RESULTS

The results obtained in the mutagenic study in pigeonpea have been dealt with separately in regard to M₁, M₂ and M₃ generations, respectively. In M₁ generation studies were carried out on the differential effects of different mutagens on biological parameters and morphological abnormalities. In M₂ generation grown from the harvested seeds of M₁, studies were organized pertaining to chlorophyll mutations especially their frequency and spectrum, effectiveness and efficiency of the mutagens used besides screening and analysis of the quantitative characters and several viable macro mutants which were selected from M₂ population have also been reported.

In M₃ generation grown from the harvested seeds of M₂, the study included screening and analysis of quantitative characters and the field testing of the viable macro-mutants isolated from M₂ population regarding their yield characteristics and biochemical features.

**Studies of mutagenic sensitivity in M₁ generation:**

The present investigation comprised the study of mutagenic sensitivity of two varieties of pigeonpea BDN 708 and BSMR 853 in regard to some biological and morphological parameters. The effect of EMS, SA and Gamma rays on pigeonpea was studied by choosing three concentrations for each mutagen. (EMS 0.05%, 0.10% and 0.15%, SA 0.010% , 0.015% and 0.020% and Gamma rays 05kR, 10kR and 15 kR). The results have been organized separately for each parameter. In order to study the mutagenic sensitivity of varieties of pigeonpea to the mutagens, the data were collected regarding the following parameters in M₁ generation.

**Biological parameters:**

1. Germination percentage
2. Seedling height
3. Chlorophyll deficient sectors/chimeras
4. Leaf morphological changes
5. Pollen sterility
6. Plant survival percentage

1) Seed germination percentage (Lethality): Graph -1 (Tables11-12)

   In pigeonpea maximum number of seeds germinated on third day after sowing in both the varieties (BDN 708 and BSMR 853). In control the germination percentage was found to be 96.67% in BDN 708 and 81.67% in BSMR 853, respectively. The results regarding germination percentage revealed that the mutagens had an inhibitory effect on germination of pigeonpea. The degree of inhibition in germination was found to be in proportion with the increasing concentration of the mutagens. Highest germination percentage was 86.67% at 0.05% EMS. The least germination percentage could be noticed at 0.020% SA treatment (71.67%) in variety BDN 708, whereas in variety BSMR 853 values ranged from 78.33% to 71.61% in case of EMS. The values of seed germination for SA treatments were 73.33% to 65.00% and 78.33% to 70.00% in case of Gamma rays.

2) Seedling height: Graph-2 (Tables 13-14)

   A general decreasing trend was observed in regard to seedling height as the concentration/dose increased. However the values were higher in majority of the treatments as compared with control. After 20 days height of seedling was noted. In control seedling height was found to be 11.46 cm in variety BDN 708 and 11.62 cm in variety BSMR 853, respectively. The seedling height in variety BDN 708 ranged from 13.46 to 12.77cm after EMS treatments, 12.17 to 11.56 after SA treatments and 12.31 to 11.06 cm after the Gamma ray treatment. At EMS 0.05% concentration the maximum seedling height 14.08 cm was observed and lowest seedling height of 11.15 cm could be recorded in 0.020% SA concentration in variety BSMR 853.
3) Chlorophyll deficient sectors: Graph-3 (Tables 15-16) (Plate-2)

The critical screening of the M₁ generation of pigeonpea revealed the induction of chlorophyll deficient sectors of different types in the leaves at all concentrations/doses of mutagens. Such sectors were yellow (xantha), light or dull green (viridis) and yellow green (chlorina) types. They were found at the margins of leaflets and distributed throughout the leaf lamina.

From the glance of tables 15 and 16 it would look clear that the varied concentrations/doses of the mutagens EMS, SA and Gamma rays have proved effective in inducing the chlorophyll deficient sectorial types in both the varieties of pigeonpea.

The frequency of chlorophyll deficient sectorial plants ranged from 3.00% to 5.67% and 3.67% to 4.67% after EMS treatments, from 4.00% to 6.33% and 4.00% to 5.67% after SA treatments and 3.33% to 6.33% and 5.00% to 7.33% after Gamma ray treatments in both the varieties of pigeonpea.

4) Leaf morphological changes: Graph- 4 (Tables 17-18) (Plate-3)

In the mutagenic treated plants, leaf morphological changes were observed revealing different types. They exhibited variations in the shape and size as compared with the control plants. Considerable frequency of leaf change carrying plants could be observed in both the varieties as a result of mutagenic treatments. Leaf morphological changes comprised leaf margin, showing distortions and notches, leaf lamina displaying leathery and embossed surface and leaf showing retuse and obtuse apex. The frequency of the leaf change carrying plants revealed an enhancing feature with the gradual rise in concentration /dose of the EMS, SA and Gamma rays.

The frequency of plants carrying leaf morphological changes ranged from 3.3% to 4.3% and 2.7% to 4.7% after EMS treatments in variety BDN 708 and BSMR 853 of pigeonpea, respectively. In case of SA treatments, the frequency values ranged from 2.3% to 5.7% and 3.0% to 5.0% in variety BDN 708 and BSMR 853 of pigeonpea. Also in case of Gamma ray doses, plants with leaf
morphological changes ranged from 3.7% to 6.3% and 3.3% to 5.0% in BDN 708 and BSMR 853 varieties of pigeonpea, respectively.

5) Pollen sterility: Graph-5 (Tables19-20)

Pigeonpea demonstrated effective response as regards pollen sterility with increasing concentrations/dose of the mutagens in both the varieties. In case of control 3.66% pollen sterility in BDN 708 varietal material and 4.63% pollen sterility in BSMR 853 variety of pigeonpea could be observed. The maximum pollen sterility (10.87%) could be seen at 0.020% SA in variety BSMR 853. The pollen sterility values ranged from 3.84% to 5.17% and 4.88% to 6.68% after EMS, 7.23% to 8.56% and 9.14% to 10.87% after SA treatments and 5.58% to 10.40% and 8.93% to 10.34% after the Gamma ray treatment in BDN 708 and BSMR 853 varieties of pigeonpea, respectively.

6) Survival of plants at maturity: Graph-6 (Tables21-22)

The percentage of plants surviving in the field upto maturity was recorded. Both chemical and physical mutagenic treatments showed decreased values for the plant survival at maturity with increasing concentrations. The survival of plants at maturity showed a gradual decrease with an increase in concentration /dose of the mutagenic treatments.

In variety BDN 708, the survival ranged from 88.33% to 75.00% in EMS, 85.00% to 76.67% in SA and 86.67% to 70.00% in Gamma ray doses while in BSMR 853 variety the survival ranged from 85% to 73.33% in EMS, 81.67% to 73.33% in SA and 73.33% to 68.33% in Gamma ray treatment. The highest survival values 88.33% and 85.00% could be seen at 0.05% EMS in BDN 708 and BSMR 853, respectively. The lowest survival values (70.00% and 68.33%) were noticeable at 15kR dose of Gamma rays in case of both the varieties of pigeonpea.

STUDIES IN $M_2$ AND $M_3$ GENERATIONS:

Chlorophyll mutations: (Plate-4)

The $M_2$ generation was raised from the seed progenies of $M_1$ plants. The chlorophyll mutants were scored at the seedling stage. They were of three different
types such as *xantha*, *chlorina* and *viridis*. The chlorophyll mutants were identified using the criteria suggested by Gustafsson (1940) and Blixt (1961).

Chlorophyll mutations are considered as indicators of mutability. *Xantha* mutants displayed a bright yellow colour. In some mutants the colour was little lighter. It was found in early stage of development of plant. *Chlorina* mutants showed yellowish green colour. A few of them converted to normal green type. The *viridis* mutants showed dull light green colour. This colour gradually changed to the normal green colour during the subsequent growth phases of the plant.

The chlorophyll mutants such as *chlorina* and *viridis* grew well, some got flowered, bore pods and survived till the maturity. Most of them bred true in the further M$_3$ generation. In case of pigeonpea all the three mutagens induced different types of chlorophyll mutants. The spectrum of induced chlorophyll mutants was quite broad in both the varieties of pigeonpea and the response of the varieties towards the different mutagens was differential.

**Frequency of chlorophyll mutants: Graph -7 (Tables 23-24)**

Among the two chemical mutagens, SA (0.015%) proved to be very much successful in inducing the highest frequency (3.77%) of chlorophyll mutants in variety BDN 708, while in BSMR 853 the SA concentration (0.010%) induced the highest frequency (5.33%) of chlorophyll mutants. The frequency of chlorophyll mutants varied from 2.56 % to 3.46 % and from 1.46 % to 2.07% after Gamma ray treatment in both the varieties BDN 708 and BSMR 853 of pigeonpea, respectively. The frequency of chlorophyll mutants ranged from 1.42% to 2.29% and 1.42 % to 2.32% after EMS treatment.

**Spectrum of chlorophyll mutants :( Tables 25-26)**

Within the various chlorophyll mutants recorded, the *chlorina* occurred in higher frequency while *viridis* and *xantha* in low frequencies. *Chlorina* mutants could be observed in all treatments of Gamma rays, EMS and SA. The highest frequency 80.00% was recorded at 0.10% EMS treatment in variety BDN 708. *Chlorina* was observed in all treatments of mutagens. At the dose of 15kR
Gamma rays, the frequency was as high as 75.00% in variety BSMR 853. *Viridis* mutants were also recorded in most of the treatments of EMS and SA in both the varieties. The highest frequency 50% was noticeable at 0.010% SA in variety BDN 708. *Xantha* mutants could be observed in all treatments of SA and highest frequency 50.00% was recorded at 0.05% EMS treatment in both the varieties of pigeonpea. The *albina* type of chlorophyll mutant was not observed in the present study.

**Effectiveness of mutagens: - Graph 8 (Tables 27-28)**

The mutagenic effectiveness is a measure of point mutations induced by a unit dose of mutagen. The data pertaining to this parameter varied for each concentration of mutagens in both the varieties of pigeonpea. The effectiveness of various mutagens can be understood through a critical perusal of tables 27 and 28. The mutagenic effectiveness is a measure of factor mutations induced by a unit dose of mutagen. (Konzak *et al.*, 1965).

In case of EMS treatments, a variable trend could be seen in effectiveness values in both the varieties of pigeonpea as far as EMS and SA are concerned. The lower concentration of SA was more effective with effectiveness 1.066 in variety BSMR 853. In SA treatment the effectiveness values ranged from 0.470 to 1.066 in variety BSMR 853, while the values ranged from 0.372 to 0.754 in variety BDN 708. In Gamma ray treatment, the effectiveness values decreased with the increasing concentrations. It ranged from 0.170 to 0.542 and 0.138 to 0.292 in varieties BDN 708 and BSMR 853, respectively.

**Mutagenic efficiency: Graph 9 (Tables 29-30)**

Efficiency of mutagens is the ratio of chlorophyll mutations induced in $M_2$ generation to the various biological damages induced in $M_1$ generation such as lethality, and pollen sterility. From the data on total mutagenic efficiency values, it could be observed that the 10 kR Gamma ray in variety BDN 708 and 0.010% SA concentration in variety BSMR 853 were the most efficient in regard to lethality and pollen sterility. However the Gamma ray treatment could be found least
efficient as far as lethality and pollen sterility are concerned in variety BSMR 853, where the values ranged from 0.230 to 0.269. The values of 0.350 to 0.623 and 0.283 to 0.782 after treatment of SA could be recorded in varieties BDN 708 and BSMR 853, respectively.

**Mutation Rate: (Table 31)**

The mutation rate was calculated by taking the mean values of efficiency for each treatment. This has given an idea about the average rate of mutation induction per mutagen. By considering the mutation rates based on efficiency, the order of mutagens changed as mutagen carried different values in respect of lethality and pollen sterility. The mutation rates in variety BDN 708 for lethality were 0.116 (EMS), 0.111 (SA) and 0.171 (Gamma rays) and the rates were 0.073 (EMS), 0.122 (SA) and 0.066 (Gamma rays) in BSMR 853 variety.

When the mutation rates for pollen sterility were considered it could be observed as 0.425 (EMS), 0.358 (SA) and 0.433 (Gamma rays) in BDN 708 and 0.323 (EMS), 0.373(SA) and 0.176 (Gamma rays) in BSMR 853. As far as mutation rates in terms of efficiency are concerned, mutation rates based on lethality and pollen sterility induced by Gamma rays and SA were more in variety BDN 708 and BSMR 853, respectively.

**Viable mutants:**

Different types of viable mutants were observed in M$_2$ generation of pigeonpea. A wide spectrum of viable mutants with varying morphological traits was observed in M$_2$ generation of both the varieties of pigeonpea. The various types of viable mutants obtained in pigeonpea were:

1. High yielding
2. Tall
3. Dwarf
4. Branched
5. Early flowering
6. Early maturing
7. Light green pod
8. Small pod
9. Two seeded pod
10. Five seeded pod

**Frequency of viable mutants: (Tables 32-37)**

All the concentrations of the mutagens used succeeded in inducing the different types of viable mutants. The frequency of viable mutants revealed an increasing trend with gradual increase in concentration/dose of all the mutagens in both the varieties of pigeonpea. The frequency of viable mutants showed the highest values at 0.05% (EMS), 0.020% (SA) and 10kR (Gamma ray) treatments in pigeonpea except BSMR 853 variety where the highest value was 9.09% at 05 kR dose of Gamma rays. The frequency of viable mutants ranged from 3.17% to 5.97% in EMS, 4.10% to 7.04% in SA, 2.98% to 9.45% in Gamma ray and 3.33% to 4.47% in EMS, 4.83% to 13.23% in SA and 6.34% to 9.09% in Gamma ray treatments in BDN 708 and BSMR 853 varieties, respectively.

Data of the spectrum and relative percentage of viable mutants scored in M₂ generation shown in tables 34 and 35 have revealed a random trend with increase in concentration (%)/dose of all the mutagens in both the varieties of pigeonpea.

High yielding mutant which is one of the productive mutants has shown highest relative percentage (33.32% and 25%) after 05 kR Gamma ray treatment and SA treatment (0.015%) in BDN 708, while 33.33% and 22.22% relative percentage after treatment of 0.010% SA and 0.020% SA, respectively in BSMR 853 variety could be noted. In BDN 708 tall mutant showed highest relative percentage (40%) at 0.020% SA treatment. The relative percentage BSMR 853 variety at 0.015% SA treatment also showed (40%). For dwarf mutant, relative percentage was found highest after Gamma ray 15kR (50.0%) and 0.10% EMS treatment in BDN 708 while in BSMR 853 variety the same value was noted (50.00%) after 0.15% EMS treatment.
Early flowering mutant showed highest relative percentage 33.32% after SA treatment (0.010%) and 40.00% after SA treatment (0.015%) in the two varieties, respectively. Gamma ray treatment in BSMR 853 variety showed highest relative percentage 25.00% and 19.95%, respectively, for small pod mutant. Branched mutants showed highest values of 33.32 at 05 kR dose in BDN 708 and 25.00% at 10 kR dose of Gamma rays in variety BSMR 853.

**DESCRIPTION OF MUTANTS:**

**Viable mutants in variety BDN 708 (Table -36) (Plates -5, 6, 7, 8)**

1. **High yielding:** These mutants showed large number of pods per plant. The average number of pods per plant was 591.36 as compared to control (349.23). They attained similar branches and acquired slightly late flowering as compared with control. The productivity in terms of seeds per plant was better than control.

2. **Tall mutants:** These mutants showed a height of 241.33 cm as against 231.33 in control. The period for maturity in this mutant was comparable with that of control. The productivity in terms of pods and seeds per plant in such mutants was better than the control plants. They had lesser weight than control.

3. **Dwarf mutant:** These mutants were characterized by an extreme reduction in plant height. It was 174.33cm as against 231.33cm for control. All the characters in this mutant demonstrated reduced values as compared with control except for the character of days to pod maturity.

4. **Branched mutant:** These mutants showed 25.33 branches. The productivity in terms of pods per plant in such mutant was better as compared to control plant. Wight of hundred seeds and seeds per pod was higher than the control.

5. **Early flowering:** The duration of flowering in such mutants was 102.33 days as against 116.80 days in control. They acquired flowering quite earlier (13-14 days) than control. The productivity in terms of pods per plant was slightly more than the control plants.

6. **Early maturing:** These mutants demonstrated a feature of early maturity of plants. They attained maturity in 158.33 days as against 169.07 days in control.
They acquired flowering little earlier than control and the productivity in terms of seeds per plant was better than control. The number of seeds per pod was found to be increased as compared with control.

7. Light green pod:- These mutants were characterized by development of green pods without patches or shade like control. It yielded 198.66 pods which was less than the control plant.

8. Dark black pod:- In this mutant the pods were found to be blackish in colour as compared with control. It had more value of seeds per pod and hundred seed weight than the control plant.

9. Xantha:- These mutants were characterized by development of xantha chlorophyll as compared with control. They attained height of 206.00 cm and 164.33 days to pod maturity as against 231.33 cm and 169.07 days in control, respectively.

10. Small compact leaves:- In this mutant, leaves were found to be small in size and compactly arranged on stem as compared to control. The seeds of this mutant were more and had lesser weight than the control.

11. Erect and high yielding:- It was a branched mutant having 516.67 pods per plant against control and 22.67 numbers of branches per plant.

Viable mutants in variety BSMR 853 :- (Table -37) (Plates -5, 6, 7, 8)

1. High yielding:- In pigeonpea, these mutants showed large number of pods per plant. The average number of pods per plant was 714.34 as compared to control. They attained 209 cm height with 27 branches on stem.

2. Tall mutants:- These mutants showed a height of 214.34 cm as against 197.87 cm in control whereas the yield was less than the control plant.

3. Dwarf mutant: - Reduced height of plant was demonstrated by this mutant. It was 148 cm as against 197.87 cm for control. All characters in this mutant were found reduced as compared to control.

4. Branched mutant: - These mutants showed 28.67 branches. The productivity in terms of hundred seed weight was found to be more as compared to control.
5. Early flowering: - These mutants attained flowering in 108.66 days and 11-12 days before the control. These mutants showed negative correlation between days to flowering and 100 seed weight.

6. Early maturing: -These mutants revealed a feature of early maturity of plants. They attained maturity in 158.66 days as against 181.80 days in control. They acquired flowering earlier than control and the productivity in terms of seeds per plant in such mutants was less than control. Weight of 100 seeds was found to be decreased as compared with control in such mutants.

7. Xantha:-These mutants attained height of 202.67 cm and 171.34 days for pod maturity as against 197.87cm and 181.80 days in control, respectively.

8. Two seeded mutant:-The pods of these mutants contained only two seeds per pod. Productivity in this mutant was lesser than control plant.

9. Three seeded mutant:-Pods of such mutants contained three seeds and weight of hundred seeds was less than the control.

10. Five seeded mutant: - These mutants produced pods which carried five seeds per pod. The number of pods per plant in them was 510 and they showed the increased 100 seed weight and number of seeds per pod than the control.

11. Reddish pod mutant:-It is dark red coloured mutant, also taller (205.66) than control. It shows 108.67 seeds per pod and 09.63gm weight of hundred seeds. Total number of pods per plant were lesser than control.

12. Small pod: - In these mutants length of pod decreased than the control. Pods were looking small in size than the control plant. They matured in 179.66 days with lesser hundred seed weight than the control plants.

**QUANTITATIVE CHARACTERS IN M$_2$ AND M$_3$ GENERATIONS:**

In the present investigation an attempt was made to estimate the induced variability in the M$_2$ and M$_3$ generations. Data on the mean values, standard error, shift in mean, and coefficient of variation of different quantitative characters in the M$_2$ and M$_3$ generations of pigeonpea are presented in tables 38 to 65. The induced variability in respect of the following parameters was studied.
i) Days to flowering
ii) Number of primary branches
iii) Days of pod maturity
iv) Plant height
v) Number of pods per plant
vi) Number of seeds per pod and
vii) Hundred seed weight.

A thorough statistical analysis was carried out by computing the mean, standard error and coefficient of variation using standard formulae (Mungikar 1997). The shift in means and variance were also studied to assess the amount of induced variability due to mutagenic treatments. The data pertaining to \( M_2 \) and \( M_3 \) generations recorded for the different polygenic traits in both the varieties of pigeonpea are presented separately.

1) **Days to flowering (Tables 38-41):**

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.

2) **Number of primary branches per plant (Tables 42-45):**

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.
3) **Days to pod maturity (Tables 46-49):**

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.

4) **Plant height (Tables 50-53):**

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.

5) **Number of pods per plant (Tables 54-57):**

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 the mutagenic treatments.
6) **Number of seeds per pod (Tables 58-61):**

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.

7) **Hundred seeds weight (Tables 62-65):**

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.

**Biochemical studies:**

In the present investigation eleven viable mutants were biochemically analyzed regarding the parameters of water soluble protein content, carbohydrate content, percentage of nitrogen content, crude protein content, total ash content, calcium content and phosphorus content.

**Water soluble protein content (Tables 66-67):**

Water soluble seed protein content (%) present in $M_3$ viable mutants of both varieties of pigeonpea has been shown in Tables 66-67. The viable mutants in both the varieties of pigeonpea showed variability in water soluble protein content. The protein content in control was 19.55% in variety BDN 708 and 19.90% in variety BSMR 853. In variety BDN 708 highest value (21.15%) for
soluble protein was observed in early maturing mutant, while the lowest (17.00%) was in dwarf mutant. In variety BSMR 853, the highest soluble seed protein value (22.20%) was noticed in three seeded mutant while lowest (17.89%) could be found in branched and five seeded mutant.

**Carbohydrate content (Tables 68-69):**

The carbohydrate content was estimated in the viable mutants of pigeonpea varieties BDN 708 and BSMR 853. In control of variety BDN 708 and BSMR 853, the carbohydrate content was 44.33 % and 43.83%, respectively. Most of the viable mutants exhibited maximum carbohydrate content. Dwarf mutant showed maximum (48.33%) carbohydrate content while the least (36.50%) carbohydrate content has been shown by the small compact leaves mutant. In variety BSMR 853, the highest carbohydrate content could be noted in small pod mutant (46.02%) and lowest in the (39.33%) three seeded mutant.

**Total nitrogen and crude protein content (Tables 70-71):**

Nitrogen content of the viable mutants of the varieties BDN 708 and BSMR 853 of pigeonpea ranged from 1.95% to 3.33% and 2.24% to 3.17%, in different mutants. Increase in nitrogen content was observed in the erect and high yielding mutant (3.33%) than the control (2.34%) in variety BDN 708 and (3.17%) in small pod mutant than the control (2.42%) in variety BSMR 853. The crude protein content in the mutants ranged from 13.50% to 20.79% % as compared to control 14.61% in variety BDN 708. In variety BSMR 853, highest crude protein percentage could be recorded in small pod mutant (19.82%) and lowest in early flowering mutant (14.02%) as compared to control plant (15.13%).

**Total ash content (Table 72-73):**

In variety BDN 708 total ash content decreased except for the light green pod mutant (4.42%) as compared to control plant (4.36%). While highest value could be recorded in branched mutant (5.37%) in variety BSMR 853 in comparison to control plant (3.90%).
Calcium and Phosphorus content (Tables 72-73):-

The mean calcium content of viable mutants ranged from 0.25% to 0.37% and 0.26% to 0.51% in varieties BDN 708 and BSMR 853, respectively. While the mean phosphorus content of viable mutants ranged from 0.56% to 0.72% and 0.58% to 0.80% in varieties BDN 708 and BSMR 853 of pigeonpea, respectively. Higher contents of calcium and phosphorus were found in high yielding mutant (0.37%) and small compact leaves mutant (0.72%) in BDN 708 variety of pigeonpea, respectively. The highest percentage of calcium and phosphorus was recorded in early flowering branched mutant (0.51%) and high yielding mutant (0.80%). Lowest value in high yielding mutant (0.26%) for calcium and (0.58%) for phosphorus could be recorded in five seeded mutant in variety BSMR 853 of pigeonpea.

Protein profile: (Plate -10)

The protein polymorphism of different viable mutants revealed a wide variability with respect to the number and mobility of bands. Molecular characterization of all the viable mutants of pigeonpea varieties BDN 708 and BSMR 853 obtained in the present investigation was carried out by their protein profiles by employing Native-PAGE and SDS-PAGE. The characterization studies were carried out on seed storage proteins (Water soluble proteins).

Native PAGE gel analysis of viable mutants of pigeonpea variety BDN 708 showed considerable variation in protein profiling. In control plant, tall, branched and early flowering mutants a total of 09 protein bands were recorded. Maximum 12 bands could be found in early maturing mutant. Native PAGE gel analysis of viable mutants of pigeonpea variety BSMR 853 showed considerable variation in protein profiling. In control total 08 protein bands were recorded. Highest 13 bands could be observed in xantha mutant followed by 10 bands in three seeded mutants.
In the present analysis the seed protein banding pattern of viable mutants of both the varieties showed differences in regard to presence or absence of bands, besides number and mobility of bands.

SDS-PAGE analysis of viable mutants of pigeonpea variety BDN 708 ranged from 12 to 19 bands as compared to 14 bands in control (Plate-10). Maximum number of polypeptide bands was found in the high yielding (19) mutant having the molecular weight of 111.12 kD. Highest molecular weight (111.66 kD) was observed in small compact leaves mutant, which had 17 protein bands. While minimum number of polypeptide bands could be noted in tall and early flowering mutants. Lower molecular weight of protein bands could be found in tall mutant (91.90kD).

SDS-PAGE analysis of viable mutants of pigeonpea variety BSMR 853 revealed a wide range of protein polymorphism and variability with respect to number and mobility of polypeptide bands. The polypeptide bands of the viable mutants of the variety ranged from 09 to 13 as compared to 12 bands in control (Plate-10). Maximum number of polypeptide bands 13 was found in the three seeded and 12 bands of protein could be observed in the tall, branched, xantha and early flowering with branched mutant while minimum number of polypeptide bands (09) could be recorded in five seeded mutants. Highest molecular weight was observable in three seeded and xantha mutants (114.40 kD). While the least molecular weight could be found in small pod mutant (75.40 kD).