$ generations. Similar observations were also made by Chary (1983), Vandana and Dubey (1990), Rayyan (1995), Gunasekaran *et al.* (1998) and Shinde (2007). Increase in hundred seeds weight as a result of treatment with mutagen has been reported by Pawar *et al.,* (1979), Singh (1973), Biradar (2004), while decrease in hundred seed weight was reported by Dahiya (1977).

## CONCLUSION

Mutation breeding has become an alternative to conventional breeding with the sole objective of developing better cultivars of economically important crops. Virtually all economically important characters with which plant breeder has to deal are polygenic in nature and the genotype for these characters cannot be directly measured being highly modified by environment. These polygenic characters governed by a large number of independent genes are also called metric traits as they can be studied only through biometrical investigation. The inductions of micromutations in polygenic systems controlling the quantitative characters are important for crop improvement.

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