SPATIAL ANALYSIS OF PHYSICAL AND SENSORY ATTRIBUTES OF COFFEE BEANS

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A paper from the Proceedings of the
17th International Conference on Precision Agriculture and 11th Brazilian Congress on Precision and Digital Agriculture
13-15 July 2026
Porto Alegre, Brazil

Abstract.

Arabica coffee (*Coffea arabica* L.) is one of the crops with the greatest economic and social relevance in Brazil, with beverage quality being a differential of broad commercial value. This study aimed to evaluate the spatial variability of the physical and sensory attributes of coffee beans. The study was conducted during the 2023-24 crop season in a 27-hectare plot belonging to Fazenda Mandaguari, in Indianópolis, Minas Gerais, cultivated with the Topázio cultivar under drip irrigation. A regular grid of 50 georeferenced points was installed in the area to collect data on altitude, soil texture, and bean yield. Altitude was recorded using a global navigation satellite system (GNSS) receiver, Garmin® E-Trex Vista®. Soil texture was determined in the laboratory from composite samples (0-0.2 m) collected at the sampling grid points. To obtain the yield, four plants were selected (two contiguous plants in two adjacent rows); all fruits were removed by manual harvesting, sun-dried on a drying patio to a moisture content of approximately 11.7%, and processed to finally obtain the final mass weight of the beans. From these data, zones of different potentials (ZP) were defined using the Smart Map plugin in the QGIS environment. The bean quality analysis consisted of physical and sensory analyses. For the former, the beans were classified according to sieve size, defects (black, sour, immature, insect damaged, shell, and shell core beans), and coffee type. Sensory analysis was performed according to the Specialty Coffee Association (SCA) protocol, considering the previously defined homogeneous zones. The data were analyzed using descriptive statistics and geostatistics. The results showed the presence of spatial structure for all evaluated sieves, except for sieve 10 (peaberry beans), and for the black, insect damaged, and immature bean defects, with ranges varying from 125 m (sieve 15) to 485 m (sieve 17). Based on altitude, texture, and yield data, four zones of different potential (ZP) were defined, highlighting ZP-3, which obtained the highest sensory score (84.5 points), related to a higher proportion of beans retained in larger sieves (16 and 17) and a lower occurrence of defects. In contrast, ZP-4 presented the lowest sensory score (80.3 points), associated with a higher frequency of defects and a predominance of smaller beans. From the data, it is possible to verify the existence of spatial variability in the physical and sensory attributes of coffee beans. The integration of the analyses is valid. Although some defects, such as immature and black beans, are present, positive attributes of body, aroma, and balance compensate for the negative effects, allowing a superior beverage quality to be achieved. It is evident that the integration of the physical and sensory analyses of the beans, associated with the use of Precision Agriculture tools, allows

understanding the existence of spatial variability in coffee quality for some attributes, reinforcing the need for site-specific management strategies aimed at adding value to the product.

Keywords.
Coffea arabica, Geostatistics, Spatial variability, Management zones, Specialty coffee, Physical-sensory attributes.

Introduction

Coffee farming seeks constant improvement in both quantitative levels, reflected in productivity, and qualitative levels, reflected in the sensory quality of the bean. Coffee (Coffea arabica L.) management can benefit from the use of precision agriculture when management zones (MZ) are delimited. These zones help in understanding the complex soil-plant interaction that influences productivity and the beverage. Climate and nutritional variations within each MZ can alter the chemical composition and maturation of the beans, impacting the sensory quality and the final score for this commodity (SCA, 2008; WORKU, 2012). This study aimed to evaluate the spatial variability of the physical and sensory attributes of coffee beans.

Materials and Methods

The study was conducted at Fazenda Mandaguari, Indianópolis-MG, Brazil, in a 27 ha plot cultivated with Coffea arabica L., cultivar Topázio. The plot has an altitude of 980m, Red Latosol (Oxisol) soil, and drip irrigation management. Data collection was carried out using a regular georeferenced grid of 50 points. In the plot, sampling zones (ZM) were defined integrating productivity, altitude, and soil texture data. Productivity was determined by manually collecting the fruits, considering four plants per point. Productivity was calculated after the grains were dried on a patio to 11.5% moisture and processed.

The physical characterization of the grains was performed for each sampling point, using sieves 10 (pocket beans) and 16 to 19 (large grains). Defects considered the presence of black, burnt, green, broken, shell, and shell core grains, according to the official Brazilian classification (COB). The sensory profile was obtained for each of the previously defined management zones. Physical defects were removed from the samples and evaluated by Q-Graders, considering scores from 0 to 100 according to the Specialty Coffee Association (SCA) protocol.

The collected data were subjected to descriptive statistical analysis, Pearson correlation ($p < 0.05$), and spatial dependence, based on semivariogram modeling and Kriging interpolation using geostatistics. The definition of management zones was based on the Fuzzy K-means algorithm with the aid of the Smart Map plugin in the QGIS environment.

Results and Discussion

There was spatial dependence for most of the evaluated physical attributes, with a strong spatial structure for the grains retained on the coarse sieves, except for sieve 10 (moca). This shows that grain size is not randomly distributed in the plot. The range values varied from 125 meters (sieve 15) to 485 meters (sieve 17), indicating the ideal scale for monitoring. The definition of management zones delimited the area into four zones of different potentials (ZP-1 to ZP-4). ZP-3 showed the best qualitative performance, with the highest sensory score (84.5 points). This result was correlated with the higher proportion of large grains (sieves 16 and 17) and the lower incidence of physical defects. In turn, ZP-4 presented the lowest qualitative potential of the plot, with a sensory score of 80.3 points. The behavior of this production zone was associated with a predominance of smaller grains (fine sieves) and a high quantity of physical defects (black and immature grains), which lead to unevenness and astringency in the beverage. The use of Precision Agriculture tools allows us to understand the spatial variability of attributes associated with the qualitative behavior of the beverage, enabling the validation of strategies that increase

the added value of the product in the Cerrado Mineiro region.

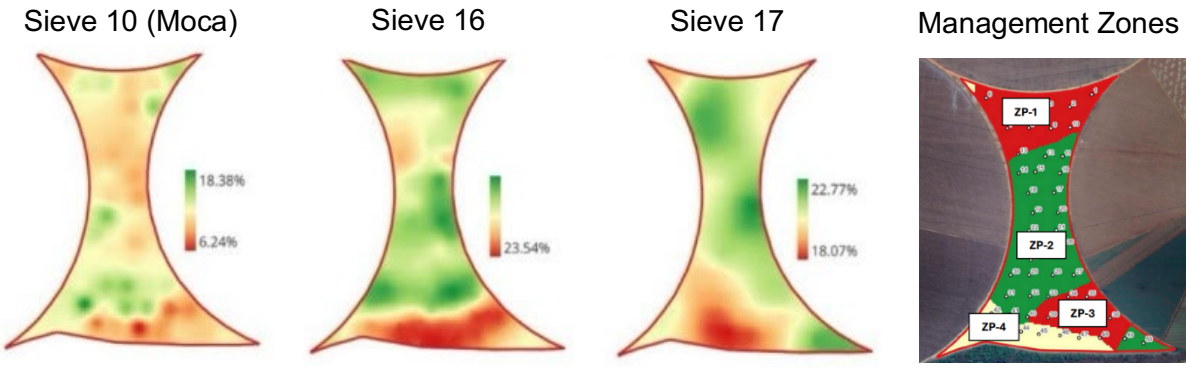

Fig. 1 Interpolated maps for grains retained on sieves 10 (moca), 16 and 17 and a map defining management zones showing zones of different potentials (ZP).

Conclusion

There is spatial variability in the physical attributes of the evaluated coffee beans, and this is directly related to the final quality of the beverage. Defining zones with different potentials is a viable tool for the sensory analysis of coffee. Zones with a higher predominance of large coffee beans and a lower occurrence of defects may signify beverages with higher sensory scores.

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