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INFLUENCE OF MINERAL FERTILIZATION ON MAIZE GRAIN QUALITY PARAMETERS: COMPARATIVE AND MULTIVARIATE ANALYSIS IN THE CASE OF 2025–2026 AGRICULTURAL YEAR

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Abstract: This study evaluated the variation in key quality parameters of maize grains in relation to different levels of nitrogen (N), phosphorus (P), and potassium (K) fertilization during the 2025–2026 agricultural year. Descriptive results indicated that the hectoliter weight varied between 73.5 and 78.7 kg/hl, the thousand-kernel weight between 158.0 and 200.2 g, the protein content between 8.0 and 9.6%, the oil content between 5.3 and 6.5%, and the moisture content between 12.9 and 16.0%. Variant V15 recorded the highest values for hectoliter weight and protein content, while the maximum value for thousand-kernel weight was observed in V10, and the highest oil content in V3. The study provided a basis for the multidimensional characterization of maize grain quality and for identifying fertilization variants associated with favorable quality profiles.

• Introduction

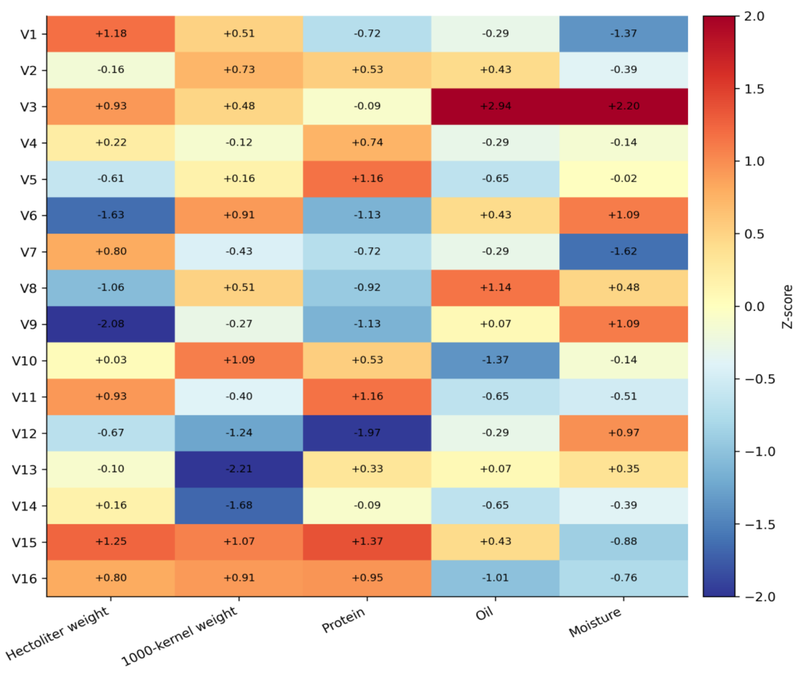
Maize (*Zea mays* L.) is one of the most important agricultural crops globally, playing an essential role in providing food, animal feed, and industrial resources (ERENSTEIN ET AL., 2022; REVILLA ET AL., 2022). The quality of maize kernels is a multidimensional characteristic, defined by the interaction between physical properties, chemical composition, and technological attributes (CARBAS ET AL., 2024; MAHAMA ET AL., 2026; TIAH ET AL., 2026). Mineral fertilization is one of the key technological factors that can influence both crop productivity and the qualitative characteristics of the grains in maize cultivation (MA ET AL., 2012; CALERO-RIOS ET AL., 2026). From the perspective of agronomic management, the relationships between fertilization and quality parameters must be interpreted within the context of the variability of pedoclimatic conditions. Multivariate analysis (PCA) facilitates the dimensionality reduction of a dataset by transforming the initial variables into a smaller number of orthogonal components, which capture a significant portion of the total variability. In agronomic research, this approach can help highlight differences between experimental treatments and identify the indicators that contribute most to their separation (CAO ET AL., 2025; KARA ET AL., 2025; MATTHEW, 2025).

• Material and method

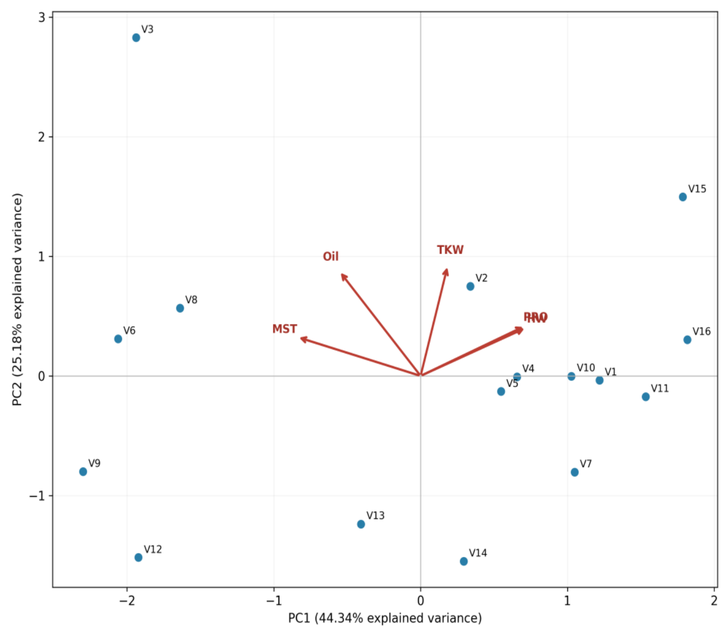
The study and applied research under field conditions were conducted at ARDS Lovrin, Timiș County, Romania. The field experiment was carried out during the 2025–2026 agricultural year, under a non-irrigated cropping system. The 'Andreea' maize hybrid was cultivated. Sowing took place on April 17, 2026, targeting a density of 65,000 plants/ha. Five grain quality indicators were analyzed: hectoliter weight (HW, kg/hl), thousand-kernel weight (TKW, g), protein content (PRO, %), oil content (Oil, %), and grain moisture (MST, %). The Perten Instruments device was used to determine these quality parameters.

• Results and discussions

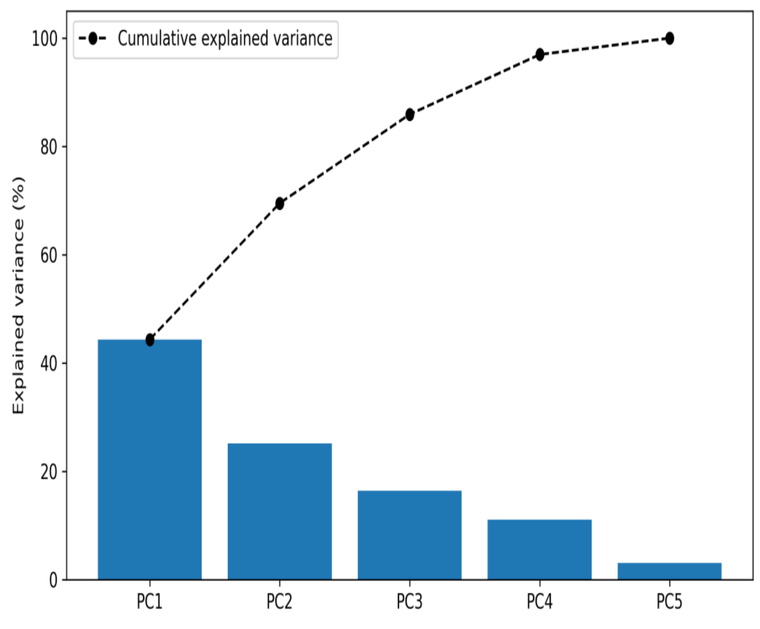
The hectoliter weight (HW) ranged from 73.50±0.39 kg/hl to 78.70±0.39 kg/hl, with an overall mean of 76.75±0.39 kg/hl. The coefficient of variation of only 2.04% indicated a relatively high degree of homogeneity for this indicator across the 16 variants. The maximum value was observed in variant V15, characterized by the N200P80K80 combination, while the minimum value was recorded in variant V9, corresponding to the N100P80K0 combination. The thousand-kernel weight (TKW) exhibited the highest relative variability among the analyzed indicators, with a coefficient of variation of 6.87%. Values ranged from 158.00±3.20 g (in variant V13) to 200.20±3.20 g (in variant V10), with an overall mean of 186.31±3.20 g. The range of 42.20 g highlighted significant differences in the physical characteristics of the kernels across the experimental variants, suggesting that the processes of kernel formation and grain filling did not progress uniformly. For the direct comparison of indicators expressed in different units of measurement, the values were standardized by transforming them into Z-scores (Figure 3). Principal component analysis was used to identify the main directions of variation in quality parameters and to highlight the differences among the 16 experimental variants. PCA was applied to the standardized matrix of the five indicators, ensuring that each variable contributed to the analysis independently of its unit of measurement or initial range. The first two principal components accounted for a cumulative 69.52% of the total data variability—specifically, 44.34% for PC1 and 25.18% for PC2. The distribution of the experimental variants in the plane of the first two principal components is presented in Figure 4. The distribution of the PCA results confirmed that the differentiation among experimental variants cannot be explained by a single quality parameter. While the first component described a gradient primarily associated with hectoliter weight, protein content, and moisture, the second component highlighted the contribution of thousand-kernel weight and oil content. The relatively high proportion of variance explained by the first two components confirmed the utility of PCA for the exploratory representation of the data (Figure 5).



Standardized quality heatmap



PCA biplot of maize grain quality across NPK treatments



Variance explained by principal components

• Conclusions

The research highlighted differences among the 16 NPK mineral fertilization variants regarding the physical and biochemical characteristics of maize grains, and demonstrated the utility of an integrated assessment of quality parameters, based on descriptive, comparative, and multivariate data analyses. Overall, the results indicated that the assessment of NPK fertilization efficiency should be conducted by integrating multiple quality indicators, since treatments associated with higher values for one parameter do not necessarily ensure similar performance for the other parameters. The research provides an exploratory basis for identifying fertilization combinations with favorable quality profiles and justifies extending the investigations through multi-year experiments, with independent replicates and detailed characterization of pedoclimatic conditions.

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