Genetic Variability Study in Little Millet (*Panicum miliare* L.) Genotypes in Relation to Yield and Quality Traits

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**Abstract**

The extent of genetic variability present in any base population is most important for the success of breeding programme. Greater the variation in the material, better is the chance for selecting promising and desired types. Hence, thirty two genotypes of little millet were studied for genetic variability study at Hill Millet Research Station in randomized block design for different morphological and biochemical traits viz., days to 50% flowering, days to maturity, zinc content (mg), plant height at maturity (cm), 1000 seed weight (g), fiber content (%), number of productive tillers per plant, Protein content (%), number of branches per panicle, ash content (%), panicle length (cm), fat content (%), grain yield per plant(g), calcium content (mg), straw yield per plant (g), iron content (mg). The results of the present study indicated all the sixteen characters had a wide range of variability in the different little millet genotypes. High estimates of genotypic and phenotypic variance were observed for days to 50% percent flowering, plant height at maturity, panicle length, straw yield per plant, days to maturity and calcium content. High genotypic and phenotypic coefficient of variation found in number of productive tillers per plant, grain yield and straw yield per plant. In the present study the high heritability coupled with high genetic advance was observed for number of productive tillers per plant, grain yield per plant, straw yield per plant, 1000 seed weight, protein content, ash content, fat content, calcium content, iron content and fiber content which, indicated that these characters are largely governed by additive genes and selection for improvement of such characters could be rewarding.

**Keywords**

Little millet, Genetic variability, Heritability, Genetic advance as % of mean

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**Introduction**

Little millet belongs to the family Poaceae, sub-family Panicoideae and the tribe Paniceae (Rachie, 1975). Little millet was domesticated in the Eastern Ghats of India occupying a major portion of diet amongst the tribal people and spread to Sri Lanka, Nepal, and Myanmar (De Wet et al.,). Little millet (*Panicum miliare* L.) is grown in India under various agro-ecological situations and commonly known as samai, samo, moraio, vari, kutki. India is well
known for its rich agro-biodiversity and prime contributor with 473 accessions (Upadhyaya et al., 2016) In India, little millet having 1.42 lakh tones of production. In Gujarat, little millet is cultivated in an area of 10,634 hectares with 9,526 tonnes of production having the productivity of 896 kg/ha (Anonymous, 2015). The area under this crop is mainly concentrated in the districts of The Dangs, Valsad, Navsari of South Gujarat and Panchmahal of middle Gujarat.

Little millet is a hardy crop which can withstand drought better than most of other cereal crops and water logging to a certain degree, also. Besides India, it is cultivated in Nepal and Western Burma. The potentiality of little millet has not been exploited in India and the yield levels are very low there by indicating a greater scope for exploitation of this millet under Indian condition. In India, little millet growing states are Karnataka, Tamil Nadu, Odisha, Madhya Pradesh, Chattisgarh, Jharkhand, Andhra Pradesh, Uttarakhand, Maharashtra and Gujarat. In Gujarat, generally little millet crop is grown in hilly tract of The Dangs and Valsad district and locally known as “Vari or Moraio”. The productivity of little millet is low due to poor soil fertility and age-old cultivation methods.

The existence of variability is essential for resistance to biotic and abiotic factors as well as for wider adaptability in different set of environment. Variability refers to the presence of differences among the individuals of plant population. Variability results due to differences either in the genetic constitution of the individuals of a population or in the environment in which they are grown. Selection is also effective when there is presence of ample genetic variability among the individuals in a population. Hence, insight into the magnitude of genetic variability present in a population is of paramount importance to a plant breeder for starting a judicious breeding programme. Greater the variation in the material, better is the chance for selecting promising and desired types. The genetic variability is calculated from phenotypic observations, which are the results of interaction of genotypes and environment.

The yield potential of little millet is low and plagued with a number of genetical and morphological reasons. Though, the crop has been important over centuries, more concentrated research efforts are geared in recent years to evolve improved varieties and develop production technology.

Hence, the present study conducted on thirty two little millet genotypes to harness the information related to genetic variability, heritability and genetic advance for different traits.

**Materials and Methods**

The experiment was conducted at Hill Millet Research Station, Navsari Agricultural University, Waghai (The Dangs) using 32 genotypes of little millets in randomized block design with three replications. The gross plot is divided into three blocks which were taken as a replications while the blocks are further divided into equal 32 plots. Five randomly selected plants from each genotypes in each replications were used to record observations for morphological characters. Data were recorded on total 16 morphological and biochemical traits viz., days to 50 % flowering, days to maturity, zinc content (mg), plant height at maturity (cm), 1000 seed weight (g), fiber content (%), number of productive tillers per plant, Protein content (%), number of branches per panicle, ash content (%), Panicle length (cm), fat content (%), grain yield per plant(g), calcium content (mg), straw yield per plant (g), iron content (mg). The mean of five plants was subjected to statistical analysis, to estimate analysis of
variance as suggested by Panse and Sukhatme (1967). Genotypic and phenotypic coefficient of variability were computed according to the method suggested by Burton (1952). Heritability in broad sense was calculated as per the formula given by Allard (1960). Range of heritability was categorized as suggested by Robinson et al., (1949). Genetic advance was expressed as per cent of mean by using the formula expounded by Johnson et al., (1955). Traits were classified as having high, moderate or low genetic advance as per the method suggested by Johnson et al., (1955).

**Results and Discussion**

**Analysis of variance**

The genotypic differences were highly significant for all the sixteen characters indicating considerable amount of genetic variability among the genotypes tested in the present study, suggesting ample scope for improvement of yield and various yield attributing characters. The genotypic mean square values were highly significant for all quantitative traits, implying that the genotypes tested were highly variable (Table 1.).

Similar results for most of the characters were also reported by Yadav and Shrivastava (1976), Reddy (1984), Chidambaram and Palanisamy (1996), Ananda et al., (2015), Anuradha et al., (2017) in little millet, while Satish et al., (2003), Kebar et al., (2006), Chemeda and Gemechu, (2010), Priyadharshini et al., (2011), Luli et al., (2012), Salini et al., (2010), Subramanian et al., (2010), Ganapathy et al., (2011), Haradari et al., (2012), Reddy et al., (2013), Karad and Patil (2013), Dhanalakshmi et al., (2013), Joshi (2013), Chaudhari et al., (2013), Suryanarayana et al., (2014), Saundaryakumari and Singh (2015), Vasadia (2015), Jyotsana (2016), Devaliya et al., (2018) in remaining small millets.

**Variability studies**

Success of any crop improvement programme depends upon the variability in the material. A large amount of variation is necessary in a breeding population to enable the breeder to carry out effective selection.

The range, mean, genotypic, phenotypic and environmental variance, phenotypic and genotypic coefficients of variation, heritability and expected genetic advance as percentage of mean for sixteen characters are presented in Table 2 and 3.

High estimates of genotypic and phenotypic variance were observed for days to 50% percent flowering, plant height at maturity, panicle length, straw yield per plant, days to maturity and calcium content. Similar finding were also reported by Reddy (1984) for straw weight, panicle length; Vasadia (2015) for days to 50% percent flowering, straw yield, plant height in little millet, while in finger millet similar finding were also reported by Kebere et al., (2006) for plant height, days to heading, days to maturity; Reddy et al., (2013) for 50% flowering, plant height, ear head length, straw yield; Dhanalakshmi et al., (2013) for 50% percent flowering, plant height; Suryanarayana et al., (2014) for days to maturity, plant height; Devaliya et al., (2018) for plant height, days to 50 % flowering, straw yield per plant and days to maturity.

Low estimates of genotypic and phenotypic variance were observed for number of productive tillers per plant, number branches per plant, grain yield per plant, 1000 seed weight, protein content, ash content, fat content, iron content, zinc content and fiber content. Similar results in finger millet were also obtained by John (2007) for number of productive tillers per plant, 1000 grain weight and grain yield per plant; Kebere et al., (2006)
for number of productive tillers per plant, grain yield per plant and 1000 grain weight; Suryanarayana et al. (2014) for number of productive tillers per plant and seed yield per plant.

High genotypic and phenotypic coefficient of variation found in number of productive tillers per plant, grain yield, straw yield per plant. Similar results were also obtained by Reddy (1984) for straw weight, grain yield, number of tillers and Selvi et al. (2014) grain yield per plant and number of basal tillers per plant in little millet, while Selvarani and Chandarasekaran (2000) number of productive tillers per plant; Keber and Patil (2006) for grain yield per plant; Nirmalakumari et al. (2010) for grain yield and number of productive tillers per plant; Priyadarshini et al. (2011) for number of productive tillers per plant; Ganapathy et al. (2011) number of productive tillers per plant; Dhamdhere et al. (2011) for productive tillers per plant; Lule et al. (2012) for grain yield per plant; Chaudhari et al. (2013) for number of productive tillers per plant; Suryanarayana et al. (2014) for seed yield plant per plant, productive tillers per plant and Devaliya et al. (2018) for grain yield per plant in remaining small millets.

The lower value of genotypic coefficient of variation and phenotypic coefficient of variation observed for days to 50 % flowering, plant height at maturity, days to maturity. Similar results were also obtained by Keber et al. (2006) for days to maturity; Dhamdhere et al. (2011) days to maturity; Lule et al. (2012) days to 50 % flowering and days to maturity; Reddy et al. (2013) for 50 % flowering, plant height and days to maturity; Suryanarayana et al. (2014) for days to 50 % flowering and days to maturity; Ananda et al. (2015) for days to heading; Jyotsna et al. (2016) for days to maturity. The most probable reason could be the phenotypic plasticity occurring in those traits is the main source of variation than the genetic variance. Such result also indicated that selection is not effective for those traits because of the narrower genetic variability.

In the present study, the difference between PCV and GCV were lower for most of the characters suggesting negligible role of environment in the expression of traits, therefore improvement by phenotypic selection is possible. It is not possible to determine the amount of variability, which is heritable, with the help of genotypic coefficient of variation alone. Burton (1952) also suggested that GCV together with a heritability estimates would provide better insight for amount of genetic gain expected through phenotypic selection.

The characters days to 50 % flowering, plant height, number of productive tillers per plant, panicle length, grain yield per plant, straw yield per plant, days to maturity, 1000 seed weight, protein content, ash content, fat content, calcium content, iron content, zinc content, fiber content exhibited high heritability estimates which, indicated that these characters are largely governed by additive genes and selection for improvement of such characters could be rewarding. Similar results were also obtained by Yadav and Srivastava (1976) for days to flowering, days to maturity, plant height, number of tillers per plant, length of panicle, grain yield per plant, straw yield per plant and 100 seed weight; Reddy et al. (1984) grain yield per plant, straw yield per plant, days to maturity, plant height; Selvi et al. (2014) for 50 % flowering, plant height, number of productive tillers per plant, grain yield per plant, straw yield per plant, 1000 seed weight; Ananda et al. (2015) for grain yield, days to heading, panicle length, straw yield, 1000 grain weight, plant height and days to heading; Jyotsna et al. (2016) for days to 50 % flowering, days to maturity, plant height and grain yield and Anuradha et al. (2017) for 50 % flowering,
Table 1: Analysis of variance (Mean Sum of Square) for sixteen different characters of little millet

| Source of variance | Degrees of freedom | PH     | NOT | NOB | PL  | GY  | SY  | DM   |
|--------------------|--------------------|--------|-----|-----|-----|-----|-----|------|
| Replication        | 2                  | 33.87  | 61.94 | 0.34 | 0.36 | 7.70 | 0.29 | 2.52 | 0.59 |
| Genotypes          | 31                 | 237.59** | 530.67** | 7.78** | 1.52** | 51.81** | 11.25** | 60.11** | 97.23** |
| Error              | 62                 | 17.99  | 90.31 | 0.28 | 0.28 | 6.44 | 0.19 | 4.13 | 10.41 |
| S. Em ±            |                    | 2.44   | 5.48  | 0.30 | 0.30 | 1.46 | 0.25 | 1.17 | 1.86  |
| C.D at 5 %         |                    | 6.92   | 15.51 | 0.87 | 0.87 | 4.41 | 0.72 | 3.32 | 5.26  |
| C.V %              |                    | 3.96   | 5.78  | 7.46 | 7.65 | 7.45 | 7.84 | 11.54 | 2.38  |

| Source of variance | Degrees of freedom | TW     | PR    | ASH   | FAT   | Ca   | Fe   | Zn   | FIB  |
|--------------------|--------------------|--------|-------|-------|-------|------|------|------|------|
| Replication        | 2                  | 0.01   | 0.34  | 0.04  | 0.025 | 198.81 | 0.08 | 0.03 | 0.20 |
| Genotypes          | 31                 | 0.36** | 2.08** | 0.80** | 0.55** | 3970.89** | 1.95** | 1.42** | 7.41** |
| Error              | 62                 | 0.008  | 0.15  | 0.02  | 0.01  | 63.48 | 0.11 | 0.04 | 0.15 |
| S. Em ±            |                    | 0.05   | 0.23  | 0.09  | 0.08  | 4.60  | 0.19 | 0.12 | 0.22 |
| C.D at 5 %         |                    | 0.14   | 0.65  | 0.25  | 0.23  | 13.00 | 0.55 | 0.34 | 4.94 |
| C.V %              |                    | 5.08   | 7.81  | 5.59  | 4.09  | 3.57  | 5.09 | 3.07 | 4.94 |

* Significant at P = 0.05, ** Significant at P = 0.01

Where,

- **DF** = Days to 50% flowering
- **GY** = Grain yield per plant (g)
- **NOT** = Number of productive tillers per plant
- **NOB** = Number of branches per panicle
- **PL** = Panicle length (cm)
- **PH** = Plant height at maturity (cm)
- **SY** = Straw yield per plant (g)
- **FAT** = Fat content (%)
- **Fe** = Iron content (mg)
- **Zn** = Zinc content (mg)
- **Ca** = Calcium content (mg)
- **FIB** = Fiber content (%)
- **PR** = Protein content (%)

DF= Days to 50 % flowering
GY= Grain yield per plant (g)
ASH= Ash content (%)
FIB= Fiber content (%)
PH= Plant height at maturity (cm)
SY= Straw yield per plant (g)
FAT= Fat content (%)
NOT= Number of productive tillers per plant
DM= Days to maturity
Ca= Calcium content (mg)
NOB= Number of branches per panicle
TW= 1000 seed weight (g)
Fe= Iron content (mg)
PL= Panicle length (cm)
PR= Protein content (%)
Zn= Zinc content (mg)
| Sr. No. | Characters                                      | Range          | Mean   | Component of variance |
|--------|------------------------------------------------|----------------|--------|-----------------------|
|        |                                                |                |        | Genotypic          | Phenotypic | Environmental |
| 1.     | Days to 50% flowering                           | 87.66-118.33   | 107.03 | 73.20                | 91.19      | 17.99        |
| 2.     | Plant height at maturity (cm)                    | 133.93 -189.2  | 164.24 | 146.78               | 237.102    | 90.31        |
| 3.     | Number of productive tillers per plant          | 4.46 - 10.82   | 7.18   | 2.50                | 2.78       | 0.28         |
| 4.     | Number of branches per panicle                  | 5.53 - 7.77    | 6.96   | 0.41                | 0.69       | 0.28         |
| 5.     | Panicle length (cm)                             | 25.27 - 41.03  | 33.66  | 15.12               | 21.56      | 6.44         |
| 6.     | Grain yield per plant (g)                       | 2.33 - 8.55    | 5.63   | 3.68                | 3.88       | 0.19         |
| 7.     | Straw yield per plant (g)                       | 9.75 - 25.33   | 17.61  | 18.65               | 22.79      | 4.13         |
| 8.     | Days to maturity                                | 121.66 - 145.33| 135.03 | 28.94               | 39.35      | 10.41        |
| 9.     | 1000 seed weight (g)                            | 1.3 - 2.63     | 1.80   | 0.11                | 0.12       | 0.084        |
| 10.    | Protein content (%)                             | 3.5 - 6.73     | 5.10   | 0.64                | 0.80       | 0.15         |
| 11.    | Ash content (%)                                 | 1.7 - 3.7      | 2.80   | 0.25                | 0.28       | 0.024        |
| 12.    | Fat content (%)                                 | 2.23 - 4.37    | 3.44   | 0.17                | 0.19       | 0.01         |
| 13.    | Ca content (mg)                                 | 157.88 - 291.57| 222.79 | 1302.47             | 1365.95    | 63.48        |
| 14.    | Fe content (mg)                                 | 4.53 - 7.73    | 6.70   | 0.61                | 0.73       | 0.11         |
| 15.    | Zn content (mg)                                 | 4.31 - 7.76    | 6.80   | 0.45                | 0.50       | 0.04         |
| 16.    | Fiber content (%)                               | 4.06 - 10      | 8.05   | 2.42                | 2.57       | 0.15         |

Table 2: Range, mean, component of variance for sixteen characters of little millet.
Table 3 GCV%, PCV%, heritability, genetic advance and genetic advance as present of mean of sixteen characters in thirty two genotype of little millet

| Sr. No. | Character                             | GCV % | PCV % | Heritability (broad sense %) | Genetic advance | Genetic advance % of mean |
|---------|---------------------------------------|-------|-------|-----------------------------|-----------------|--------------------------|
| 1.      | Days to 50% flowering                 | 7.99  | 8.92  | 80                          | 15.79           | 14.75                    |
| 2.      | Plant height at maturity (cm)         | 7.37  | 9.73  | 61                          | 19.63           | 11.95                    |
| 3.      | Number of productive tillers per plant | 22.01 | 23.24 | 89                          | 3.08            | 42.94                    |
| 4.      | Number of branches per panicle        | 9.21  | 11.97 | 59                          | 1.01            | 14.60                    |
| 5.      | Panicle length (cm)                   | 11.55 | 13.79 | 70                          | 6.70            | 19.92                    |
| 6.      | Grain yield per plant (g)             | 34.08 | 34.97 | 94                          | 3.85            | 68.42                    |
| 7.      | Straw yield per plant (g)             | 24.51 | 27.09 | 81                          | 8.05            | 45.69                    |
| 8.      | Days to maturity                      | 3.98  | 4.64  | 73                          | 9.50            | 7.03                     |
| 9.      | 1000 seed weight (g)                  | 19.14 | 19.80 | 93                          | 0.68            | 38.11                    |
| 10.     | Protein content (%)                   | 15.69 | 17.53 | 80                          | 1.47            | 28.93                    |
| 11.     | Ash content (%)                       | 18.14 | 18.98 | 91                          | 1.00            | 35.71                    |
| 12.     | Fat content (%)                       | 12.24 | 12.90 | 89                          | 0.82            | 23.91                    |
| 13.     | Ca content (mg)                       | 16.19 | 16.58 | 95                          | 72.59           | 32.58                    |
| 14.     | Fe content (mg)                       | 11.69 | 12.75 | 84                          | 1.48            | 22.07                    |
| 15.     | Zn content (mg)                       | 9.95  | 10.42 | 91                          | 1.33            | 19.60                    |
| 16.     | Fiber content (%)                     | 19.32 | 19.94 | 93                          | 3.10            | 38.56                    |
Fig. 1 Heritability (broad sense %) and genetic advance (% of mean) of various quantitative characters of little millet
Fig. 2 Different genotypes of little millet showing difference in panicle shape and size
**Fig. 3** Different genotypes of little millet showing difference in panicle shape and size
Plant height, number of productive tillers per plant, panicle length, grain yield per plant, days to maturity in little millet, while Selvarani and Chandirasekaran (2000) for days to 50 % flowering, plant height, number of productive tillers per plant, grain yield per plant and ear head length; Keber et al., (2006) days to flowering and finger length; Nirmalakumari et al., (2010) for grain yield per plant; Subramanian et al., (2010) for grain and dry fodder yield per plant; Salini et al., (2010) for days to 50 % flowering, plant height, number of productive tillers per plant, panicle length, grain yield per plant and 1000 seed weight; Ganapathy et al., (2011) for productive tillers per plant and seed yield per plant; Priyadarshini et al., (2011) for plant height, number of productive tillers, seed protein content and grain yield per plant; Dhamdhere et al., (2011) for number of productive tillers per plant, seed yield per plant, days to 50 % flowering, plant height, finger length; Luli et al., (2012) for finger length, days to heading, plant height, 1000 seed weight; Hardari et al., (2012) plant height, finger length and days to 50% flowering; Wolie et al., (2013) for number of productive tillers per plant, 1000 grain weight number of tillers per plant, finger length, days to 50 % flowering; Karad and Patil (2013) for fodder yield per plant, days to 50 % flowering, days to maturity and plant height; Suryanarayana et al., (2014) seed yield plant per plant and main ear head length; Saundaryakumari and Singh (2015) for grain yield per plant, number of tillers per plant, panicle length, days to 50 % flowering, and 1000 grain weight, Das et al., (2017) for grain yield, protein content and calcium content and Devaliya et al., (2018) grain yield per plant, number of productive tillers per plant, straw yield per plant, main ear head length in remaining small millets.

In the present study the high heritability coupled with high genetic advance was observed for number of productive tillers per plant, grain yield per plant, straw yield per plant, 1000 seed weight, protein content, ash content, fat content, calcium content, iron content and fiber content.

It forces to conclude that these characters are governed by additive gene action. Similar results were also obtained by Yadav and Srivastava (1976) for number of tillers per plant, grain yield per plant, straw yield per plant and 100 seed weight; Reddy et al., (1984) for grain yield per plant and straw yield per plant; Selvi et al., (2014) for number of productive tillers per plant, grain yield per plant, straw yield per plant, 1000 seed weight; Ananda et al., (2015) for grain yield; Jyotsna et al., (2016) for grain yield and Anuradha et al.,(2017) for number of productive tillers per plant, grain yield per plant in little millet.

While Selvarani and Chandirasekaran (2000) for number of productive tillers per plant, grain yield per plant; Keber et al., (2006) for days to flowering, finger length; Nirmalakumari et al., (2010) for grain yield per plant; Luli et al., (2012) for grain yield and 1000 grain weight; Salini et al., (2010) for number of productive tillers per plant, grain yield; Chemda and Gemechu (2010) for productive tillers per plant; Priyadarshini et al., (2011) for number of productive tillers per plant, seed protein content, and single plant grain yield; Ganapathy et al., (2011) for productive tillers per plant and seed yield per plant; Dhamdhere et al., (2011) for number of productive tillers per plant and seed yield per plant; Ulaganathan and Nirmalakumari (2011) for single plant grain yield, productive tillers per plant and 1000 seed weight; Hardari et al., (2012) for grain yield; Wolie et al., (2013) for...
number of productive tillers per plant and 1000 grain weight; Karad and Patil (2013) for fodder yield per plant; Suryanarayana et al., (2014) for seed yield per plant per plant; Saundaryakumari and Singh (2015) for grain yield per plant, number of tillers per plant and 1000 grain weight; Vasadia (2015) for number of productive tillers per plant, straw yield per plant and 1000 seed weight; Das et al., (2017) for grain yield, protein content and calcium content and Devaliya et al., (2018) for grain yield per plant, number of productive tillers per plant, straw yield per plant in remaining small millets.

In general present results indicated that high heritability coupled with high genetic advance as % of mean and moderate to high GCV and PCV were observed for the traits number of tillers per plant, grain yield per plant, straw yield per plant, 1000 seed weight, protein content, ash content, fat content, calcium content, iron content, fiber content indicating these characters are under the control of additive gene effect (Panse, 1957).

Therefore, for further improvement in these traits, mass selection or progeny selection would be worthwhile.

Similar results were reported by Yadav and Srivastava (1976) for straw yield per plant and 100 seed weight; Ananda et al., (2015) for grain yield; Jyotsna et al., (2016) for grain yield; Anuradha et al., (2017) for number of tillers per plant and grain yield per plant and Selvi et al., (2014) for number of tillers per plant, grain yield per plant, straw yield per plant and 1000 seed weight in little millet, while Selvarani and Chandirasekaran (2000) for grain yield per plant; Nirmalakukari et al., (2010) for number of productive tillers per plant, grain yield per plant, panicle length and plant height; Salini et al., (2010) for number of productive tillers per plant, grain yield per plant and 100 seed weight and Das et al., (2017) for grain yield in remaining small millets.

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