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# Estimation of genetic parameters and evolving suitable selection criteria for grain yield in pearl millet under rainfed conditions of Andhra Pradesh

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**Abstract**
During the rainy season of 2018, thirty-seven pearl millet hybrids were investigated for genetic variability parameters and character association for nine different biometrical traits. Yield and its attributing traits revealed wide range of variability among the hybrids, especially for the grain yield that was to be exploited. Days to 50% flowering and days to maturity had low phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) values. Whereas, plant height, panicle length, panicle diameter, 1000-grain weight were low to medium and number of productive tillers per plant, dry fodder yield and grain yield were medium to high values. Overall, grain yield had high PCV, GCV, heritability and genetic advance as a *per cent* of mean, which is crucial for crop improvement selection criteria. Association studies revealed that grain yield was highly significant and positively correlated with panicle length followed by panicle diameter, plant height and days to maturity which suggested real relationship between these traits and grain yield. Hence, these traits were taken into consideration while developing yield-related selection criteria in pearl millet improvement program.

**Keywords:** pearl millet, genetic parameters, correlation and grain yield

## Introduction
Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is climate resilient and coarse-grained cereal crop with excellent photosynthetic efficiency and dry matter production capacity. It is predominantly produced in semi-arid areas of tropical and sub-tropical countries for food and dry fodder. Pearl millet is a nutrient-dense staple food grain with high in fiber content, proteins and several macro and micro nutrients, thus ensuring food and nutritional security. In India, it is the fourth most frequently cultivated food crop, after rice, wheat and maize. It occupies an area of 6.93 m ha with a production of 8.61 million tonnes and has a productivity of 1243 kg/ha (Anonymous, 2019) [1]. It can thrive under adverse conditions like low rainfall and soil fertility. In arid areas, landraces/OPVs (open pollinated varieties) that are low yielders are mostly cultivated during *Kharif* season. The low production of pearl millet in India demands the development of more adaptable, stable, high-yielding varieties and hybrids.
Knowledge of genetic variability, interaction among yield and yield contributing traits is the base for the crop improvement system. Plant breeding programmes are primarily focused on increasing productivity, which is measured in terms of yield per unit area. The complex nature of yield is associated with yield contributing traits which are interconnected among them. The nature and degree to which yield is associated with other characters allows breeders to anticipate the relative effect of various characters on yield improvement, allowing them to select desired traits that are critical to yield improvement. Keeping the aforementioned considerations in view, the present investigation was undertaken with the goal of estimating genetic variation, heritability and genetic advance in order to provide reliable selection criteria for grain yield enhancement through correlation studies.

## Materials and Methods
The experimental material consisted of thirty-seven initial pearl millet hybrids including four standard checks. The hybrids were evaluated in rainy seasons of 2018 at the Agricultural Research Station, ANGRAU, Ananthapuramu, (latitude: 14º 41' N, longitude: 77 º 40' E and 373 m above mean sea level) located in the scarce rainfall zone of Andhra Pradesh, India. The trial was laid out in Randomized Block Design with three replications. Each entry was sown in a three rows plot of 4.0 m length keeping row-to-row and plant-to-plant distance of 50 cm and 15 cm, respectively. To achieve good crop growth, standard cultural and agronomic practices

were used. Entire crop cycle was completed with a rainfall of 210 mm received in 8 rainy days. This year (2018) was designated as drought year as it recorded a cumulative rainfall of 268 mm received in 14 rainy days, compared to a normal rainfall of 553 mm with average rainy days of 34. Five competitive plants per hybrid in each replication were selected randomly for recording observations on different characters *viz*., plant height (cm), number of productive tillers per plant, panicle length (cm) and panicle diameter (cm), while observations on days to 50% flowering, days to maturity, dry fodder yield (kg/ha) and grain yield (kg/ha) were recorded on plot basis. 1000-grain weight, a sample of 1000 grains were counted randomly from the threshed grain and the weight is recorded in grams. The analysis of variance (ANOVA) method, as described by Singh and Chowdary (1985) [16], was used. Burton's method (1952) [3] was used to calculate the variability parameters, genotypic and phenotypic coefficients of variation (GCV and PCV). The method proposed by Lush (1940) [9] was used to calculate estimates of broad sense heritability. Johnson *et al.*, (1955) [6] proposed a method for calculating expected genetic advance. PCV and GCV (Robinson *et al.*, 1949) [13] and GA and GAM (Johnson *et al.*, 1955) [6] were classified into three groups: low (0-10%), moderate (10.1-20%) and high (>20%). Heritability was classified into three categories: low (0-30%), moderate (30.1-60%) and high (>60%). The genotypic and phenotypic correlations between yield and its component traits were calculated using Falconer (1981) [5] methodology.

## Results and Discussion

The analysis of variance revealed substantial variations in all characters across genotypes except for the number of productive tillers per plant and panicle diameter (Table 1), suggesting that there was enough variation among the tested hybrids. The mean, range of variation, estimates of phenotypic and genotypic coefficient of variation (PCV and GCV), heritability in broad sense and genetic advance as *per cent* of mean for nine characters involving 37 hybrids of pearl millet were presented in Table 2. In this study genotypes exhibited high range of variation for all the traits offering a great scope for selection and improvement. Grain yield ranged from 573.00 kg/ha to 2150.00 kg/ha. Similarly, Dry fodder yield was also varied between 1501.70 kg/ha and 3303.70 kg/ha. Plant height showed a variation from 95.67 cm to 141.33 cm, with 1.33 to 3.33 productive tillers per plant. Flowering period varied from 38.33 days to 48.33 days. The hybrids were divided into two groups based on flowering period: ten entries for early flowering and 27 entries for medium flowering. Similarly, maturity also varied between 68.33 and 79.00 days. The shortest panicle was 15.37 cm in length, while the largest was measured 26.20 cm long. Similarly, panicle diameter was also variable, ranging from 1.93 cm to 2.97 cm. The greatest and lowest 1000-grain weights were 10.40 g and 5.67 g, respectively. Kumar *et al.*, (2014) [8] and Shobha Rani *et al.*, (2019) [15] observed high range for days to 50% flowering, plant height, panicle length, panicle diameter, dry fodder yield and grain yield.

The estimates of the PCV were greater than the GCV for all the traits under study, suggesting that environmental factors had an impact on the expression of these traits. Hight to moderate co-efficient of variation was observed for grain yield (28.46, 33.73), dry fodder yield (13.29, 28.58) and no. of. Productive tillers per plant (9.10, 29.24). Likewise, high estimates of variability were reported by Nehra *et al.*, (2017) [11] for number of productive tillers per plant and dry fodder yield; Anuradha *et al.*, (2018) [2] for grain yield. Whereas, moderate to low co-efficient of variation was observed for 1000-grain weight (10.64, 17.37), panicle length (8.47, 14.07), panicle diameter (8.97, 13.62) and plant height (8.79, 12.01). This indicated the existence of sufficient variability for attempting selection to improve these traits in the genotypes studied. These findings were in consonance with Patil *et al.*, (2018) [12] for panicle diameter; Sowmiya *et al.*, (2016) [17] for both plant height and panicle diameter. It suggests that selection might be effective based on these traits with high and medium PCV and GCV values and that their phenotypic expression could be a useful indicator of genetic potential. Low GCV and PCV was noticed for days to 50% flowering (5.95, 6.21) and days to maturity (3.64, 3.91) indicating a limited range of variability for these traits, limiting the possibilities for easy selection. Similar kind of observations were also reported by Sharma *et al*., (2018) [14] for days to flowering and days to maturity.

The heritable fraction of phenotypic variance is called heritability. The dependability with which the genotype will be identified by its phenotypic manifestation is indicated by the magnitude of heritability. Heritability ranged from 9.68% for no. of. Productive tillers per plant to 91.72% for days to 50 % flowering. Very high heritability estimates were recorded by days to 50 % flowering (91.72) followed by days to maturity (86.94) and grain yield (71.16). High heritability indicates selection will be successful. Heritability combined with genetic advance as *per cent* of mean (GAM) will accurately predict the genetic gain expected from selection efforts than heritability alone (Johnson *et al*., 1955) [6]. Hence, high heritability coupled with high genetic advance as *per cent* of mean could be considered for selection of elite genotypes. In the present investigation, high heritability coupled with high genetic advance as *per cent* of mean was observed for grain yield (71.16, 49.45) indicating presence of additive gene action and selection is effective for this trait.

High heritability coupled with low GAM and GCV was observed for days to 50 % flowering (91.72, 11.74 and 5.95) and days to maturity (86.94, 7.00 and 3.64) indicating the role of non-fixable genetic variation in the expression of these traits and recurrent selection would be more effective to improve this character. Such confirmatory results were also given by Vidyadhar *et al.*, (2007) [18] and Yaqoob *et al.*, (2015) [19]. Moderate heritability coupled with moderate genetic advance as *per cent* of mean and GCV was registered for plant height (53.60, 13.26 and 12.01), 1000-grain weight (37.56, 13.43 and 10.64) panicle length 36.22, 10.50 and 8.47) and panicle diameter (43.36, 12.16 and 8.97) which indicated the preponderance of non-additive gene action. Hence, it could be suggested that improvement of these characters might be difficult through simple selection. Whereas, low heritability coupled with low GAM and GCV were observed for no. of. Productive tillers (9.68, 5.83 and 9.10) and dry fodder yield (21.63, 12.74 and 13.29) indicating that environment is the main role in governing these traits and that selection may be ineffective. Similar results have been reported by Anuradha *et al.*, (2018) [2] and Naoura *et al.*, (2019) [10].

Grain yield is determined by a number of interconnected traits. Breeders always look for genetic variation among traits to select desirable types. Some of these characters are strongly associated to each other and to grain yield. To create selection criteria, it is necessary to investigate the association between these traits and their relationship with grain yield. The nature of the association between grain yield and yield components, as well as among themselves, was assessed using phenotypic and genotypic correlation coefficients and the results were presented in Table 3. Grain yield was positively associated with plant height (rg=0.768, rp =0.583) whereas the no. of productive tiller per plant was negatively associated with grain yield (rg= -0.597, rp = -0.077). This suggests that tall plants with no tillers is associated with better yield in pearl millet and is a major determining feature for grain yield and same is true with hybrids. Similarly, among panicle traits, panicle length (rg= 0.808, rp = 0.404) and panicle diameter (rg=0.578, rp =0.352) had significant positive correlation at genotypic as well as phenotypic levels, which reveals both panicle length and panicle diameter are more important selection criteria for grain yield improvement. Grain yield had highly significant positive correlation with days to 50 % flowering (rg=0.394, rp =0.296) and days to maturity (rg=0.376, rp=0.302) which indicates duration had much related with grain yield. However, grain yield was negatively associated with1000-grain weight (rg= -0.208, rp = -0.113) and non-significant positive correlation was observed with dry fodder yield (rg=0.029, rp =0.172). Similar kind of highly significant positive association of grain yield with plant height, panicle length and panicle diameter were reported by Sowmiya *et al.*, (2016) [17], Dehinwal *et al.*, (2017) [4] and Anuradha *et al.*, (2018) [2]. Days to 50 % flowering had positive and significant association with days to maturity (rg=0.987, rp=0.946), plant height (rg= 0.330, rp = 0.194), panicle length (rg= 0.484, rp = 0.277) and panicle diameter (rg= 0.465, rp = 0.298) at genotypic as well as phenotypic levels. Which was also confirmed with earlier reports by Vidyadhar *et al.*, (2007) [18] and Kaushik *et al.*, (2018) [7].

Dry fodder yield had positive and significant association with plant height (rg=0.303, rp = 0.300), panicle diameter (rg= 0.304, rp = 0.243) and 1000-grain weight (rg=0.310). This suggests that plant height and panicle diameter were more closely linked to dry fodder yield than any other traits. Similar results were reported by Kaushik *et al.*, (2018) [7] for 1000-grain weight and plant height. Similarly, highly significant negative correlation was observed with number of productive tillers per plant (rg= - 0.522) followed by day to maturity (rg=- 0.213). These two traits are negative selection criteria for increasing dry fodder yield. Panicle length and panicle diameter showed highly significant positive association with day to 50 % flowering, days to maturity and plant height. However, 1000-grain weight had high significant negative correlation at genotypic level. This indicated that late maturing hybrids were better yielders than the early maturing hybrids in pearl millet.

**Table 1:** Analysis of variance for grain yield and yield contributing characters in 37 pearl millet hybrids

| Source | DF | Mean sum of squares | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Days to 50 % flowering** | **Days to maturity** | **Plant Height (cm)** | **Productive tillers (no./plant)** | **Panicle Length (cm)** | **Panicle Diameter (cm)** | **1000 -grain weight (g)** | **Dry Fodder Yield (kg/ha)** | **Grain Yield (kg/ha)** |
| Replication | 2 | 2.63 | 1.77 | 45.66 | 2.95 | 5.17 | 1.54 | 4.88 | 20.60 | 46.24 |
| Genotype | 36 | 19.37** | 21.69** | 420.47** | 0.58 | 15.64** | 0.20 | 3.15* | 58.56* | 56.66* |
| Error | 72 | 0.57 | 1.03 | 94.15 | 0.44 | 5.78 | 0.06 | 1.12 | 32.03 | 6.75 |

*, ** significant at 5% and 1% levels, respectively

**Table 2:** Genetic parameters for yield contributing characters in 37 pearl millet hybrids

| S. No. | Character(s) | Mean | Range | | Coefficient of variation (%) | | Heritability (%) | Genetic advance as *per cent* of mean (%) |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Genotypic | phenotypic | | |
| 1 | Days to 50 % flowering | 42.07 | 38.33 | 48.33 | 5.95 | 6.21 | 91.72 | 11.74 |
| 2 | Days to maturity | 72.01 | 68.33 | 79.00 | 3.64 | 3.91 | 86.94 | 7.00 |
| 3 | Plant Height (cm) | 118.66 | 95.67 | 141.33 | 8.79 | 12.01 | 53.60 | 13.26 |
| 4 | Productive tillers (no./ plant) | 2.38 | 1.33 | 3.33 | 9.10 | 29.24 | 9.68 | 5.83 |
| 5 | Panicle Length (cm) | 21.40 | 15.37 | 26.20 | 8.47 | 14.07 | 36.22 | 10.50 |
| 6 | Panicle Diameter (cm) | 2.41 | 1.93 | 2.97 | 8.97 | 13.62 | 43.36 | 12.16 |
| 7 | 1000 - grain weight (g) | 7.72 | 5.67 | 10.40 | 10.64 | 17.37 | 37.56 | 13.43 |
| 8 | Dry Fodder Yield (kg/ha) | 2236.75 | 1501.70 | 3303.70 | 13.29 | 28.58 | 21.63 | 12.74 |
| 9 | Grain Yield (kg/ha) | 1433.36 | 573.00 | 2150.00 | 28.46 | 33.73 | 71.16 | 49.45 |

**Table 3:** Genotypic and phenotypic correlation coefficients between different yield contributing characters in 37 pearl millet hybrids

| **Character(s)** | **Days to 50 % flowering** | **Days to maturity** | **Plant Height (cm)** | **Productive tillers (no./plant)** | **Panicle Length (cm)** | **Panicle Diameter (cm)** | **1000 - grain weight (g)** | **Dry Fodder Yield (kg/ha)** | **Grain Yield (kg/ha)** |
|---|---|---|---|---|---|---|---|---|---|
| Days to 50 % flowering | 0.000 | 0.987** | 0.330** | 0.251** | 0.484** | 0.465** | -0.002NS | -0.121NS | 0.394** |
| Days to maturity | 0.946** | 0.000 | 0.352** | 0.276** | 0.484** | 0.492** | -0.003NS | -0.213* | 0.376** |
| Plant Height (cm) | 0.194* | 0.221* | 0.000 | -0.216* | 0.885** | 0.647** | -0.216* | 0.303** | 0.768** |
| Productive tillers (no./plant) | 0.079NS | 0.109NS | -0.036NS | 0.000 | -0.063NS | 0.339** | -0.100NS | -0.522** | -0.597** |
| Panicle Length (cm) | 0.277** | 0.314** | 0.499** | -0.018NS | 0.000 | 0.359** | -0.297** | 0.079NS | 0.808** |
| Panicle Diameter (cm) | 0.298** | 0.307** | 0.407** | 0.036NS | 0.430** | 0.000 | 0.109NS | 0.304** | 0.578** |
| 1000 - grain weight (g) | 0.000NS | 0.024NS | -0.011NS | -0.101NS | -0.024NS | 0.095NS | 0.000 | 0.310** | -0.208* |
| Dry Fodder Yield (kg/ha) | -0.069NS | -0.079NS | 0.300** | -0.006NS | 0.080NS | 0.243** | 0.086NS | 0.000 | 0.029NS |
| Grain Yield (kg/ha) | 0.302** | 0.296** | 0.583** | -0.077NS | 0.404** | 0.352** | -0.113NS | 0.172NS | 0.000 |

Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficient; *Significant at 0.05 probability, **Significant at 0.01 probability

**Conclusion**

In nutshell, this study showed the existence of wide range of variations for most of the traits, as well as possibility of genetic gain per grain yield through selection among the pearl millet genotypes. According to the association analysis the traits *viz.,* panicle length, panicle diameter, plant height and days to maturity is responsible for the grain yield enhancement in pearl millet.

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