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THE DEVELOPMENT OF CUSTARD APPLE FLOWER BUD UNDER NITROGEN AND POTASSIUM NUTRITION[1]

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ABSTRACT – The custard apple tree (*Annona squamosa* L.), has increased in cultivation due to good prices in the national market. However, there are few studies regarding the fruit's nutrition. The aim of this study was to verify the influence of N and K levels in developing the flower buds in two growing cycles, corresponding to the time of high temperatures (spring-summer) and another milder season (autumn-winter). The experiment was conducted in a rural property located in the municipality of Anagé, Bahia, installed in a randomised complete block design with 3 blocks, arranged in a factorial 4 x 4, obtained by the combination of the following levels of N (0, 16.875, 33.750 and 67.500 g plant^{-1}) in the form of urea and K (0, 22.5, 45.0 and 90.0 g plant^{-1}) in the form of potassium chloride, applied every fifteen days (every fortnight / every two weeks). It was evaluated the vigor of floral buds, measured by determining its weight and the length of them. At the end of the study it was concluded that the vigor of the floral buds tended to increase with elevated levels of nitrogen in the coldest period of the year (dry season with low in temperature). In the spring-summer period (rainy season and high temperature) the vigor of the flower buds was reduced as they increased the doses of N. Potassium did not affect the vigor of the flower buds in these considered periods. There was no interaction between N and K levels for the vigor of the flower buds.
Index terms: *Annona squamosa* L., Annonaceae, growth, nutrition, floral quality.

DESENVOLVIMENTO DE BOTÕES FLORAIS DA PINHEIRA EM FUNÇÃO DA ADUBAÇÃO NITROGENADA E POTÁSSICA

RESUMO - A pinheira (*Annona squamosa* L.) tem seu plantio aumentado em detrimento dos bons preços alcançados no mercado nacional. Porém, existem poucos estudos sobre sua nutrição. O presente trabalho teve como objetivo verificar a influência dos níveis de N e K no desenvolvimento de seus botões florais em dois ciclos de cultivo, que corresponderam à época de temperaturas elevadas (primavera-verão) e outra mais amenas (outono-inverno). O experimento foi desenvolvido em propriedade rural localizada no município de Anagé-BA, instalado no delineamento de blocos casualizados, com 3 blocos, arranjados num esquema fatorial de 4 x 4, obtidos pela combinação dos seguintes níveis de N (0; 16,875; 33,750 e 67,500 g planta^{-1}) na forma de ureia e K (0; 22,5; 45,0 e 90,0 g planta^{-1}), na forma de cloreto de potássio, aplicados quinzenalmente. Foi avaliado o vigor dos botões florais, medidos através da determinação de sua massa e do comprimento dos mesmos. Ao final do estudo, pôde-se concluir que o vigor dos botões florais da pinheira tendeu a aumentar com a elevação das doses de nitrogênio no período mais frio do ano (período seco com queda de temperatura). No período de primavera-verão (período chuvoso e de alta temperatura), ocorreu redução do vigor dos botões florais a medida que aumentaram as doses de N. O potássio não afetou o vigor dos botões florais da pinheira nas épocas consideradas. Não houve interação entre os níveis de N e K para o vigor dos botões florais.
Termos para indexação: *Annona squamosa* L., Anonáceas, crescimento, nutrição, qualidade floral.

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INTRODUCTION

Brazil has distinguished itself worldwide as major producer of fruit, especially tropical and subtropical. Within the genus *Annona*, the fruit (*Annona squamosa* L.), also known as 'fruta do conde'or 'ata', is commercially successful, as it is popular with consumers due to the taste (SOUZA et al., 2012; ZUCARELI et al., 2007).

Silva et al. (2007) pointed out that especially in the north-east of the country, culturally and from a socio-economic point of view this fruit is acquiring great importance. The increase in cultivation in the South-East and North-East, especially in irrigated areas, is due to the possibility of more than one crop per year and the good prices obtained in the main consumer markets (NIETSCHE et al., 2009).

The fruit (*Annona squamosa* L.) stands out economically in the fresh fruit market, and it is ready for consumption straight from the tree. For this reason, its production is aimed almost exclusively to this market, being sold in supply chains within cities such as São Paulo, Belo Horizonte and Salvador, among others (SOUZA et al., 2012).

Several factors are attributed to the high productivity and quality of the fruit, where the genetic factor is crucial, other aspects are also important, such as fertilization, irrigation, cultivation etc. The Annonacea extracts large quantities of mineral elements from the soil, and this extraction can vary depending on the cultivation intensity and the material that was taken, which is mainly the fruits. Thus, there may be a nutritional deficit to subsequent productions if fertilization is not practised (SÃO JOSÉ et al., 2014).

Despite the exploration of custard, as well as other Annonacea of economic importance which are not new in Brazil, information regarding the nutritional requirements is scarce (MALAVOLTA et al., 1997; MARSCHENER, 1997; DECHEN; NACHTIGALL, 2006; CAVALCANTE et al., 2012; CAVALCANTE et al., 2014; CUNHA et al., 2015). The works of greatest importance, involving nutrition, are old (SADHU; GHOSH, 1976).

However, this becomes important because of the balanced nutrition that can promote proper development of flower buds and accordingly the effective fruiting and subsequent fruit development.

The study of flower buds development to the detriment of plant nutrition is practically non-existent with regard to the study of Annonaceae. São José et al., (2014) reported that studies in India showed that flower bud of custard were strongly affected by the lack of N.

The emergence of flower buds in custard apple trees occurs approximately 10 to 15 days after pruning, which is required to have nutrients available in sufficient quantities for the plant to carry out their metabolic and physiological processes when issuing vegetative branches accompanied by flower buds. In this phase it is extremely important the availability of N, as it is the direct responsible element for the growth of new branches with flower buds and especially the good leafiness (SÃO JOSÉ, et al., 2014).

Nitrogen availability results in an increase of the plant's vigor, probably influenced by the increase in gibberellin synthesis, the phyto-hormone which is related to vegetative growth.

Being so, N is related to the number and length of vegetative and fruitful (productive) branches, the number of leaves and fruit, to the size and quantity of flowers. The most developed flowers usually have in their gynoecium a larger number of carpels, where if properly pollinated, will lead to bigger fruits, a very important feature in productivity and fruit quality, in the market point of view.

Annonaceae extracts from the soil a large quantity of mineral elements, despite the hardiness appearance. The custard apple tree draws different amounts of nutrients depending on the period of growth and development, and environmental conditions in which they are exposed, especially temperatures and rainfall. Normally in the rainy season associated with high temperatures there is significant growth of branches, leaves and flower buds in comparison to cooler times.

The mineral elements most sought by culture are nitrogen and potassium, with average values from 7.17 to 5.19 kg per tonne exported of fresh fruit, respectively. In India when the custard apple tree is not fertilized it goes into gradual decline where malformation of fruits happens, reducing their market value (SÃO JOSÉ et al., 2014).

The availability of nitrogen immediately after pruning the custard apple tress promotes leafiness plants, positively affecting the production of photoassimilates that will nourish the flowers, fruits and other parts of the plant. Potassium nutrient is highly required in the fruit formation period. The absence in this period along with calcium and nitrogen absence, causes poor fruit quality (SÃO JOSÉ et al., 2014).

This study is aimed to evaluate the influence of nitrogen and potassium fertilization in the development of custard apple tree floral buds in two growing cycles, one at the spring-summer period, with rainfall and high temperatures, and another at the autumn-winter period without rain and lower temperatures.

MATERIAL AND METHODS

The experiment was conducted from December 2013 to May 2014 in a commercial orchard of custard apple tress in Rancho Alegre Farm, in the town of Anagé in southwest of Bahia State, Brazil, where semi-arid climate prevails, with average annual temperature of 22,3^{o}C; being the average of the maximum temperature of 29,0^{o}C and minimum of 19,0^{o}C, with average rainfall of 656 mm per year^{-1} and typical caatinga vegetation. (exclusive brazilian sime-arid vegetation biome). The farm is located in the approximate cartographical coordinates of: 14º26 'south latitude and 41º04' west longitude from Greenwich to 335 meters of altitude, data obtained by a GPS (Garmin Etrex, Legend Hcx).

The temperature and pluviosity data were obtained through the Data Collection Platform (DCP) located in the city of Anagé-BA under the name "PCD 32494 - Station: Anagé- BA" (Figures 1 and 2).

In the experiment, (useful plants), 144 custard apple tree plants were used, with the age of four years old, originating from un-grafted seedlings with an average of 1.50 m in height; 0.90 m crown (capony) diameter and 0.21 m trunk diameter from 0.10 m above the ground, being planted in a spacing of 5.0 x 2.5 m, making up a total of 800 plants per hectare, daily irrigated by micro-sprinkling with an micro spraying per plant, where the quantity of water used was 30L per plant h^{-1}, with irrigation time of three hours.

Plants were pruned using manual pruning shears, then manual defoliation of pruned branches, starting from the end to the base, which were approximately 0.20 m long and with a minimum diameter of 0.01 m, smaller branches were eliminated. This defoliation is common practice among producers of custard apple tree that aims to force and to uniform the sprouting of new branches and flowers.

The application of nutrients was started five days after the pruning of plants, with intervals of 15 days, always obeying the dosages of the respective treatments. To monitor the experiment, soil samples were collected at depths 0 to 20 cm and 20 to 40 cm in rows at each plant and in the middle of the rows of the specimens. These samples were sent for analysis and the results are shown in Table 1.

During the execution of the experiment 30 flowers were collected per treatment when they showed early separation of the petals at the pre-anthesis stage.

At this stage the flowers were weighed and measured in length. The weight measurements were performed on a weighing-scale of 0.1 g of precision and measurements were taken with a digital caliper ruler.

The flowers were collected about two months after their prunings, namely: first pruning in 10-07-2013 with gathering and weighing flowers on 07-12-2013 (period between the spring seasons / summer, when there is increased temperatures and higher rates of rainfall in the area), the second pruning was held on 07-04-2014 and the collected and weighed flowers on 05-31-2014 (the period between autumn seasons / winter when temperatures drops and low rates of rainfall in the area).

Taking into account the exportation of these nutrients and fertilizer currently held by producers, it was evaluated the effects of fortnightly applications of N (0, 16.875, 33.750 and 67.500 g plant^{-1}) which is equivalent to (0, 37.5, 75.0 and 150.0 grams of urea per plant) and K_2O (0, 22.5, 45.0 and 90.0 g plant^{-1}) equal to (0, 37.5, 75.0 and 150.0 grams of potassium chloride per plant), using factorial arrangement 4 x 4, obtaining thus sixteen treatments in a randomized block design with three replications and three plants per experimental plot.

After testing the normality of the data, they were analyzed through variance and regression, using the SISVAR program, version 5.3 (FERREIRA, 2010).

RESULTS AND DISCUSSION

It was found that there were significant differences in the amount of N applied regarding the weight of flower buds in both flowering and the first bloom to the length thereof. There was no significant effect on the amount of K nor the interaction of the quantities N x K, both the mass and the length of flower buds, the two flowerings evaluated (Table 2).

The no significance to the amount of K applied can be explained by the existing values in the experimental area, specifically (specially) in the planting line presented 270 and 86 mg / dm³, and in between the planting lines with 240 and 150 mg/ dm³ for the depths from 0 to 20 cm and 20 to 40 cm, respectively (Table 1). Generally, the higher levels of K contributed to the homogenization results by the availability of the nutrient in the soil had no impact to the presence of any imbalance process caused by the high level of the existing element in the soil added and mixed via the experimental fertilization.

Going to nitrogen analysis, the average masses of the evaluated treatments (Figure 3) in the first season (flowering of December 2013) showed decreasing linear trend with increasing amount of N used, which is opposite to the behavior of the second season (May 2014) that showed increasing linear behavior.

The decreasing linear trend seen in the first stage can be explained by the fact that in this period there was more rainfall in the area (Figure 1), releasing large amount of nitrogen to the soil, causing in an natural way greater leafiness and development of flower buds. Probably, the soil was already with high contents of N due to rain and that the extrinsic application of this element did not contribute to greater absorption thereof by the custard apple tree in order to positively affect the vigor of the buds, on the contrary, the probable excess reduced the development of the flower buds, possibly by a nutritional imbalance. As reported Souza and Fernandes (2006), there is input of N to the soil through named as rain drag, where oxides of N are produced in the atmosfere by electrical discharges and rainfall.

Furthermore, based on the study of Bredemeier and Mundstock (2000), who reported that in the course of the plant development, when a new leaf is emerging, most of the carbohydrate is directed towards the development of new organ, simultaneously, there is a decrease in translocation rate of these compounds to root systems, reducing energy availability at the root, which reduces the nitrogen absorption rate, occurring oscillation of the absorption rate of this element during the plant's life cycle which is synchronized with apperance of new leaves. This fact was probably occurred in the first stage of blossoming of this study.

Observing the results in relation to nitrogen, the length of the flower buds (Figure 4) followed the same trend of the evaluation of the mass, ie, linear decreasing in the first blossom and linear increase in second bloom. The lower growth occurred in the first blossoming, probably is due to the fact of the addition of N in the soil via thunderstorm rainfall in this same period (Figure 1), plus the addition of extra N by the fertilizations, causing an imbalance among other nutrients.

The opposite was observed in the second flowering, where it was found that as N increased, there was a development on the length of flower bud, probably due to the absence of nitrogen added during the rainy season (Figure 2), leaving the ground with concentrations of that nutrient which was below the minimum necessary for proper vegetative growth of the plant, as well as the flower bud.

It was found as it shows in table 3, that the values obtained in mass and length of the first blossoming (December / 2013) were superior to those of the second blossoming (May / 2014), both for doses of N and for K rates, probably influenced by the higher temperature period and rainfall which stimulates the custard apple tree development (Figures 1 and 2).

Important to note that in the semi-arid climate conditions it is possible to produce custard fruit out of the normal harvest time, that is, from December to May.

TABLE 1 - Chemical analysis of the experimental soil area. Anagé-BA, 2015.

Parameter analyzed	Units	Analysis result			
		At planting lines		Between the planting lines	
		0 - 20 cm	20 - 40 cm	0 - 20 cm	20 - 40 cm
Phosphorus Mehlich[1/]	mg/dm³	4,0	1,0	5,0	2,0
Potassium[1/]	mg/dm³	270,0	86,0	240,0	150,0
Sulfur[2/]	mg/dm³	6,0	3,0	5,0	4,0
Calcium[3/]	cmol	3,5	2,3	4,3	4,1
Magnesium[3/]	cmol	1,5	1,3	1,6	1,5
Aluminium (Al)[3/]	cmol	0,0	0,0	0,0	0,0
H + Al[4/]	cmol	1,1	1,2	1,1	1,1
pH em H_2O[5/]	-	7,4	6,4	7,2	7,2
Organic matter[6/]	dag/kg	2,1	1,0	2,0	1,4
Iron[1/]	mg/dm³	59,0	34,0	82,0	42,0
Zinc[1/]	mg/dm³	1,1	0,8	0,9	0,5
Copper[1/]	mg/dm³	1,6	1,3	1,4	0,9
Manganese[1/]	mg/dm³	106,0	80,0	159,0	105,0
Boron[7/]	mg/dm³	0,59	0,64	0,61	0,46
Sodium[1/]	mg/dm³	120,0	88,0	97,0	75,0
Relation Ca/Mg	-	2,3	1,8	2,7	2,7
Relation Ca/K	-	5,1	10,4	7,0	10,7
Relation Mg/K	-	2,2	5,9	2,6	3,9
Sat. Ca na CTC (T)	%	51,5	45,8	56,5	57,9
Sat. Mg na CTC (T)	%	22,1	25,9	21,0	21,2
Sat. K na CTC (T)	%	10,2	4,4	8,1	5,4
Saturation index Na	%	7,7	7,6	5,5	4,6
Base Sum (SB)	cmol	5,7	3,8	6,5	6,0
CTC efetive (t)	cmol	5,7	3,8	6,5	6,0
CTC at pH 7,0 (T)	cmol	6,8	5,0	7,6	7,1
Sat. Aluminium (m)	%	0,0	0,0	0,0	0,0
Base saturation	%	83,8	76,1	85,6	84,5

1/ Extraction: HCl 0,05 mol/L + H_2SO_4 0,025 mol/L
2/ Extraction: $Ca(H_2PO_4)^2$ 0,01 mol/L
3/ Estraction: KCl 1 mol/L
4/ Buffer Solution SMP
5/ pH in H_2O 1:2,5
6/ Oxidation: $Na_2Cr_2O_7$ $2H_2O$ + 4 mol/L H_2SO_4 10 mol/L
7/ Extraction: $BaCl_2$ $2H_2O$ 0,125%

TABLE 2 - Analysis Summary of variance with F test and coefficient of variation for the mass (g) and length (cm) of Custard apple tree flower buds in two blossomings. Anagé-BA, 2015.

FV	GL	Medium square			
		Mass (g) in each flowering		Length (cm) on each flowering	
		December/2013	May/2014	December/2013	May/2014
Blocks	2	0,028*	0,054*	0,042 ns	0,036 ns
N	3	0,167*	0,033*	0,125*	0,028 ns
K	3	0,012ns	0,005ns	0,003ns	0,033 ns
NK	9	0,009ns	0,007ns	0,017ns	0,006 ns
Residue	30	0,008	0,009	0,014	0,013
CV (%)		6,830	8,250	3,990	4,200

TABLE 3 - Average score of mass (g) and length (cm) of flower buds from two flowerings, due to the levels of N and K. Anagé-BA, 2015.

Doses of N (g plana^{-1})	Mass (g) in each flowering		Lenght (cm) in each flowering	
	Dec/2013	May/2014	Dec/2013	May/2014
0	1,483	1,054	3,105	2,660
16,875	1,339	1,103	2,940	2,678
33,750	1,296	1,133	2,920	2,750
67,500	1,200	1,180	2,869	2,753
Doses of K (g plana^{-1})				
0	1,366	1,135	2,960	2,644
22,5	1,296	1,126	2,946	2,693
45,0	1,348	1,086	2,947	2,746
90,0	1,308	1,123	2,981	2,758
Average view	1,330	1,118	2,959	2,710

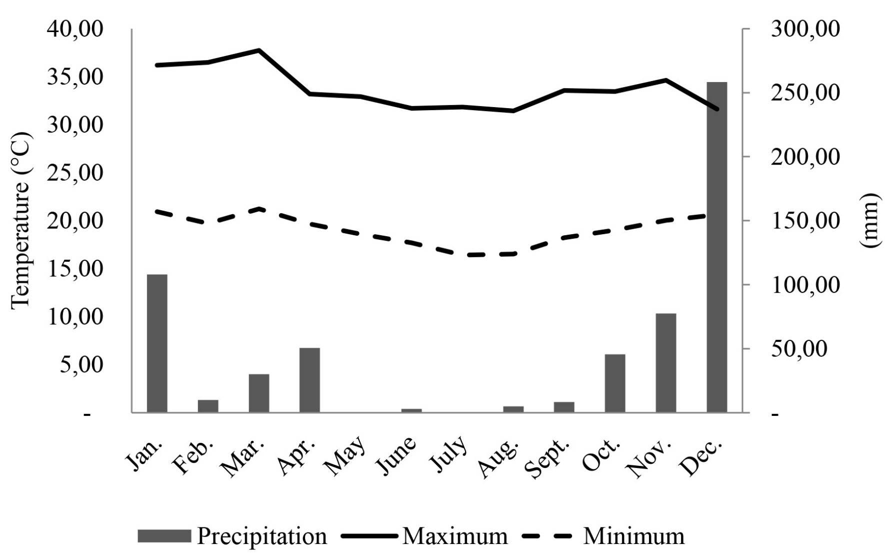


FIGURE 1 - Monthly precipitation and average temperature of maximum and minimum in 2013, Anagé-BA.

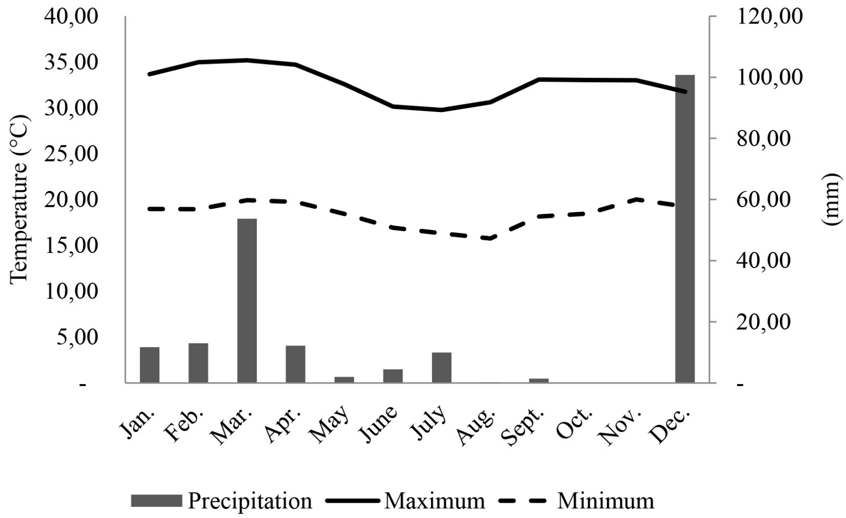
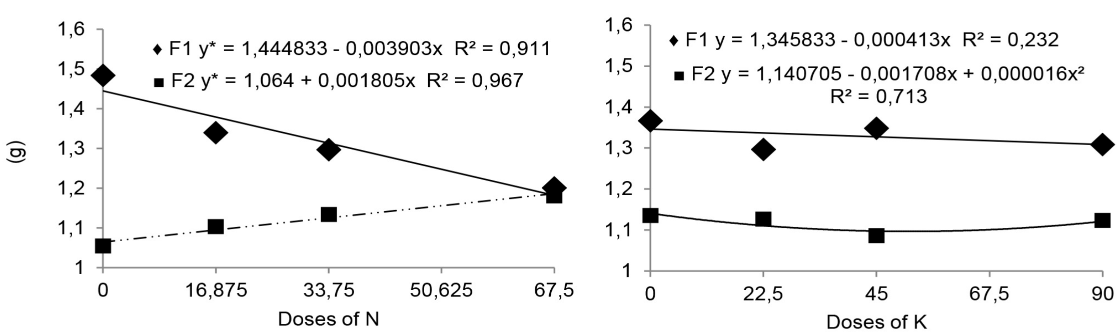


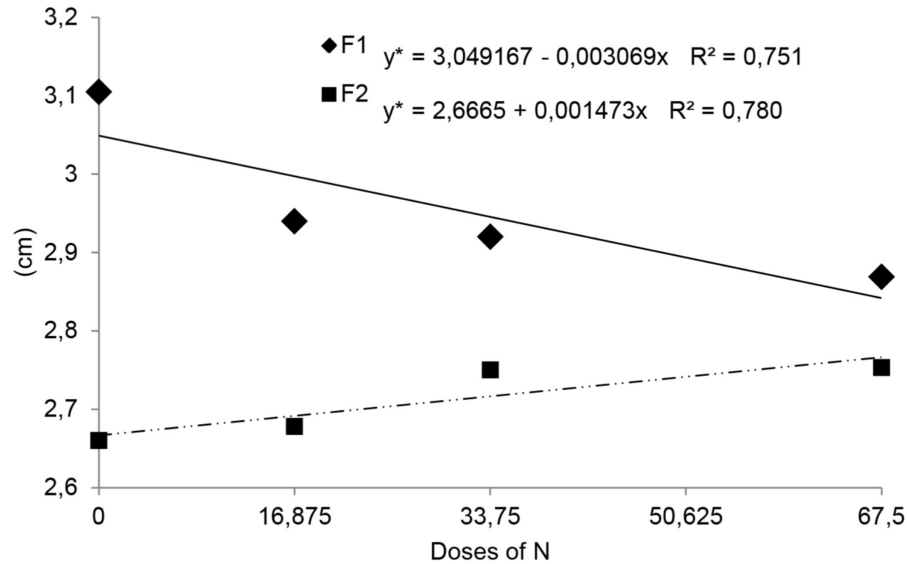
FIGURE 2 - Monthly precipitation and average temperature of maximum and minimum in the year 2014*, Anagé-BA.

*There were no reported rainfall data from 10/26/2014 to 10/12/2014 period.



F1 - Flowering 1 at 07-12-2013; F2 - Flowering 2 at 31-05-2014.

FIGURE 3 - Average mass (g) of flower buds from two flowerings, due to the doses of N and K. Anagé-BA, 2015.



F1 - Flowering 1 at 07-12-2013; F2 - Flowering 2 at 31-05-2014.

FIGURE 4 - Average length of flower buds (cm), from two flowerings, due to the doses of N. Anagé-BA, 2015.

CONCLUSION

In the conditions of how the work was performed, it can be concluded that the vigor of the custard apple tree floral buds tend to increase with increase of the amount of nitrogen applied in autumn-winter periods (no rain and low temperatures). In periods of spring-summer (with rain and high temperature) the vigor of the flower buds is reduced as it increases the amount of applied N. Potassium does not affect the vigor of custard apple floral buds in any of the two climatic conditions considered and does not occur interaction between N and K to the vigor of flower buds.

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