Genetical Studies of Mutant Lines in M₃ Generation of Finger Millet (Eleusine coracana (L.) Gaertn)

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ABSTRACT

M₃ generation of thirty four mutant lines was developed from genotype Girge local which was irradiated with 500 Gydose of gamma rays which was studied along with three checks viz., Dapoli-1, Dapoli-2 and Dapoli safed for estimation of genetic parameters. The genetic parameters viz., Components of variances, coefficient of variations, heritability, genetic advance and genetic advance as per cent of mean were estimated for quantitative and qualitative traits. Significant differences among the entries were studied for all the traits. The estimated data on genetic parameters revealed that genotypic and phenotypic variances were highest for calcium content followed by grain density, indicating highest wide variability for this character. The traits viz., iron content, number of productive tillers, calcium content, straw yield plant⁻¹, number of fingers plant⁻¹, and main earhead length were recorded with high GCV and PCV. Higher heritability was observed in the traits viz., iron content, calcium content, protein content, number of productive tillers plant⁻¹, main earhead length, main earhead length and number of fingers plant⁻¹. The high genetic advance was estimated for the character, calcium content (92.46 mg/100g) and grain density (11.95). Only calcium content showed high heritability accompanied with high genetic advance among all the studied traits indicates that, most likely their heritability is due to additive gene effects and selection is effective for this trait. The mutant lines viz., 18 NMS-12 and 18 NMS-34 were found early flowering and early maturing among the studied mutant lines. Regarding to quality parameters high iron content was observed in mutant lines 18 NMS-24 (23.72 mg/100g) and 18 NMS-18 (22.28 mg/100g). The mutant lines viz., 18 NMS-21 (11.05%) and 18 NMS-15 (10.56%) recorded higher protein content. While the lines 18 NMS-10 (360 mg/100g) and 18 NMS-20 (354 mg/100g) recorded higher calcium content. The mutant lines viz., 18 NMS-31 and 18 NMS-23 were recorded significantly higher values for yield and yield contributing traits viz., grain yield plant⁻¹, weight of earhead plant⁻¹, number of fingers plant⁻¹, main earhead length, grain density and number of productive tillers plant⁻¹. Which may be exploited for commercial purpose after multilocation testing along with suitable check if found promising.

Keywords
Finger millet, Genetic coefficient of variance, Phenotypic coefficient variance, Genetic variability, Heritability, Genetic advance

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**Introduction**

Finger millet [(*Eleusine coracana* (L) Gaertn)] is still considered as staple food in many rainfed hilly and tribal areas of India. It is grown on 1.14 million hectares with total production 1.82 million tonnes and productivity of 1601 Kg/ha. (Anon., 2017-18) in India. In Maharashtra, the largest area under finger millet is found in Konkan region viz., 33 thousand hectares with production 36 thousand tones and productivity 1122 Kg/ha. (Anon., 2018-19). Ragi is commonly called as “Nutritious millet” as the grains are nutritionally superior to many cereals providing fair amount of proteins, minerals, calcium and vitamins in abundance to the people. It is the cheapest and preferred food crop of economically suppressed but physically hard working people. It is appreciated by the people, because it can digest slowly thereby furnish energy for hard work throughout the day.

Finger millet meets the first and most needs of mankind, the energy and hunger satisfaction. It leaves a sense of being well fed to any farmer. The protein of finger millet has been reported to possess a fairly high biological value, which is needed for the maintenance of nitrogen equilibrium of the body. The higher fibre content of finger millet helps in many ways as it prevents constipation, high cholesterol formation and intestinal cancer. Hence, people suffering from diabetics are advised to eat finger millet and other small millets instead of rice (Eswari *et al.*, 2014).

Genetic improvement through conventional breeding approaches depends mainly on the availability of diverse germplasm and presence of enormous genetic variability. Adequate variability is not available in the gene pool to change the plant ideotypes. Estimation of genetic parameters in the context of trait characterization is an essential component in developing high yielding varieties.

Hence, an attempt was made by using mutation breeding to estimate the extent of variation for yield contributing traits in thirty four finger millet mutant lines by studying the genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance, which may contribute to formulation of suitable selection indices for improvement in this crop. In finger millet where there are very small florets which is very difficult to emasculation and hybridization the mutation breeding has been playing a key role in creating variability (Sawardekar, 2016).

**Materials and Methods**

The present investigation was carried out at the Research Farm of Agricultural research station, Shirgaon, Ratnagiri, Dist. Ratnagiri (MS). 34 mutant lines selected from the Girgelocal genotype were used for study. The local finger millet variety Girge local was treated with 500 Gy during May, 2018. The effect of gamma rays on yield contributing traits was studied in M1 generation. M1 generation was sown on 25/06/2018 and harvested on October, 2018. M2 generation was grown during Rabi, 2018-2019. Sown on 18/01/2019 and transplanted on 10/02/2019 and selections were made during 1st week of May, 2019.

The effect of gamma rays on yield contributing traits was studied in M1 generation. M1 generation was sown on 25/06/2018 and harvested on October, 2018. M2 generation was grown during Rabi, 2018-2019. Sown on 18/01/2019 and transplanted on 10/02/2019 and selections were made during 1st week of May, 2019.

Individual plants in M2 generation were selected on the basis of phenotypic characters and harvested separately during Rabi, 2018-19. The thirty four selected plant progenies of M2 plants for growing of M3 generation were
sown along with three checks viz., Dapoli-1, Dapoli-2 and DapoliSafed on 25/06/2019 for growing the seedlings.

The 22 days seedlings were transplanted in main field on 17/7/2019. The seedlings were transplanted at the spacing of 20×10 cm. Three rows of each mutant lines of 3m length were transplanted in three replications in Randomized Block Design (RBD). All required package of practices were implemented. The recommended doses of fertilizers were 80 kg N/ha, 40 kg P₂O₅/ha. The nitrogen dose was given in two splits, 40 kg N/ha given as basal dose and 40 kg N/ha was given 30 days after transplanting. All plant protection measures were applied as per need.

Five plants were selected randomly from net plot of each mutant lines and the following observations were recorded viz., days to 50% flowering, days to maturity, weight of earhead (g), main ear head length (cm), plant height (cm), number of productive tillers plant⁻¹, grain density (No. of grains/cm), number of fingers ear⁻¹, grain yield plant⁻¹ (g), straw yield plant⁻¹ (g), harvest index (%), test weight (g), protein content (%), calcium content (mg/100g) and iron content (mg/100g) traits on morphological fixed mutant lines of M₃ generation.

The mean of all the plants for each trait under each replication was subjected to analysis (Panse and Sukhathme, 1954). The estimate of genotypic variance and phenotypic variance were worked out according to the method suggested by Johnson et al., (1955) using mean square values from the ANOVA table 1.

Phenotypic and genotypic coefficient of variances were calculated based on the method advocated by Burton et al., (1952). Broad sense heritability was estimated as per the method described by Lush (1940) and traits were classified as having high, moderate and low heritability as per the method of Johnson et al., (1955). Genetic advance was estimated according to the method suggested by Johnson et al., (1955), and expressed as percentage of mean. Traits were classified as having high, moderate or low genetic advance as per cent of mean as per the method suggested by Johnson et al., (1955).

**Results and Discussion**

In the present investigation, various statistical parameters of variability like mean, range, variance components and coefficients of variation, heritability in broad sense, genetic advance and genetic advance as per cent of mean were studied which provide basic information regarding the genetic properties of the population based on which breeding methods are formulated for further improvement of the crop. The analysis of variance showed a wide range of variation and significant differences for all the characters under study (Table 1).

**Mean performance for quantitative parameters**

The mutant lines viz., 18 NMS-23 (11.80 cm) followed by 18 NMS-31 (11.47 cm), 18 NMS-24 (11.20 cm) and 18 NMS-30 (11.20 cm) were found with highest main earhead length. Similar results were recorded by Keerthana et al., (2019), Jyothsna et al., (2016) and Devaliya et al., (2018).

The mutant lines viz., 18 NMS-8 (78.67 cm) followed by 18 NMS-27 (80.13 cm), 18 NMS-2 (81.07 cm) were found to be dwarf genotype which is desirable traits for lodging resistance. Similar results were reported by Chavan et al., (2019), Shet et al., (2009), Devaliya et al., (2018) and Keerthana et al., (2019). The mutant lines 18 NMS-23 (2.27), 18 NMS-24 (2.13) and 18 NMS-30 (2.13)
recorded significantly higher number of productive tillers plant⁻¹. Similar results were recorded by Muduli and Misra (2008), Jyothsna et al., (2016), Chavan et al., (2019) and Devaliya et al., (2018). The Mutant lines viz., 18 NMS-12 (115.67 days), 18 NMS-14, 18 NMS-18 and 18 NMS-27 each with mean 116 days and 18 NMS-17 with 116.67 days maturity duration were said to be early maturing.

Similar results were recorded by Chavan et al., (2019), Singamsetti et al., (2018) and Jyothsna et al., (2016). The mutant lines viz., 18 NMS-10 (81.33 days), 18 NMS-12 (81.33 days), 18 NMS-11 (82.33 days) and 18 NMS-34 (82.67 days) were recorded with less number of days to 50 per cent flowering. Similar results were recorded by Shet et al., (2009), Chavan et al., (2019), Jyothsna et al., (2016) and Devaliya et al., (2018). The mutant lines viz., 18 NMS-1 (17.27 g/plant), 18 NMS-2 (16.27 g/plant) and 18 NMS-22 (16.20 g/plant) were found with numerically higher straw yield plant⁻¹ and found good for fodder purpose.

Similar results were recorded by Anuradha and Patro (2019), Prashantha et al., (2018) and Joel et al., (2005). The higher test weight was observed in mutant line viz., 18 NMS-26 (2.99g) followed by 18 NMS-2 (2.93g), 18 NMS-13 (2.85g), 18 NMS-9 (2.83g). Similar results were recorded by Shet et al., (2009), John (2006) and Devaliya et al., (2018). The mutant lines viz., 18 NMS-23 (7.26) followed by 18 NMS-15 (7.07 and 18 NMS-31 (6.80) were recorded with highest numbers of fingers plant⁻¹.

Similar results were recorded by Aviya and Mullainathan (2018) and Muduli and Misra (2008). The higher weight of earhead was seen in mutant line viz., 18 NMS-31 (9.40g/plant), 18 NMS-23 (9.35g/plant), 18 NMS-32 and 18 NMS-24 each with mean value 9.20g/plant and 18 NMS-27 (9.13g/plant). Similar range for weight of earhead plant⁻¹ was recorded by Lad et al., (2018), Prashantha et al., (2018) and Subramanya et al., (2019).

The mutant lines viz., 18 NMS-31 (8.33 g/plot) followed by 18 NMS-23 (8.27 g/plot), 18 NMS-30 (8.10 g/plot), 18 NMS-16 (8.0 g/plot) and 18 NMS-24 (7.97 g/plot) were found high yielding among all the mutant lines. Similar results were also reported by Mohitepatil (2007), Anuradha and Patro (2019), Muduli and Misra (2008), Devaliya et al., (2018) and Das et al., (2017).

The mutant lines viz., 18 NMS-9 (39.40%), 18 NMS-31 (39.13 %), 18 NMS-24 (38.75 %) and 18 NMS-32 (38.72 %) were recorded with significantly higher harvest index. Similar results were reported by John (2006), Prashantha et al., (2018) and Lad et al., (2018). The mutant lines viz., 18 NMS-23 (91.67 grains/cm), 18 NMS-22 (86.33 grains/cm), 18 NMS-16 (81.67 grains/cm) and 18 NMS-31 (77.67) were recorded with high grain density. Similar results were recorded by Mohitepatil (2007) and Ambhavane et al., (2015).

Mean performance for quality parameters

The mutant lines viz., 18 NMS-21 (11.05), 18 NMS-15 (10.56%), 18 NMS-32 (10.35%) and 18 NMS-27 (10.33%) recorded significantly higher protein content. Similar results were recorded by Jawale et al., (2019), Chavan et al., (2019), Devaliya et al., (2018) and Das et al., (2017). The mutant line viz., 18 NMS-24 (23.72 mg/100g), 18 NMS-7 (22.83 mg/100g) and 18 NMS-18 (22.28 mg/100g) were recorded with higher iron content.

Similar values were recorded by Jawale et al., (2019), KaziTahsin et al., (2017) and Chavan et al., (2019). The mutant line viz., 18 NMS-
10 (360 mg/100gm), 18 NMS-20 (354 mg/100g) and 18 NMS-14 (351.33 mg/100g) were recorded with higher calcium content. Similar range and general mean were recorded by Jawale et al., (2019), Chavan et al., (2019) and Das et al., (2017).

**Component of variations**

Maximum phenotypic variance for M₃ generation was found for calcium content followed by grain density, plant height and iron content. Similarly, maximum genotypic variance was observed in calcium content followed by grain density, iron content and plant height. Similar results were recorded by Chavan B. R. et al., (2019), John (2006), Devaliya et al., (2018) and Muduli and Misra (2008). The mutant lines viz., 18 NMS-12 (81.33 days to 50% flowering and 115.67 days to maturity) and 18 NMS-34 (82.67 days to 50% flowering and 117.67 days to maturity) were found early flowering and early maturing than all the studied mutant lines. The mutant lines viz., 18 NMS-31 and 18 NMS-23 recorded significantly higher values for yield and yield contributing traits viz., grain yield plant⁻¹, weight of earhead plant⁻¹, number of fingers plant⁻¹, main earhead length, grain density and number of productive tillers plant⁻¹ and were also recorded with numerically higher harvest index.

All these traits indicate additive effect showing scope for selection. Similar results were recorded by Shet et al., (2009), Jawale et al., (2019), Keerthana et al., (2019), John (2006), Devaliya et al., (2018), Suryanarayana et al., (2014), Jyothsna et al., (2016), Muduli and Misra (2008) and Das et al., (2017).

**Genetic advance as per cent of mean**

The higher (more than 20%) values of genetic advance as percentage of mean was reported for the traits viz., iron content, number of productive tillers plant⁻¹, calcium content (mg/100g), main earhead length, protein content (%) and number of fingers plant⁻¹. The lower (less than 10%) value for genetic advance as per cent of mean was recorded for the traits viz., days to maturity, days to 50% flowering, plant height, test weight and weight of earhead plant⁻¹. The moderate (10-20%) value for genetic advance as per cent of mean was recorded for the traits viz., grain density, straw yield plant⁻¹, grain yield plant⁻¹ and harvest index. Similar values were recorded by Ambavne et al., (2015), Jawale et al., (2019), Keerthana et al., (2019), John (2006), Devaliya et al., (2018) and Muduli and Misra (2008). The mutant lines viz., 18 NMS-12 (81.33 days to 50% flowering and 115.67 days to maturity) and 18 NMS-34 (82.67 days to 50% flowering and 117.67 days to maturity) were found early flowering and early maturing than all the studied mutant lines. The mutant lines viz., 18 NMS-31 and 18 NMS-23 recorded significantly higher values for yield and yield contributing traits viz., grain yield plant⁻¹, weight of earhead plant⁻¹, number of fingers plant⁻¹, main earhead length, grain density and number of productive tillers plant⁻¹ and were also recorded with numerically higher harvest index.

Regarding to quality parameters the mutant lines viz., 18 NMS-21 (11.05%) and 18 NMS-15 (10.56%) recorded higher protein content. Calcium content analysis revealed that the mutant lines 18 NMS-10 (360 mg/100g) and 18 NMS-20 (354 mg/100g) recorded higher calcium content. High iron content was observed in mutant lines 18 NMS-24 (23.72 mg/100g) and 18 NMS-18 (22.28 mg/100g). The moderate (10-20%) value for genetic advance as per cent of mean was recorded for the traits viz., grain density, straw yield plant⁻¹, grain yield plant⁻¹ and harvest index.
Table 1: Analysis of variance (ANOVA) for the different characters studied in M₃ generation of Finger millet

| Sr. No. | Characters                                      | Mean Sum of Squares | Replications | Treatments | Error  |
|---------|------------------------------------------------|---------------------|--------------|------------|--------|
| 1       | Plant height (cm)                              | 11.15               | 114.39*      | 79.51      |
| 2       | Main earhead length (cm)                       | 4.19                | 8.15**       | 0.924      |
| 3       | No. of productive tillers plant⁻¹              | 0.034               | 0.319**      | 0.034      |
| 4       | Days to 50% flowering                          | 63.85               | 33.43*       | 20.62      |
| 5       | Days to maturity                               | 33.12               | 20.86*       | 10.97      |
| 6       | Test weight (g)                                | 0.004               | 0.082*       | 0.052      |
| 7       | No of fingers plant⁻¹                          | 0.261               | 2.254**      | 0.334      |
| 8       | Straw yield plant⁻¹ (g)                        | 5.99                | 8.98**       | 1.94       |
| 9       | Weight of earhead plant⁻¹ (g)                  | 0.712               | 1.75**       | 0.700      |
| 10      | Grain yield plant⁻¹ (g)                        | 1.656               | 2.10**       | 0.770      |
| 11      | Harvest Index (%)                              | 1.2021              | 38.61**      | 11.42      |
| 12      | Grain density (No. of grains cm⁻¹)             | 36.01               | 287.70**     | 76.71      |
| 13      | Protein content (%)                            | 0.484               | 5.430**      | 0.392      |
| 14      | Calcium content (mg/100g)                      | 608.12              | 7777.91**    | 496.77     |
| 15      | Iron content (mg/100g)                         | 5.82                | 72.15**      | 1.41       |

* Significant for 5% level of significance ** Significant for 1% level of significance

Table 2: Estimates of phenotypic (σ²p), genotypic (σ²g) and environmental (σ²e) variance for M₃ generation of Finger millet

| Sr. No. | Characters                                      | σ²p   | σ²g   | σ²e   |
|---------|------------------------------------------------|-------|-------|-------|
| 1       | Plant height (cm)                              | 85.80 | 14.29 | 71.51 |
| 2       | Main earhead length (cm)                       | 3.33  | 2.41  | 0.924 |
| 3       | No. of productive tillers plant⁻¹              | 0.130 | 0.094 | 0.036 |
| 4       | Days to 50% flowering                          | 24.89 | 4.27  | 20.62 |
| 5       | Days to maturity                               | 14.27 | 3.30  | 10.97 |
| 6       | Test weight (g)                                | 0.062 | 0.01  | 0.052 |
| 7       | No of fingers plant⁻¹                          | 0.974 | 0.640 | 0.334 |
| 8       | Straw yield plant⁻¹ (g)                        | 4.29  | 2.34  | 1.94  |
| 9       | Weight of earhead plant⁻¹ (g)                  | 1.05  | 0.35  | 0.70  |
| 10      | Grain yield plant⁻¹ (g)                        | 1.21  | 0.44  | 0.77  |
| 11      | Harvest Index (%)                              | 20.48 | 9.06  | 11.42 |
| 12      | Grain density (No. of grains cm⁻¹)             | 147.04| 70.33 | 76.71 |
| 13      | Protein content (%)                            | 2.07  | 1.68  | 0.392 |
| 14      | Calcium content (mg/100g)                      | 2923.82| 2427.05| 496.77|
| 15      | Iron content (mg/100g)                         | 24.99 | 23.58 | 1.41  |
Table 3 Estimates of genetic parameters for various characters of M3 generation of Finger millet

| Sr. No | Characters                        | Mean  | Range | PCV (%) | GCV (%) | Heritability (%) | Genetic Advance | Genetic Advance as % of mean |
|-------|----------------------------------|-------|-------|---------|---------|------------------|-----------------|-----------------------------|
|       |                                  | Min.  | Max.  |         |         |                  |                 |                             |
| 1     | Plant height (cm)                | 88.46 | 74.07 | 109.33  | 10.47   | 4.27             | 16.66           | 3.18                        | 3.59                        |
| 2     | Main earhead length (cm)         | 8.68  | 5.40  | 11.80   | 21.03   | 17.87            | 72.27           | 2.72                        | 31.30                       |
| 3     | No. of productive tillers plant-1| 1.58  | 1.13  | 2.27    | 22.75   | 19.36            | 72.43           | 0.54                        | 34.95                       |
| 4     | Days to 50% flowering            | 87.47 | 79.33 | 93.00   | 5.70    | 2.36             | 17.17           | 1.76                        | 2.02                        |
| 5     | Days to maturity                 | 120.09| 115.67| 125.00  | 3.15    | 1.51             | 23.12           | 1.80                        | 1.50                        |
| 6     | Test weight (g)                  | 2.65  | 2.31  | 2.99    | 9.37    | 3.81             | 16.50           | 0.085                       | 3.18                        |
| 7     | No of fingers plant-1            | 5.52  | 3.20  | 7.27    | 17.87   | 14.49            | 65.74           | 1.34                        | 24.21                       |
| 8     | Straw yield plant-1 (g)          | 13.83 | 10.27 | 17.27   | 14.97   | 11.07            | 54.67           | 2.33                        | 16.87                       |
| 9     | Weight of earhead plant-1 (g)    | 8.28  | 6.53  | 9.40    | 12.39   | 7.15             | 33.34           | 0.70                        | 8.51                        |
| 10    | Grain yield plant-1 (g)          | 6.90  | 4.40  | 8.33    | 15.98   | 9.67             | 36.60           | 0.83                        | 12.06                       |
| 11    | Harvest Index (%)                | 33.38 | 26.32 | 39.40   | 13.56   | 9.02             | 44.26           | 4.13                        | 12.36                       |
| 12    | Grain density (No. of grains cm-1)| 66.18 | 45.67 | 91.67   | 18.32   | 12.67            | 47.83           | 11.95                       | 18.05                       |
| 13    | Protein content (%)              | 8.62  | 6.25  | 11.05   | 16.70   | 15.04            | 81.05           | 2.40                        | 27.88                       |
| 14    | Calcium content (mg/100g)        | 284.29| 196.67| 360.00  | 19.02   | 17.33            | 83.01           | 92.46                       | 32.52                       |
| 15    | Iron content (mg/100g)           | 16.49 | 7.41  | 23.72   | 30.32   | 29.45            | 94.34           | 9.72                        | 58.92                       |
Plate 1 Earheads of high yielding mutant lines 18 NMS – 31 and 18 NMS – 23
Heritability in broad sense

Higher heritability (more than 60%) was observed in the traits *viz.* iron content, calcium content, protein content, number of productive tillers plant$^{-1}$, main earhead length, main earhead length and number of fingers plant$^{-1}$. The moderate (30–60%) heritability
was observed in traits viz., straw yield plant$^{-1}$, grain density, harvest index and weight of earhead plant$^{-1}$. The lower (less than 30%) heritability was estimated in trait, grain yield plant$^{-1}$ followed by test weight, plant height, days to 50% flowering and Days to maturity. Similar results were recorded by Jawale et al., (2019) and Chavan et al., (2019), Keerthana et al., (2019, John (2006), Devaliya et al., (2018) and Das et al., (2017).

**Genetic advance**

The high genetic advance estimated was for the character, calcium content (92.46) and grain density (11.95). Similar results were recorded by Jawale et al., (2019), Chavan et al., (2019), John (2006), Devaliya et al., (2018) and Muduli and Misra (2008).

The genotypic and phenotypic variances were found highest for calcium content followed by grain density, indicating highest wide variability for this character. Similar results were recorded by Chavan B. R. et al., (2019), John (2006) and Devaliya et al., (2018). Calcium content showed high heritability accompanied with high genetic advance indicates that, most likely their heritability is due to additive gene effects and selection may be effective Jawale et al., (2019) and Chavan et al., (2019).

The traits viz., main earhead length, number of productive tillers plant$^{-1}$, number of fingers plant$^{-1}$, protein content and iron content exhibited high heritability and low genetic advance, indicates non additive gene action and selection for such traits may not be rewarding Devaliya et al., (2018) and Muduli and Misra (2008). Low heritability accompanied with low genetic advance was showed in the traits viz., plant height, days to 50 % flowering, days to maturity and test weight indicates that, these characters were highly influenced by environment, Chavan et al., (2019), John (2006). The mutant lines viz., 18 NMS-31 and 18 NMS-23 recorded significantly higher values for yield and yield contributing traits viz., grain yield, weight of earhead plant$^{-1}$, number of fingers plant$^{-1}$, main earhead length, grain density and number of productive tillers plant$^{-1}$ which may be exploited for commercial purpose after multilocation testing along with suitable check if found promising.

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