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RESPONSE OF VEGETATIVE PERFORMANCE IN SOYBEAN CULTIVARS SUBMITTED TO DEFICIT IRRIGATION

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ABSTRACT

Agricultural crops present phenological stages of less susceptibility to soil water deficit, in which the deficit irrigation management strategy can be used. In this context, the objective was to evaluate the influence of deficit irrigation management during different stages of development in three soybean cultivars in the edaphoclimatic conditions of the southern cerrado of Piauí. The research was conducted from September 2020 to January 2021, in the municipality of Uruçuí-PI (with geographic coordinates of 07º 13’ 46” S, 44º 33’ 22” W), under an experimental design of randomized blocks, in a split-plot scheme, where the treatments, composed in the plots, were defined according to the time of induction of the water deficit of 50% of the crop’s potential evapotranspiration - ETpc, via climate, in three soybean phenological stages (vegetative, flowering and production formation), and the subplots, were composed of three cultivars (FT 4191; FT 3181 and BG 478 IPRO), with three replications. In order to verify the effects of the imposed treatments, the following variables were evaluated: plant height, number of leaves and total dry mass of the aerial part. Variables were maintained for statistical analysis by Tukey’s test (cultivars) and Scott-Knott’s test (deficient irrigation treatments). The vegetative characteristics of the investigated soybean cultivars (plant height, number of leaves and shoot dry mass production) are drastically affected when the imposition of water deficit (50% of ETpc) is induced throughout the production cycle. Under such water conditions, the FT 4181 and 3191 IPRO cultivars stood out among the investigated cultivars, thus being identified as the most tolerant to reduced water availability in their different phenological stages.

Palavras-Chave:
Glycine max (L.) Merrill
Déficit regulado
Evapotranspiração

RESPOSTA DO DESEMPENHO VEGETATIVO EM CULTIVARES DE SOJA SUBMETIDAS A IRRIGAÇÃO DÉFICITÁRIA

RESUMO

As culturas agrícolas apresentam estádios fenológicos de menor suscetibilidade ao déficit hídrico do solo, nos quais a estratégia de manejo da irrigação deficitária pode ser empregada. Neste contexto, objetivou-se avaliar a influência do manejo da irrigação deficitária ao longo de diferentes estádios de desenvolvimento em três cultivares de soja nas condições edafoclimáticas do cerrado sul piauiense. A pesquisa foi conduzida durante os meses de setembro de 2020 a janeiro de 2021, no município de Uruçuí-PI (com coordenadas geográficas de 07º 13’ 46” S, 44º 33’ 22” W), sob delineamento experimental de blocos ao acaso, em esquema de parcelas subdivididas, onde os tratamentos, compostos nas parcelas, foram definidos em função da época de indução do déficit hídrico de 50% da evapotranspiração potencial da cultura - ETpc, via clima, através da combinação em diferentes estádios fenológicos da soja (vegetativo, floração e formação da produção), e as subparcelas, foram compostas por três cultivares (FT 4191; FT 3181 e BG 478 IPRO), com três repetições. Para averiguar os efeitos dos tratamentos impostos, avaliou-se às seguintes variáveis: altura das plantas, número de folhas e a fitomassa seca total da parte aérea. As variáveis foram submetidas à análise estatística pelo teste de Tukey (cultivares) e teste de Scott-Knott (tratamentos de irrigação deficitária). As características vegetativas das cultivares de soja investigadas (altura de plantas, número de folhas e produção de fitomassa seca da parte aérea) são afetadas drasticamente quando a imposição do déficit hídrico (50% da ETpc) é induzida ao longo de todo o ciclo produtivo. Sob tal condição hídrica, as cultivares FT 4181 e 3191 IPRO se destacaram entre as cultivares investigadas, sendo assim apontadas como as mais tolerantes a reduzida disponibilidade hídrica em suas diferentes fases fenológicas.

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INTRODUCTION

The soybean crop (*Glycine max* L.) has been consolidating more and more as the primary grain produced in Brazil, in the MATOPIBA region, made up by the states of Maranhão, Tocantins, Piauí and Bahia, and is currently known as the new agricultural frontier of the country. In Piauí, mainly in the southern region of the state, the production has been growing continuously due to the opening of new areas for grain production and also because of the genetic improvement so that the crop can express its high productivity value under the edaphoclimatic conditions in the region (PEREIRA *et al*., 2018).

The soybean crop is the major agriculture product in the state of Piauí, with about 52% of production, followed by corn with about 42%. The total grain production expected for Piauí, in the first prediction for 2020, with data released by the Technical Office for Economic Studies of the Northeast (ETENE), is a record in the historical series, with values of around 4.89 million tons. This represents an increase of 10.84% compared to the harvest obtained in 2019, which was 4.42 million tons (BANCO DO NORDESTE, 2020).

According to Lima (2016), the geographic space of Piauí is highly conducive for the development of agribusiness. Its tropical Weather combined with the terrain combined with technological innovations are the factors that boosted this sector of the economy even in times of economic recession. The southeastern mesoregion of Piauí includes the main oilseed producing municipalities, Uruçuí, Ribeiro Gonçalves and Baixa Grande do Ribeiro, among others located in the Cerrado biome. With a vast area still to be cultivated, Piauí shows a high growth potential, with expectations for the expansion of crops of commercial importance such as soybean.

The increasing International pressure on the rational use of water resources, irrigators are increasingly required to have more effective control over irrigation practices. Therefore, the use of management strategies that increase efficiency in water use, it is possible to maximize production and product quality per unit of water Applied in the crop (BERNARDO *et al*., 2019).

Therefore, knowledge of the performance of plant species in the application of regulated deficit irrigation management can be a great value when aiming at an increase in water productivity (FERNÁNDEZ *et al*., 2020) and can explain the tolerance capacity and/or or sensitivity to water deficit of crops when imposed throughout their different phenological stages (COELHO *et al*., 2020), considering that the effects of water deficits vary with the stages in which they manifest and whose responses may even indicate harmful effects of the deficit on development and production (COTRIM *et al*., 2017), although they may result in a functional balance between the water used and the productive potential achieved (CHAI *et al*., 2016).

As a result, the objective of this work was evaluate the influence of deficit irrigation management during different stages of development in three soybean cultivars in the edaphoclimatic conditions of the southern Cerrado of the state of Piauí.

MATERIAL AND METHODS

The experiment was conducted at the State University of Piauí (UESPI), in the municipality of Uruçuí, state of Piauí, within the geographic coordinates 07º13’ 46” S, 44º33’ 22” W and an average altitude of 167 m, in an area that includes the Cerrado biome.

The climate in the region, according to the Köppen classification, is Aw-type, tropical hot and humid, with a wet summer and dry winter, average annual temperature of 26.1ºC, annual average relative humidity of 64.2% and annual rainfall ranging from 800 and 1200 mm (MEDEIROS *et al*., 2013).

Table 1 shows the climate data (Average air temperature, Relative air humidity, Rainfall and Wind speed) collected during the experimental period. It was observed a significant volume of rainfall, which occurred mainly during the cultivation phases in which the soybean crop demands more water (flowering and formation and/or grain filling). As a result, there was a direct interference in the responses of plants to the imposition of treatments at times of induction of water deficit, thus hindering a more precise response on the effects of water deficiency that occurred during the different phases of cultivation, in the different assessed soybean cultivars.

The soybean cultivars chosen were the following: BG 478 IPRO; FT 4181 IPRO and FT 3191 IPRO, all used in the productive areas of the municipality of Uruçuí, where high-tech farms are located with vast areas of seed production, these being conventional cultivars, endowed with characteristics that meet current needs and increase productivity. Table 2 shows the configuration of the imposed treatments.

The soybean crop cycle was divided into three phenological stages (I, II and III), distributed as follows: phenological stage I, from emergence to 48 days after emergence (DAE) (VE to V6); phenological stage II, from 49 to 89 DAE (R1 to R6) and phenological stage III, from 90 to 120 DAE (R7 to R9).

The experiment followed a statistical design in randomized blocks, in a split-plot scheme, with three replications, where the treatments for the imposition of water deficits (50% of the crop potential evapotranspiration - ETpc) at different stages of development were allocated and the cultivars in the subplots.

The total useful area occupied by the soybean crop was 8.0 x 12.0 m = 96.0 m², where the treatments were allocated. The plots, individually, occupied a useful area of 12.0 m², and were made up of 40 plants, distributed in eight planting rows. The subplots occupied, separately, a useful area of 2.4 m², being composed of eight plants distributed in the planting line. Sowing fertilization was carried out through the application of 20 kg ha^{-1} of N (Urea); 50 kg ha^{-1} of P_2O_5 (simple superphosphate) and 50 kg ha^{-1} of K_2O (potassium chloride) in furrows, whose needs were based on soil analysis and the crop nutritional requirements (SFREDO, 2008).

Before setting up the experiment, soil samples were collected in the 0-0.20 m layer to determine the chemical and physical-hydric characteristics of the experimental area, covering the area in a zig-zag pattern and collecting subsamples with the aid of a Dutch type auger, in such a way that a representative composite sample was obtained for the sampled layer. The result of the chemical and granulometric analysis of the soil in the experimental area is shown in Table 3.

Table 1. Weather data obtained over the experiment

Month	Temperature (ºC)	Relative humidity (%)	Rainfall (mm)	Wind speed (m s^{-1})
September	30.7	45.6	0.0	4.0
October	33.1	52.6	95.0	3.5
November	32.3	66.1	215.5	3.3
December	30.3	76.7	813.0	3.0
January	29.7	79.0	167.7	2.9
Mean	31.2	64.0	---	3.3
Sum	---	---	1291.2	---

Source: Author, 2022

Table 2. Identification of treatments (plots) that will be used in the experiment

Identification	Description
T1	Full irrigation (control)
T2	Water deficit at the phenological stage III
T3	Water deficit at the phenological stage II
T4	Water deficit at the phenological stages II and III
T5	Water deficit at the phenological stage I
T6	Water deficit at the phenological stages I and III
T7	Water deficit at the phenological stages I and II
T8	With water deficit at the phenological stages I, II and III

Table 3. Result of the chemical and particle size analysis of the soil used in the experiment

pH $CaCl_2$	O. M g kg^{-1}	P mg dm^{-3}	Sorptive Complex						
			K	Ca	Mg	Al	H + Al	SB	CEC
			.... cmol dm^{-3}						
5.8	12.7	104.6	0.23	3.31	0.61	0.00	0.49	4.15	4.64
Sorptive Complex Saturation					Micronutrients				
V	m	Ca	Mg	K	S	Fe	Mn	Cu	Zn
.... %					.... mg dm^{-3}				
89.4	0.0	71.3	13.1	4.9	4.04	56.36	17.77	0.65	12.57
Particle Size Analysis								Texture Class	
.... g kg^{-1}									
	Sand		Silt		Clay			Sandy	
	800		110		90				

O.M.: Organic Matter; P: Phosphorus; K: Potassium; Ca: Calcium; Mg: Magnesium; Al: Aluminium; H + Al: Total or potential acidity; SB: Sum of bases; CEC: Cation exchange capacity; V: base saturation; m: Aluminium saturation; S: Sulfur; Fe: Iron; Mn: Manganese; Cu: Copper and Zn: Zinc.

The irrigation management method used in this work was based on the weather, with daily reference evapotranspiration data – ETo (Penman-Monteith method - FAO), for calculating irrigation depths, obtained through the EVAPO® application (MALDONADO JÚNIOR; VALERIANO; ROLIM, 2019). The data of the cultivation coefficients of the soybean crop used were, as follows: initial phase 0.35; growth phase 0.75; intermediate phase 1.25; final phase 0.75 (DOOREMBOS & KASSAM, 1994).

The experiment was irrigated using a localized drip irrigation system, with one irrigation line per row of plants, with one emitter per plant, spaced by 0.30 m and with a flow per emitter of 2.0 L h^{-1}, which were previously evaluated in the field, under normal operating conditions, according to the methodology described by Keller and Karmelli (1975). The irrigation time was calculated based on Equation (1):

$$Ti = 60\,x\,\frac{f\,.\,ETpc\,.\,Ap}{Ea\,.\,qi} \quad (1)$$

Where,
Ti = Irrigation time (minutes);
f = Adjustment factor for irrigation regimes (0.50 or 1.0, dimensionless);
ETpc = Potential crop evapotranspiration (mm day^{-1});
Ap = Useful area of plants (0.3 m^2);
Ea = Irrigation system efficiency (dimensionless);
qi = Flow rate per treatment (2.0 L h^{-1}).

The variables intended for growth analysis, for the measurements of plant development parameters were the following: plant height (PH), measured using a measuring tape graduated in centimeters; Number of leaves (LN), manually counted in each trefoil, with values expressed in units per plant; and Total dry phytomass of the aerial part (FSTPA), evaluated through the different parts of the plant (leaves, stems and pods), carefully separated and identified, where they were later allocated in kraft paper bags for drying in an oven with forced air circulation at 60 ºC for 72 h, and the results are expressed in g plant^{-1}.

For the statistical analysis, the SISVAR software was used (FERREIRA, 2019). Regarding interpretation of the results, analysis of variance was carried out by applying the F test and when a significant effect was observed for the treatments imposing the deficit depths, the Scott-Knott test was performed for means clustering. For comparison of the means among the assessed cultivars, the Tukey test was used ($p \leq 0.05$).

RESULTS AND DISCUSSION

Table 4 shows the summary of the analysis of variance for the vegetative growth data (plant height – HEIGHT; number of leaves – Nleaves and total dry phytomass of the aerial part – FSTPA). The results show the interaction between the factors (times of induction of water deficit x cultivars), that all the vegetative variables were significantly influenced by the test of Tukey at the level of 5% and 1% of probability. Therefore, we tried to show the results of the interaction between the assessed factors through tables for a better visualization of the behavior of the cultivars before the different treatments imposed.

It can be seen in Figure 1 the plant height variable (HEIGHT) that the highest result obtained (150.00 cm) was found for the FT 4181 IPRO cultivar within the T6 treatment, referring to the imposition of the water deficit induction period (50% of ETpc) during stages I and II, corresponding to the vegetative and flowering stages and/or grain formation and filling (Table 2). The worst result for plant height (84.16 cm) was found for the same cultivar (FT 4181 IPRO) within the T8 treatment, referring to the imposition of the water deficit induction period throughout the entire crop development cycle.

According to Rocha *et al*. (2012), plant height is an important characteristic for recommending a cultivar to be introduced in a region, and it may be related to grain yield, weed control and also losses during mechanized harvesting. The smaller height of plants obtained in the treatment with water deficit during the phenological stages I, II and III (T8) corroborates the results found by Ferrari, Paz and Silva (2015), when they found a reduction in

Table 4. Summary of analysis of variance for the vegetative data of plant height (HEIGHT), Number of leaves (NLeaves) and total dry phytomass of the aerial part (FSTPA) in soybean crops subjected to irrigation deficit in their different grwoing phases

Source of variation	DF	Mean Squares		
		HEIGHT	NLeaves	FSTPA
Periods (P)	7	1016.44^{**}	2412.72^{ns}	927.53^{ns}
Block	2	899.05^{*}	6470.37^{*}	1496.66^{*}
Error (L)	14	159.71	1077.17	357.17
Cultivar (C)	2	955.79^{*}	1049.71^{ns}	466.35^{ns}
Periods x Cultivar	14	534.89^{**}	859.72^{*}	433.08^{*}
Error (C)	32	182.56	336.64	176.74
Corrected total	71			
CV - E (%)		10.72	44.08	29.82
CV - C (%)		11.47	24.64	20.98

SV: Sources of Variation; DF: Degrees of Freedom; (*) Significant by the F test at 5%; (**) Significant by the F-test at 1%; (^{ns}): non-significant; CV: Coefficient of variation

Table 5. Plant height (HEIGHT – cm) of three cultivars of soybean irrigated in periods of water deficit induction in different grwoing phases

Water deficit induction periods	Cultivars		
	FT 4181 IPRO	FT 3191 IPRO	FT 4181 IPRO
T1	107.16 aB	114.66 aA	122.83 aA
T2	123.00 aA	133.83 aA	114.50 aA
T3	133.50 aA	119.00 abA	99.50 bB
T4	122.83 aA	99.16 aA	117.00 aA
T5	133.00 aA	117.33 abA	102.33 bB
T6	150.00 aA	130.83 aA	126.16 aA
T7	117.00 aA	136.83 aA	113.16 aA
T8	84.16 bC	121.50 aA	89.00 bB

Means followed by the same lowercase letter, among cultivars, within each period of induction of water deficit do not differ among each other by the test of Tukey ($p \leq 0.05$) and means followed by the same capital letter, among treatments of periods of water deficit induction, within each cultivar, do not differ by the Scott-Knott test ($p \leq 0.05$)

the height of the plants with the increase of the water deficit, such behavior being, according to the authors, caused by the decrease in the number of nodes and length of internodes.

In na experiment carried out by Simeão (2015) in evaluating the influence of deficit irrigation applied in different stages of soybean cultivation, cultivar BRS Sambaíba, in the edaphoclimatic conditions of Bom Jesus, in the state of Piauí, the author found that the height of plants showed variations in the results when subjected to deficient depths at different stages of development, indicating that, regardless of the phenological phase in which the water deficit occurred, plant height is Always reduced. Also, according to the author, the reduction in plant height is more drastic when the lack of water occurs in the flowering and grain filling phase, a period considered critical, as the crop requires more water to meet its metabolic activities.

As for the variable number of leaves (NLeaves), it can be seen in Figure 2 that the highest result obtained (117.6 leaves) was found for the cultivar FT 3191 IPRO within the T6 treatment, referring to the imposition of the induction period of water deficit (50% of ETpc) during stages I and II (vegetative and flowering and/or grain formation and filling, respectively). The worst result for the number of leaves (38.83 leaves) was obtained in the cultivar (FT 4181 IPRO) in the T8 treatment, referring to the imposition of the water deficit induction period throughout the entire development cycle of the crop.

According to Santos and Carlesso (1998), the reduction in the emission of leaves is related to changes at the cellular level in the plant and another factor is also involved: the less the plant expands the aerial part, the smaller the number of leaves, which affects the development of new leaves by the crop, because of the reduction in active photosynthesis. Therefore, such information confirms the results obtained in the present work, where it was found that the plants subjected to water deficit throughout the entire production cycle, presented a smaller number of leaves.

The results obtained in the present research also corroborate with those of Nunes *et al*. (2016), who, when evaluating the effect of deficit irrigation management in different soybean cultivars, found a decrease in the emission of new leaves for plants subjected to deficit irrigation throughout the entire phenological cycle.

Taiz *et al*. (2017) highlight the morphophysiological mechanism of plants due to the need to resolve this conflict between water conservation by the plant and the CO_2 assimilation rate for carbohydrate production, as one of the first reactions of plants in relation to water deficit. That is, the water deficit induces the plant to develop strategies such as decreasing leaf emission, stomatal closure, accelerating senescence and abscission, which lead them to save water to be used in later periods, leading them to try to achieve the production of grains.

Table 6. Number of leaves (Nleaves – units) of three soybean cultivars irrigated in periods of induction of water deficit in different grwoing stages

Water deficit induction seasons	Cultivars		
	FT 4181 IPRO	FT 3191 IPRO	FT 4181 IPRO
T1	100.33 aA	63.93 aB	96.00 aA
T2	69.83 aB	93.83 aA	70.83 aA
T3	62.50 aB	75.00 aB	50.16 aB
T4	78.16 aA	66.83 aB	62.83 aB
T5	92.50 aA	74.50 aB	49.83 aB
T6	58.66 bB	117.16 aA	93.50 abA
T7	96.66 aA	104.83 aA	78.16 aA
T8	38.83 aB	51.50 aB	40.50 aB

Means followed by the same lowercase letter, among cultivars, within each period of induction of water deficit do not differ among each other by the test of Tukey (p≤0.05) and means followed by the same capital letter, among treatments of periods of water deficit induction, within each cultivar, do not differ by the Scott-Knott test (p≤0.05)

The reduction in leaf development may also be related to the difficulty of the plant, under water stress caused by the lack of water, to absorb nutrients from the soil. According to Barbosa (2017), water deficit reduces perspiration rate, which reflects on nutrient uptake. As a result, nutritional deficiency can be one of the factors that restrict the plant from completing normal leaf development.

As for the variable total dry phytomass of the aerial part (FSTPA), it is possible to see in Figure 3 that the highest result obtained (83.66 g plant^{-1}) was found for the cultivar FT 3191 IPRO in T1 treatment, referring to application of full irrigation (100% of ETpc) during all cultivation phases. However, the results obtained in treatments T2 (81.23 g plant^{-1}), T3 (76.75 g plant^{-1}) and T6 (79.98 g plant^{-1}), for the same cultivar, did not differ statistically between them. The lowest FSTPA yields (39.75 and 41.00 g plants^{-1}) were obtained in the cultivars (BG 478 IPRO and FT 4181 IPRO, respectively) under the T8 treatment, referring to the imposition of the water deficit induction period (50% of ETpc) throughout the crop development cycle. Similar results are shown by Simeão (2015) when they found a higher production of aerial part dry mass in plants subjected to full irrigation.

Jaleel et al. (2009) point out that if the period of water stress during the soybean development phase persists for a long time, the lack of water can cause physiological changes in the plant, such as the presence of poorly developed plants, decline in the symbiotic fixation of atmospheric nitrogen, smalll leaves, short internodes, leaflet closure, reduction in the phytomass, flower drop and abortion, decrease in the number of pods, empty pods which increases the susceptibility to pathogens and pests, stomatal closure, resulting in difficulty in gas exchange and reduction in productivity (SINCLAIR *et al*., 2007). In this context, the adverse effects provided by the lower water availability in the plants submitted to the induction of the deficit depth throughout the entire development cycle are consistent with the statements already mentioned as under such treatment the lowest values of the phytomass production of the aerial part (stems, leaves and pods) were obtained.

In most cases, through the deficit caused by the reduction of the water layer, the response between plants can be estimated by quantifying productivity, growth (accumulation of dry matter), or the primary process of CO_2 assimilation, which are related with overall plant growth (TAIZ *et al.*, 2017). Fancelli and Dourado Neto (2000), point out that the low availability of water for the plants, associated with an excessive transpiration rate, promote an immediate closure of the stomata, resulting in the paralysis of photosynthesis, which consequently causes serious reductions in the amount of biomass.

Changes in the photosynthetic process directly reflect on agronomic variables such as plant height, number of leaves and dry and fresh mass of the leaf and stem. Due to the reduction in the photosynthetic rate, the plants have a lower

Table 7. Production of total dry biomass of the aerial part (FSTPA – g plant^{-1}) of three soybean cultivars irrigated in water deficit induction period in different grwoing phases

Water deficit induction periods	Cultivars		
	FT 4181 IPRO	FT 3191 IPRO	FT 4181 IPRO
T1	67.31 aA	83.66 aA	63,.51 aA
T2	48.11 bB	81.23 aA	48.91 bB
T3	78.45 aA	76.75 aA	58.41 aA
T4	82.51 aA	53.98 aB	65.26 aA
T5	65.55 aA	43.25 aB	49.35 aB
T6	65.48 aA	79.98 aA	72.41 aA
T7	77.91 aA	55.96 aB	68.64 aA
T8	41.00 aB	53.48 aB	39.75 aB

Means followed by the same lowercase letter, among cultivars, within each period of induction of water deficit do not differ among each other by the test of Tukey ($p \leq 0.05$) and means followed by the same capital letter, among treatments of periods of water deficit, within each cultivar, do not differ by the Scott-Knott test ($p \leq 0.05$).

production of photoassimilates, which would be destined for their growth and development, and may reduce seed production. Another explanation for the reduction in these variables could be the fact that cells lose turgor when the plant is going through periods of water deficit, which decreases stomatal conductance and cell expansion, resulting in a limitation in the crop growth (JALEEL *et al*., 2009).

CONCLUSION

- The water deficit (50% of ETpc) imposed throughout the soybean production cycle resulted in a drastic reduction in all evaluated parameters (plant height, number of leaves and dry mass production of the aerial part).
- The FT 4181 and 3191 IPRO cultivars were those that obtained the highest responses upon the imposition of the deficit depth (50% of the ETpc) during the vegetative and flowering phenological stages and production formation (grain filling), being, therefore, the most indicated for the edaphoclimatic conditions of the Cerrado southern Piauí.

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AUTHORSHIP CONTRIBUTION STATEMENT

LOPES, T.S.: Conceptualization, Investigation, Writing – original draft, Writing – review & editing; **SOARES, R.W.F.:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing; **PEREIRA FILHO, J.V.:** Conceptualization, Methodology, Project administration, Supervision, Writing – original draft; **NASCIMENTO, T.A.L.:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing; **SANTOS, N.C.:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing; **PEREIRA, C.C.M.S.:** Formal Analysis, Project administration, Supervision, Writing – original draft, Writing – review & editing.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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