# GENETIC VARIABILITY FOR SEED NUTRITIONAL COMPOSITION IN PEARL MILLET GENOTYPES ANALYZED BY BIPLOT METHOD

## VARIABILIDAD GENÉTICA PARA LA COMPOSICIÓN NUTRICIONAL DE SEMILLAS EN GENOTIPOS DE MIJO PERLA ANALIZADOS POR EL MÉTODO BIPLOT

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## ABSTRACT

This study evaluated the chemical composition of pearl millet seeds belonging to different genotypes by biplot analysis. Seeds of 26 different pearl millet populations obtained from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) within the scope of TÜBİTAK 219O103 run by Şırnak University were used. The seeds were ground and analyzed for their chemical composition, i.e., acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), digestible dry matter (DDM) and dry matter intake (DMI) rate. The results revealed that crude protein ratio varied between 11.74-19.24%, whereas ADF ratio differed between 3.44-11.43%. Similarly, NDF ratio varied between 10.23-23.47%, while DDM ratio ranged between 79.98-86.21%. Likewise, DMI ratio differed between 5.11-11.72%. Scatter plot obtained after biplot analysis indicated three different groups based on the analyzed traits. The first group contained DDM and DMI, whereas the second group consisted of ADF and NDF. The protein ratio was in the third group. It was determined that ADF-NDF and DMI-DDM properties were negatively correlated with each other. According to biplot, genotypes ‘A5-13’, ‘A13-6’ and ‘B1-7’ were prominent for ADF -NDF, DMI-DDM, and protein ratio, respectively. Therefore, these genotypes can be used in future studies to induce the desired traits.

**Keywords**: Pearl millet; genotypes; biplot; chemical composition.

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## RESUMEN

Este estudio evaluó la composición química de semillas de mijo perla pertenecientes a diferentes genotipos mediante análisis biplot. Se utilizaron semillas de 26 poblaciones diferentes de mijo perla obtenidas de ICRISAT (Instituto Internacional de Investigación de Cultivos para los Trópicos Semiáridos) dentro del alcance de TÜBİTAK 219O103 administrado por la Universidad de Şırnak. Las semillas se molieron y analizaron en cuanto a su composición química, es decir, fibra detergente ácida (FDA), fibra detergente neutra (FDN), proteína cruda (PB), materia seca digestible (MSD) y tasa de consumo de materia seca (MSD). Los resultados revelaron que la proporción de proteína cruda varió entre 11,74 y 19,24 %, mientras que la proporción de FAD varió entre 3,44 y 11,43 %. Del mismo modo, la relación FDN varió entre 10,23-23,47%, mientras que la relación DDM osciló entre 79,98-86,21%. Asimismo, la relación DMI difirió entre 5.11-11.72%. El diagrama de dispersión obtenido después del análisis biplot indicó tres grupos diferentes según los rasgos analizados. El primer grupo contenía DDM y DMI, mientras que el segundo grupo constaba de ADF y NDF. La proporción de proteína estaba en el tercer grupo. Se determinó que las propiedades ADF-NDF y DMI-DDM estaban negativamente correlacionadas entre sí. Según el biplot, los genotipos 'A5-13', 'A13-6' y 'B1-7' fueron prominentes para la relación ADF-NDF, DMI-DDM y proteína, respectivamente. Por lo tanto, estos genotipos pueden usarse en futuros estudios para inducir los rasgos deseados.


**Palabras clave:** Mijo perla; genotipos; biplot; composición química.

## INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a well-known tropical C4 small-grained cereal crop with exceptional photosynthetic efficiency and dry matter production. It is the only cereal crop that thrives in the dry, arid, and semi-arid portions of the tropics, where other grain crops fail to grow (Sanjana Reddy et al., 2021). Pearl millet is a staple cereal crop that supplies food and fodder for >90 million people who are severely resource constrained. Cultivation of this plant is concentrated in the dry and semiarid regions of Asia and Sub-Saharan Africa. India is the largest producer of this crop in Asia, and its output exceeds that of any other nation in the region combined. It contains a higher concentration of both macro and micro nutrients than other varieties of cereals, suggesting that it may have a high nutritious value (Anuradha et al., 2017).

Millions of impoverished farmer families and their livestock rely on pearl millets for food, fuel, and stover/dry fodder. Green fodder is another common usage for pearl millet cultivars. Pearl millet and Napier grass interspecies hybrids are perennials that provide green feed throughout the year. Due to its heat tolerance and low water needs, pearl millet is an excellent feed crop for dry climates. Because of this, it is often grown in areas where the weather conditions, such as rainfall, temperature, and soil fertility, are too harsh for the cultivation of other grains (Kumar et al., 2012). Ruminants may rely heavily on pearl millet as a staple meal. Nutritionally, it doesn't provide much since it's poor in digestible calories, crude protein, and minerals. To improve the nutritional content of fodder, small farmers have not made extensive use of chemical or biological approaches. Genetic manipulation offers an alternative and potentially valuable method for enhancing the nutritional content of straw and stover (Zerbini and Thomas, 2003).

Genetic modification has the potential to significantly increase fodder quality by increasing tillering potential, leafiness, and stem sweetness. Landraces of pearl millet are a source of potentially useful genetic diversity, but they are not yet being fully exploited to increase fodder production (Jindal et al., 2009). Forage quality may be estimated by its protein, fiber, and lignin content in the dry matter, as well as its in vitro and in vivo dry matter digestibility (Ouendeba et al., 1996; Jindal et al., 2009).

For the development of high-yielding fodder types, knowledge of variability and character connection between different attribution factors is essential (Nguyen et al., 2019). Pearl millet has a high level of genetic variation, especially for yield components, adaptability, and quality. Taking use of this variation might lead to the development of hybrids and cultivars with very high feed production rates (Bikash et al., 2013). This research aimed to assess the variation in fodder production and related traits among pearl millet inbred lines.

## MATERIALS AND METHODS

The IP numbers of pearl millet genotypes obtained from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) within the scope of TUBITAK 219O103 project carried out by Şırnak University are given in Table 1.

Table1. The IP numbers of pearl millet genotypes used in the current study.

| POPULATIONS | IP NO | POPULATIONS | IP NO |
|---|---|---|---|
| A1-4 PG 2020 Şanlıurfa | 869 | A13-6 PG 2020 Şanlıurfa | 18545 |
| A1-16 PG 2020 Şanlıurfa | 2246 | A15-12 PG 2020 Şanlıurfa | 22269 |
| A5-13 PG 2020 Şanlıurfa | 7978 | A15-16 PG 2020 Şanlıurfa | 17862 |
| A5-14 PG 2020 Şanlıurfa | 8022 | B1-7 PG 2020 Şanlıurfa | 1098 |
| A6-5 PG 2020 Şanlıurfa | 8276 | B4-7 PG 2020 Şanlıurfa | 6113 |
| A6-14 PG 2020 Şanlıurfa | 8707 | B4-9 PG 2020 Şanlıurfa | 6275 |
| A7-8 PG 2020 Şanlıurfa | 9492 | B4-10 PG 2020 Şanlıurfa | 6278 |
| A8-2 PG 2020 Şanlıurfa | 10151 | B7-12 PG 2020 Şanlıurfa | 9645 |
| A9-10 PG 2020 Şanlıurfa | 11799 | B12-16 PG 2020 Şanlıurfa | 17465 |
| A9-11 PG 2020 Şanlıurfa | 11811 | B14-3 PG 2020 Şanlıurfa | 19722 |
| A10-8 PG 2020 Şanlıurfa | 12669 | B14-4 PG 2020 Şanlıurfa | 19816 |
| A10-13 PG 2020 Şanlıurfa | 13261 | B15-7 PG 2020 Şanlıurfa | 21244 |
| A12-12 PG 2020 Şanlıurfa | 16540 | B15-8 PG 2020 Şanlıurfa | 21283 |

Seeds of the pearl millet genotypes were ground in a mill and passed through 1 mm for chemical analysis. Crude protein analyzes were performed by the methods specified in AOAC (1990). The ADF and NDF constituting the cell wall were performed by the method specified in Van Soest (1963) and Van Soest and Wine (1967), respectively. Digestible dry matter (DDM) and dry matter intake (DMI) ratios were also calculated. The following formulas were used for the calculations (Morrison, 2003).

DDM = 88.9 - (0.779 x ADF)
DMI = 120 / NDF

Correlation and GI-biplot analyses were used to analyze five nutritional composition traits [i.e., acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), digestible dry matter (DDM) and dry matter intake (DMI)] from the seeds of 26 pearl millet genotypes (Yan and Kang, 2003; Yan, 2014). Three different GI-biplot graphs were created to visually interpret the relationships between the analyzed traits. All statistical analyses were made in the GGE-biplot program (Yan, 2014).

The JMP-Pro13 statistical tool was used to evaluate the data gathered during the study. Differences among treatments means were categorized using Tukey's post-hoc test. The associations between genotypes and characteristics were analyzed using the Genstat-12th statistical software (VSN International, 2011), and the models were evaluated according to the procedures described by Yan and Tinker (2006).

## RESULTS AND DISCUSSION

Crude protein, ADF, NDF, DDM and DMI ratios evaluated in the seeds of several pearl millet genotypes were shown to be statistically significant at the 99% probability level (Table 2).

Crude protein ratios of the seeds belonging to pearl millet genotypes varied between 11.74-19.24%. Crude protein ratios varied greatly across genotypes, with ‘B1-7’ yielding the highest and ‘A8-2’ yielding the lowest values for crude protein. The results of the current study agree with the findings of Sawaya et al. (1984), Osman (2011), Dias-Martins et al. (2018) and Tomar et al. (2021). However, the crude protein ratio values obtained in the current study are higher than the values reported by Obizoba and Atii (1994), Nambiar et al. (2011), Kiprotich et al. (2015), Malik (2015), Obadina et al. (2016) and Marmouzi et al. (2018). Different genotypes may account for this variation. The availability of crude proteins is dependent on anti-quality factors such as proanthocyanins (Broderick, 1995).

The ADF and NDF ratios of seeds belonging to pearl millet genotypes varied between 3.44-11.43% and 10.23-23.47%, respectively. The highest ADF ratio was obtained from the genotype ‘A8-2’, while ‘A1-4’ and ‘A13-6’ genotypes resulted in the lowest ADF ratio, which were in the same group statistically. Our findings regarding the ADF ratio obtained from the experiment are in accordance with the results reported by Marmouzi et al. (2018) from Morocco. The highest NDF ratio was obtained from the genotypes ‘A5-13’, ‘A8-2’ and ‘B12-16’, while the lowest was obtained from the genotype ‘A13-6’. Our findings regarding the NDF ratio are similar to those reported by Marmouzi et al. (2018).

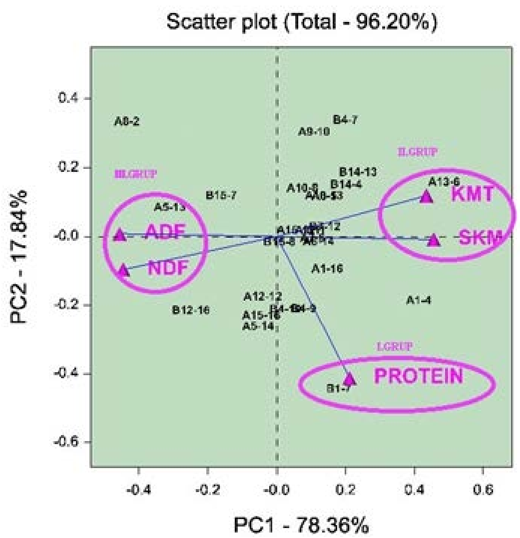
The DDM ratios of pearl millet genotypes varied between 79.98-86.21%. The highest DDM rate was noted for the genotyped ‘A13-6’ and ‘A1-4’, while the genotype ‘A8-2’ resulted in the lowest value in this regard. The DMI rate varied between 5.11-11.72%. The highest DMI rate was recorded for the genotype ‘A13-6’, whereas genotypes ‘A5-13’, ‘A8-2’ and ‘B12-16’, resulted in the lowest values of DMI.

Table 2. The ADF, NDF, crude protein, DDM and DMI values for different pearl millet genotypes included in the study.

| GENOTYPE / VARIETY | CRUDE PROTEIN | ADF | NDF | DDM | DMI |
|---|---|---|---|---|---|
| A10-13 | 14.94 l | 6.02 jk | 15.28 h-k | 84.20 de | 7.85 efg |
| A10-8 | 14.76 m | 6.84 fg | 15.43 hıj | 83.56 hı | 7.77 fgh |
| A1-16 | 16.67 f | 6.23 ıj | 15.12 ı-l | 84.04 ef | 7.93 efg |
| A12-12 | 16.21 gh | 7.21 ef | 20.10 bc | 83.27 ıj | 5.96 no |
| A13-6 | 16.25 g | 3.44 n | 10.23 n | 86.21 a | 11.72 a |
| A1-4 | 18.23 b | 3.64 n | 12.05 m | 86.06 a | 9.95 b |
| A15-12 | 15.23 k | 6.46 ghı | 17.44 efg | 83.86 fgh | 6.88 ıjk |
| A15-16 | 16.95 de | 8.05 d | 18.81 d | 82.62 k | 6.37 lmn |
| A5-13 | 13.64 q | 9.85 b | 23.47 a | 81.22 m | 5.11 p |
| A5-14 | 16.85 e | 7.32 e | 20.40 b | 83.19 j | 5.88 o |
| A6-14 | 16.05 hı | 6.51 ghı | 15.14 ı-l | 83.82 fgh | 7.92 efg |
| A6-5 | 15.03 l | 5.86 jk | 14.97 ı-l | 84.32 de | 8.01 d-g |
| A7-8 | 15.65 j | 5.91 jk | 16.33 gh | 84.29 de | 7.35 hı |
| A8-2 | 11.74 r | 11.43 a | 23.43 a | 79.98 n | 5.12 p |
| A9-10 | 13.74 pq | 6.54 ghı | 14.41 jkl | 83.79 fgh | 8.32 de |
| A9-11 | 15.63 j | 6.47 ghı | 15.75 hı | 83.85 fgh | 7.61 fgh |
| B12-16 | 16.04 hı | 9.64 b | 23.23 a | 81.39 m | 5.16 p |
| B14-13 | 14.47 n | 4.37 m | 14.83 ı-l | 85.49 b | 8.08 def |
| B14-4 | 14.98 l | 5.36 l | 14.14 l | 84.72 c | 8.48 d |
| B15-7 | 14.14 o | 9.04 c | 19.22 cd | 81.85 l | 6.24 mno |
| B15-8 | 15.32 k | 6.75 gh | 18.28 de | 83.63 gh | 6.56 klm |
| B1-7 | 19.24 a | 5.78 k | 15.80 hı | 84.39 d | 7.59 gh |
| B4-10 | 17.04 cd | 7.26 e | 17.54 ef | 83.24 j | 6.84 jkl |
| B4-7 | 13.85 p | 5.64 kl | 13.02 m | 84.50 cd | 9.22 c |
| B4-9 | 17.13 c | 6.45 hı | 16.97 fg | 83.87 fg | 7.07 ıj |
| B7-12 | 15.96 ı | 6.66 gh | 14.26 kl | 83.70 gh | 8.42 d |
| Ort. | 15.61 | 6.72 | 16.76 | 83.66 | 7.44 |
| CV (%) | 0.38 | 1.78 | 2.08 | 0.10 | 1.88 |

Differences among genotypes were statistically significant at the 99% probability level where means are followed by different letters. Means followed by the same letters are statistically non-significant.

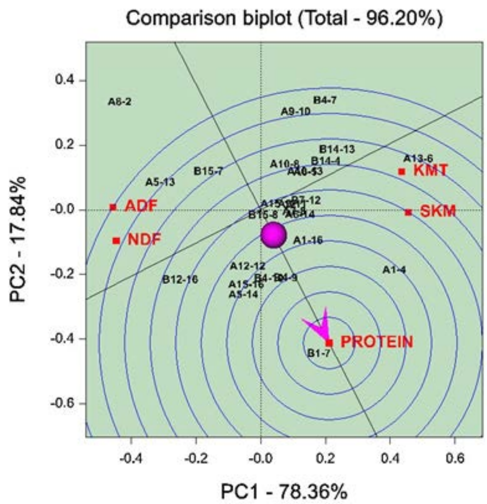
***Interpretation of the relationship between genotype and studied traits through Scatter Biplot and Comparison Biplot Models***




Research using GGE Biplot analysis yields a scatter plot graph that reveals how the researched parameters and genotypes are related in different ways depending on the angle between the vectors. The distance and closeness of the angle between two genotypes or characteristics affects the nature of their interactions.

According to the findings of Yan and Kang (2003), a positive and significant relationship was reported if the angle between the vectors representing the features in the graph obtained from the Biplot analysis was less than ninety degrees, and a negative and insignificant relationship was reported if the angle was greater than ninety degrees. Notable results were found for the 'A5-13' genotype regarding ADF and NDF, 'A13-6' genotype for DDM and DMI, and 'B1-7' genotype for protein ratio. There is a strong correlation between these characteristics given that the angle between the ADF and NDF and DDM and DMI is less than 90 degrees. The protein ratio has a broad angle, which suggests it is unrelated to other variables. It has also been shown that the characteristics under investigation may be divided into three categories. The protein ratio was in the first group, DDM and DMI in the second group, and ADF and NDF were in the third group. However, groups comprising of ADF and NDF, and DDM and DMI were inversely related, which indicates that these traits have a negative relationship with each other (Basbag et al., 2020).

There is a positive and significant correlation between the traits in the same group. Basbag et al. (2018), on the other hand, found that protein ratio had a positive and significant relationship with DDM and DMI values.




The core of a perfect testing environment is shown in Figure 2. So, the optimal test environment would be the most unique, whereas the ideal target environment would be the most prominent genotype in terms of the traits being evaluated. According to the comparison biplot graph, ‘B1-7’ genotype is closest to the center, which indicates the ideal location. For this reason, ‘B1-7’ genotype is the closest and ideal environment for the origin of the concentric circles for the protein ratio. The high rate of PC1 in the ideal test environment indicates that the genotypic effect is high and therefore important in categorizing the genotypes. The PC2 refers to general environments. In this graph, the ideal environment is the center, and the circles are located concentrically (Yan et al., 2000). Yan and Kang (2003) interpreted the ideal genotype as the most stable and the highest grain yield in their biplot analysis. The genotype ‘A8-2’ was located in the farthest position for examined traits in the current study. The genotype ‘A5-13’ was prominent for ADF and NDF, whereas ‘A13-6’ was significant for DDM and DMI. The genotype ‘A8-2’ seems to be the least desirable option across all analyzed traits since it is distant from the graph's optimal center. However, the genotypes utilized in this research should be evaluated in field circumstances over the course of several years, and recommendations should be obtained after relevant investigations.

The analyses of the seed contents of the pearl millet genotypes evaluated in the research concluded that the genotypes had substantial potentials in terms of nutritional content. The ‘A13-6’ genotype proved superior for DDM and DMI, ‘A5-13’ for ADF and NDF ratio, and ‘B1-7’ for crude protein. Variety registration and animal nutrition will both benefit greatly from the incorporation of these genotypes into breeding programs for the studied traits. However, before these genotypes are included into breeding programs, the performance difference between standard varieties in terms of various attributes must be tested, and the genotypes with better traits must be taken into yield trials over several years.

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