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Fungicides used on postharvest bananas

Fungicidas aplicados em pós-colheita de bananas

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Abastract. There is little information available on the postharvest behavior of bananas after the application of fungicides in the Registro-SP region. This study aims to evaluate the soluble solids (ºBrix), pH, and total acidity of the bananas after the application of fungicides. The experimental outline was completely randomized in a 4x2 fungicidal factorial with two concentrations for each fungicide and two degrees of maturity, plus control treatment using only water, repeated in each season. Each experiment had three replications with four tiers of five fruits. For refrigerated bananas, higher values of ºBrix were observed in fruits treated with Propiconazole and Imidazole. For non-refrigerated bananas, minor ºBrix values were observed for fruit treated with Azoxystrobin in autumn and lower pH values and higher acidity for bananas that were treated with Azoxystrobin in winter. We conclude that for refrigerated bananas, the products do not interfere with the quality of the fruit, regardless of their concentrations, in spring, summer and autumn, because the values of ºBrix, pH and acidity did not differ from the control sample. The same was observed for non-refrigerated bananas in summer and winter.

Keywords: disease, ripening, quality

Resumo. Pouca informação se tem sobre o comportamento pós-colheita de frutos de banana após a aplicação de fungicidas na região de Registro-SP. Objetivou-se avaliar os sólidos solúveis (ºBrix), pH e acidez total titulável das bananas após a aplicação de diferentes fungicidas. O delineamento experimental utilizado foi inteiramente casualizado em esquema fatorial 4x2, quatro fungicidas, duas concentrações para cada fungicida e dois graus de maturação, mais tratamento controle utilizando somente água, repetidas nas quatro estações do ano. Cada experimento teve três repetições com 4 buquês de 5 frutos. Para as bananas climatizadas os maiores valores de ºBrix foram observados nos frutos tratados com Propiconazol e Imidazol. Já para as bananas não climatizadas os menores valores de ºBrix foram observados para os frutos tratados com Azoxistrobina no outono e os menores valores de pH e maiores de acidez foram paras as bananas tratadas com Azoxistrobina no inverno. Conclui-se que para as bananas climatizadas os produtos não interferem na qualidade dos frutos, independentemente de suas concentrações, nas estações de primavera, verão e outono, pois os valores de ºBrix, pH e acidez não diferiram da testemunha. O mesmo foi observado para as bananas não climatizadas no verão e inverno.

Palavras-chaves: doença, amadurecimento, qualidade

Introduction

In 2012 the volume of global gross banana exports reached a record high of 16.5 million tonne, the increase is primarily explained by the growth of exports from Latin America and the Caribbean (FAO 2015).

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The center of origin of most varieties of banana is tropical Asia, with secondary centers in Africa and Pacific Islands. They are descended of two wild species: *Musa acuminata* and *Musa balbisiana*; banana plants have spread to all tropical and subtropical regions of the globe (PBMH; 2006).

Among the areas where this plant has adapted is Vale do Ribeira in the state of São Paulo. This region has several advantages that have allowed the intensification of banana production, such as privileged microclimates, availability of land, water, labor, labor and available technology. Among the major agronomic characteristics of the Registro-SP region is that there are many banana growers responsible for much of the production of São Paulo state, but little is known about shelf life behavior of these fruits. Traveled mostly by small farmers, the culture of banana has an important socio-economic role in many emerging countries, contributing not only to generate income but also to fix the hand labor in rural areas (Souza, 2010).

Although one of the main fruits exported from Brazil, the banana is far from leading exportations to developed countries. The produce is generally disqualified for European and American markets, as they do not meet their requirements, especially regarding the organoleptic characteristics of bananas (Matthiesen & Boteon, 2011).

This fruit has been chosen for study because of the great economic potential it represents for the banana producers of the Vale do Ribeira, and the small available amount of research conducted with fungicides during postharvest. The banana fruit diseases during postharvest reduce their quality and shelf life. However, the fungicides application in this phase can reverse this process, hence the importance of knowing the fruit's reaction to the application of different fungicides after refrigeration and harvest. Given the almost total lack of research investigating the possible uses of these fungicides in postharvest on main cultivars marketed in the country, and given the subjective grading system employed by producers and supermarkets, chemical treatments must be determined and criteria created so as to better classify these fruits in postharvest and pre-consumption. Most of the Brazilian production of banana is destined for the domestic market and is typically harvested, handled and transported in a deficient and inadequate form, contributing to substantial losses in post-harvest (Maia et al., 2008).This research will provide a basis to better understand the behavior of these fruits, with and without the fungicides application at different concentrations, in refrigerated and non-refrigerated bananas in the phase preceding their consumption; thus innovating the concept and techniques of postharvest for producers in the main supplier region of São Paulo by creating techniques and selecting criteria to increase the competitiveness of these products on the market and improving the quality and extending the shelf life of these fruits.

Material and Methods

The premature Nanica banana *(Musa* spp.*)* bunches were harvested from two-year-old plants on a single producer's commercial plantation in the county of Registro, SP. Then tiers were selected within the bunches, with priority given to the central areas, discarding the two proximal tiers and three distal tiers, aiming for better uniformity of fruit during ripening in postharvest. Each experiment was repeated in every season of the year, on the last month of each season.

The bananas later received treatments in the Plant Production UNESP Registration laboratory. The treatments consisted of: water (control sample), Thiabendazole (250 mg L^{-1}), Thiabendazole (500 mg L^{-1}), Propiconazole (250 mg L^{-1}), Propiconazole (500 mg L^{-1}), Azoxystrobin (250 mg L^{-1}), Azoxystrobin (500 mg L^{-1}), Imidazole (250 mg L^{-1}) and Imidazole (500 mg L^{-1}). The fruits were immersed in the different fungicides suspensions for three minutes. After the elapse of immersion time, the tiers were removed, allowed to dry, packed into export boxes and kept in the laboratory for analyses.

Air conditioning – or ripening induction – was performed using acetylene (calcium carbide) with two applications every 24 hours, and one-hour resting periods, as recommended by Moreira (1987).

The evaluated characteristics were: soluble solids (º Brix), pH and titratable acidity. Soluble solids (° Brix) were determined with an aliquot made from crushed fruits and filtered with gauze, previously measured by refractometry through ABBE type refractometer as recommended by the AOAC (1970). Soluble solids were measured at more than 50% when the fruits of the control

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group reached a score greater than or equal to 6 in the classification table of Cavendish banana (Figure 1).

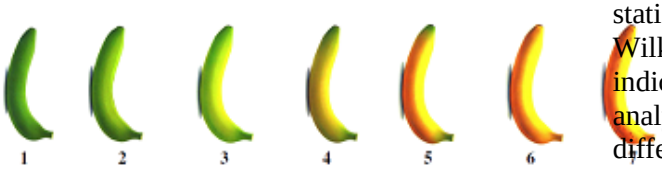

Figure 1: Index of peel color according to the Cavendish banana classification group (Nanica and Grande Naine) during the physiological maturation process.

For the determination of pH, fruits were crushed in a mortar with a porcelain pistil, then the pH was measured in the aqueous extract, prepared with 10g of fresh material ground and diluted with 100 mL of distilled water through the pot as recommended by the IAL (1985).

The titratable acidity (g $100g^{-1}$) was determined with 0.1 N NaOH in the same aqueous extract prepared for the pH up to pH 8.1, and expressed as g of malic acid $100g^{-1}$pulp, as recommended by the IAL (1985). The acidity and pH were measured when more than 50% of the fruits in the control group reached a score greater than or equal to 6 in the classification table of Cavendish banana (Figure 1).

We performed a multivariate analysis of variance for the variables º Brix, pH and acidity for each of the stations, and product factors, concentration and product x concentration. All these analyses were done for air-conditioned and non air-conditioned bananas, and all products were compared to the control sample. For this statistic, significant values show that values f Wilks' Lambda with values of p less than 0.05 indicate that at least one of the averages in the analyzed fruit is different from the significant differences for the studied factors (Hair et al., 2005).

Results and Discussion

Refrigerated bananas

The highest values of ºBrix were observed only during the winter season when fungicides Propiconazole and Imidazole were used, which were statistically higher ($p < 0.05$) regardless of the concentration used (Table 1). These fruits with these products could be more mature than the control sample at the time they were collected for analysis, with a higher Brix. Chitarra and Chitarra (2005) report that the Brix values tend to increase with increasing maturity. Both Propiconazole and Imidazole may have contributed to the acceleration of maturation, because the values of these Brix were higher than 21º Brix, a value considered to be a ripe fruit. Manoel and Vieites (2009) consider the range of 1.5° Brix for green fruit and 21° Brix for ripe fruit, the same occurred with pH showed lower values due to the ripening of the fruit. The values of pH and acidity did not differ statistically.

Table 1. Averages of analyzes º Brix, pH and acidity of bananas acclimatized- Station winter

Product	Concentration	Averages (ºBrix)	Averages (pH)	Averages (Acidity)
Control sample	ZERO	20.8333	5.3100	0.1697
Propoiconazole	250 ML	23.2667	5.2700	0.1653
	500 ML	22.8333	5.2867	0.3037
Imidazole	250 ML	22.9000	5.1900	0.3238
	500 ML	23.4333	5.1900	0.1787
	p- value	0,04	0,01	0,41

Non-refrigerated bananas

Table 2 shows that the lowest values of Brix were recorded only in autumn, when the product Azoxystrobin was used; these values being statistically superior ($P < .05$). Bananas treated with Azoxystrobin during autumn could be less mature at the time of their collection for laboratory analysis. As for the remaining bananas treated with the remaining products no other changes were observed in fruit quality, since the values of ºBrix, pH acidity did not differ statistically between them.

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Table 2. Averages of analyzes º Brix, pH and acidity of bananas not acclimatized-station fall

Product	Concentration	Averages (ºBrix)	Averages (pH)	Averages (Acidity)
Control sample	ZERO	22.2333	5.0900	0.3305
Azoxystrobin	250mL	16.0000	5.1733	0.3171
	500mL	9.0333	5.5067	0.2635
	p- value	0,04	0,88	0,62

Table 3 shows that in winter, lower pH values and higher acidity were observed for bananas treated with Azoxystrobin, without any differences in the concentrations used, these values being higher ($p < 0.05$). The high acidity can be explained by the incomplete maturity of the fruit at the time of data collection for analysis, as the ripe fruits tend to increase the pH and decrease the Acidity with maturation. Chitarra and Chitarra (2006) report that in the range of acid concentration between 2.5 and 0.5%, the pH increases with the reduction of acidity were not observed for the pH and acidity of the refrigerated winter bananas, since there was no significant difference for this and other seasons.

Table 3. Averages of analyzes º Brix, pH and acidity of bananas not acclimatized-station winter

Product	Concentration	Averages (pH)	Averages (Acidity)
Control sample	ZERO	5.2733	0.2144
Azoxystrobin	250mL	4.6967	0.4065
	500mL	4.7633	0.4020
	p- value	0,04	0,02

Conclusions

For refrigerated bananas, fungicides should not be applied regardless of their concentration in spring, summer and fall, because the values of º Brix, pH and acidity did not differ from the control sample.

As for non-refrigerated bananas, fungicides should not be applied in the spring and summer regardless of their concentrations, as they also did not differ from the control sample.

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