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NATURE OF GENE ACTION GOVERNING PHYSIOLOGICAL, NUTRITIONAL TRAITS AND GRAIN YIELD IN PEARL MILLET (*PENNISETUM GLAUCUM* L.)

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ABSTRACT

One hundred genotypes of Pearl millet including three checks were tested during kharif, 2024 in an Alpha lattice design to understand the genetic mechanisms governing grain yield, nutritional (Iron, Zinc and Protein content in seeds) and physiological traits (harvest index, relative water content and SPAD chlorophyll meter reading). Variability was found high for iron and zinc while moderate variability for grain yield, harvest index, protein and low variability for relative water content and SPAD chlorophyll meter reading at 60 DAS were recorded. Moderate to high coefficients of variation, high heritability along with high genetic advance as percent of mean noted for iron and zinc content in grains, grain yield per plant, protein content and harvest index indicated the predominance of additive gene action these traits and hence, an early and simple selection would be advisable for bringing genetic improvement. This might consistently manifest in future generations resulting in increased effectiveness of the breeding program. High heritability coupled with moderate genetic advance over percent mean and low variability registered for relative water content indicated the operation of both additive and non-additive gene actions for the trait. Moderate heritability along with low genetic advance and variability for SPAD chlorophyll meter reading at 60 DAS revealed the governance of non-additive gene action and can be improved by heterosis breeding as simple selection might not be effective.
Keywords **:** Pearl millet, Variability, grain yield, Physiological and Nutritional traits.

Introduction

Pearl millet (*Pennisetum glaucum* (L.) is a coarse cereal and ranks sixth among major cereal crops in terms of area in the world after rice, wheat, maize, barley and sorghum. The protogynous nature of its hermaphrodite flowers makes pearl millet extensively cross-pollinated. Pearl millet has become a preferred crop for growing in arid and semi-arid because of its drought tolerance and low inorganic fertilizer requirement. It is also nutritionally superior and rich in micronutrients such as iron and zinc and can mitigate malnutrition and hidden hunger. Genetic variability, heritability, and genetic advance offer insights into the kind and degree of genetic control for agronomic and economic traits. Genetic variability provides the basis for selection whereas heritability estimates indicate the observed variation that is genetically inherited. Heritability, together with genetic advance, assists breeders in selecting appropriate breeding strategies and achieving genetic improvement for specific traits. The present study in pearl millet was conducted to estimate genetic parameters for physiological, nutritional traits and grain yield so to infer the gene actions associated in governing the traits.

Materials and Methods

The experiment included 97 pearl millet inbred lines and three checks (ABV04, SBH 888, Pittaganti), arranged in an Alpha lattice design with two replications. Genotypes were nursery-sown in July 2024 and transplanted in August at ARS, Ananthapuramu. Each was planted in a single 4-meter row, spaced 45 cm between rows and 15 cm within rows. Fertilizer application was 60 N + 30 P_2O_5 + 20 K_2O kg/ha, with half the nitrogen and all phosphorus and potassium as basal dose, while the remaining nitrogen was top-dressed after 35 days. Standard agricultural practices were maintained throughout the crop period.

Grain yield and harvest index data were collected from five randomly selected competitive plants of each genotype in each replication. SPAD Chlorophyll meter reading (SCMR) was measured on third leaf from the top of the main axis at 60 days after owing using SPAD meter of Minolta, NJ, USA. The harvest index for each genotype was calculated using the formula described by Donald (1962). Relative water content (RWC) was determined as a percentage according to Weatherley (1950). Grain iron and zinc contents were determined following Tandon's (1999) procedure. Nitrogen content in pearl millet genotypes was determined by the Kjeldahl method with a KEL PLUS distillation unit. Crude protein content was calculated by multiplying the nitrogen content by 6.25 and expressed as a percentage. Heritability in broad sense [h2(b)] was calculated by the formula given by Lush (1940) and heritability estimates were categorized as suggested by Johnson *et al.* (1955b). The genetic advance was estimated by the formula given by Johnson *et al.* (1955a and the range of genetic advance as per cent of mean was classified according to Johnson *et al.* (1955b)

The Mean values for each trait across two replications were subjected to statistical analysis using the R Programming statistical package. Differences among genotypes with respect to various traits were evaluated for statistical significance via analysis of variance, following the model established by Panse and Sukhatme (1961). Genotypic and phenotypic variances, along with genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), were computed according to Burton’s (1952) formula. Variation ranges were classified as recommended by Sivasubramanian and Madhava Menon (1973).

Results and Discussion

Mean performance of the pearl millet genotypes

The mean, range of variation and most superior genotypes for each trait were presented in Table1.

SPAD Chlorophyll Meter Reading at 60 DAS

The mean values for SPAD chlorophyll meter readings at 60 days after sowing (DAS) ranged from 50.5(API 1029) to 67.2(API 1084) with a mean of 58.92. Higher SCMR readings were observed in API 1084 followed by API 2056 and API 1083. Two genotypes recorded SCMR readings significantly exceeding the general mean. Nine genotypes recorded higher SCMR readings compared to the superior check, SBS 888 (62.7) (Table1).

Relative Water Content (%)

Among the 100 genotypes, API 1073 (62.5%) registered the lowest relative water content while API 1007 (89.6%) recorded the highest. The general mean for relative water content was 76.12%. The genotypes API 1007, AP 1045 and API 1011 exhibited superior performance for the trait. Thirty-three genotypes were found significantly superior to the general value. Thirty-four genotypes outperformed the best check, ABV 04 (79.0%) for the trait (Table1)

Harvest Index (%)

Among the 100 genotypes, harvest index varied between 24.3% (API 2001) and 56.2% (SBS 888) with a general mean value of 40.19%. The superior performance was exhibited by SBS 888 followed API 2007 and API 1058. Thirty-five genotypes showed significantly higher harvest index compared to the general mean value (40.19%). None of the genotypes recorded higher mean value for harvest index than the best check, SBS 888 (56.2%) (Table 1).

Iron Content in grain (ppm)

Iron content among the 100 genotypes ranged from 24.1 ppm (API 1087) to 223.5 ppm (API 1012) with a general mean of 86.94 ppm. Iron content was observed high in API 1012 followed by API 1039 and API 1018. Hence, these genotypes can be utilized in development of biofortified pearl millet varieties for iron and zinc. The mean values of 42 genotypes were found to be significantly higher than the general mean value. A total of 52 genotypes outperformed the superior check, SBS 888 (66.8 ppm) (Table 1).

Zinc Content in grain (ppm)

Maximum zinc content was recorded in API 1039 (80.3 ppm) and minimum in API 2018 (10.4 ppm). The general mean value for zinc content was 80.3 ppm. Among the 100 genotypes, API 1039 followed by API 1018 and API 1111 recorded highest zinc content which can be further exploited in breeding programmes. Twenty-eight genotypes registered significantly higher zinc content than the general mean value while, 65 genotypes showed more zinc content than the superior check, ABV 04 (18.9 ppm) (Table1).

Protein Content in grain (%)

Mean values for protein content in grains ranged from 5.4% (API 2035) to 15.0% (API 1106) with a general mean of 9.09 %. The genotypes API 1106 followed by API 1045 and API 2012 displayed highest protein content. Forty-nine genotypes registered significantly more protein content than the general mean value while 17 genotypes recorded more mean protein content than the best check, ABV 04 (10.3%) (Table1).

Grain Yield per plant (g)

Among the 100 genotypes, highest grain yield per plant was recorded by SBS 888 (53.9 g) and lowest by API 2001 (18.5 g) with a general mean value of 29.59 g. The genotypes SBS 888 followed by API 2054 and API 2052 registered higher grain yield per plant. Twenty-nine genotypes were significantly superior to general mean value but found none were superior to the best check SBS888 (53.9g) (Table 1).

Genetic Variability parameters

Estimates of genotypic and phenotypic coefficients of variation for all the traits studied were presented in Table 2. In the present study, the differences between the phenotypic coefficient of variation and genotypic coefficient of variation were low for all the traits, indicating the less effect of environment on the expression of the traits.

Genotypic and Phenotypic Coefficient of Variation

The traits *viz*., zinc content (GCV = 54.03% and PCV = 54.07%) followed by iron content (GCV = 50.96% and PCV = 50.98%) recorded higher estimates of coefficients of variation demonstrating the presence of enormous amount of innate variability among the genotypes that remained unaffected by environmental factors. Hence, a simple selection for these traits would be effective for further improvement (Table2) Similar findings were reported by previous workers for zinc content (Anuradha *et al*.,2018; Subbalakshmi *et al*., 2018a; Priyanka *etal.,* 2019; Jaiswal *et al*., 2025) and iron content (Anuradha *et al*., 2018; Subbalakshmi *et al*., 2018a;Priyanka *et al*., 2019; Andhale *et al*., 2024; *Thomas et al*., 2018;Goswami *et al*., 2023; Jaiswal *et al*., 2025). Moderate estimates of coefficient of variation were recorded for grain yield per plant (GCV = 18.31% and PCV = 18.76%), protein content (GCV = 17.14% and PCV = 17.19%) and harvest index (GCV = 15.59% and PCV = 15.88%).This suggested that there was enough variation among the genotypes under study for making selections and to enhance these traits. (Table2).These results were resonated with the findings of Thomas *et al*. (2018), Pryanka *et al*., (2019), Swamynatham *et al*. (2019), Kedarnath *et al.* (2021), Yadav *et al.* (2022), Jain *et al*. (2023) and Kumar *et al*. (2023) for grain yield per plant; Thomas *et al*. (2018) and Goswami *et al*. (2023) for protein content; Priyanka *et al*. (2019), Kedarnath *et al.* (2021), Yadav *et al.* (2022) and Goswami *et al*. (2023) for harvest index.

Estimates of coefficient of variation were low for SPAD chlorophyll meter reading (GCV = 3.94% and PCV = 6.40%) and relative water content (GCV= 7.46 and PCV =7.73) demonstrating a limited range of variability for these traits and thus constraining the potential for selection. Lower estimates of coefficient of variation were reported previously for relative water content by Singh *et al*. (2018) and Naik *et al*. (2022) for SPAD chlorophyll meter readings (Table 2).

Heritability in broad sense

Broad sense heritability (h2b) quantifies the proportion of total phenotypic variance explained by genetic variance. Estimates of heritability combined with the coefficient of variation would provide the clearest picture of the amount of advance that can be anticipated from selection. Higher estimates of heritability were recorded for iron content (99.95%) followed by zinc content (99.86%), protein content (99.41%), harvest index (96.35%), grain yield per plant (95.18%), and relative water content (93.02%). Higher heritability indicates a stronger genetic influence across different environments. Early generation selection based on *per se* performance can be useful for these traits (Table2). These results are in accordance with the findings of Anuradha *et al*. (2018); Subbalakshmi *et al*. (2018a) and Andhale *et al*. (2024) for grain yield and nutritional traits (Nehra *et al.,* 22017; Sumathi and Revathi 2017; Rasitha *et al*. (2019; Rajpoot *et al*., 2023; Singh *et al.,* 2023). SPAD chlorophyll meter reading recorded moderate heritability (37.78%) and similar results were reported by Priyanka *et al*. (2019) and Kumar *et al*. (2023)

Genetic Advance

Heritability estimates alone do not provide reliable information regarding the genetic mechanisms underlying the expression of a particular trait, nor do they predict the extent of genetic improvement achievable through selection of superior individuals. Johnson *et al*. (1955a) observed that integrating heritability estimates with measurements of genetic advance offers superior predictive value for selection response compared to using heritability estimates alone. Higher estimates of genetic advance were observed for iron content (91.26) followed by zinc content (29.44) while moderate estimates for harvest index (12.70 and relative water content (11.28) and grain yield per plant (10.89). This indicates that selection will be rewarding for these traits and to bring genetic improvement. The traits *viz*.; Protein content (3.20), and SPAD chlorophyll meter reading

(2.94) registered low genetic advance and implying that these traits are governed by non-additive gene action (Table 2)

Genetic Advance as Per Cent of Mean

Higher estimates of genetic advance as percent of mean were recorded for iron content (111.23), zinc content (104.96), grain yield per plant (36.79), protein content (35.21), harvest index (31.51), while moderate estimates of genetic advance as percent of mean were noted for relative water content (14.82). Low genetic advance as percent of mean was recorded for SPAD chlorophyll meter reading (4.99) (Table 2).

Conclusions

High heritability coupled with high genetic advance as percent of mean n recorded for iron content, zinc content, grain yield per plant, protein content, harvest index signifies that these traits are predominantly governed by additive genes, and an early and simple selection is advisable and might consistently manifest in future generations, resulting in increased effectiveness of the breeding program. High heritability coupled with moderate genetic advance over percent mean registered for relative water content indicate that this trait is governed by additive genes Moderate heritability coupled with low genetic advance for SPAD chlorophyll meter reading reveals that this trait is governed by non-additive gene action and can be improved by heterosis breeding as simple selection might not be effective.

Table 1: Mean, range of variation for the traits studied and superior genotypes identified in Pearl millet

S. No	Character(s)	Mean	Maximum	Minimum	Superior genotypes identified
1	SPAD meter reading	58.92	50.51(API 1029)	67.21(API 1084)	API2025, API1083
2	Relative Water Content (%)	76.12	62.46) (API1073	89.60(API1007)	API,1007,1045,1011
3	Harvest index (%)	40.30	24.31(API2001)	56.97(SBS 888)	SBS888, API1058,2007
4	Iron content in grains (ppm)	86.94	24.05(API1087)	223.45(API1012)	API1012,1018,1039
5	Zinc content in Grains (ppm)	26.97	10.40(API2018)	80.30(API1039)	API1018, 1039, 1111
6	Protein content in grains (%)	9.08	5.36(API2035)	15.00(API1106)	API1045,2012
7	Grain yield (g/plant)	29.59	18.7(API20010	53.95(SBS 888)	API2025, 2054, SBS 888

Table 2: Estimates of genetic parameters for physiological and nutritional traits and Grain yield in pearl millet

S.No	Character(s)	GCV (%)	PCV (%)	Heritability (h2B)	Genetic advance	Genetic advance over mean (%)
1	SPAD meter reading	3.94	6.40	37.78	2.94	4.94
2	Relative Water Content (%)	7.46	7.73	93.02	11.28	14.82
3	Harvest index (%)	15.59	15.88	96.35	12.70	37.51
4	Iron content in grains(ppm)	50.96	50.98	99.95	91.26	104.96
5	Zinc content in Grains(ppm)	54.03	54.07	99.86	29.44	111.23
6	Protein content in grains (%)	17.14	17.19	99.41	3.20	35.21
7	Grain yield (g/plant)	18.31	18.76	95.18	10.89	36.79

References

Andhale, G.R., Shinde, C.S., Bhavsar, V.V and Barhate, K.K. (2024). Estimation of variability and genetic diversity in different genotypes of pearl millet (*Pennisetum glaucum* L.). *International Journal of Advanced Biochemistry Research*. **8**(9): 207-213

Anuradha, N., Satyavathi, C.T., Bharadwaj, C., Sankar, M., Singh, S.P and Pathy, T.L. (2018). Pearl millet genetic variability for grain yield and micronutrients in the arid zone of India. *Journal of Pharmacognosy and Phytochemistry*. **7**(1): 875-878.

Burton, G.W. (1952). Quantitative inheritance in grasses. *Proceedings of Sixth International Grassland Congress.* **1**: 277-283.

Donald, C. M. (1962). In search of yield. *Journal of the Australian Institute of Agricultural Sciences.* **28**:171-178.

Gowswami, P.A., Patel, H.S and Patel, P.R. (2023). Study of genetic variability, heritability and genetic advance for yield and its component traits in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *Pharma Innovation*. **12**: 4305-4308.

Jain, S.K., Deewan, D.K.D., Prakash, O and Sharma, L.D. (2023). Character Associations and Path Coefficient Analysis for Grain Yield and Yield Contributing Traits in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]. *Annals of Arid Zone*. **62**(2): 127-133.

Jaiswal, A., Kumhar, B.L., Kharbas, A.S., Choudhary, K., Gocher, K., Nayak, P.K and Yadav, T.V. (2025). Analysis of Variability Parameters in Restorer Lines of Pearl Millet [*Pennisetum Glaucum* (L.) R. Br.]. *Plant Archives*. **25**(1): 523-527.

Johnson, H. W., Robinson, H. F and Comstock, R. E.(1955a). Estimate of genetic and environmental variability in soybean. *Agronomy Journal*. **47**: 314-318

Johnson, H.W., Robinson, H.F and Comstock, R.E. (1955b). Genotypic and phenotypic correlation in soybean and their implications in selection. *Agronomy Journal*. **47**: 477-483.

Lush, J.L. (1940). Intra-sire correlation and regression of offspring in dam as a method of estimating heritability of characters. *Proceedings of American Society of Animal Production*. **33**: 292-301.

Naik, B.S.K. (2022). Genetic analysis of grain yield, morpho-physiological and nutritional traits in CGMS based hybrids of pearl millet (*Pennisetum glaucum* (L.) R. Br.). *Ph.D. Thesis.* Acharya N. G. Ranga Agricultural University, Guntur

Panse, V.G and Sukhatme, P.V. (1961). *Statistical methods for agricultural workers*, 2nd edition, ICAR, New Delhi.

Priyanka, V. (2019). Genotype by trait biplot analysis for yield, physiological and nutritional traits in pearl millet (*Pennisetum Glaucum* (L.) R. Br.). *M.Sc. Thesis.* Acharya N.G. Ranga Agricultural University, Guntur.

Priyanka, V., Shanthi, P., Reddy, D.M and Reddy, B.R. (2019). Genetic variability studies on yield, physiological and nutritional traits in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *International Journal of Current*

Singh, J and Chhabra, A.K. (2018). Genetic variability and character association in advance inbred lines of pearl millet under optimal and drought condition. *Ekin Journal of Crop Breeding and Genetics*. **4**(2): 45-51.

Sivasubramanian, S and Madhavamenon, P. (1973). Combining ability in rice. *Madras Agricultural Journal*. **60**: 419-421.

Swamynatham, S. (2019). Genetic divergence studies in pearl millet (*Pennisetum glaucum* (L.) R. Br.). *M.Sc. (Ag.) Thesis*. Acharya N.G. Ranga Agricultural University, Guntur.

Thomas, A.M., Babu, C and Iyanar, K. (2018). Genetic variability and association studies in pearl millet for green fodder yield and quality traits. *Electronic Journal of Plant Breeding*. **9**(3): 1263-1271.

Varshney, R.K., Shi, C., Thudi, M., Mariac, C., Wallace, J., Qi, P., Zhang, H., Zhao, Y., Wang, X., Rathore, A and Srivastava, R.K. (2017). Pearl millet genome sequence provides a resource to improve agronomic traits in arid

Weatherley, P.E. (1950). Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. *New Phytologist*. **49**: 81-87.

Yadav, M.K., Sanadya, S.K., Kumar, A., Kumar, A., Kumar, R and Gupta, P.C. (2022). Genetic Variability Parameters and Inter-relationship among Yield and its Attributes in Pearl Millet (*Pennisetum glaucum*) Hybrids. *Biological Forum–An International Journal*. **14**(2): 662-666.