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Phenology and production of guava tree cv. "Paluma" pruned at different seasons in Mossoro – RN, Brazil.

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Abstract

The pruning allows fruit harvest in different periods, according to the grower decision, being economically viable. The harvest can be scheduled according to the agronomical traits and due to the market price. The experiment was conducted in the didactic orchard of the Federal University of the Semi-Arid Region (UFERSA), from April 2013 to December 2014, in the municipality of Mossoro-RN. It was carried out in a randomized block design, with treatments arranged in a split-plot, which were composed by pruning periods, conducted in April (2013), November (2013) and July (2014). The subplots consisted of pruning intensities (short, medium and long); with four repetitions, where the experimental unit consisted of two plants that was pruned with 8 marked branches. From pruning to harvest, the the following botanical characteristics were evaluated in the marked branches: number of emitted sprouts by branches pruned at the day 15th (NBE); number of established branches by branches pruned at the day 50th (NRE); number of productive branches (NRP); vegetative number (VRN) and the total number of fruits (NFT). The evaluated characteristics presented a significant effect. The long pruning resulted in a higher number of fruits for all evaluated seasons. The best months for pruning was November and July. The guava tree 'Paluma' cycle, from pruning to harvest can vary according to the period of pruning, with 132 days in July and 150 days in April.

Keywords: *Psidium guajava* L., phenology, production

Introduction

Fruit growing has many advantages, among which are highlighted the increase of employment opportunities, the people fixation in the field, the distribution of local and regional income and the regional production of fruits of high commercial value, generating profits and foreign exchange for the coutntry. Among the alternatives is the guava tree growing, an activity of high profitability.

Brazil is the third world´s largest fruit producer with 40 million tons per year, but it participates with only 2% of the global trade in the sector, which are related to strong domestic consumption (Brazilian Yearbook of Fruit Growing, 2010).

The commercial orchards of guavas located in Rio Grande do Norte are in the coast, semiarid and West regions, mainly in the Irrigated District of Baixo Asú (DIBA in Baraúna municipality, RN, with orchards formed mostly by the variety "Paluma", with 'in natura' fruits being commercialized in the regional market (nearby cities) in supermarkets and fairs (Alencar, 2011).

The fruit pruning allows the fruit harvesting at a certain period, choosed by growers. It is economically feasible, being possible to harvest the fruits in the periods of lower market supply, achieving better prices (Ramos et al. 2011).

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stages of development (phenophases) during the annual cycle of perennial plants is essential for the application of good agricultural practices in the agronomic management of the crop.

Thus, the prognosis of the time in which the various phenomena will occur is essential for the planning of all activities related to the production and marketing of the fruit. Segantini (2010) concludes that studies on fruit species in each growing region are necessary, mainly to define the most suitable season and types of pruning.

Thus, the aim of the present study is to characterize the phenology and production og guava trees cv. 'Paluma' submitted to different prunning methods and in different seasons in Mossoro, RN, Brazil.

Material and methods

The study was carried out from April, 2013 to December, 2014 at the didatic orchard at the Federal Rural University of the Semiarid region (UFERSA), East Campus, Mossoró, RN, Brazil.

The experiment was composed of three year-old plants of 'Paluma' cultivar, propagated by grafting and cultivated at a spacing of 6 x 4 m, in medium-textured soil and irrigated by micro-spreading, arranged in a block design with four repetitions, where the treatments were distributed in a subdivided plots scheme and the plots consisted of the different pruning seasons (04/20/2013, 11/20/2013 and 07/16/2014) and subplots consisted of three intensities of fructification pruning.

The intensities of fruit pruning were classified according to the distance at which the branches were pruned from the base in: short (pruned 1/3 from the base, medium (pruned 1/2 of its length, from the base) and long (prining at 2/3 od itd length, from the base) (Figure 2). All plant branches were pruned without considering its diameter, and during the pruning process all fruits and flowers present in the plant were eliminated. The experimental unit consisted of two plants with 8 pruned branches marked with colored ribbons.

At each pruning season, 12 plants considered homogeneous for age, plant height, crown shape and sanity and vigor were selected, located in the middle of the plot. Each fruit pruning season was divided into three blocks with four plants per plot.

The mean air temperature data and the actual precipitation of the region during the period of the experiment were obtained from the Automatic Weather Station, located at UFERSA (Federal Rural Semi-Arid University), in Mossoró-RN (Table 1).

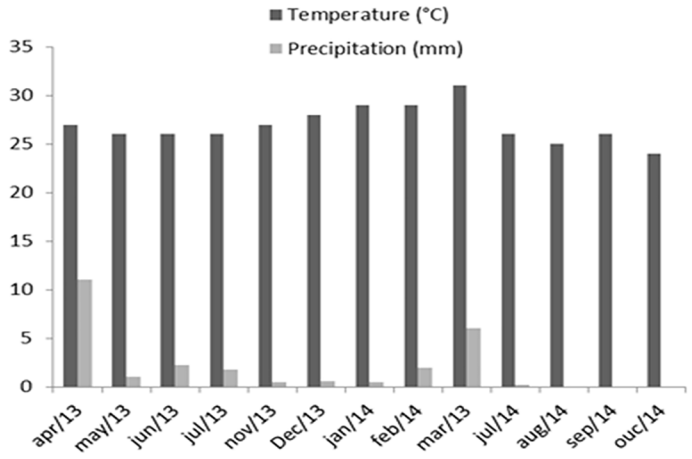

Figure 1. Climatic data at the region of the study during the experiment.

Soil and leaf analyzes were performed at the Laboratory of Soil, Water and Plant Analysis of the Agricultural Research Company of Rio Grande do Norte - EMPARN.

From the pruning to fruit harvest, the following botanical characteristics were evaluated in the marked branches: number of issued shoots per branch pruned at 15 days (NBE); number of branches established per branch pruned at 50 days (NRE); number of productive branches (NRP); number of vegetative branches (NRV); total number of fruits (NFT); production (PROD) and yield (Y).

The considered phenological characterization of the "Paluma" guava tree was the period from the pruning to the beginning of fruit harvest.

Preceding the beginning of the anthesis, period of flowers opening, the number of established productive branches (NRP) was evaluated. From the end of the anthesis (Photo 3), the total number of fruits (NFT) in these same branches was evaluated on every 15 days until the beginning of maturation, occurring at 70 days after the end of the anthesis.

During the course of the experiment, no phytosanitary issued was detected by pest and disease attacks.

The data were submitted to variance analysis and the means compared by the Tukey´s test at 5% of probability. All statistical analysis were perfoming using the SISVAR software (Ferreira, 2008).

Results and discussion

The total cycle of the "Paluma" guava tree, from pruning to the beginning of the concentrated fruit harvest, ranged from 132 to 150 days (85 to 135 days after the end of anthesis), under the present experiment conditions (Table 2).

Table 2. Phenophases of the "Paluma" guava tree, in three pruning seaons, in Mossoró-RN.

Phenological phase	Apr/DAP	Nov/DAP	Jul/DAP
	2013	2013	2014
Days after pruning			
1 - Beginning of sprouting and vegetative growth	15 to 25	15 to 35	15 to 25
2 – Flowering	25 to 50	35 to 55	25 to 45
Cycle from pruning to flowering	**50**	**55**	**45**
Days after anthesis			
3 – Physiological fall of fruits	0 to 45	0 to 40	0 to 35
4 – Phase I - growing	0 to 42	0 to 45	0 to 42
5 – Phase II - growing	42 to 75	45 to 75	42 to 75
6 – Phase III – growing	75 to 120	75 to 125	75 to 120
7 – Beginning of maturation	75	70	75
8 – Concentrated fruit harvest	105 to 135	85 to 135	85 to 135
Cycle from flowering to the concentrated harvest	**105**	**85**	**115**
Cycle (pruning to harvest)	**150**	**135**	**132**

The earliest period occurred in the period of highest average air temperature (pruning in November) and the longest cycle occurred in the period of lower average air temperature (pruning in April). The interval of 15 days between the evaluations did not allow to detect differences in the phenological cycle between the pruning intensities adopted; however, early precocity was observed at the beginning of the phenophases in the branches submitted to the medium and long prunings in relation to the branches submitted to short pruning.

Ramos et al. (2011) studying pruning seasons in the seasonality, production and quality of the "Paluma" guava tree fruits, observed that the cycle between the pruning until the beginning of the concentrated fruit harvest ranged from 197 to 234 days, with pruning held in June showing the shortest period. Serrano et al. (2008) analyzing the phenological and productive characteristics of pruned "paluma" guava trees in different seasons and intensities in the north of the Rio de Janeiro State, verified that the guava cycle from pruning to the fruit harvest ranged from 168 days, for pruning in October to 210 days, for the prunung held in February. Studies by Hojo et al. (2007) found that the pruning cycle was 214.2, 211.4, 247.8 and 237.3 days for pruning in September, December, March and June.

The phenophase, comprised from the appearance of flower buds until the end of flowering ranged from 25 to 55 days after pruning (DAP) (Table 2).

In a study in north of the Rio de janeiro State, Serrano et al. (2008) observerd number of days after pruning from hte appearance of flower buds and the end of flowering ranging from 28 to 84 days. Ramos et al. (2010), analyzing the production and fruit quality of the "Paluma" guava tree, submitted to different pruning

seasons in subtropical climate observed the lowest fruiting cycle when the pruning was in October (71 days). Serrano et al. (2008) observed that the pruning cycle until the end of the flowering when plants were pruned in August (70 days) lower when compaed to pruning in October, December and February (84 days).

Flowering of pruned plants in July was earlier when compared to plants pruned in April and November. The plants pruned in July were submitted to the natural flowering stimulus, verified at this time of year, with high air temperature at the time of emission and increase of the new sprout, which may have benefited the precocity of flowering (Table 2).

According to Serrano et al. (2008), the flowering of pruned plants in August and February was earlier than when the pruning was carried out in October and December. According to the author, this fact can be explained by the natural flowering stimulus of guava trees that occurs between August and September and by the low precipitation that occurred before pruning in August and February. In addition, the high temperatures occurred at the time of emission and growth of the new sprouting of plants pruned in February may have favored the precocity of flowering.

The greater the temperature during the flowering season, lower de period of flowering. This is in accordance to Neis et al. (2010), who verified that the plants with prunings in seasons 1 and 2 presented cycles with higher average temperatures (spring and summer), while the plants pruned in seasons 3 and 4 had their cycle influenced by lower average temperatures (autumn and winter).

In all seasons, new shootings appeared with higher intensity from 15 DAP (Table 2), but due to the low average air temperature, a delay of sprouting was observed in the first week after pruning.

The time and intensity of fruiting pruning influenced the botanical characteristics evaluated after pruning. The effect of the interaction between the number of shoots, the number of established branches, the number of productive branches and the number of fruits per pruned branch (Tables 3 and 6).

Table 3. Interactions between seasons and fruiting pruning intensities, according to the number of emitted sprouts (NBE), number of established branches (NRE) and number of productive branches (NRP) of guava tree cultivar "Paluma", Mossoró – RN, Brazil.

Pruning	NBE			NRE			NRP		
	Apr/13	Nov/13	Jul/14	Apr/13	Nov/13	Jul/14	Abr/13	Nov/13	Jul/14
Short	2.60 Ba	1.89 Bc	2.13 Bb	2.27 BAa	1.81 Bb	2.16 Ba	1.72 Aa	1.48 Aa	1.79 Ba*
Medium	2.82 Ba	2.10 Bb	2.03 Bb	2.59 Aa	2.01 Bb	2.03 Bb	2.08 Aa	1.60 Aa	1.66 Ba
Long	3.28 Aa	2.81 Aab	2.86 Aa	2.14 Bb	2.66 Aa	2.96 Aa	1.47 Ba	1.95 Aab	2.42 Ab

* Means followed by the same letter, uppercase in columns and lowercase in lines, are not different according to Tukey´s test at 5% of probability

The branches submitted to long pruning emitted higher number of shoots, regardless of the season (Table 3). This process can be explained by the fact that the branches submitted to long pruning have a longer length and, consequently, a higher number of buds after pruning. These results confirm those of Serrano et al. (2008) that regardless the pruning season, the plants submitted to the long pruning showed a greater number of shoots and established branches, while the plants submitted to short pruning presenting the lowest values for these characteristics.

For the number of established branches, it was observed that the long pruning performed in April presented lower number of branches when compared to the other fruiting prunings (Table 3). When the long pruning was carried out in November and July, it presented higher values when compared to the medium and short prunings (Table 4). According to Serrano (2007), it is possible to verify that the growth of the established branches submitted to long pruning indicates that the larger the reserve and the number of leaves kept in pruned branches, the greater will be the growth of the new branches, with a direct relation between the source and the drain in the same pruned branch.

It was also observed that the highest values for number of productive branches were when short and medium pruning was

performed in April. The long pruning performed in July resulted in higher averages than the other prunings (Table 4). When the pruning was carried out in November, no difference in the number of productive branches in relation to the intensity of fruit pruning was observed.

The average number of fruits per established branch, from the end of the anthesis to the beginning of the fruit maturation is presented in Table 4. Regardless the pruning intensity, it was verified that the highest values occurred in the branches submitted to the fruiting pruning in July. The increase in the number of fruits occurred in April at 90 and 105 DAA, probably due to the trend of flowering and natural fruiting of the guava tree which occurs in the winter.

An interaction was observed between the seasons and the fruiting pruning intensities for the number of fruits per established branch. In Table 6, the observed values for the three seasons and fruiting pruning are presented.

Table 4. Average number of fruits per pruned branch of "Paluma" guava trees submitted to different seasons and intensities of fruit pruning, in Mossoró – RN, Brazil.

	Days after the end of anthesis (DAA)						
TREATMENTS	**15**	**30**	**45**	**60**	**75**	**90**	**105**
PRUNING							
Short	2.93 AB	2.3 A	2.1 A	2.1 A	2.41 A	2.33 A	2.04 B*
Medium	3.17 A	2.27 A	1.98 A	2.12 A	2.07 B	2.15 A	2.12 B
High	2.42 B	1.99 B	1.7 B	1.18 B	2.05 B	1.9 B	2.38 A
SEASON							
Apr/13	2.39 B	1.89 B	1.8 B	1.99 B	2.03 B	2.22 A	2.21 A
Nov/13	2.56 B	2.05 B	1.81 B	1.82 B	2.05 B	2.07 B	2.10 B
Jul/14	3.58 A	2.61 A	2.17 A	2.22 A	2.27 A	2.22 A	2.23 A

* Means followed by the same letter in columns are not different according to Tukey´s test at 5% of probability.

Table 6. Interaction between pruning inensities and pruning seasons for the number of fruits (NF) per pruned branch of "Paluma" guava trees, in Mossoró – RN, Brazil.

PRUNING	**NF**		
	Abr/13	**Nov/13**	**Jul/14**
Short	1.85 Ab	2.11 Aa	1.53 Cc*
Medium	1.92 Ab	2.13 Aa	1.90 Bb
Long	1.95 Ab	2.17 Aa	2.16 Aa

* Means followed by the same letter, uppercase in columns and lowercase in lines are not different according to Tukey´s test at 5% of probability.

It was verified that the long pruning performed in July resulted in a higher number of fruits in relation to medium and short prunings. In the prunings performed in April and November, there was no difference between the number of fruits among the types of pruning. This is most likely due to the fact that pruned branches at these seasons were not suitable for the type of pruning that they were submitted to. According to Serrano et al. (2008) the short or drastic pruning provides lower number of fruits per branch and lower fruit set in 'Paluma' guava trees.

Ramos et al. (2010), found a number of fruits per plant of 385 when evaluating the production and quality of 'Paluma' guava fruits, submitted to different pruning seasons in subtropical climate. Serrano et al. (2007) in Pedro Canário-ES, Brazil, observed higher number of fruits when performing long pruning.

The values observed in this study are within the range described by the authors mentioned above (Table 6).

It was observed that phase I of fruit growth occurred until 45 DAA, phase II, between 45 and 75 DAA, and phase III from 75 to 120 DAA (Table 3), which is equivalent to a period of 45 days in every season.

In prunings performed in April and July, the phase of rapid fruit growth (phase I) was shorter, while the slow growth stage (phase II) presented a longer duration, with a consequent delay in the beginning of fruit maturation (Table 3). The longer phase II duration of fruit growth of the pruned plants in April and July probably occurred due to the period of this phenophase, being observed from June and September,

whith the beginning of the drop in average air temperature (Figure 1). Serrano et al. (2007) verified that the "Paluma" guava tree submitted to different seasons and intensities of fruit pruning also presented an increase in the duration of the second stage of growth of the fruits, when they developed during the winter period.

The pruning season did not influenced the fruit length at 105 DAA (Table 7). As the "Paluma" guava cycle was higher when pruning was performed in April (Table 3), the fruits produced at this time showed growth up to 120 DAA.

There was no difference in fruit length regarding the type of pruning (Table 7), corroborating with Serrano et al. (2007) who also did not verify differences in any interval of evaluation regarding the fruit length and pruning intensity. Mika (1986) observed that more severe prunings cause a decrease in the number of fruits and, as a result, an increase in the size of the fruits occurs due to the increase in the relation between source (leaf) and drain (fruit). This behavior is commonly observed when the same pruning method is adopted for all plant branches.

Table 7. Fruit length (mm) of "Paluma" guava trees, submitted to different seasons and intensities of fruit pruning, in Mossoró – RN, Brazil.

	DAYS AFTER THE END OF ANTHESIS (DAA)						
TREATMENTS	**15**	**30**	**45**	**60**	**75**	**90**	**105**
PODA							
Short	16.86 A	24.48 B	33.17 B	36.26 A	38.51 B	40.91 A	42.15 B*
Medium	16.49 A	26.21 BA	35.50 BA	57.52 A	39.99 BA	43.77 A	44.15 AB
Long	17.86 A	30.74 A	39.32 A	42.82 A	41.94 A	41.32 A	46.85 A
SEASON							
Apr/13	16.4 A	25.85 A	32.59 B	55.62 A	39.95 A	43.16 A	43.56 A
Nov/13	16.44 A	27.79 A	37.70 A	39.17 A	39.62 A	44.08 A	44.33 A
Jul/14	18.27 A	27.79 A	37.70 A	41.78 A	40.88 A	44.74 A	45.27 A

* Means followed by the same letter in columns are not different according to Tukey´s test at 5% of probability.

In the present study the pruning was performed according to the individual diameter of each branch. Thus, the plant did not become completely defoliated, probably providing a faster recovery due to the adjustment in the balance between source and drain.

There was no interaction for fruit diameter between the seasons and the pruning intensities. The fruit diameters in all evaluated intervals showed no diferences according to pruning intensities or seasons (Table 8). At 120 DAA, fruits produced from pruning in April (longer cycle) resulted in an average of 52.04 mm, which is lower than those observed for prunings in November and July (shorter cycle), with averages of 66.38 mm and 64.61 mm, respectively.

Ramos et al. (2010) observed differences in transverse diameters for plants without pruning (6.35 cm) compared to those pruned in October (6.68 cm), affirming that research studies gives guava tree growers practical answers, since the pruning can be indicated for the production of table guava, when the fruit size is a requirement of the consumer market.

Table 8. Fuit diameter (mm) from "Paluma" guava trees submitted to frutification pruning in different seasons and intensities. Mossoró – RN, Brazil.

	DAYS AFTER THE END OF ANTHESIS (DAA)						
TREATMENTS	**15**	**30**	**45**	**60**	**75**	**90**	**105**
PRUNING							
Short	13.59 A	21.67 A	28.78 A	32.26 A	32.85 A	36.14 B	36.34 B*
Medium	10.87 AB	28.19 A	29.23 A	32.29 A	32.90 A	37.02 AB	37.10 AB
Long	12.40 A	23.23 A	30.13 A	32.77 A	34.25 A	39.06 A	38.61 A
SEASON							
APr/13	12.17 A	27.32 A	27.67 A	31.30 A	33.27 A	36.81 A	36.89 A
Nov/13	12.51 A	22.86 A	30.24 A	32.13 A	33.31 A	37.54 A	37.32 A
Jul/14	12.17 A	22.86 A	30.24 A	33.89 A	33.42 A	37.88 A	37.84 A

* Means followed by the same letter in columns are not different according to Tukey´s test at 5% of probability.

Long pruning resulted in fruits above the avarage of fruit weight and short pruning of an average of 209.15 g/fruit, a different result than that observed by Serrano et al. (2007), which verified that despite the pruning season, the plants submitted to short pruning showed the lowest yields and number of fruits per plant; however, produced the heaviest fruits. This fact probably occurred because the branches submitted to long pruning were not physiologically adequate for this type of pruning, since in this study the thickness of the branch was not considered, so that pruning did not have the expected effect (Table 2). The plants pruned in November and July resulted in higher average of fruit weight, with 174.14g for the two seasons, and lower average was observed for plants pruned in April, with 118.98g (Table 9).

The highest production were observed in trees with long prunings performed in April and November with 41.53 kg / plant and 68.95 kg / plant, with yields of 17,318 kg ha^{-1} and 28,752 kg ha^{-1}, respectively, above the values observed for medium and short prunings. For prunings performed in July, the medium pruning resulted in higher values than the long and short prunings, with poduction of 43.71 kg / plant and yield of 18,228 kg ha^{-1} (Table 10).

Table 9. Average fruit weight (g) of "Paluma" guava trees submitted to different seasons and intensities of fruit pruning, in Mossoró – RN, Brazil.

	PMF		
PRUNING	**Short**	**Medium**	**Long**
	126.86 b	131.25 b	209.15 a*
SEASON	Apr/13	Nov/13	Jul/14
	118.98 b	174.14 a	174.14 a

* Means followed by the same letters in lines are not different according to the Tukey´s test at 5% of probability.

Table 10. Production (Kg/plant) and Yield (Kg ha^{-1}) of guava tree "Paluma", submitted to different seasons and intensities of fruit pruning in Mossoró – RN, Brazil.

PRUNING	**PRODUCTION**			**YIELD**		
	Apr/13	**Nov/13**	**Jul/14**	**Apr/13**	**Nov/13**	**Jul/14**
Short	18.48 Bc	44.58 Ba	34.32 Bb	7.706.53 Bc	18.887.81 Ba	14.312 Bb*
Medium	24.42 Bb	43.71 Ba	43.71 Aa	10.181.93 Bb	18.228.95 Ba	18.228 Aa
Long	41.53 Ab	68.95 Aa	34.75 Bb	17.318.74 Ab	28.752.76 Aa	14.491.62 Bb

* Means followed by the same letter, uppercase in columns and lowercase in lines, are not different according to Tukey´s test at 5% of probability.

According to (Medeiros, 2012), when evaluating pruning seasons and intensities in the production and quality of guava fruits in Quixeré, CE, Brazil, it was observed a higher production in long pruning for the three pruning seasons (November / 2010, March / 2011 and February / 2012), with values of 209.1, 140.47 and 115.12 kg / plant, respectively. This production is justified because the plants were in a full production period (8 years), unlike the present study, in which the plants present 4 years.

The decrease in plant production with the April pruning was mainly due to the decrease in the number of fruits produced, as well as the average weight of the fruits (Table 6 and 9). Hojo et al. (2007) observed this same relation for "Pedro Sato" guava trees, in Lavras, MG, Brazil, where the plants that presented the highest production also presented fruits with lower fresh mass. This behavior is commonly observed when the same type of pruning in all plant branches is adopted.

Conclusions

Under the conditions of the study developed in Mossoró, RN, Brazil, it can be concluded that:

The long prunning resulted in highest number of fruits, for all evaluated seasons.

The best season for pruning was the months of November and July.

The range of the "Paluma" guava tree cycle, from pruning to harvest, varies according to the season of fructification pruning, from 132 days in July to 150 days in April.

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