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PEANUT CULTIVARS SUBMITTED TO IRRIGATION LEVELS AND NITROGEN ADUBATION IN TROPICAL CLIMATE

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JOÃO D. BARBIERI[1*], RIVANILDO DALLACORT[2], CLEONIR A. FARIA JUNIOR[3], PAULO S. L. DE FREITAS[3], MARCO A. C. DE CARVALHO[4]

[1*]Corresponding author. University of the State of Mato Grosso/ Tangará da Serra - MT, Brasil.
E-mail: jd.barbieri@hotmail.com

ABSTRACT: The objective of this study was to define the best irrigation level in a sprinkler system, submitted to nitrogen doses in covering in the municipality of Tangará da Serra - MT, for two cultivars of peanut (*Arachis hypogaea* L.). The experiment was carried out in the experimental field of the State University of Mato Grosso (UNEMAT), located geographically in latitude 14º39'S; Longitude 57º25'W, at 440 meters of altitude. The climate is classified as tropical humid megathermal (Aw), with annual average rainfall of 1,830 mm and average temperature of the air 24.4ºC. The soil is classified as Dystroferric Red Latosol. The experimental design was in randomized blocks where 4 levels (30, 70, 110 and 150% of the reference evapotranspiration, ET_0) were determined. In each level, 0, 30, 60, 90 and 120 Kg ha^{-1} of nitrogen were applied in two peanut cultivars IAC Tatu ST and IAC Runner 886. Each plot had 24 lines per 12 m length, 4 lines for each dose of N in each level and cultivar with 0.45 m spacing between lines. The irrigation level that provided the highest productivity in the development cycle for both peanut cultivars was 110% of ET_0. While the levels of 30 and 70% of the ET_0 allowed greater growth in height, but smaller productivities, the 150% ET_0 level showed higher yields in the husk, and lower grain yield due to the high germination rate of the grain yet in the plant. For Tatu cultivar, doses of 60 to 90 kg ha^{-1} of N increase productivity, whereas for Runner cultivar nitrogen fertilization did not affect productivity.

KEYWORDS: evapotranspiration, correlation, productivity.

INTRODUCTION

The Peanut culture (*Arachis hypogaea* L.) is an important option for the Cerrado of Mato Grosso because it presents a satisfactory profitability, because it is a crop adapted to the edaphoclimatic conditions of the region and because it develops well under conditions of second harvest in the State. According to information from the IBGE (2015), the State of Mato Grosso produces an average of 310 tons annually of 2,500 kg ha^{-1} of peanuts annually and this production is increasing with each harvest.

In the case of soybeans, the production of biodiesel has a high potential for oil production per hectare, presenting 40% of oil content in comparison to soybeans, which reaches 25% (Silveira et al., 2011). Graef (2012) affirm that the culture has great participation in family agriculture and moves several productive sectors as the production of food for human and animal consumption.

The culture presents a more efficient stomatal closure mechanism, reducing respiration before the photosynthetic activity is irreversibly damaged, this is a characteristic of resistance to climatic elements, like water availability (Anjum et al., 2011). However, the level of damage caused to the peanut crop by water deficiency is determined by the intensity, duration of stress and phenological stage in which the crop is found (Duarte et al., 2013).

According to Azevedo et al. (2014) in irrigated agriculture it is necessary to know the determining factors in the irrigation management that directly interfere in the greater or lesser water

[2] University of the State of Mato Grosso/ Tangará da Serra - MT, Brasil.
[3] State University of Maringá/ Maringá - PR, Brasil.
[4] University of the State of Mato Grosso/ Alta Floresta - MT, Brasil.

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consumption, and to determine the water needs of the crops according to the different phenological stages.

The peanut development cycle varies from 90 to 115 days for early varieties and from 120 to 140 days for late varieties, and depending on the climate their water requirements range from 500 to 700 mm.

The plant is not sensitive to photoperiod and develops well in environments with average daily temperatures between 22 °C and 28 °C, but if during the growing phase the average prevailing temperature is below 18°C or above 33° C, production may be significantly affected (Assunção & Escobedo, 2009).

According to Neto et al. (2012), nitrogen is the element most absorbed by plants, because, besides being fundamental in the photosynthetic process, it is present in the amino acids that act in the synthesis of structural and functional proteins. There are several studies evidencing the need for nitrogen application in the peanut crop (Crusciol & Soratto, 2007; Mantovani et al., 2012; Rowland et al., 2012).

Correlating the need of nitrogen for the greater photosynthesis efficiency, in terms of water availability, this study aims to identify if nitrogen fertilization influences the crop water requirement. In addition, evaluate grain yield, production components and growth of two peanut cultivars; one of early cycle and one of late cycle, under field conditions, for the municipality of Tangará da Serra - MT.

MATERIAL AND METHODS

The experiment was carried out in the experimental field of the State University of Mato Grosso (UNEMAT), in Tangará da Serra, located geographically at latitude 14º39'S; longitude 57º25'W, at 440 meters of altitude. According to Köppen, the climate of the region is classified as wet tropical metameric (Aw), where they are elevated temperatures, rainy summer and dry winter, with annual average rainfall of 1,830 mm and average temperature of the air 24.4 ºC. The soil is classified as Red Dystroferric Latosol, with 689g of clay per kg of soil (Dallacort et al., 2011).

The cultivars used for this experiment were IAC Tatu ST and IAC Runner 886 of early and late cycle, respectively, being the most cultivated in the region. Mechanical sowing was performed on July 14th, 2014, with a density of 10 plants per m^{-1}, and 0.45m spacing between lines as recommended by Barbieri et al. (2016). The N-P-K formulation (5-30-15) was used in a dosage of 400 kg ha^{-1} and liming with 2,000 kg ha^{-1} of dolomitic limestone, following the recommendations of the crop and soil analysis.

The experimental design was a randomized block design in a 4x5x2 factorial scheme and four replications, with four irrigation levels (30, 70, 110, 150%) of reference evapotranspiration (ET_0), five nitrogen doses (0, 30, 60, 90 and 120 kg ha^{-1}), and two cultivars (IAC Tatu ST and IAC Runner 886).

Each treatment of irrigation level had 24 rows by 12 m of length for each cultivar. The nitrogen doses were applied in 4 rows and the evaluations were done in the two central rows, so the experimental area for each level with the five nitrogen doses and two cultivars was 259.2 m^2. Each irrigation treatment was analyzed by the distance of the sprinkler radius (12 m). In this area, the crop was also used as a border between the levels. The total area used for the experiment was 1814.4 m^2.

After the sowing, the fixed conventional sprinkler irrigation system was installed, using 16 Fabrimar® sprinklers, model A232 ECO with nozzle 4.8 x 3.2 mm, arranged with spacing of 12 by 18 meters, covering the entire area, with the Christiansen coefficient of uniformity of 82% and average level of 10.2 mm h^{-1} under pressure of 294 kPa.

The initial irrigation was the same for all treatments until the homogeneous establishment of the crop in the field, applying 100% ET_0 level (120 mm). After 20 DAS, the treatments started with the different irrigation levels according to the percentage of ET_0 (30, 70, 110 and 150%), where this was calculated daily before irrigation.

For the determination of the required real irrigation (RRI), the total water availability in the soil (TWA = 1.3 mm cm^{-1}) was calculated, from the known values for the permanent wilting point and field capacity, in the retention curve of the experimental area. Thus the total water capacity available for the plants was (TWC = 52 mm) and the actual water capacity (AWC = 26 mm), considering root system depth (Z = 0.4 m) and availability factor (p = 50%). Thus, to define the irrigation shift, were considered the water replacement levels defined as treatments, corresponding to the percentages of the ET_0 values, which were determined daily.

For the calculation of ET_0 and the irrigation need, data were collected from a Campbell Scientific® automatic station, available by the Center of Technologies and Geostatistics (CETEGEO) located in the agrometeorology laboratory of the State University of Mato Grosso. These are data on temperature, precipitation, solar radiation, wind speed, relative air humidity and atmospheric pressure, which are then used to estimate the reference potential evapotranspiration (ET_0), Penman-Monteith-FAO method (Allen et al., 1998).

For the ET_0 calculation, [eq. (1)] was used, proposed by Allen et al. (1998):

$$ETo = \frac{0.408\Delta\,(Rn - G) + \gamma \dfrac{900}{T + 273} U_2 (e_s - e_a)}{\Delta + \gamma\,(1 + 0.34 U_2)} \tag{1}$$

where,

ET_0= reference evapotranspiration (mm d^{-1});

Rn = net solar radiation on the crop (MJ $m^{-2}d^{-1}$);

G = density of soil heat flux (MJ $m^{-2}d^{-1}$);

T = air temperature at two meters high (ºC);

U_2= wind speed of two meters high (m s^{-1});

e_s= steam saturation pressure (kPa), which is estimated by the mean of es (T. max) and es (T. min);

e_a= current steam pressure (kPa);

$e_s - e_a$= pressure deficit and vapor saturation (kPa $ºC^{-1}$);

Δ= steam pressure curve (kPa $ºC^{-1}$) and,

γ= psychometric constant (kPa $ºC^{-1}$).

Coverage fertilization with different doses of nitrogen was performed 40 days after emergence, using as source urea - $CO(NH_2)_2$ that present 45% of nitrogen. The applied doses were 0; 66.66; 133.33; 200 and 266.66 kg ha^{-1} of urea.

Harvest was carried out at 95 DAS (10/17/2014) for the cultivar IAC Tatu ST and at 125 DAS (11/17/2014) for the cultivar IAC Runner 886, with 4 replications of 10 plants from the two central rows of each treatment, in each block. The plants were harvested separately and stored for three days in a shed, with the purpose of natural reduction and homogenization of the moisture of the pods. The variables analyzed in this study were: plant height, number of pod per plant, weight of 1000 grains, pod productivity, grain yield and yield.

Data were submitted to analysis of variance and multiple linear regression, using the software SISVAR 5.3 (Ferreira, 2011). In the regression analysis, the equations that best fit the data were chosen based on the significance of the regression coefficients at the level of 1 % (**) and 5% (*) by the selection process of Backward, and in the highest coefficient of determination (R^2).

For the generation of the graphs, the STATISTICA 10.0® program was used where the numerical coefficients of the models generated by SISVAR were inserted for each variable.

RESULTS AND DISCUSSION

In the period of the experiment, in this region rainfall is scarce and sporadic occurring concomitantly falls in temperature and significant increase in the relative humidity of the air, and consequently reducing evapotranspiration. In addition, it reduces the physiological development of the crop and diminishes its productive potential. A fact also observed by Duarte et al. (2013) analyzing plant height and number of pods per plant, where the crop, when submitted to water deficit, presented significantly lower values.

Regarding climatic aspects during the experimental period (Figure 01), the average reference evapotranspiration in the period was 3.5 mm d^{-1}, calculated by the Penman-Monteith-FAO 56 method (Allen et al., 1998), and the sum of precipitation was 261.3 mm, obtained by the meteorological station.

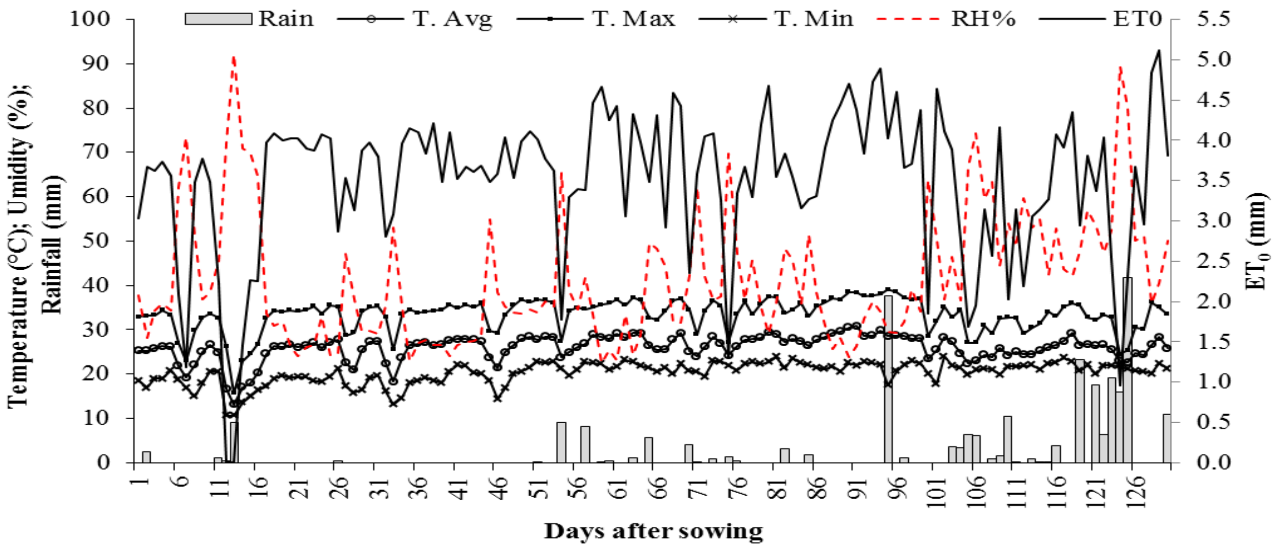

FIGURE 1. Minimum, average and maximum temperature, relative humidity, precipitation and reference evapotranspiration for the period of the experiment conducted in Tangará da Serra.

The reference evapotranspiration is directly related to the relative humidity and it can be observed that the higher the humidity the lower the ET_0, this fact is related to the potential of water in the soil, where low relative humidity of the air increases the potential difference between one soil maintained in field capacity, and at atmosphere.

In Table 02 are the data of the water levels applied through irrigation, throughout the cycle of the cultivars, and adding to each level, the total precipitate of 261.3 mm, resulting in the total level of water available to the plant. The variations between the applied water levels were around 200 mm.

TABLE 2. Total level applied and precipitated (mm) throughout the cycle of each cultivar.

Class	Irrigation and Rainfall (mm)	
	IAC Tatu ST	**IAC Runner 886**
30 % Et_0	218	263
70 % Et_0	410	462
110 % Et_0	601	662
150 % Et_0	793	862

The summary of the analysis of variance for the different levels, doses and cultivars showed significant effects (Table 3), at a significance level of 1% and 5% for the F Test, for all variables. Proving that the amount of water available to the plant and nitrogen fertilization influenced all the variables evaluated. Arruda et al. (2015), evaluating peanut cultivars under water stress observed that plant height and number of pods are highly responsive to water supply.

TABLE 3. Summary of the analysis of variance for plant height (PH), number of pod per plant (NPP), weight of 1000 grains (W1000) and husk productivity (HPROD), grain yield (GY) and yield (YIELD) for Peanut cultivars according to the applied irrigation levels (Levels) and nitrogen dose (Dose).

IAC Tatu ST							
F.V.	L.D.	Medium Square					
		PH	NPP	W1000	HPROD	GY	YIELD
Level	3	0.203**	552.259**	162972.620**	257523189.317**	179499167.410**	743.828**
Dose	4	0.009**	429.414**	2976.256*	29085757.773**	20393184.812**	102.246**
Interaction	12	0.010**	265.494**	4611.881**	16328688.346**	7152942.089**	34.978*
Block	3	0.001	56.146	15926.420	65718.260	316901.329	23.627
Error	57	0.001	32.288	969.756	3042795.99	1596206.130	15.325
C.V.(%)		5.01	11.74	4.50	13.50	14.61	5.96

IAC Runner 886							
F.V.	L.D.	Medium Square					
		PH	NPP	W1000	HPROD	GY	YIELD
Level	3	0.570**	433.070**	35165.136**	18331197.999**	7851225.419**	400.349**
Dose	4	0.289**	161.588**	3037.978**	9976776.152**	3420545.276**	141.940**
Interaction	12	0.053**	155.170**	3772.505**	2820356.182**	1586227.454**	188.079**
Block	3	0.002	3.153	496.744	108385.495	57160.506	82.510
Error	57	0.002	11.153	556.740	437844.660	171130.305	31.329
C.V. (%)		6.10	22.38	6.41	20.92	22.89	10.06

*Significant at 5% probability, **Significant at 1% probability of error.

The coefficients of variation varied from moderate to low for the cultivar IAC Tatu ST, generally indicating high experimental precision. Meanwhile, the cultivar IAC Runner 886 presented higher values of C.V. % for, number of pods per plant and yield in the husk and grains. High values were also observed by Azevedo et al. (2014), for cultivars of late cycle and prostrate sized, which in clayey soils show large reductions in productivity due to crop losses.

For the variable plant height, low doses of nitrogen are less influenced by irrigation. At doses higher than 60 kg ha^{-1} plant height responds positively to the 110% level of ET_0, higher than that, plant height decreases. Similar results were found by Sousa et al. (2014) who also evaluated irrigation levels following the Penman-Monteith method proposed by FAO 56 (Allen et al., 1998), but in a drip system.

According to Duarte et al., (2013) cultivars of erect habit (IAC Tatu ST) are more susceptible to increased nitrogen doses and have a greater ability to adjust to water scarcity; this allows the cultivar to present significant responses to dose increase and irrigation level when dealing to plant height.

Arruda et al. (2015) studying the cultivar IAC Tatu, under conditions of water deficit, observed little tolerance to drought and high productive potential, besides verifying that plant height is a variable highly influenced by water deficit (Figure 02).

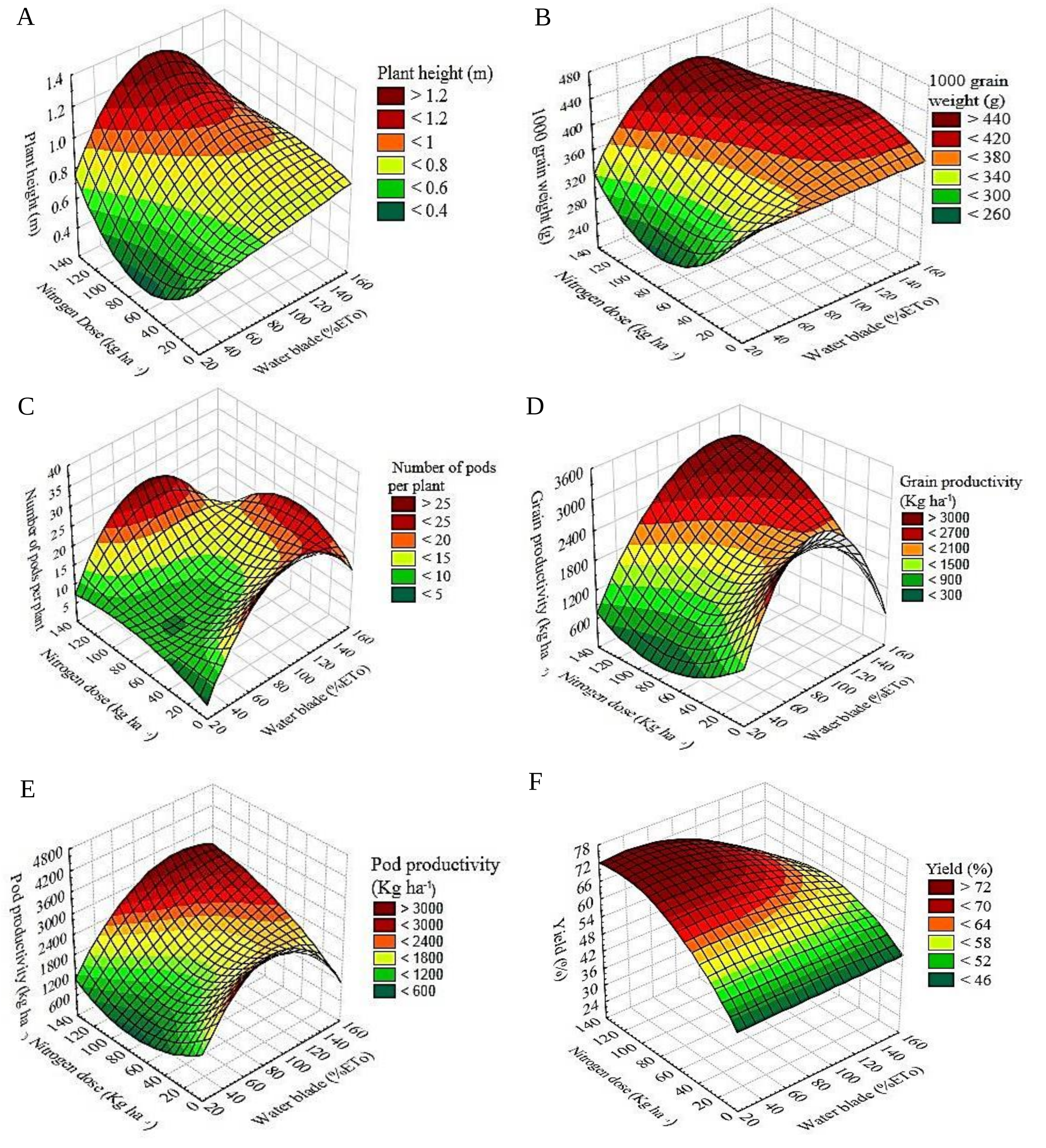

FIGURE 2. **(A, B, C, D, E and F)** – Level and dose interaction for the variables, A - plant height (m), B - 1000 grain weight (g), C - number of pods per plant, D - grain productivity (kg ha^{-1}) E - pod productivity (kg ha^{-1}) and F - Yield (%), respectively for the IAC Tatu ST.

For the 1000 grains weight, the increase of the nitrogen dose does not present great variations, but when submitted to irrigation levels above 110% of ET_0, the dose of 120 kg ha^{-1} of N increases by 40 grams the total weight of 1000 grains. According to Bastos et al. (2012), the grain weight is influenced by water deficiency in the grain filling stage, and when the water requirement is reached, the N rates become efficient for grain filling.

The number of pods per plant presents variation with the interaction between slides and N doses, in irrigations above 70% of ET_0, the application of N must be greater than 90 kg ha^{-1}, so that the plants produce more than 25 pods per plant.

In irrigations above 110%, doses of 30 to 90 kg ha^{-1} of N present 25 pods per plant. However, without the application of N, the number of pods per plant can reach 25 only with the use of irrigation at the level of 70 to 110% of ET_0. We can then state that fertilization is not feasible under conditions of water stress.

It was observed in several studies (Duarte et al., 2013, Sousa et al., 2014, Arruda et al., 2015) where the irrigation was the main factor that interfered in the reproductive phase of the crop, reducing the number of pods per plant, interfering in the formation of pods, elongation and penetration of the gynophore in the soil.

Grain productivity had a similar variation to pod productivity, presenting higher values on levels of 110 to 150% of ET_0 and with 120 kg ha $^{-1}$ of N. However, the treatments with 0 and 30 kg ha^{-1} of N also presented yields close to 1,700 kg ha^{-1} for grains and 3,500 kg ha^{-1} with pod.

Studies evaluating nitrogen doses in the peanut crop state that high doses of N increase plant susceptibility to pest attack, which may be a limiting factor for production (Lourenção et al., 2007).

Lima (2011), also studying the peanut crop, observed that nitrogen is the nutrient most extracted by the plant and that its deficiency causes reduction in the absorption of phosphorus.

The maximum productivity obtained was in treatments with irrigation of 110% of ET_0 and application of 120 kg ha^{-1} of N, however, levels between 70 and 110% of ET_0 followed by 0 and 30 kg ha^{-1} of N showed significantly equal productivity, then calculations are required to determine the cost-effectiveness in the decision-making.

The productivity ranged from 650 to 3,500 kg ha^{-1}, and values close to higher productivity were found for this cultivar in the region of São Paulo (4,200 kg ha^{-1}) by Assunção & Escobedo, (2009), and the lowest one were found by Azevedo et al. (2014), studying water suppression, the minimum productivity reached 325.12 kg ha^{-1}, where the crop received 119.38 mm of water throughout the cycle.

Yield increases as higher nitrogen doses are applied, however for levels above 110% of ET_0 the yield decreased. This fact occurred in studies in which the increase of the irrigation level in the peanut crop increased the index of losses due to the humidity excess, occurring the germination of the seed yet in the plant (Assunção & Escobedo, 2009).

The cultivar IAC Runner 886 has different morphological characteristics of the cultivar IAC Tatu ST. This is a prostrate growth habit, presenting lower plant height, large beige-colored grains, large pods and in greater number per plant, these characteristics allow the cultivar to present higher productive potential (Rowland et al., 2012).

The cultivar IAC Runner 886 showed higher growth in the irrigation treatment of 110% of the ET_0 and nitrogen fertilization in coverage of 60 to 90 kg ha^{-1} (Figure 03).

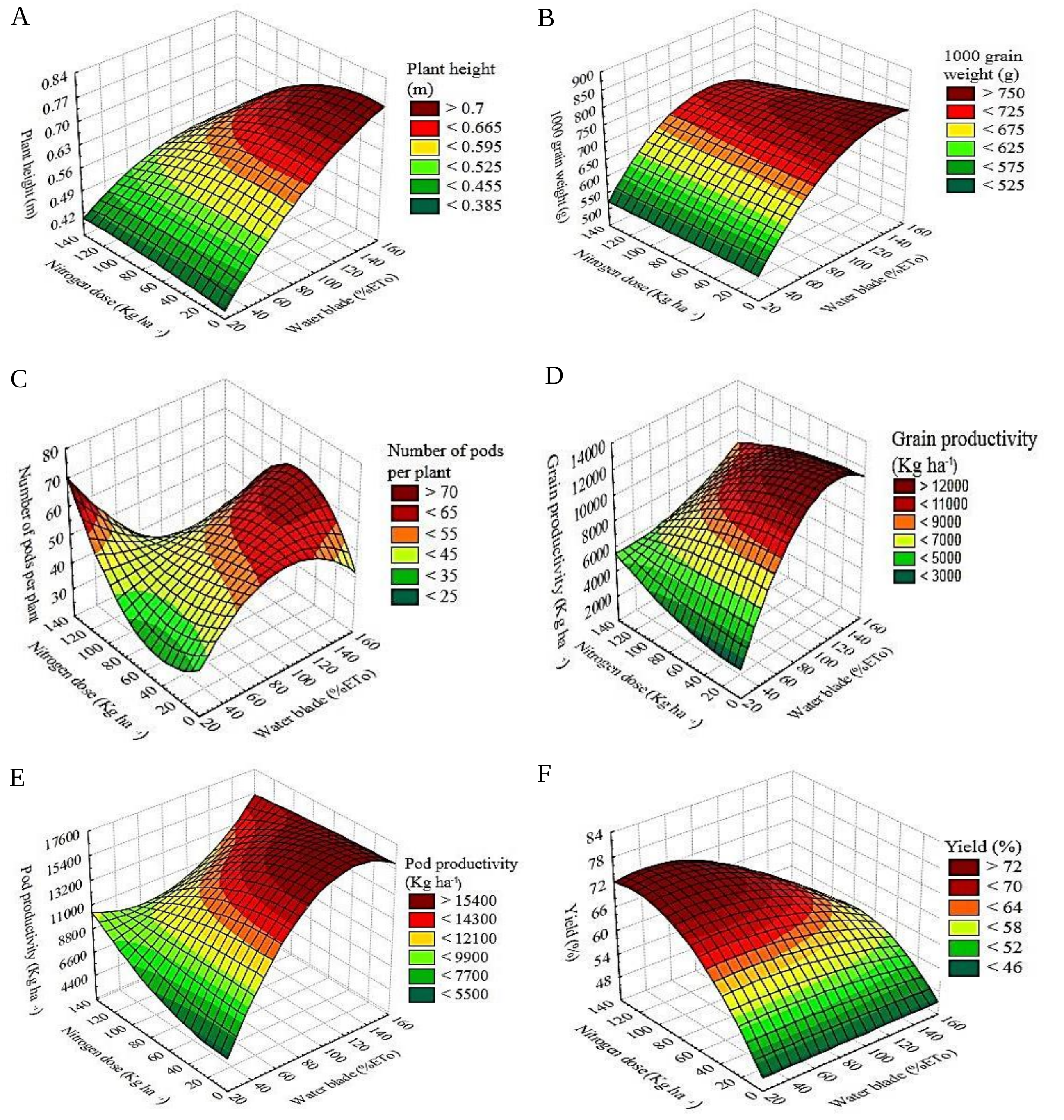

FIGURE 3. **(A, B, C, D, E and F)** – Level and dose interaction for the variables, A - plant height (m), B - 1000 grain weight (g), C - number of pods per plant, D - grain productivity (kg ha^{-1}) E - pod productivity (kg ha^{-1}) and F - Yield (%), respectively for the IAC Runner 886.

Plant height was higher for the highest levels and low nitrogen doses, reaching 0.8 m in the level of 150% of ET_0 with 0 and 30 kg ha^{-1} of N. In higher N rates (90 and 120 kg ha^{-1}) the plant height is reduced to 0.45 m. Similar results for plant height in different irrigation levels were found by Sousa et al. (2014) with variation in height from 0.30 to 0.50 m.

The weight of 1000 grains was of 0.750 kg in a level of 150% of ET_0 without application of nitrogen, that is, the application of nitrogen does not increase the weight of 1000 grains. These results corroborate with studies by Pereira et al. (2012), where they affirm that nitrogen absorbed by roots and gynophores are translocated to the leaves and stems increasing vegetative growth.

The treatments of 30 to 60 kg ha^{-1} of N in the level of 110 to 150% of ET_0 provided on average 65 pods per plant. According to Rowland et al. (2012), irrigation promotes the penetration of the gynophores in soil due to the highest soil moisture, and for Almeida et al. (2000), the nitrogen availability favors the absorption of phosphorus, an important nutrient in fruit formation.

Grain productivity was similar to grain yield, with values close to 6,000 kg ha^{-1} of grain and 9,000 kg ha^{-1} in pod, in the treatments with levels of 110 to 150% of ET_0, but with low doses of N, 0 and 30 kg ha^{-1}. Doses of N superior to 30 kg ha^{-1} did not result in higher yields of grains.

The cultivar IAC Runner 886 showed no increase in yield when applied nitrogen doses in covering. These results corroborate with those of Lanier et al. (2005) and Raes et al. (2009), which evaluated peanut’s response in nitrogen doses and inoculation of nitrifying bacteria, observed that in soils not cultivated with legumes inoculation provides higher yields, but when applied nitrogen doses in covering can inhibit the nodulation.

The yield of grains was 70% greater in doses of 90 to 120 kg ha^{-1} of N, in relation to the doses of 0, 30 and 60 kg ha^{-1}. According to Junjittakarn et al. (2014) the peanut crop extracts 75% of the total N in the fruits while the other 25% is distributed between the leaves and branches. Also according to these authors, the high N extraction for the fruits and the availability of this nutrient favors the yield between the pod and the grains.

However, the yield does not mean higher yields because it is observed that the treatments that obtained higher productivity presented lower yields, this is because the yield is related only with weight of the pods in relation to the grains.

The yield of the two peanut cultivars was not influenced by irrigation, since the yield may be high in low productivities, in which, low pod / grain difference, high yield; high difference between pod / grain, low yield.

The cultivar IAC Runner 886 presented higher productivities in treatments where the applied irrigation level was greater than 100% of the ET_0 and the nitrogen dose below 60 kg ha^{-1}. These results are similar to that of several authors, who studied water levels and Nitrogen doses indicate that the suppression of irrigation at any time during the peanut cycle inhibits all components of crop production, while the nitrogen presents a significant response in treatments where irrigation or soil moisture is in adequate conditions for the development of the culture (Assunção & Escobedo, 2009; Duarte et al., 2013).

For the scientific community, this study contributes to determine the best water level and N dose for the peanut crop, as well as to offer the producers a new culture option for the state of Mato Grosso, aiming at the rotation of cultures and their cultivation in irrigated areas.

CONCLUSIONS

The irrigation level of 110% of ET_0 (601 mm) for the early cultivar IAC Tatu showed higher productivity in the application of 120 kg ha^{-1} of N. Late cultivar IAC Runner 886 presented higher productivity in treatments with 110% of ET_0 with application of 662 mm of water throughout its cycle and with doses of 30 kg ha^{-1} of nitrogen in covering.

For both cultivars the application of nitrogen in covering provides greater development and productivity of the plants, when the water requirement is reached.

The yield of the two peanut cultivars (IAC Tatu and IAC Runner) was not influenced by irrigation, but the nitrogen doses of 90 to 120 kg ha^{-1} presented higher percentages (74%) of grains in relation to the total weight.

The cultivar IAC Runner, due to the habit of prostrate growth, rooting in the stem in contact with the soil and late cycle, absorb the nutrients with greater efficiency, thus they do not respond in high productivities with nitrogen fertilization.

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