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SCIENTIFIC COMMUNICATION

CHANGES IN THE CHARACTERISTICS OF 'PRATA' BANANA TREATED WITH CYTOKININ AND GIBBERELLIN [1]

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ABSTRACT- Plant growth regulators can influence fruit yield and quality. This study aimed to evaluate the effect of cytokinin and gibberelin on the agronomic and physicochemical characteristics of banana fruits cv. 'Prata' (*Musa* spp. AAB), according to the formation period and position in the bunch. The experiment was conducted in a completely randomized 2 x 5 factorial design, two periods of bunch development (summer and winter), five treatments and ten replicates. To study the effect of position in the bunch, split plot was adopted, considering in the plot, 2 x 5 factorial and in subplots, hand 1, hand 4 and last hand. Treatments consisted of 2 pulverizations with water, 150 mg L^{-1} cytokinin, 200 mg L^{-1} of gibberellic acid, 100 mg L^{-1} of cytokinin plus 200 mg L^{-1} of gibberellic acid and 200 mg L^{-1} of cytokinin plus 200 mg L^{-1} of gibberellic acid, applied from the fourth to the last hand of the bunch. Cytokinin and gibberellin, alone or associated, regardless of formation period and position, did not affect the size and physicochemical characteristics of fruits, only delayed the bunch harvest.
Keywords: *Musa* spp., plant growth regulators, yield, quality.

ALTERAÇÕES NAS CARACTERÍSTICAS DA BANANA-'PRATA' TRATADA COM CITOCININA E GIBERELINA

RESUMO - Reguladores vegetais podem influenciar na produção e na qualidade do fruto. O objetivo do estudo foi avaliar o efeito de citocinina e giberelina nas características agronômicas e físico-químicas de frutos de banana 'Prata' (*Musa* spp. AAB), em função do período de formação e posição no cacho. Adotou-se o delineamento inteiramente casualizado, em esquema fatorial 2 x 5, dois períodos de formação do cacho (verão e inverno) e cinco tratamentos e dez repetições. Para estudo do efeito da posição no cacho, adotaram-se parcelas subdivididas, considerando na parcela o esquema fatorial 2 x 5, e na subparcela, a penca 1, penca 4 e última penca. Foram duas pulverizações com água, 150 mg L^{-1} de cinetina, 200 mg L^{-1} de ácido giberélico (AG_3), 100 mg L^{-1} de cinetina mais 200 mg L^{-1} de AG_3 e 200 mg L^{-1} de cinetina mais 200 mg L^{-1} de AG_3, da quarta penca até a última penca do cacho. Citocinina e giberelina, isoladas ou associadas, independentemente do período de formação e posição, não afetam o tamanho e as características físico-químicas do fruto, apenas atrasam a colheita do cacho.
Termos para indexação: *Musa* spp., reguladores vegetais, produção e qualidade.

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Banana has a wide variation in size depending on the position that the fruit occupies in the bunch. Bunches located at the base contain fruits 30-40% larger than those located in the apex (JULLIEN et al., 2001), and this gradient is detrimental because the bunch is harvested whole. Competition for photoassimilates during cell division, the first phase of fruit formation, is the major cause of the problem (JULLIEN et al., 2001), and as this process is regulated by hormones, it can be controlled with plant growth regulators (ZHANG ;WHITING 2013).

Exogenous cytokinin induces parthenocarpy and promotes cell division in the tissue of various fruits (AINALIDOU et al, 2015), while gibberellin stimulates cell expansion (ZHANG; WHITING, 2013). Both hormones exhibit synergistic effect in the growth of cherry fruits (ZHANG; WHITING, 2013).

In banana, 100 mg L^{-1} of cytokinin CPPU immediately sprayed and one month after the emergence of the last hand in the bunch, induced greater size and soluble solids content in fruit pulp (HASSAN et al., 2009), while 200 mg L^{-1} gibberellin applied in the bunch at seven and thirty days after emergence increased fruit size and weight and hence production (KUMAR et al., 2011). More recently, Biwas and Lemtur (2014) found that the application of 50 mg L^{-1} of gibberellin in the bunch one month after emergence increased the weight of bunches and hands, as a result of increased fruit size. The aim of this study was to evaluate the effect of cytokinin and gibberellin on the agronomic and physicochemical characteristics of banana fruits cv. 'Prata', according to the formation period and position in the bunch.

The experiment was conducted in a 5-year-old production area of "Prata" cultivar (*Musa* spp. AAB) in Registro -SP (24º 28 '17"S, 47 50' 39"W, 20 m asl), whose soil was clayish Oxisol, Typic Hapludox, and the climate was humid tropical without dry season, according to Köeppen. A completely randomized design in a 2 x 5 factorial was adopted, two periods of bunch development (summer and winter), five treatments and ten replicates. To study the effect of position in the bunch, split plot was adopted, considering in the plot, 2 x 5 factorial design and in subplots, hand 1, hand 4 and last hand. Regulators were dissolved in water at concentrations of 150 mg L^{-1} kinetin (CIT 150); 200 mg L^{-1} AG_3 (GA 200); 100 mg L^{-1} kinetin plus 200 mg L^{-1} AG_3 (CIT 100 + GA 200) and 200 mg L^{-1} kinetin plus 200 mg L^{-1} AG_3 (CIT 200 + GA 200). To all solutions, 0.1% of nonionic emulsifier Tween 20 was added and 120ml were applied from the fourth to the last hand in the bunch after the opening of inflorescence bracts in the summer, on 12.21.12 and 01.27.13, and in the winter, on 06/17/13 and 07/28/13.

Harvest was performed when fruits of the last hand reached 30 mm in diameter and the number of hands, weight of bunch, stalk, hand 1,hand 4 and the last hand of the bunch were determined, and in these, the number, diameter and size of fruits. The 4th hand was stored at 25°C until fruits reached completely yellow skin color when they were evaluated for: post-harvest period; b) weight loss; c) firmness with portable penetrometer; d) pH; e) titratable acidity in pH meter (AOAC, 1997); f) soluble solids in digital refractometer (TRESSLER; JOSLYN, 1961), and g) skin color with colorimeter. Weather data were collected and thermal sum was calculated by adopting 14°C as basal temperature (GANRY; MEYER, 1975). Data were submitted to analysis of variance and treatment means to the Tukey's test.

The filling time in the winter was 32 days higher than in the summer, while the bunch weight was 3.1 kg lower due to differences in climate variables. In the summer, the average maximum and minimum temperatures were, respectively, 30.1 and 20.6°C, while in the winter, 23.7° C and 14.4°C. Precipitation and accumulated radiation in the summer were 602.6 mm and 21.4 MJ m^{-2}, and in the winter, 458.2 mm and 15.1 MJ m^{-2}.

Once bunches formed in both periods did not differ on the number of hands, weight differences are due to differences in the weight of stem and hands (Table 1). Bunches formed in the summer had higher weight in hand 1 due to the increased number and size of fruits. However, in bunches formed in the winter, the number of fruits in hand 4 and in the last hand was greater than in the summer, while the average diameter of fruits was higher in the summer compared with winter. However, there were no differences between periods for weight of hand 4 and the last hand of the bunch.

Plant growth regulators influenced only the filling time, according to the bunch formation period. In the summer, there were no differences between treatments, while in the winter, bunches treated with 150 mg L^{-1} cytokinin showed longer filling time, followed by 100 mg L^{-1} cytokinin + 200 mg L^{-1} gibberellic acid and 200 mg L^{-1} cytokinin + 200 mg L^{-1} gibberellic acid, which did not differ from each other, then, 200 mg L^{-1} gibberellic acid, and finally water. Compared to water, plant growth regulators extended the filling phase from 5 to 19 days.

Cytokinin regulates the source / drain

activity among tissues, influencing both the flow of phytoassimilates as nutrients, which also helps to justify its application in the last hands (ZALABÁK et al., 20013). Gibberellin interferes in the allocation of carbohydrates in fruit tissues (ZHANG; WHITING, 2013).

The lack of effect of plant growth regulators, in particular gibberellic acid in concentrations and application frequency similar to those used by Kumar et al., (2011), can be attributed to the physiological state of fruits due to the weather condition, to plant limitation in the production of photoassimilates, even through the drain strength was high. In the winter, the deficit of carbohydrates could be attested by the lower bunch weight compared to summer, despite the same number of hands (drain) in both periods. Sprays were planned based on the results of Jullien et al., (2001) for the 'Grande Naine' cultivar, which found that cell division ceased to 350 degrees-day from the inflorescence issue in proximal fruits (hand 1) and 420 degrees-day in distal fruits (hand 7). In this study, sprays in the summer were performed at 140 to 539 degrees-day and in the winter at 109 and 238 degrees-day, indicating that at least one spray in the summer and two the winter were performed in the cell division stage in distal fruits.

The position in the bunch was the main cause of variation in the hand weight, number and size of fruits, in isolation or in interaction with the bunch formation period, without the influence of cytokinin or gibberellin. In the summer, there were decreases in the hand weight along the bunch of 21.54 and 22.80%, respectively, when comparing the weight of hand 1 and hand 4 and hand 4 with the last hand (Figure 1). The reduction in the weight of hand 1 and hand 4 was only due to the reduction in the number of fruits, while when comparing the weight of hand 4 with the last hand, associated with reduced fruit size. In the winter, there was no difference in the hand weight, number and size of fruits of hand 1 and hand 4, only in size. The reduction in the number of fruits as a function of the hand position suggests limitation of photoassimilates in the differentiation of the inflorescence. For size, the difference between periods occurred only among fruits of hand 1, while for diameter, among fruits of hand 4 and last hand.

The post-harvest period was higher in the winter due to the lower metabolic intensity during fruit formation (Table 1). As a consequence, weight loss was higher in the winter than in the summer. Fruits formed in the winter also had more soluble solids and titratable acidity; however, lower firmness. Although differences in soluble solids and titratable acidity were not found, Kumar et al., (2011) detected, respectively, increase and decrease of these variables in banana treated with 200 mg L^{-1} of gibberellin.

Regardless of fruit formation period, Cytokinin and gibberellin do not affect the size and physicochemical characteristics of fruits, only delay the bunch harvest, which makes their use not recommended.

TABLE 1- Harvest and post-harvest characteristics of ripe 'Prata' banana fruits of hand 4 as a function of the fruit formation period.

	Harvest characteristics							
	BTF/day	BW/g	SW/kg	HN	WH1/kg	NFH1	LFH1/cm	DFH1/cm
Summer	113.5 b	21.2 a	2.6	8.41	2.5 a	19.9 a	19.6 a	3,4
Winter	146.0 a	18.1 b	2.1	8.50	2.0 b	17.3 b	18.6 b	3,4
F	880.0^{ns}	8.9**	15.5**	0.15^{ns}	8.6**	8.5**	6.4*	0,7^{ns}
Mean	129.7	19.7	2.4	8.45	2.2	18.7	19.1	3,4
vc (%)	3.3	18.5	19.8		16.5	17.4	7.6	7,2
	WH4/kg	NFH4	LFH4/cm	DFH4/cm	WLH/kg	NFLH	LFLH4/cm	DFLH/cm
Summer	2.0	14.9 b	18.6	3.5 a	1.5	13.9 b	16.7	3,5 a
Winter	1.8	16.3 a	18.3	3.4 b	1.5	15.2 a	16.2	3,3 b
F	3.3^{ns}	24.1**	1.0^{ns}	11.7**	0.6^{ns}	24.6**	3.0^{ns}	7,1**
Mean	1.9	15.6	18.4	3.5	1.5	14.5	16.5	3,4
vc (%)	15.6	7.4	7.3	6.6	12.9	6.8	7.2	6,0
	Post-harvest characteristics							
	PHP/days	WL/%	SS/ºBrix	TA/g mallic acid 100 g^{-1}		PF/N	L	Hº
Summer	7.0 b	3.8 b	22.7 b	0.8 b		10.7 a	73.8 a	89.9 a
Winter	15.8 a	4.9 a	24.8 a	0.9 a		9.0 b	72.6 b	87.6 b
F	143.7**	6.9*	20.3**	17.3**		7.7*	13.9**	105.0**
Mean	11.4	4.3	23.7	0.9		9.9	73.2	88.8
vc (%)	19.1	26.2	15.8	12.0		16.9	1.7	0.9

Bunch weight (MC); stem weight (ME); weight of hand 1 (MP1); number of fruits in the hand (1 NFP1); size of fruits in hand 1 (CFP1); Bunch filling time (BFT), bunch weight (BW), stalk weight (SW), hand number (HN), weight of hand 1 (WH1); number of fruits in the hand 1 (NFH1); length of fruits in hand 1 (LFH1); diameter of fruits in hand 1 (DFH1); weight of hand 4 (WH4); number of fruits in hand 4 (NFH4); length of fruits in hand 4 (LFH4); diameter of fruits in hand 4 (DFH4); weight of last hand (WLH); number of fruits in the last hand (NFLH); length of fruits in the last hand (LFLH); diameter of fruits in the last hand (DFLH); post-harvest period (PHP); weight loss (WL); soluble solids (SS); titratable acidity (TA); pulp firmness (PF); lightness (L) and Hue angle (H^{o}).
In the column, means followed by different letters differ by the Tukey test, $p < 0.05$;
* Significant by the F test, $p < 0.05$; ** Significant by the F test, $p < 0.01$.

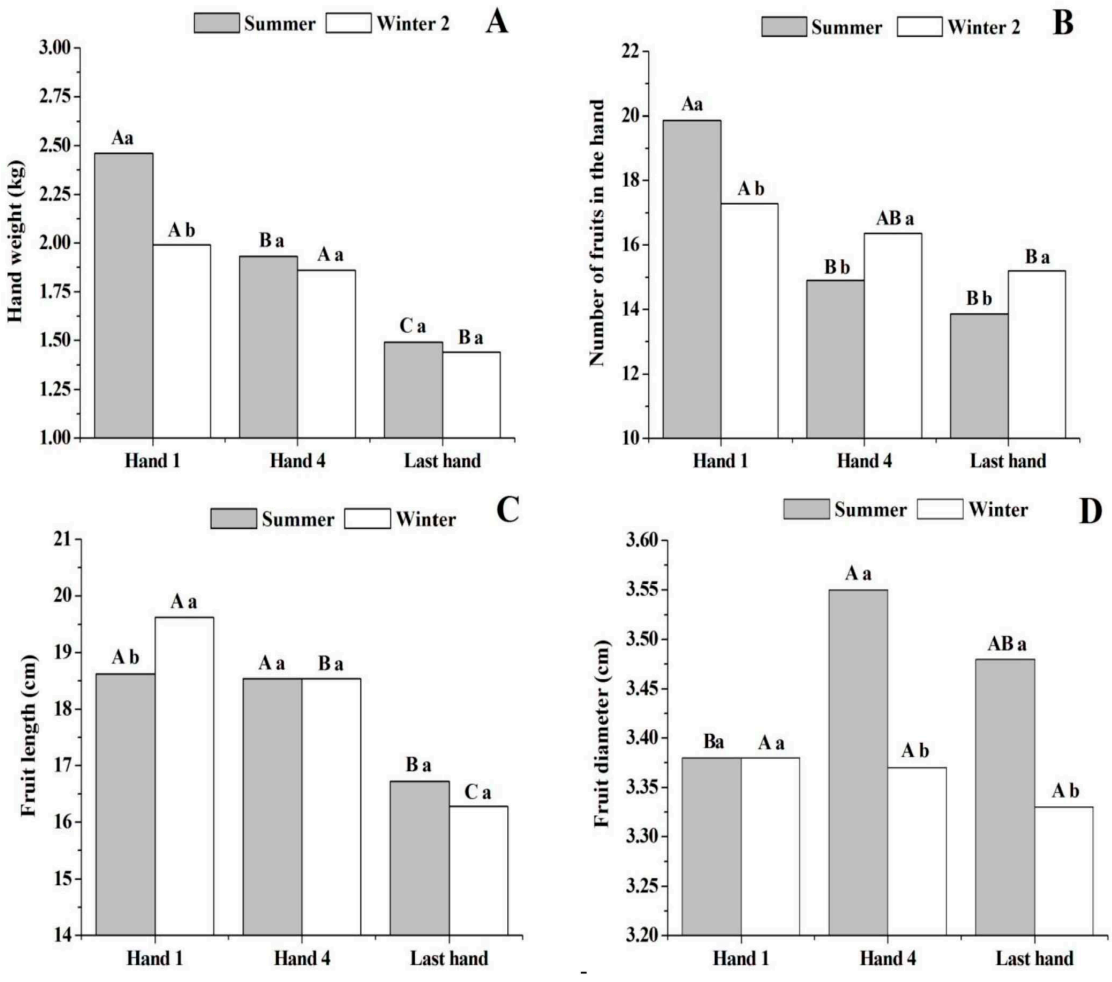

FIGURE 1-Effect of the bunch formation period and hand position in the bunch on the hand weight (A); number of fruits per hand (B) and length (C), and fruit diameter (D) of 'Prata' banana.

Means followed by different capital letters for hand position in the bunch and small letters for bunch formation period differ by the Tukey test, $p < 0.05$.

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