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PRODUCTIVE AND PHYSIOLOGICAL PARAMETERS OF PEANUT CULTIVARS

PARÂMETROS PRODUTIVOS E FISIOLÓGICOS DE CULTIVARES DE AMENDOIM

Lucas Aparecido Manzani Lisboa[1]; Matheus Luis Oliveira Cunha[1]; Fernando Takayuki Nakayama[2]; Ignácio José de Godoy[3]; Rodrigo Aparecido Vitorino[2]; Paulo Alexandre Monteiro de Figueiredo[1]

[1]São Paulo State University (Unesp), College of Agricultural and Technological Sciences, Dracena, Brazil. E-mail: lucas.lisboa@unesp.br
[2]Paulista Agribusiness Technology Agency, Regional Paulista Regional Camp, Adamantina, Brazil.
[3]Agronomic Institute of Campinas (IAC) - Center for Analysis and Technological Research of Grain and Fiber Agribusiness

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Resumo

Studies of adaptability, agronomic characterization and productive potential of peanuts, including information on physiological characteristics, make it a strategy for choosing the best cultivar. In view of the above, the objective of this work was to verify the physiological characteristics and productivity of different peanut cultivars. In January of 2019 an experiment was installed in the Paulista Agribusiness Technology Agency, Regional Paulista Regional Camp, located in the municipality of Adamantina, state of São Paulo. The experimental design was in randomized blocks with six treatments, that is, peanut cultivars: Tatu, Semper Verde, OL3, OL5, 503 and 505 and with six replications totaling 36 plots, where each plot was composed of three plants. The Tatu cultivar showed low values of morphological characteristics and productivity compared to other cultivars. The cultivars OL3, OL5, 503 and 505 showed higher averages of productivity. Great genetic variability was observed among the cultivars evaluated in this research due to the results obtained in the physiological and productivity variables.

Abstract

Estudos de adaptabilidade, caracterização agronômica e potencial produtivo do amendoim, incluindo informações sobre características morfofisiológicas, tornam-no uma estratégia para a escolha da melhor cultivar. Diante do exposto, o objetivo deste trabalho foi verificar as características fisiológicas e a produtividade de diferentes cultivares de amendoim. Em janeiro de 2019 foi instalado um experimento na Agência Paulista de Tecnologia do Agronegócio, Acampamento Regional Paulista, localizado no município de Adamantina, estado de São Paulo. O delineamento experimental foi em blocos casualizados com seis tratamentos, ou seja, cultivares de amendoim: Tatu, Sempre Verde, OL3, OL5, 503 e 505 e com seis repetições totalizando 36 parcelas, sendo cada parcela composta por três plantas. A cultivar Tatu apresentou baixos valores de características morfológicas e produtividade em relação às demais cultivares. As cultivares OL3, OL5, 503 e 505 apresentaram maiores médias de produtividade. Grande variabilidade genética foi observada entre as cultivares avaliadas nesta pesquisa devido aos resultados obtidos nas variáveis fisiológicas e de produtividade.

INTRODUCTION

Peanuts (*Arachis hypogaea* L.) originated in South America, and today they are cultivated in all tropical and temperate regions, being considered one of the main oil crops produced in the world, ranking fifth in the production ranking worldwide (USDA, 2017). In Brazil, the state of São Paulo stands out as the largest producer, with a production of 477.7 thousand tons in the 2017/2018 harvest, with a planted area of 124.7 thousand hectares and productivity of 3.831 kg ha^{-1} (CONAB, 2019). The use of peanuts in Brazil is limited due to the high price and low supply of seeds on the market, given that these seeds are imported from neighboring countries (DE ASSIS *et al.*, 2016).

Peanuts are divided into three groups; Virginia, Valencia and Spanish, according to the plant's morphology. In Brazil, the botanical types Valencia and Virginia are the most cultivated for commercial purposes (HEID *et al.*, 2016). The peanut cultivars belonging to the Valencia groups have a central axis with flowers, erect or semi-erect growth habit, few secondary and sometimes tertiary branches, short cycle, with three or four seeds (Batista, 2019). Virgínia cultivars, on the other hand, show low habit and abundant branching, long cycle, absence of flowers in the central axis and pods with two seeds (VALLS, 2005).

In some regions of Brazil, more specifically the southeast region, studies of adaptability, agronomic characterization and productive potential of peanut cultivars that include information on structural characteristics such as light interception, IAF, leaf angles (SILVA *et al.*, 2010) and morphological characteristics such as CO_2 assimilation rate, water use efficiency and transpiration are still scarce. Given the above, the objective of this work was to verify the physiological characteristics and productivity of different peanut cultivars in Western Paulista.

MATERIAL AND METHODS

Characteristics of the experimental area

In January of 2019 an experiment was installed in the Paulista Agribusiness Technology Agency, Regional Paulista Regional Camp, located in the municipality of Adamantina, state of São Paulo, with the following geographic coordinates: 21°40'24.024"S and 51°8'31.088"W, with an approximate altitude of 420 m. The climate of the region is characterized as Aw according to Köppen and Geiger, with rainy summer and dry winter, with an average temperature of 22.1°C and a rainfall of 1204 mm per year.

The soil of the area was classified as Dystrophic red-yellow argisol (Embrapa, 2013) with good drainage and presented the chemical attributes according to Table 1.

Table 1. Chemical attributes of the soil of the area of experiment in moment of the planting.

pH	OM	P	K	Ca	Mg	H+Al	Al	SB	CEC	V%	m%
$CaCl_2$	g dm^{-3}	mg dm^{-3}	---------------------------------- $mmol_c$ dm^{-3} -----------------------------------								
4.7	10	15	2.2	12	6.0	16	1.0	20.2	36.2	56	5.0

OM: organic matter; SB: Sum of bases; CEC: Cation exchange capacity; V%: Base saturation; m%: Aluminum saturation.

Dolomitic limestone was applied in total area and the planting was carried out after 15 days of its application, the fertilization of planting was according to Raij et al. 1996.

Experimental design

The experimental design was in randomized blocks with six treatments, that is, peanut cultivars: Tatu, Sempre Verde, OL3, OL5, 503 and 505 and with six replications totaling 36 plots, where each plot was composed of three plants. The planting spacing of the seed was 0.50, making 100.000 plants per hectare.

Parameters evaluated

Gas exchange parameters

After seven years the following parameters were determined, gas exchange was evaluated via non-destructive analyses using a portable gas exchange device (Infra-Red Gas Analyzer − IRGA, brand ADC BioScientific Ltd®, model LC-Pro). The following parameters were determined: CO_2 assimilation rate expressed by area (A – μmol CO_2 m^{-2} s^{-1}), transpiration (E – mmol H_2O m^{-2} s^{-1}), stomatal conductance (gs – mol H_2O m^{-2} s^{-1}), internal CO_2 concentration in the substomatal chamber (Ci – μmol mol^{-1}), efficient water use (EUW – μmol CO_2 m^{-2} s^{-1} / mmol H_2O m^{-2} s^{-1}), determined by the formula: EUW = A/E and efficient use of carbon (EUC – μmol CO_2 m^{-2} s^{-1} / mmol CO_2 mol air^{-1}), determined by the formula: EUW = A/Ci. The initial conditions imposed for the measurements were 1500 μmol m^{-2} s^{-1} of photosynthetically active radiation (PAR) provided by LED lamps, 380 ppm of CO_2, and a chamber temperature of ambient.

Concentration de chlorophyll A e B

The concentrations of chlorophylls A and B were determined by converting the values of the SPAD Index, using the portable fluorometer model CCM-200 Plus (Opti-Sciences Inc®) according to the methodologies described by Parry *et al.*, (2014) and Chang and Troughton (1972).

Leaf histology

Was collected a fully expanded leaf fragment from the third branch from the apex of each plant. All fragments of plant tissues received the procedures relevant to dehydration, diaphanization, inclusion and packaging and with the aid of a microtome, cross sections of eight μm were performed on each tissue fragment.

The first transversal sections without damage caused by cut of plants tissues were chosen for preparation of the histological slides. These section were fixed with patches (albumin), were tinted with safranin with a 1% ratio, and were set in microscope and glass slides wih Entellan®. All slides were observed with an Olympus® optical microscope model BX 43, to measure anatomic parameters through the software cellSens Standart that was calibrated with a microscopic ruler in the same gains. Leaf tissues were measured: xylem diameter (XD), phloem diameter (PD) and palisade parenchyma thickness (PPT) (LISBOA *et al.*, 2018). For all variables, six measurements were made per slide, totaling 24 measurements per treatment.

Statistical analysis

In all of the datasets considered, the normality of the data was analyzed using the Anderson-Darling test and homoscedasticity was analyzed with the variance equation test (or Levene's test). The results were subjected to statistical analysis using Assistat 7.7 static software (SILVA and AZEVEDO, 2016) system for Windows 7.0. The means were compared using the Scott Knott ($p<0.05$) (BANZATTO and KRONKA, 2013), by using.

RESULTS

According to analysis of variance (Table 2), only the internal concentration of CO_2 and the efficiency of water use did not have a statistically significant difference with means and standard deviations of 53.85 and 1.12, respectively.

Regarding the CO_2 assimilation rate, the Tatu cultivar had the lowest average (16.26 μmol CO_2 m^{-2} s^{-1}), differing statistically from the other cultivars analyzed in the study. For transpiration the greatest results were obtained by cultivars SV (6.82 mmol H_2O m^{-2} s^{-1}), OL5 (6.83 mmol H_2O m^{-2} s^{-1}) and OL3 (6.75 mmol H_2O m^{-2} s^{-1}), however the value of this variable for cultivating Tatu (4.97 mmol H_2O m^{-2} s^{-1}) was the lowest result obtained.

Table 2. Analysis of variance of CO_2 assimilation rate expressed by area (A – μmol CO_2 m^{-2} s^{-1}), transpiration (E – mmol H_2O m^{-2} s^{-1}), stomatal conductance (gs – mol H_2O m^{-2} s^{-1}), internal CO_2 concentration in the substomatal chamber (Ci – μmol mol^{-1}), efficient water use (EUW), efficient use of carbon (EUC - μmol CO_2 m^{-2} s^{-1} / mmol CO_2 mol air^{-1}) of peanut cultivars.

	A	E	gs	Ci	EUW	EUC
p value	0.0001**	0.0001**	0.0001**	0.6987ns	0.0630ns	0.0068**
OA	22.49	6.28	0.33	259.24	3.59	0.09
SD	7.28	0.72	0.07	54.23	1.10	0.04
MSE	1.48	0.14	0.01	11.07	0.22	0.008
CV (%)	32.35	11.60	21.38	20.91	30.78	46.33

OA: overall average; SD: standard deviation; MSE: Mean standard error; CV: Coefficient of variation. Ns – p>=0.05; * – 0.01=<p<0.05; ** – p<0.01. The averages followed by the same letter do not differ statistically from each other. The Scott Knott test was applied at the 5% probability level.

Evaluating stomatal conductance, it was observed that cultivar SV (0.40 mmol H_2O m^{-2} s^{-1}) stood out with the best result and cultivars 505 (0.30 mmol H_2O m^{-2} s^{-1}) and Tatu (0.26 mmol H_2O m^{-2} s^{-1}) presented the worst values within the analyzed characteristic. For efficiency in the use of carbon the greatest results were presented by cultivars OL3 (0.111 μmol CO_2 m^{-2} s^{-1}), OL5 (0.101 μmol CO_2 m^{-2} s^{-1}) and 503 (0.098 μmol CO_2 m^{-2} s^{-1}).

The results of chlorophyll A and B showed similarity in the behavior of the cultivars in both variables where the cultivar OL5 (Chlorine A - 361.67 and Chlorine B - 120.55 μmol m^{-2}) had the best value, as shown in the Table 3. In contrast, the cultivar Tatu (Chlorine A-132.03 and Chlorine B- 44.01 μmol m^{-2}) had the worst results (Fig. 1).

Table 3: Analysis of variance of Chlorophyll A and B (Cloro A and B - μmol m^{-2}) and average yield values of peanut cultivars.

	Cloro A	Cloro B	Prod
p value	0.0001**	0.0001**	0.0001**
OA	250.03	83.34	4330.00
SD	56.52	18.84	383.49
MSE	23.07	7.69	191.74
CV (%)	22.60	22.60	8.85

OA: overall average; SD: standard deviation; MSE: Mean standard error; CV: Coefficient of variation. Ns – p>=0.05; * – 0.01=<p<0.05; ** – p<0.01. The averages followed by the same letter do not differ statistically from each other. The Scott Knott test was applied at the 5% probability level.

In general, the cultivar Tatu showed the lowest values of the morphophysiological characteristics evaluated in this research.

According to the productivity averages (Fig. 2), the cultivars OLR (4971.25 kg ha^{-1}), 503 (4935.00 kg ha^{-1}), 505 (4682.50 kg ha^{-1}) and OL3 (4503, 75 kg ha^{-1}) had the highest values of this variable, standing out when compared to cultivars SV and Tatu.

According to the values of the correlation between the variables (Fig 3), it was observed that stomatal conductance showed a direct correlation with sweating. The efficiency of water use was directly related to the CO_2 assimilation rate and productivity. Chlorophyll A was directly related to chlorophyll B and productivity, where the same is true for chlorophyll B, which was related to chlorophyll A and productivity. Finally, productivity showed a positive relationship with

CO_2 assimilation rate, water use efficiency, chlorophyll

A and B.

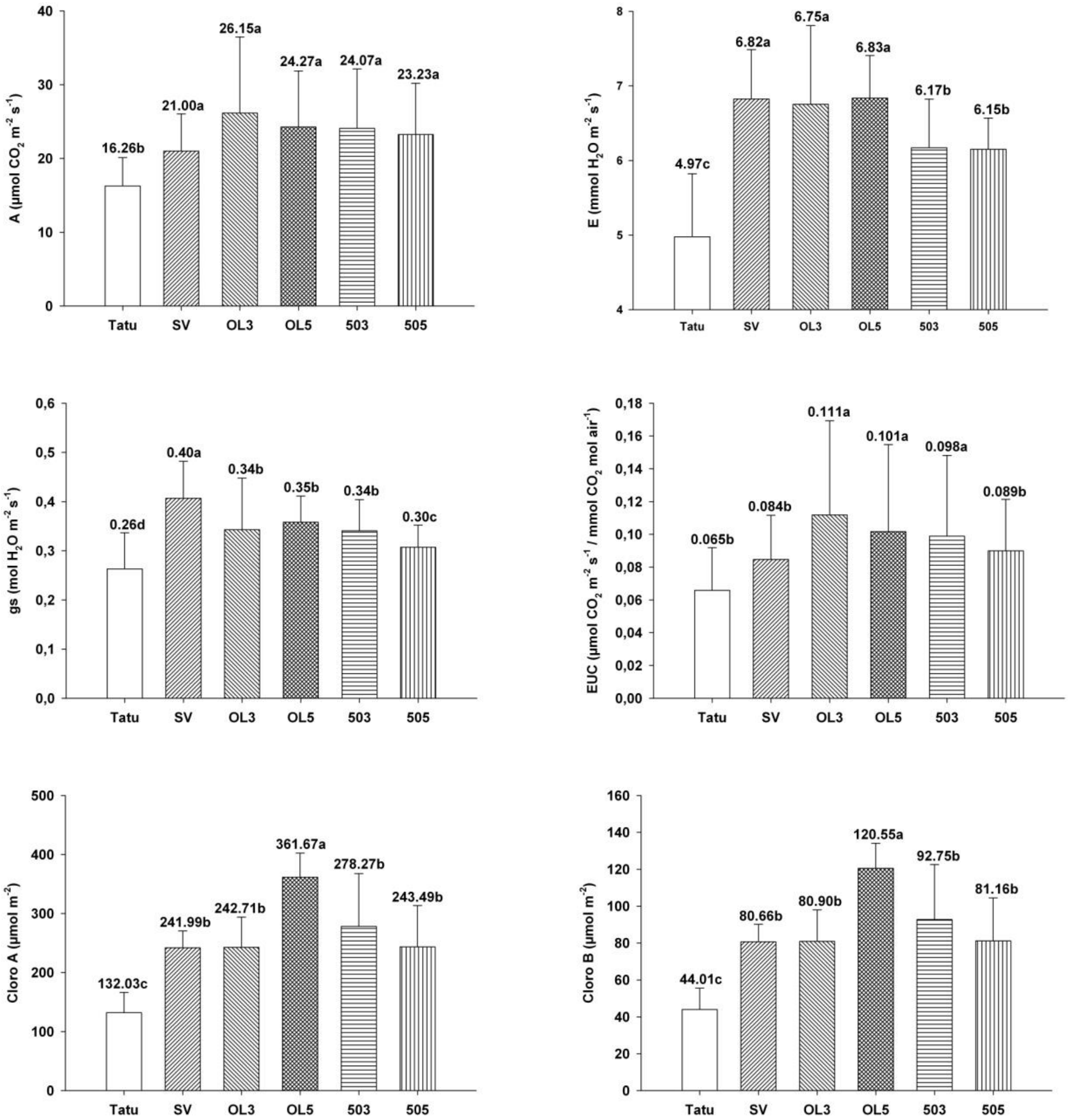

Figure 1 - Mean values of physiological parameters of peanut cultivars. The Scott Knott test was applied at the 5% probability level.

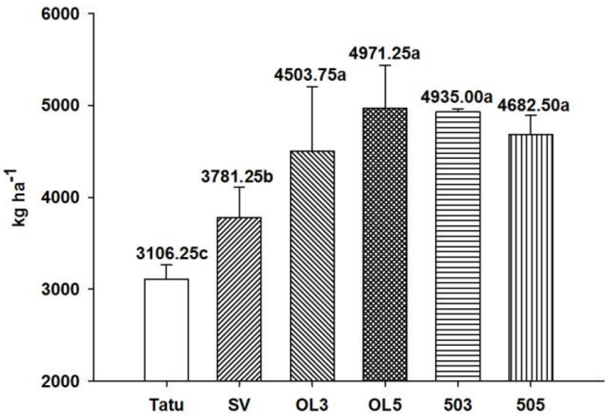

Figure 2 - Average values of productivity of peanut cultivars. The Scott Knott test was applied at the 5% probability level.

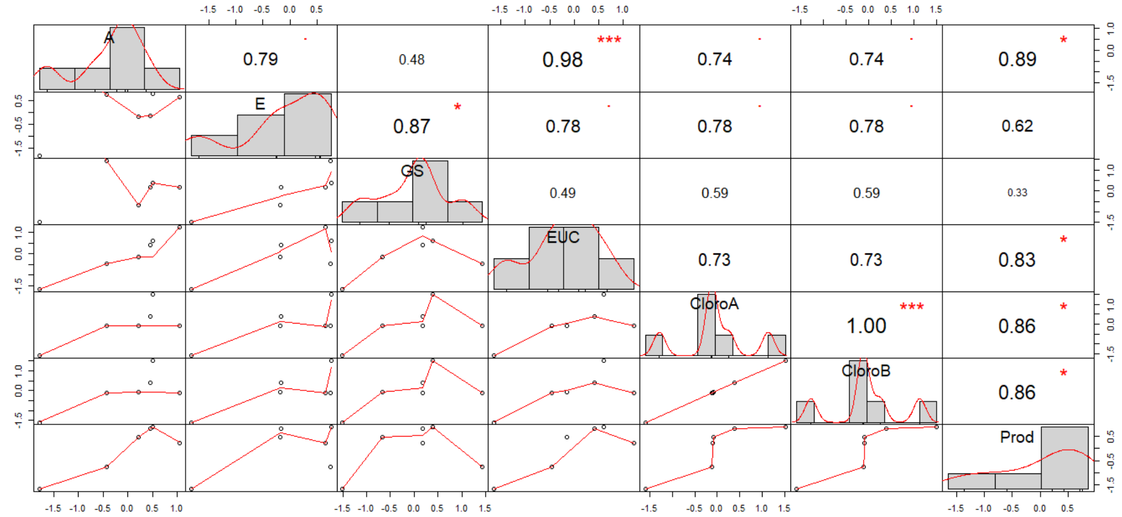

Figure 3 - Correlation and matrix of the dispersion graph of the morphological characteristics and productivity of peanut cultivars. *** p=0, *p<0,05. CO_2 assimilation rate, transpiration (E – mmol H_2O m^{-2} s^{-1}), stomatal conductance (gs – mol H_2O m^{-2} s^{-1}), internal CO_2 concentration in the substomatal chamber (Ci – µmol mol^{-1}), efficient water use (EUW), efficient use of carbon (EUC - µmol CO_2 m^{-2} s^{-1} / mmol CO_2 mol air^{-1}), Chlorophyll A and B (Cloro A and B - µmol m^{-2}).

DISCUSSION

The low results presented by the cultivar Tatu is due to the fact that this cultivar is old and with low technological levels compared to the other cultivars used in this research which were recently developed with a higher level of technology, using genotypes with better agronomic characteristics during the stages of the genetical enhancement. According to Martins (2006), the cultivar Tatu was officially launched in 2000, however Zanotto (1993), Gabriel (1996) and Lopes (1976) already carried out research on this cultivar, which means that it had been in existence for a long time before its official launch. In the specifications of the cultivars by IAC, it was observed that cultivars 503 and 505 have a productive potential of 6.500 kg ha^{-1} and OL3 7.000 kg ha^{-1}, therefore these cultivars must have better morphophysiological characteristics that provide them with higher indices of their characteristics. agronomic, since it was observed in this work the linear relationship between productivity with levels of chlorophyll A and B, water use efficiency and CO_2 assimilation rate.

Another factor that may have contributed to the higher results of low-growing cultivars (SV, 503, 505, OL3, and OL5) compared to the upright cultivar (Tatu) is due to the fact that according to Fisher and Cruz (1994) peanuts can reach IAF above three, before two weeks of growth. Gobbi et al (2009) found that forage peanut IAF at the time the canopy intercepted 95% at shading levels 0, observing mean IAF values of 2.7. The efficiency in the interception of photosynthetic radiation is related to the plant's IAF, where the increase in IAF will increase the interception of radiation (SANQUETTA et al., 2014), so there will be greater assimilation of CO_2, transpiration and chlorophyll. In this research it was observed during the evaluations that the cultivar Tatu had lower IAF, consequently its interception of photosynthetic radiation was affected which caused low values of the morphological characteristics analyzed.

The efficiency of water use is the amount of carbon fixed during photosynthesis for each water molecule lost during this process, this explains the linear relationship between CO_2 fixation with this variable. In C3 plants, such as peanuts, stomatal resistance causes a decrease in photosynthetic rate due to the high CO2 compensation point for this group of plants (TAIZ *et al.*, 2017).

Low stomatal conductance results in a lower influx of CO_2 into the chloroplasts causing reductions in photosynthetic rates (TATAGIBA *et al.*, 2015). The positive relationship between stomatal conductance and perspiration is explained by the fact that increased sweating is associated with stoma opening, where it is directly related to stomatal conductance and CO_2 level (GALON *et al*, 2010), so the greater the stomatal conductance, the greater the number of open stomata and, consequently, there will be a greater assimilation of CO_2 causing an increase in the rate of transpiration.

The low productivity of the Tatu cultivar, in addition to its low morphological characteristics, can be explained by this cultivar showing erect growth. Due to their physiological characteristics, upright cultivars have lower productivity than low-lying cultivars.

The distance that the gynophore has to travel to penetrate the soil is greater in upright cultivars, so there will be more energy expenditure to perform this function, which will result in lower yields. On the other hand, the reproductive structures of the undergrowth cultivars are closer to the soil, consequently the distance traveled by the gynophore to enter the soil is shorter, causing less energy expenditure and greater productivity. Regarding the lower average yield value of cultivar SV compared to other cultivars, except Tatu, it is due to the fact that the main characteristic of this cultivar, according to its specifications presented by IAC, is resistance to fungal diseases. According to the IAC, this cultivar can be grown without fungicide applications and its use is recommended for organic cultivation.

CONCLUSION

The cultivar Tatu showed low values of morphological characteristics and productivity compared to other cultivars.

The cultivars OL3, OL5, 503 and 505 showed higher average yields.

Great genetic variability was observed among the cultivars evaluated in this research due to the results obtained in the morphological and yield variables.

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