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COMMERCIAL CLASSIFICATION OF PEANUTS BASED ON POD PHYSICAL CHARACTERISTICS

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KEYWORDS

Path analysis, legume, production, *Arachis hypogaea* L.

ABSTRACT

Peanut (*Arachis hypogaea* L.) is a legume belonging to the Fabaceae family, whose production aims at high pod yields and quality. This study aimed to investigate peanut physical traits and point out their relationship with total pod mass. Therefore, we evaluated total pod mass and the pod physical components: grain mass, pod shell mass, pod length, greatest and smallest transverse pod diameters, number of grains per pod, pod area, pod perimeter, and fruit volume. Initially, these morphological variables were correlated by Pearson's coefficient, and a correlation network was used to graphically express the obtained results. Path analysis identified that pod total mass has a cause-and-effect relationship with the variables number of grains per pod, grain mass, and pod shell mass. As a result, these variables can be used in indirect selection for higher crop yields; therefore, monitoring pod total mass before harvest is a strategy to predict the final yield of peanuts.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a legume of the family Fabaceae. It can be consumed fresh or used for several other purposes such as the manufacturing of food, medicines, and oil extraction (Neves et al., 2020). Currently, China is the largest producer of shelled peanuts, with an estimated production of 17.80 million tons, followed by India (6.50 million tons), the United States (3.28 million tons), and Nigeria (3.20 million tons). The main producing regions are located in Asia, followed by Africa and America (USDA, 2018). In Brazil, peanut production has expanded accompanied by an increase in its processing and commercialization capacities, mainly for the foreign market, for which more than half of the production is intended (Sampaio & Fredo, 2021).

When well managed and without water and temperature limitations, peanut cultivation has a high yield and high quality of the harvested product. These characteristics result from combinations of many plant growth and development processes (Pegues et al., 2019). Crop productivity can be determined by physical factors such as fruit volume, length, and diameter, which must be standardized to help facilitate their commercialization. Correlations among such variables have been widely used to find how to increase yield in most crops. For peanut breeding programs, path analysis has been used (Tirkey et al., 2018; Rao & Venkanna, 2019; Mahmoud et al., 2020).

Given the above, this study aimed to investigate the relationships between the physical characteristics of peanut pods and their total mass production.

MATERIAL AND METHODS

The study was carried out in Bicas, Minas Gerais State, Brazil, near the geographic coordinates: 23 K, 700832.61 m E; 7596335.29 m S (UTM). According to Köppen and Geiger's classifications, the local climate is characterized as a Cwa-type. Temperature ranges from 13°C to 30°C throughout the year, and the average annual rainfall is 1,232 mm.

Table 1 shows the results of soil physical and chemical analyses.

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TABLE 1. Physical and chemical analyses of the soil in the study area.

Layer	Particle-size analysis			Chemical analysis			
	Sd	St	Cy	pH	P	K^+	OM
----- m -----	------------- % -------------			-- H_2O --	-------- mg dm^{-3} --------		-- dag kg^{-1} --
0-0.20	44	16	40	5.7	21.4	130	2.3

Layer	Chemical analysis							
	Ca^{+2}	Mg^{+2}	H^{+}+Al^{+3}	Al^{+3}	SB	CEC	BS	AS
---- m ----	---------------------------------- $cmol_c$ dm^{-3} ----------------------------------						-------- % --------	
0-0.20	2.9	2.0	2.4	0.1	3.7	6.2	58	0.0

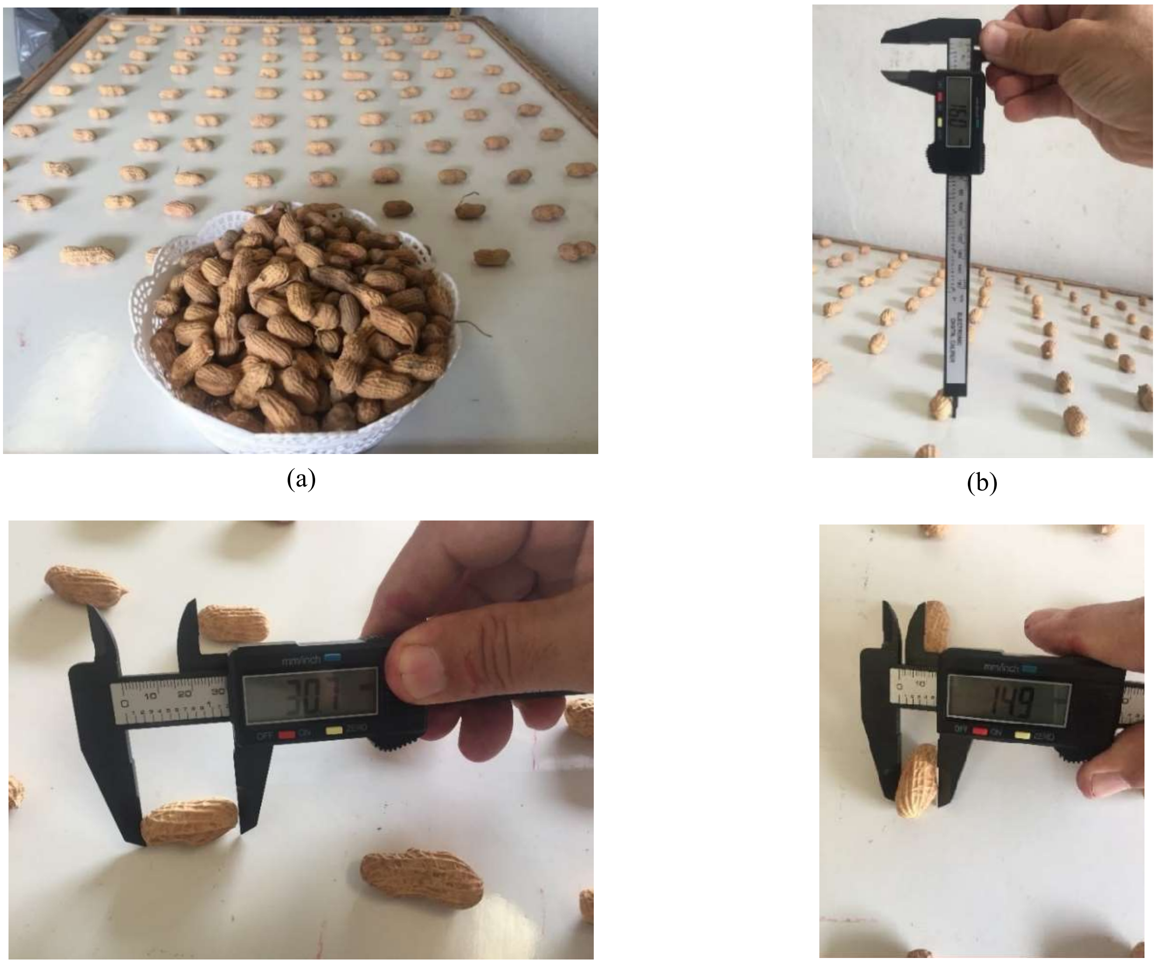
Sd: sand; St: silt; Cy: clay; SB: sum of bases; CEC: cation exchange capacity; BS: base saturation; AS: aluminum saturation.

The experimental area was tilled during the rainy season, between November 1 and 3, 2019. Planting holes had a 0.25-m diameter and 0.25-m depth and were spaced 0.50 m apart. Three seeds of the cultivar IAC OL 3 were sown per hole.

Harvest was carried out on March 09, 2020, resulting in a total cultivation cycle of 126 days. Fruits were harvested manually to avoid any influence or physical damage. After harvesting, pods were selected excluding all that showed defects to avoid any undesired influence on results. The selection was carried out according to the Normative Instruction 32 of August 24, 2016, which establishes standards for shelled peanuts and grains intended for human consumption (MAPA, 2016).

Peanut pods were placed on sieves and air-dried for 30 days. The sieves were filled with a number of pods enough to prevent moisture gradient during drying. Water content reduction was monitored by a precision balance with a 0.01-g resolution until pods reached constant mass and final water content of about 0.04 decimal units, dry basis, *db* (Araujo et al., 2015).

The physical characteristics of peanut pods evaluated were total mass (TM), grain mass (GM), and shell mass (SM). These variables were measured with the aid of a precision scale (0.1-g precision) and expressed as grams (g). The other pod measures taken were length (PL), greatest (GD) and smallest (SD) transverse diameters. These traits were obtained using a 0.01-mm digital caliper and expressed as millimeters (mm). Figure 1 illustrates the measurements that were taken (Oliveira et al., 2021).



(a) (b)

(c) (d)

FIGURE 1. Peanut (a) overview of the laboratory stage, (b) measurement of the smallest transverse diameter (SD), (c) measurement of the pod length (PL), and (d) measurement of the greatest transverse diameter (GD).

The number of peanut grains per pod (NG; dimensionless) was obtained by counting. Pod images were taken by a tripod camera set on a platform, where pods were supported. The photographs were transferred to the AutoCAD 2018 software (free version) to determine the following attributes: pod area (PA; in mm^2) and pod perimeter (PP; in mm). The, pod volume (PV) was calculated as in [eq. (1)] and expressed as mm^3 (Araujo et al., 2015; Oliveira et al., 2021).

$$PV = \pi \frac{(LE).(GD).(SD)}{6} \tag{1}$$

Where:

PV = pod volume, in mm^3;

pod length (PL) in mm,

greatest (GD) and smallest (SD) transverse diameters, in mm (Figure 2).

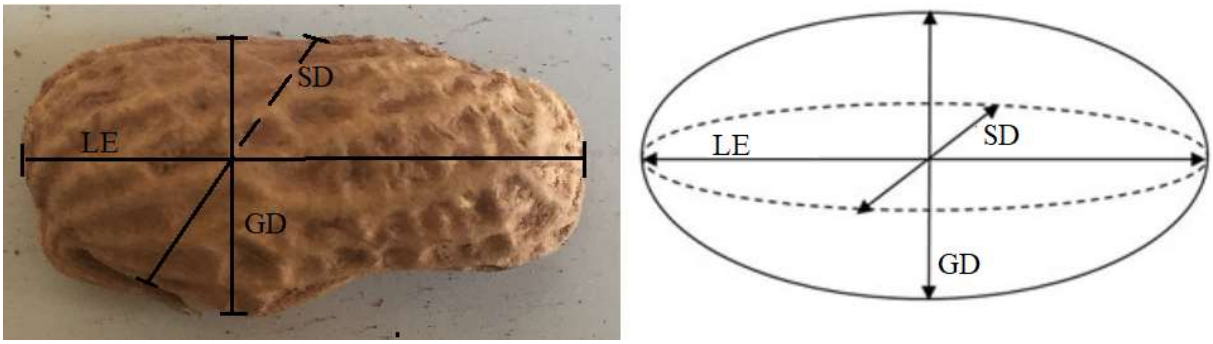


FIGURE 2. Schematic representation of the triaxial axes of peanut pods.
Source: Adapted from Araujo et al. (2015) and Oliveira et al. (2021).

Figure 3 shows a causal chain diagram containing the relationship of peanut pod total mass (TM), considered the main variable, with the other pod characteristics.

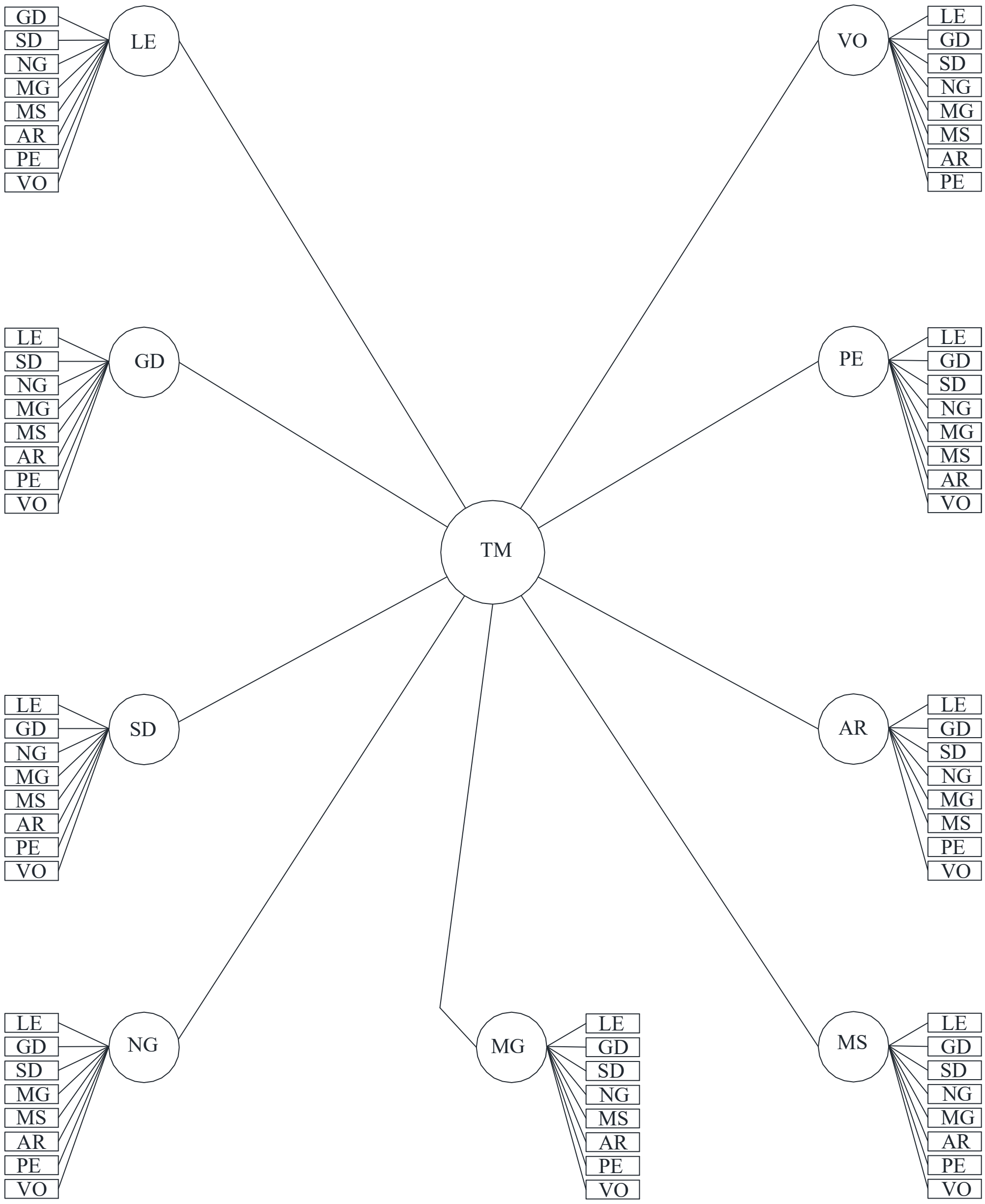


FIGURE 3. Causal chain diagram showing the relationship between peanut pod total mass (TM) and the other physical components: grain mass (GM), shell mass (SM), pod length (PL), greatest (GD) and smallest (SD) transverse diameters, number of grains per pod (NG), pod area (PA), pod perimeter (PP), and pod volume (PV) based on the path analysis performed.

First, the morphological variables were correlated by Pearson's coefficient, and a correlation network was used to graphically express the obtained results (Figure 4). Positive correlations were expressed by green lines. The magnitude of correlations was expressed by the thickness of the line connecting the two variables. The analysis was performed with the Rbio software (Bhering, 2017).

Pearson's correlations between total mass (TM) and the other physical variables were broken down into direct and indirect effects through path analysis. The statistical analyses were performed using the Genes software (Cruz, 2013).

RESULTS AND DISCUSSION

Figure 4 shows the Pearson's correlation network between the total mass and other physical parameters of peanut pods. Correlation matrix estimates ranged from -0.1686 to 0.9565** and were expressed in green and red lines. The greater the correlation degree, the thicker the line. The only negative correlation (in the red line) was found between NG and GM, but it was not significant. The use of this relationship with unit mass data facilitates the sizing of equipment intended for post-harvest of the product (Araujo et al., 2015).

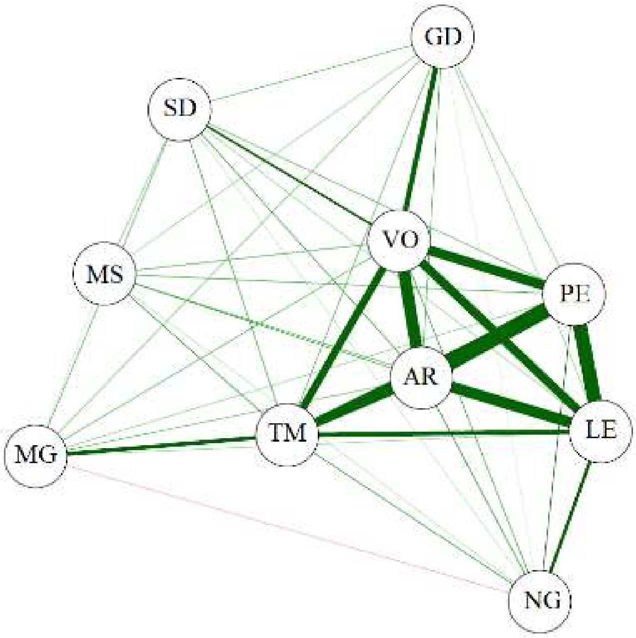


FIGURE 4. Correlation network between the morphological variable total mass (TM) and other physical components of peanut pods, namely: grain mass (GM), shell mass (SM), pod length (PL), greatest (GD) and smallest (SD) transverse diameters, number of grains per pod (NG), pod area (PA), pod perimeter (PP), and pod volume (PV). Green lines indicate positive correlations, with the correlation degree being proportional to line thickness.

PA had a high positive correlation with PP and a direct positive correlation with PV. Araujo et al. (2015), citing Yalçin et al. (2007) and Siqueira et al. (2012), reported that a projected area reduction is related to a decrease in peanut volume during drying, affecting air passage through peanut fruit mass during processing and/or drying. NG had a negative non-significant correlation with GM, which indicates that pods with a larger number of peanut kernels have lighter kernels, and the reverse is true.

Nevertheless, correlations between independent variables (high multicollinearity) are often erroneously considered synonymous with high or perfect correlation (close to +1 or -1), which is especially observed in case of overlap between variables in a regression model (Oliveira et al., 2018). Among the peculiar effects of high multicollinearity, the following can be cited: inconsistent regression coefficients and overestimation of the direct effects of explanatory variables on the response variables, leading to misinterpretation (Cruz et al., 2012). In this context, path analysis is precisely used to correct those effects.

Our results are shown in a scheme that shows the variables with the greatest direct effects on TM of peanut pods, namely: NG, GM, and SM (Figure 5). Considering that a variable is feasible for the direct selection of larger and more attractive pods, it must have a direct effect and high correlation in the same direction as the main variable. Thus, the variables NG, GM, and SM are the most suitable for direct selection since they have a cause-and-effect relationship with peanut pod TM. Tirkey et al. (2018), Rao & Venkanna (2019), and Mahmoud et al. (2020) also found a strong direct effect of GM on TM of peanut pods through a path analysis.

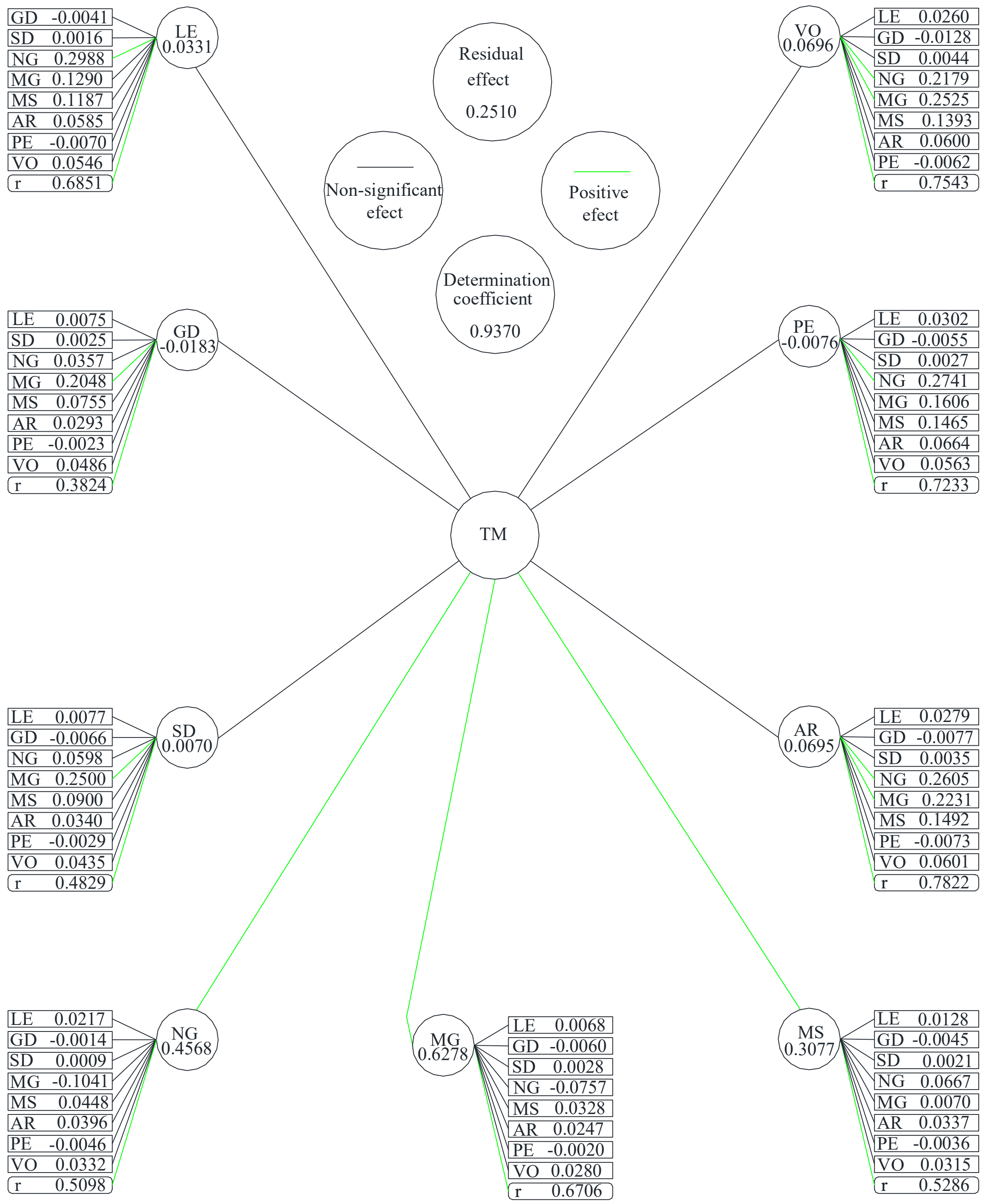


FIGURE 5. Path analysis between peanut pod total mass (TM) and other physical components: peanut grain mass (GM), pod shell mass (SM), pod length (PL), greatest (GD) and smallest (SD) transverse diameters, number of grains per pod (NG), pod area (PA), pod perimeter (PP), and pod volume (PV).

When studying different peanut varieties, Bassanezi et al. (2021) observed that larger numbers of peanut grains per pod increase peanut yield, corroborating our study. We observed a high coefficient of determination (0.9370), which, in turn, can be implemented to improve and enhance peanut yields by improving crop management. Furthermore, further studies are needed on the physical characteristics of peanuts. In this sense, Oliveira et al. (2018) found values of determination coefficient similar to ours and highlighted values above 0.70 as high.

Our results also indirectly suggest that NG is strongly influenced by PL, PA, PP, and PV. Moreover, GM had a direct and significant correlation with GD, SD, PA, and PV. Our findings were positive and demonstrate that higher values of PL, GD, SD, PA, PP, and PV can be reached by an indirect selection of those with the largest NG and GM.

CONCLUSIONS

Path analysis showed that peanut pod total mass has a cause-and-effect relationship with the number of grains per pod, grain mass, and pod shell mas. Thus, pod total mass can be used for an indirect selection aimed at increasing crop yield; therefore, monitoring pod total mass before harvest is a strategy to estimate the final productivity of peanuts. Still, experiments should be repeated in the same area of study to verify whether peanut physical characteristics behave the same way in different planting years.

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