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Sucker pruning management to change the harvest date in banana

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Abstract

Managing seasonal production variations is sometimes necessary for banana plantations. The objective of the present study was to evaluate the effect of a modified pruning, with selection of later successor suckers for the production units, on the growth, harvest time, and bunch weight of 'Prata' and 'Nanica' banana plants, when compared to conventional pruning. A completely randomized experimental design was used, with two treatments and ten replicates for the conduction of two experiments, one for each cultivar. The treatments consisted of conventional pruning and modified pruning (selection of later successor suckers). Conventional pruning was carried out maintaining the successor sucker (daughter plant), whose growth was evaluated until the flowering stage. Modified pruning was carried out with the removal of the successor sucker (daughter plant) after the flowering of the mother plant, and the subsequent successor sucker (granddaughter plant) was selected and grown as the daughter plant. The growth of the first and second suckers were quantified at intervals of approximately 60 days and the bunch weight and other production variables were determined. The pruning reduced the height and pseudostem perimeter of the first successor sucker and delayed the harvest time in at least 30 days without reducing bunch weight of both banana cultivars. The mean yields were 26.68 and 50.64 Mg ha^{-1} for the 'Prata' and 'Nanica' banana, respectively, regardless of the pruning management used. The second sucker of 'Nanica' banana presented a residual effect of the pruning on plant height, but not on production. The use of the modified pruning is feasible for changing harvest time of both cultivars. However, repeatedly use of this technique for the same production unit is not recommended, since it affects the height of the second successor sucker.

Keywords: *Musa* spp., 'Prata'; 'Nanica', desuckering, production management

Introduction

Banana is worldwide grown in tropical and subtropical countries and is the third most produced fruit in the world, with a production of 113.9 million Mg (FAOSTAT, 2020). It is one of the most consumed fruit in the world and one of the few fruits available all year round.

Banana and plantain plants are giant perennial herbs that have underground stems (rhizomes), which produce suckers (ramets) from lateral buds to ensure the next generation (Turner et al., 2020). The main developmental stages of banana plants include sucker emergence, flowering, and maturation (Tixier et al., 2007).

The suckers of banana and plantain plants are individual plants that develop at different speeds and do not follow a synchronous cycle (Turner et al., 2016).

Sucker pruning is carried out to select one of the emerging suckers at the base of the parent plant (Dorel et al., 2016); the largest sucker is selected at harvest as the plant that will produce the bunch in the following production cycle (Norgrove & Hauser, 2014; Dorel et al., 2016). The selection of vigorous suckers, combined with pruning of competing suckers (desuckering) is a key practice to control the number of production units in successive ratoon crops (Irizarry et al., 1992; Luo et al., 2018).

Management practices affect development and can adjust yield components, plant morphology and, thus, the agronomic performance of banana cultivars by modifying the source to sink ratio (Dens et al., 2008). The management of seasonal production variations for a better match of critical development phases with appropriate seasons (Turner et al., 2016) and marketing, can be done by selecting the planting time (Turner et al., 2016), younger or older suckers (Tixier et al., 2007), and defoliation (Turner & Hunter, 1987).

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Sucker pruning management affect the time for the next crop and can minimize impacts of unfavorable climate conditions on plant productivity (Turner et al., 2020) and fruit quality and oversupply of fruits in the market.

One of the most important banana-producing regions in Brazil is the Vale do Ribeira, in southern São Paulo state, whose target market is the metropolitan region of São Paulo city, which has approximately 21.2 million inhabitants, and is one of the ten most populous metropolitan regions in the world (Coltro & Karaski, 2019). This region presents a predominance of marginal tropical climate, which is characterized by occurrences of cold fronts in the autumn and spring and low photoperiod and frequency of clear sky days (Lima et al., 2019). Low temperatures increase the time for bunch emergence and production seasonality, thus affecting the supply of fruits to the market (Cottin et al., 2007).

Focused on change harvest time, the objective of the present study was to evaluate the effect of a modified pruning, with selection of the later successor suckers for the production units, on the growth, harvest time, and bunch weight of 'Prata' and 'Nanica' banana plants, when compared to conventional pruning.

Materials and Methods

The research was conducted at two commercial production farms in the municipality of Registro, state of São Paulo, Brazil (24º29'15''S, 47º50'37''W, and altitude of 25 m). The region presents an Af climate, tropical rainy without dry season, according to the Köppen classification (Alvares et al., 2013); however, it is considered as a marginal tropical climate due to the proximity to temperate climate regions (Lima et al., 2019). The predominant soil of the region was classified as a Cambissolo Haplico (Typic Dystrudept), according to the Brazilian Soil Classification System (Embrapa, 2013). 'Prata' banana (*Musa* spp. AAB group Prata subgroup, Prata cultivar) was planted in 2011 with density of 1,333 plants ha^{-1} and 'Nanica' banana (*Musa* spp. AAA group, Cavendish subgroup, Nanica cultivar) was planted in 2011 with density of 1,600 plants ha^{-1}, both using pest-free tissue-cultured banana seedlings.

A completely randomized experimental design was used, with two treatments and ten replicates (one plant each) for the conduction of two experiments, one for each cultivar. The treatments consisted of conventional pruning and modified pruning (selection of later successor suckers). The experiments begun in September for both managements, when the parent plant was at the reproductive stage. Conventional pruning was carried out maintaining the successor sucker (daughter plant), whose growth was evaluated until the flowering stage. The selection for the successor sucker was carried out considering a minimum width of 10 cm for the youngest fully expanded leaf, and the sucker position (direction) within the production unit. Modified pruning was carried out with the removal of the successor sucker (daughter plant) by destroying its apical meristem and evaluation of the emerged subsequent successor sucker (granddaughter plant), at approximately 60 days later, which was grown as the daughter plant.

Regardless of the pruning management, one additional successor plant (granddaughter plant) was selected and evaluated until the flowering stage to assess the pruning residual effect.

Plant height, pseudostem perimeter at 20 cm height, and leaf emission were evaluated every 60 days for the first (daughter plant) and second suckers (granddaughter plant), maintaining the conventional pruning in plants of both treatments. The fruit harvest was carried out adopting a minimum diameter of 30 mm for fruits of the last hand of the bunch. Total bunch weight and mean diameters and lengths of fruits of hand 1, hand 4, and last hand of each bunch were also determined. Climatic data were collected from a weather station at the São Paulo State University, Registro campus. Thermal sum, expressed as degree-days, was calculated using 13.9 °C as the base temperature (Umber et al., 2011).

Statistical analysis was carried out using the Sisvar program (Ferreira, 2011). The means were compared using the Tukey's test ($p \leq 0.05$). Regression analyses, with linear, quadratic, or cubic models were used to determine the response of the variables: height, pseudostem perimeter, and leaf emission over time. Regional mean prices were obtained from the Association of Banana Producers of the Vale do Ribeira (ABAVAR).

Results and Discussion

Cultivar Prata

In the modified pruning, the first successor sucker, evaluated at 70 days after pruning, showed plants with lower heights, pseudostem perimeters, and number of functional leaves than plants under conventional pruning (Figure 1). Plant height presented a linear growth over time under conventional pruning, and a quadratic growth under modified pruning (Figure 1). Plants under conventional pruning presented significant higher ($p<0.01$) mean height (4.24 m) than those under modified pruning (3.24 m) at the end of the vegetative cycle (Table 1)

Pseudostem perimeter of suckers over time fitted to a quadratic model for both pruning managements, whereas the number of functional leaves was linear (Figure 1). During the flowering stage, the sucker pruning managements presented different pseudostem perimeter, with 129.90 cm under conventional and 118.80 under modified pruning. No differences between the pruning managements were found for number of leaves, presenting a mean of 28 leaves at flowering (Table 1).

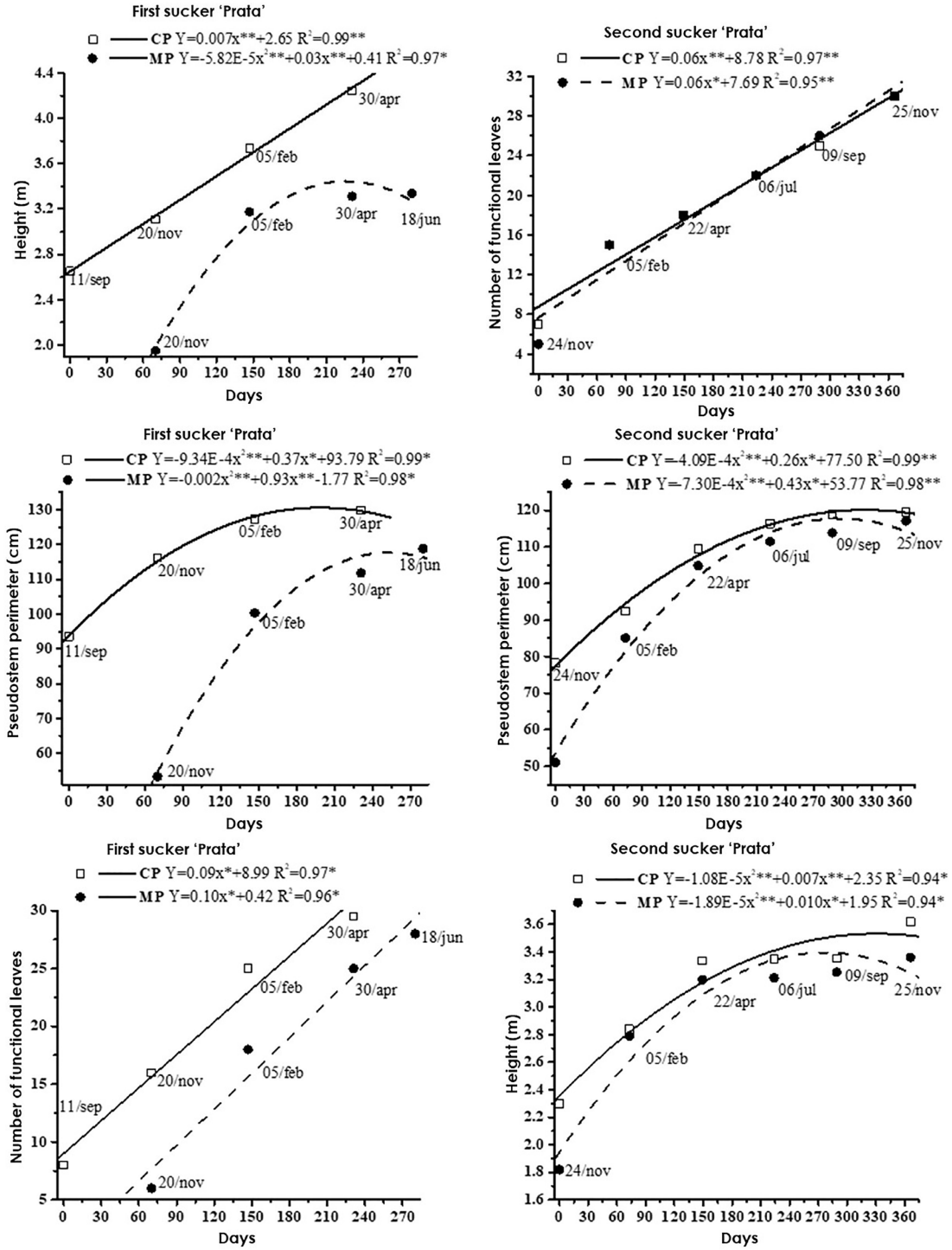

Figure 1. Vegetative characteristics of the first and second successor suckers of 'Prata' banana plants grown under conventional pruning (CP) and modified pruning (MP).

Table 1. Plant height (PH), pseudostem perimeter (PP), and number of leaves (NL) at flowering, vegetative cycle (VC), bunch weight (BW), reproductive cycle (RC) of the first and second successor sucker of 'Prata' banana plants grown under conventional pruning (CP) and modified pruning (MP).

	PH m	PP cm	NL	VC day	BM kg	RC day
			First sucker			
CP	4.24 A	129.90 A	28.00	231.00 A	20.69	129.00 A
MP	3.34 B	118.80 B	28.00	280.00 B	20.84	112.00 B
Mean	3.79	124.35	28.00	255.50	20.76	120.50
vc (%)	7.03	5.70	5.05	1.02	10.21	2.63
F	57.66**	15.61**	0.01^{NS}	1005.00**	0.02^{NS}	985.63**
			Second sucker			
CP	3.62	119.60	30.00	366.00	20.87	107.60
MP	3.36	117.20	30.00	366.00	19.21	112.80
Mean	3.49	118.40	30.00	366.00	19.54	110.20
vc (%)	8.86	4.97	3.85	0.00	12.95	9.63
F	3.48^{NS}	0.83^{NS}	0.001^{NS}	0.0001^{NS}	2.46^{NS}	1.20^{NS}

vc - coefficient of variation

*, p <0.05; **, p <0.01 and ^{NS}, not significant to F test.

The vegetative cycle presented a 49-day difference between plants of the two treatments (Table 1); the vegetative cycle conventional pruning extended until the end of autumn. However, the prevailing climate conditions, until the flowering stage, were similar in both pruning managements (Table 2). The mean total daily global radiation presented a difference of approximately 1 MJ day^{-1}, with small differences in air temperatures and relative humidity and daily water availability above 4 mm day^{-1}.

Table 2. Climate conditions in the vegetative and reproductive stages of the first successor sucker of 'Prata' and 'Nanica' banana plants grown under conventional pruning (CP) and modified (MP) pruning.

	Time day	Total radiation MJ m^{-2}	Precipitation accumulated mm	Tmax °C	Tmin °C	UR max %	UR min %	Thermal sum accumulated °day
			Vegetative cycle 'Prata' and 'Nanica'					
CP	232	4006.77	1183.12	29.81	20.16	95.44	56.02	2546.81
MP	281	4496.81	1372.61	29.09	19.55	95.66	57.36	2900.90
			Reproductive cycle 'Nanica'					
CP	129	1387.21	374.64	25.23	16.00	97.01	62.33	853.25
MP	113	1322.72	363.97	25.58	16.35	97.04	61.84	779.93
			Reproductive cycle 'Nanica'					
CP	114	1220.82	328.67	25.31	16.01	96.89	62.19	759.09
MP	106	1242.97	352.28	25.60	16.18	97.23	61.22	723.37

Temperature is the main factor that determines the development rate (Turner et al., 2016), which can be estimated by the thermal sum using the most appropriate base temperature (Fortescue et al., 2011), in the case of banana, 13.9 °C. Plants under conventional pruning had daily thermal sum in the vegetative cycle of 10.98 degree-days day^{-1}, and those under modified pruning, 10.32 degree-days day^{-1}, showing no significant difference. These findings denote that the longer time for flowering of plants under modified pruning was mainly due to the sucker size and physiological age of plants at the beginning of the experiment, and not due to the predominant climate condition in the growing period. According to Gillooly et al. (2001), plant growth and development are governed by the rate of metabolic processes, which are dependent on temperature and size (total dry weight). The main carbohydrate supply for the juvenile sucker growth is expected to come from the leaves of the current mother plant, because despite the rhizome of newly emerged suckers is already well established, first leaves are long and narrow with little leaf area (Turner et al., 2020) and are under the apical dominance of the parent plant (Donato et al., 2021).

The reproductive cycle (flowering to maturation) of the first sucker was 17 days shorter for plants under modified pruning, when compared to those under conventional pruning, coinciding with early spring, which presents slightly higher temperatures and longer photoperiod (Table 2). Bunch weight was similar between pruning managements, with mean of 20.76 kg plant^{-1} (Table 1), representing a production of 26.68 Mg ha^{-1} of fruits, which is well above the mean production reported

by Coltro and Karaski (2019) for the same region. The number of fruits per hand and mean diameters and lengths of the fruits of hand 1, hand 4, and last hand of the bunch was similar between pruning managements in both production cycles. This lack of differences in fruit yield between sucker pruning managements is probably a response of plants that is more related to climate conditions during bunch formation than to the physiological capacity of plants. The number of functional leaves, which denotes the ability of plants to generate photoassimilates (source) was similar between plants of both treatments (Table 1). Therefore, the sucker pruning managements had no effect on bunch weight of the first successor sucker of 'Prata' banana plants, but affected the harvest time, with a delay of 32 days under modified pruning, when compared to that under conventional pruning (Table 1).

The growth analysis of the second successor sucker indicated, initially, that plants under modified pruning were smaller in size and had two less leaves than plants under conventional pruning (Figure 1); however, these differences were not significant at flowering (Table 1). The vegetative cycle times were similar between plants in the two sucker pruning managements (366 days), as well as the reproductive cycle (110.20 days) and bunch weight (19.54 kg plant^{-1}). This shows that the modified pruning did not affect the development of the second successor sucker of 'Prata' banana.

Cultivar Nanica

The increases in pseudostem perimeter of the first successor fitted to a quadratic model, and plant height and leaf emergence fitted to a linear model for both pruning managements (Figure 2). The plants growth delayed under modified pruning because they were younger suckers at the beginning of the experiment.

The vegetative cycle of plants under modified pruning was longer than that of plants under conventional pruning, with means of 280 days and 231 days, respectively (Table 3), similar that shown by the 'Prata' banana cycle (Table 1), whose climate variations in the period are presented in Table 2.

This denoted a longer time between juvenile and adult-reproductive stage for plants under modified pruning, which exhibited lower heights, pseudostem perimeters, and numbers of functional leaves at flowering (Table 2). The time between bunch emission and harvest (reproductive cycle) of plants under modified pruning was shorter than that of plants under conventional pruning, which showed means of 105 and 113.60 days, respectively (Table 3). However, bunch weight was similar between plants in the two sucker pruning managements, with a mean of 31.65 kg plant^{-1}, which indicates a production of 50.64 Mg ha^{-1} of fruits, well above the production reported by Coltro and Karaski (2019).

The mean fruit diameters and lengths of hand 1, hand 4, and last hand of the bunch of the two managements were similar. However, the number of fruits in the last hand of the bunch was higher in the first cycle for plants under conventional pruning, and in the second cycle for plants under modified pruning. This difference did not exceed one fruit and did not significantly affect the hand weight.

In the modified pruning, the bunches were developed under high solar radiation and precipitation and slightly higher maximum and minimum temperatures (Table 2), which results in more favorable thermal sum and conditions for dry matter accumulation, and explains the 8 days lower reproductive cycle; although plants had two less leaves at flowering than plants under conventional pruning (Table 3). Regarding the total plant cycle, the pruning of 'Nanica' banana plants delayed the harvest in 41 days. 'Nanica' is a more cold-sensitive cultivar, thus, plants under modified pruning emitted inflorescences in June rather than in late April, reducing fruit exposure of fruits to cold temperatures (<12 °C), that are frequent in the region (Lima et al., 2019).

The analysis of the vegetative characteristics of the second successor sucker (second daughter) at the beginning of their growth showed that plants under modified pruning presented smaller heights and pseudostem perimeters, but similar number of leaves, when compared to plants under modified pruning (Figure 2). Plants under modified pruning maintained higher heights at flowering (Table 3). The vegetative cycle of plants under both sucker pruning managements was similar (289 days), as well as the bunch weight (29.66 kg plant^{-1}).

The effect of the modified pruning on the growth of the first sucker, mainly on plant height and pseudostem perimeter, up to the second sucker in the case of 'Nanica' banana, was also observed in other study (Bittebiere & Mony, 2015). Sucker pruning reduces competition for light between mother plant and sucker (Dorel et al., 2016), which explains the higher growth of successor plants.

Removing all suckers during bunch growth could favor photoassimilates allocation to bunches and increases in fruit size and bunch weight (Dorel et al., 2016). According to Dorel et al. (2016), modifying the source to sink ratio by preventing sucker growth until the harvest of the mother plant can delay the onset of the

sucker growth, which probably occurred in this study The main drain became the bunch under modified pruning, whereas the mother plant and first sucker are the main drains in the conventional pruning.

Furthermore, this sucker pruning management prevents the growth of suckers until the harvest of the mother plant to reduce light competition and, consequently, change plant morphology, mainly by reducing plant size (Bittebiere & Mony, 2015; Dorel et., 2016). The reduction in plant height and pseudostem perimeter due to the pruning was similar for both cultivars (Tables 1 and 2). Low plant height is desirable because it favors bunch harvesting operations. This response may be due to a reduction in vigor, denoting that the modified pruning should not be applied repeatedly in the same production unit.

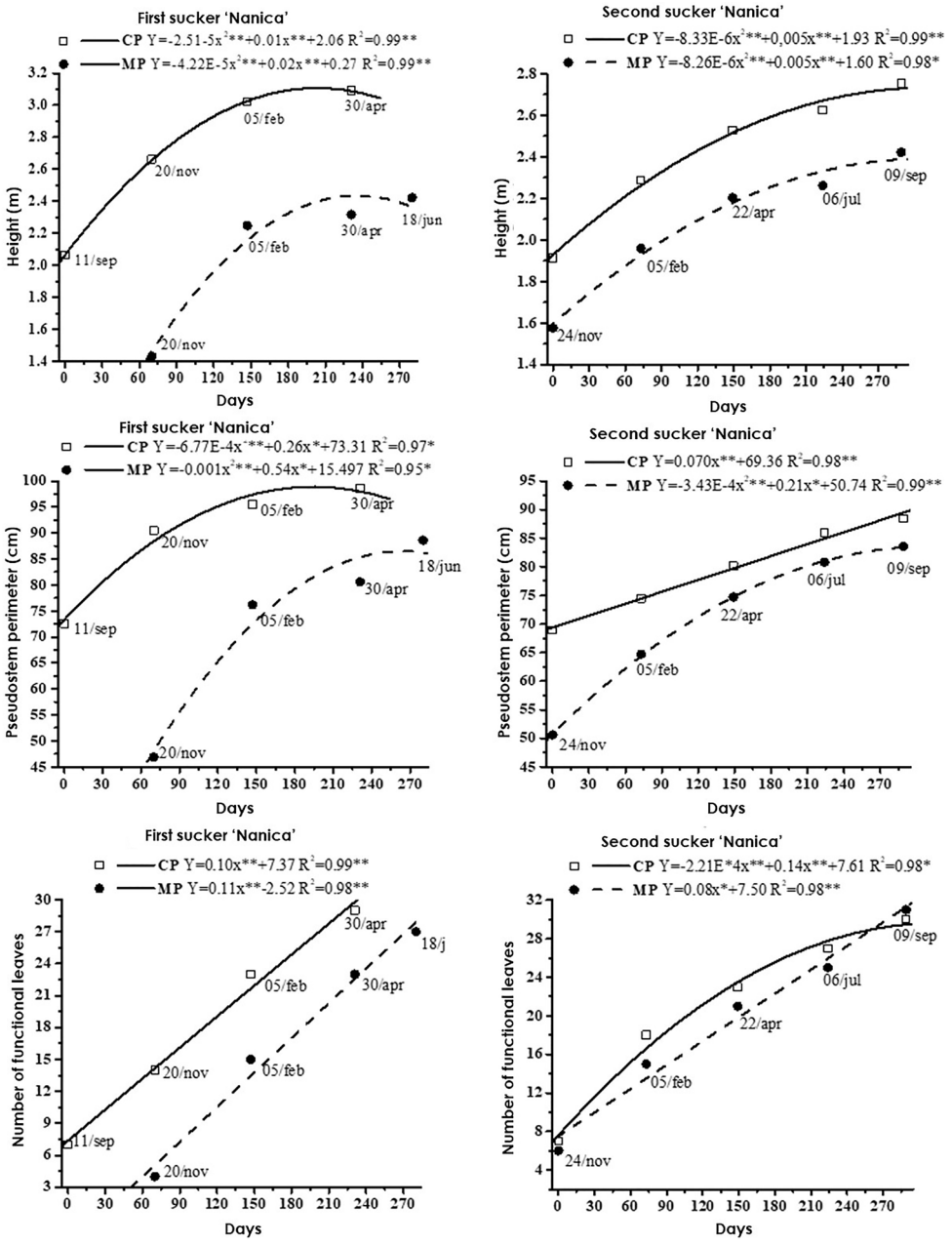

Figure 2. Vegetative characteristics of the first and second successor suckers of 'Nanica' banana plants grown under conventional (CP) and modified pruning (MP).

Table 3. Plant height (PH), pseudostem perimeter (PP), number of leaves (NL) at flowering, vegetative cycle (VC), bunch weight (BW), reproductive cycle (RC) of the first and second successor sucker of 'Nanica' banana plants grown under conventional pruning (CP) and modified pruning (MP).

	PH m	PP cm	NL	VC Day	BM kg	RC day
			First sucker			
CP	3.09 A	98.60 A	29.00 A	231.00 B	32.62	113.60 A
MP	2.42 B	88.60 B	27.00 B	280.00 A	30.68	105.00 B
mean	2.76	93.60	28.00	255.50	31.65	109.30
vc (%)	7.40	5.81	5.05	0.09	6.71	2.18
F	53.57**	16.89**	10.00**	0.01^{NS}	4.16^{NS}	65.04**
			Second sucker			
CP	2.75 A	88.40	30.00	289.00	28.95	108.60
MP	2.42 B	83.56	31.00	289.00	30.36	104.40
mean	2.45	85.98	30.50	289.00	29,66	106,50
vc (%)	7.40	9.69	0.73	0.00	0.54	8.19**
F	53.57*	1.69^{NS}	1.81^{NS}	0.00^{NS}	4.22^{NS}	3.30^{NS}

vc - coefficient of variation

*, p <0.05; **, p <0.01 and ^{NS}, not significant to F test.

The modified pruning did not affect the production, probably because it did not significantly affect the photosynthetic capacity of the successor plant, although the vegetative and reproductive cycles varied due to the impact of the management on physiology, and climate conditions. However, the economic yield was affected by the price at the harvest time for the 'Prata' banana, showing means of R$ 26.72 plant^{-1} for conventional, and R$ 21.66 plant^{-1} for the modified pruning, which were partly due to a difference of R$ 0.30 Kg^{-1} in the banana price at harvest. 'Nanica' banana presented no differences in estimated economic yield between treatments, with a mean of R$ 34.36 plant^{-1}, and a difference in price between the two harvests of only R$ 0.05 kg^{-1}.

Conclusions

The use of modified pruning for 'Prata' and 'Nanica' banana cultivars reduces plant size and delays harvest time of the first sucker in at least 30 days, without affecting the yield. However, repeatedly use of this technique for the same production unit is not recommended, since it affects the height of the second successor sucker.

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