Original Article

REDUCTION OF PAPAYA ROT (*Phytophthora palmivora*) WITH PHOSPHITE AND ACIBENZOLAR-S-METHYL IN PREHARVEST AND POSTHARVEST

*REDUÇÃO DA PODRIDÃO DO MAMÃO (*Phytophthora palmivora*) COM FOSFITOS E ACIBENZOLAR-S-METIL EM PRÉ E PÓS-COLHEITA*

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ABSTRACT: The papaya fruit rot (*Phytophthora palmivora*) is responsible for significant losses. To reduce diseases, especially in areas with climate and humidity favorable to pathogens, are adopted chemical methods, which sometimes increase the cost of production and cause severe environmental impacts. Alternatively, there are products, such as, phosphites of potassium and acibenzolar-S-methyl (ASM) that might be efficient on disease control and less aggressive to environment. Phosphites of K and ASM were evaluated in this study on the control effectiveness of papaya fruit rot at different dosages in preharvest and postharvest. The severity and percentage of disease control were evaluated for each treatment. For the pre-harvest treatments (applied six days before harvest), the phosphite of K [240 g L^{-1} K_2O, 340 g L^{-1} P_2O_5 and 50 g L^{-1} (Reforce® + Salicylic Acid)] at 3 or 6 mL L^{-1}significantly reduced disease severity, and, reduced fruit ripening. On postharvest application, ASM reduced disease severity.

KEYWORDS: Alternative control. Ripening delay. Papaya fruit rot.

INTRODUCTION

Fruit rot (*Phytophthora palmivora*) of papaya (*Carica papaya*) might be a disease that compromise fruit production. In addition, this disease is difficult to control, leading to losses in fruit yield. Fungicides used worldwide act quickly on disease, but can cause adverse effects to animals, soil and water. However, cultural, biological and physical methods can reduce the use of fungicides, as well as reduce losses due diseases, with less environmental impact. Resistance inducers and foliar fertilizers can be applied, giving protection to the fruit and increasing shelf life. Such products applied in pre-harvest decrease diseases, reduce the spread of pathogen inoculum and decrease post-harvest fruit rot (LUZ et al., 2001; BARRA et al., 2005).

The Acibenzolar-S-Methyl (ASM) [Benzothiadiazole (BTH)] is an important activator of chemical plant resistance to disease. ASM is rapidly absorbed by foliar tissues giving the plant systemic acquired resistance increase, involving salicylic acid as a signer. ASM is one of the main elicitors of enzymes and phytoalexins produced by the plant in response to physical, chemical or biological stresses. These induced substances act against fungi, causing cytoplasmic and cellular changes, disruption of the cell membrane and inactivation (CONRATH et al., 2001; DURRANT; DONG 2004; TAVARES et al., 2009).

Phosphites are foliar fertilizers that act inhibiting mycelial growth and sporulation of fungi, as well as induce substances on the host that act in the process of plant defense against infection by pathogens. Due to its high solubility and mobility, phosphites are effective in controlling diseases caused by Oomycetes. The phosphite salts have been used successfully in controlling diseases that affect cultures such as: grapevine, tomato, citrus, soybean, papaya, potatoes, melon and apple (MCDONALD et al., 2001; BRACKMANN et al., 2004; RIBEIRO JR. et al., 2006; DIANESE et al., 2007; DIANESE et al., 2009; NEVES; BLUM, 2014).

The systemic and persistent nature of defense enzymes in plants can be important in slowing the activation of latent infections that occur when tissue resistance declines. Thus, treatment with resistance inducers can be used for many post-harvest diseases, consisting of an additional and efficient tool in disease management (VENTURA; COSTA 2002). Therefore, this study aimed to evaluate the effect of different doses and formulations of three phosphites and an ASM in papaya fruit ' Sunrise Solo', applied in preharvest and postharvest.

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MATERIAL AND METHODS

Origin of the fruits and the pathogen inoculum

Phytophthora palmivora (356) used in this study was retrieved from the 'Arnaldo Garcia Medeiros' collection of *'Phytophthora'*, at the CEPEC, Bahia, Brazil. The pathogen was grown in Petri dishes with selective medium PARPH (KANNWISCHER; MITCHELL, 1978) for five days in the dark (25 ± 2ºC). Then it was transferred to plates with carrot-agar (CA) medium being kept in incubator (25 ± 2ºC) under continuous light for nine days for sporulation. After fruit inoculation and symptoms manifestation, *P. palmivora* was isolate in PARPH and its cultures were kept in test tubes with CA. The suspensions of *P. palmivora* were obtained from 20 plates containing zoosporangia of the pathogen. To each plate were added 8 mL of sterile cold distilled water (5 ± 2 ºC), and, for zoospore release the fungi cultures were subjected to thermal shock (5 ± 2° C for 20 min, and, 25 ± 2° C for 25 min). The concentration (5 x 10^5 zoospore mL^{-1}) of zoospores was estimated at Neubauer Chamber by adding 20 µL of FAA (formaldehyde, alcohol, acetic acid) fixer solution, for the zoospore encystment and counting.

The experiments were performed: (a) in field ('Alegria' Farm, Vera Cruz, Bahia, Brazil) using 24-month-old papaya trees under drip irrigation, and; (b) in the laboratory of 'Phytophthora' (CEPLAC - The Research Center of Cocoa Crop). For all experiments were used healthy fruits of uniform size ('Sunrise Solo') and at the ripening stage 2 (RITZINGER; SOUZA, 2000). After harvest, fruits were washed with soap and water, disinfected superficially in sodium hypochlorite solution (1%NaClO), and then air-dried (25 ± 3 ºC).

Effect of products against the fruit rot on pre-harvest

The products have been applied on the fruits with a costal spray up to the run-off point, at 6 and 3 d before harvest. Phosphites were applied (3; 6 mL L^{-1}) in the following formulations: Nutri Phite® (403.26 g L^{-1} K_2O, 434.28 g L^{-1} P_2O_5); Reforce® (240 g L^{-1} K_2O, 340 g L^{-1} P_2O_5); Reforce® + Salicylic acid (240 g L^{-1} K_2O, 340 g L^{-1} P_2O_5; + 50 g L^{-1} $C_7H_6O_3$). Acibenzolar-S-Methyl was applied in doses of 0.15 and 0.30 g L^{-1}[500 g L^{-1} ASM (Bion®)] and fungicide at the dose of 2 g L^{-1} [metalaxyl-M 40g kg^{-1} + mancozeb 640 g kg^{-1} (Ridomil Gold®)]. As experimental control was applied sterile distilled water. Five papaya plants were selected per replication, at random, and 20 fruits per treatment were collected. Inoculation with *P. palmivora* were made in the equatorial region of fruit epidermis with sterilized filter paper disk (5 mm ø), dipped in suspension of $5x10^5$ zoospores mL^{-1}. As experimental treatment control without pathogen were used disks dipped in distilled sterilized water. The treatments were kept for incubation in moistened plastic chamber (plastic bag with distilled water) for 72h (25 ± 2 ºC).

Effect of products on fruit rot in postharvest

This experiment was conducted ['Phytophthora' Laboratory, Plant Pathology Section of the Crop Research Center Cocoa (CEPLAC)] with 20 fruits per treatment. The fruits were immersed for 5 minutes in containers containing the products as described before, followed by air drying, inoculation, and incubation procedures mentioned in the previous item.

Effect of phosphite and ASM on the chemical characteristics of papaya

Eight days after inoculation of the pathogen and after application of the treatments in the fruits, 150 g samples were collected from each fruit pulp for the assessment of the levels of ascorbic acid (vitamin C), total titratable acidity (ATT), total soluble solids (TSS), pH and the ratio TSS/ATT. For analysis of ATT, percentage of citric acid were obtained using the technique described in AOAC (1990). The pH was measured with a digital pHmeter (Quimis Model Q 400A) and TSS was measured in refractometer [Model Rez (0-32°Brix)]. The ascorbic acid content was determined as described in Bezerra Neto et al. (1994).

Evaluation of disease and experimental design

The experiments of phosphites and efficiency of Acibenzolar-S-Methyl against fruit rot on pre-and post-harvest were repeated in a 30-d interval for confirmation of results. The experimental design was completely randomized with three application periods, 11 treatments with 10 replications each and 2 fruits per plot. The severity was determined after the withdrawal of the incubation chamber (72 h), by measuring the diameter of the lesion in two senses diametrically opposed with the aid of a digital caliper. From this value, 5 mm was subtracted (disk diameter) and then the lesion area was calculated using the formula: $S = \frac{\pi \times D1 \times D2}{4}$ where: S = lesion area; D1 = diameter-1; D2 = diameter-2, after 8-day incubation. The results were transformed in percentage of control of fruit rot, using the formula:

$RC\% = (Sctr - Strat) \times 100$. Where RC% = percentage of rot control; S_{ctr} = area of the lesion of control; S_{trat} = area of the lesion of treatment. The results were submitted to analysis of variance and averages compared by Scott-Knott test ($p \leq 0,05$), using the program SISVAR 5.3 (FERREIRA, 2011).

RESULTS AND DISCUSSION

Phosphite and ASM on fruit rot on pre-and postharvest

There was no statistical difference ($P \leq 0.05$) between the results of the two experiments to evaluate the effectiveness of control of the products. Therefore, the data there of were treated jointly. The dose and the period of application of each product affected the severity of the fruit rot. The products were more efficient when applied on pre-harvest (Table 1).

Table 1. Rot (*Phytophthora palmivora*) area of papaya treated with potassium phosphite and Acibenzolar-S-Methyl before and after harvest.

*	Active ingredient	Dose g mL L^{-1}	Rot area (mm^2) (1)		
			6 DBH(3)	3 DBH	AH(4)
T1	500 g L^{-1} Acibenzolar-S-Methyl	0.15	1762(2) bA	3305 cB	2368 bA
T2	500 g L^{-1} Acibenzolar-S-Methyl	0.30	1466 bA	2069 bA	2115 bA
T3	403,26 g L^{-1} K_2O + 434,28 g L^{-1} P_2O_5	3	4148 cA	4657 dA	3581 dA
T4	403,26 g L^{-1} K_2O + 434,28 g L^{-1} P_2O_5	6	2301 bA	3031 cB	3453 dB
T5	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5	3	3474 cA	4516 dA	3863 dA
T6	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5	6	1743 bA	4144 dC	3278 dB
T7	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5 + 5% $C_7H_6O_3$	3	1024 bA	3104 cB	3340 dB
T8	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5 + 5% $C_7H_6O_3$	6	460 aA	3383 cB	2599 cB
T9	Metalaxyl 40 g kg^{-1} + Mancozeb 640 g kg^{-1}	2	1194 bA	1395 bA	1813 bA
T10	Sterile Distilled Water + pathogen	-	7063 dB	8141 eC	3888 dA
T11	Sterile Distilled Water	-	0 aA	0 aA	0 aA
	CV (%)		28.3	21.2	21.4

* Treatament: T1 = Bion®, 0.15 g L^{-1}; T2 = Bion®, 0.30 g L^{-1}; T3 = Nutri Phite®, 3 mL L^{-1}; T4 = Nutri Phite®, 6 mL L^{-1}; T5 = Reforce®, 3 mL L^{-1}; T6 = Reforce®, 6 mL L^{-1}; T7 = Reforce®+SA, 3 mL L^{-1}; T8 = Reforce®+SA, 6 mL L^{-1}; T9 = Ridomil Gold®, 2 g L^{-1}; T10 = Control (+); (1) average of fruit rot for 20 repetitions; (2) Values followed by the same lowercase letter in each column and same capital letter in a line, did not differ (Scott-Knott test, P≤0,05); (3) Days before harvest; (4) After the harvest.

With treatments applied to 6 days before harvest (DBH), the T8 [Reforce® + salicylic acid (SA)], reduced fruit lesion area (460 mm^2) (Table 1). However, the percentage of disease control showed by T8 did not differ from T7 [Reforce®+SA] (Table 2). The results show that the use of phosphites is efficient in the control of plant diseases, mainly caused by the oomycete (SAUTTER et al., 2008). Corroborating the results obtained by Sônego et al. (2003) observed 97% control of downy mildew on leaves and grapes (Cabernet Sauvignon), after application of K-phosphite. Also, in grapevine, Pereira et al. (2010) noted that spraying with the phosphites of K (Reforce; Reforce+SA) reduced the severity of downy mildew when applied on leave. Brackmann et al. (2004) working with apples treated with K-phosphite, reported reduction on diameter of lesions of post-harvest rot in storage. Holderness (1992) used K-phosphite to control brown rot of fruit and cocoa (*Theobroma cacao* L.) tree canker caused by *P. palmivora*.

Although the mode of action of phosphites has not been elucidated with accuracy, they have been used as fertilizer and fungicide. Studies have shown that phosphites act directly on the pathogen or indirectly by activating the plant defense through the synthesis of phytoalexins, phenolic compounds and pathogenesis-related protein (BÉCOT et al., 2000; JACKSON et al., 2000; DANIEL; GUEST, 2005; SAUTTER et al., 2008).

Table 2. Percentage of control of fruit rot (*Phytophthora palmivora*) for products formulated with potassium phosphite and Acibenzolar-S-Methyl before and after papaya harvest.

*	Active ingredient	Dose g mL L^{-1}	% of control[(1)]		
			6 DBH[(3)]	3 DBH	AH[(4)]
T1	500 g L^{-1} Acibenzolar-S-Methyl	0.15	78.8[(2)] cC	65.8cB	51.5dA
T2	500 g L^{-1} Acibenzolar-S-Methyl	0.30	82.4cB	78.6dB	56.6dA
T3	403,26 g L^{-1} K_2O + 434,28 g L^{-1} P_2O_5	3	50.2bB	51.8bB	26.5bA
T4	403,26 g L^{-1} K_2O + 434,28 g L^{-1} P_2O_5	6	72.4cB	68.6cB	29.1bA
T5	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5	3	58.3bB	53.3bB	20.21bA
T6	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5	6	79.1cC	57.1bB	32.7bA
T7	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5 + 5% $C_7H_6O_3$	3	87.7dC	67.8cB	31.5bA
T8	240 g L^{-1} K_2O + 340 g L^{-1} P_2O_5 + 5% $C_7H_6O_3$	6	94.5dC	65.0cB	46.7cA
T9	Metalaxyl 40 g kg^{-1} + Mancozeb 640 g kg^{-1}	2	85.7cB	85.6dB	62.8dA
T10	Sterile Distilled Water + pathogen		0.0aA	0.0aA	0.0aA
	CV (%)		16.1	14.9	13.6

* Treatament: T1 = Bion®, 0.15 g L^{-1}; T2 = Bion®, 0.30 g L^{-1}; T3 = Nutri Phite®, 3 mL L^{-1}; T4 = Nutri Phite®, 6 mL L^{-1}; T5 = Reforce®, 3 mL L^{-1}; T6 = Reforce®, 6 mL L^{-1}; T7 = Reforce®+SA, 3 mL L^{-1}; T8 = Reforce®+SA, 6 mL L^{-1}; T9 = Ridomil Gold®, 2 g L^{-1}; T10 = Control (+); [(1)] % of control of fruit rot for 20 repetitions; [(2)] Values followed by the same lowercase letter in each column and same capital letter in a line, did not differ (Scott-Knott test, P≤0,05); [(3)] Days before harvest; [(4)] After the harvest.

The treatments T1 and T2 [Bion® (50% ASM)], T4 [Nutri Phite® (403.26 g L^{-1} K_2O; 434.28 g L^{-1} P_2O_5)], T6 [Reforce® (240 g L^{-1} K_2O; 340 g L^{-1} P_2O_5)] and T7 (Reforce®+SA) did not differ when applied to 6 DBH in relation to disease severity, resulting similar values as the fungicide (T9) on fruit protection (Table 1). The T2 applied 3 DBH presented similar results to fungicide (T9), both in disease severity (Table 1) and % of control (Table 2).

The use of ASM in pre-harvest could have induced resistance, providing protection of fruits, with consequent reduction in disease severity. ASM is chemical activator of plants resistance to disease, not exercising direct action on the pathogen (CONRATH et al., 2001).

For the treatments applied after harvest, it was observed that T1 and T2 were efficient in protecting the papaya against fruit rot, with control of 52 % and 57 % respectively (Table 2). Both treatments showed a significant decrease in the severity of the disease with an area of lesion of 2368 (T1) and 2115 (T2) mm^2, when compared to inoculated control (T10) (Table 1).

Possibly fruits treated with inductors intensify a defense reaction before the invasion of microorganisms, triggering a defensive response to infection. Therefore, the application of ASM at the beginning of the postharvest slows infection, prolonging the life of the fruits in storage. An alternative to confer protection to the fruit is to stimulate the production of natural substances, among them the phytoalexins, to increase the resistance to the pathogen, during storage and shelf life. The phytoalexins are secondary metabolites, antimicrobials, produced by the plant in response to stresses. The mode of action on fungi includes, cytoplasmic granulation, cell disorder, cell membrane rupture, and enzyme inactivation (TAVARES et al., 2009).

Postharvest application of ASM was used in melon (HUANG et al., 2000) and apples 'Golden Delicious', against *Penicillium expansum* and *Botrytis cinerea* (SPADARO et al., 2004). In papaya, Dantas et al. (2004) evaluated the potential of ASM in protecting papaya fruit against rot, indicating that the resistance inducers are effective in the control of diseases.

The T8 treatment (240 g L^{-1} K_2O, 340 g L^{-1} P_2O_5; 50 g L^{-1} $C_7H_6O_3$) was the most effective when applied on pre-harvest , differed statistically from other ones, resulting decrease in the severity of the disease (Table 1) and the increase in the percentage of control (Table 2).The treatments with phosphites in pre-harvest provided reductions in disease severity , suggesting a persistence of inductors

applied , in addition suppressed the initial inoculum of the pathogen, that contributes to reduce fruit rot. The results of this research indicate that the products application should be made at least six days before harvest, considering the plant spent of energy to produce resistance substances (HEIL, 2001).

This work showed that the treatments with ASM and phosphites induced a quick response to the pathogen, when compared to the check-control. This fact follows the premise of Dixon & Lamb (1990), to suggest that colonization of the pathogen on plants susceptible and resistant is due to the delay of the expression of systemic resistance, caused by resistance inducing agents. The systemic and persistent nature of defense enzymes in tissues of the fruit can be important in slowing the activation of latent infections that typically occur when the tissue resistance declines (VENTURA; COSTA, 2002). Thus, treatment with resistance inducers may be important in the control of postharvest diseases.

Effect of phosphites on chemical characteristics of papaya

The values of total soluble solids (SST) found in the fruits treated with phosphites and ASM were: 4.8 to 12.3 ^{o}Brix when applied at 6 DBH; 7.0 to 11.8 ^{o}Brix when applied at 3 DBH, and, 7.9 to 11.2 ^{o}Brix when applied at AH (Table 3). These values are within the acceptable range that is 7.1 e 12.5 (JAGTIANI, 1988). The total soluble solids (ºBrix) are used as index of maturity for some fruits. Gomes et al. (2002) report that soluble sugars present in fruits in combined form are responsible for sweetness, taste and attractive color, when combined to the anthocyanins, and with influence in texture, when combined to the structural polysaccharides.

Total titratable acidity (ATT) is important in the characterization of the taste of the fruit (CHITARRA; CHITARRA, 2005). ATT values obtained in this work (Table 3) are within acceptable for fruit that can vary from 0.10 to 1.15g of citric acid per 100 g of pulp (JAGTIANI, 1988).

Table 3. Chemical characteristics of papayas inoculated with *Phytophthora palmivora* and treated with potassium phosphite and Acibenzolar-S-Methyl, 8 days after incubation.

Treatment*		pH[3]	SST[4]	VC[5]	ATT[6]	SST/ATT[7]
6DBH[1]	T1	4.98 e	11.50 q	66.13 j	0.15 c	78.17 b
	T2	4.89 e	10.70 m	64.48 g	0.13 b	86.60 c
	T3	4.99 e	10.50 l	66.40 k	0.12 b	96.95 c
	T4	4.59 c	10,80 m	72.57 s	0.11 a	102.01 c
	T5	4.91 e	7.40 d	73.22 t	0.15 c	51.05 a
	T6	4.91 e	12.30 s	75.34 v	0.13 b	103.18 c
	T7	4.98 e	5.00 b	61.27 d	0.14 c	36.38 a
	T8	4.80 d	4.80 a	52.00 a	0.14 c	35.51 a
	T9	4.80 d	9.20 h	68.81 p	0.13 b	76.92 b
	T10	4.89 e	11.30 p	66.25 j	0.11 a	106.75 c
	T11	4.71 d	12.20 s	70.87 r	0.12 b	108.16 c
3DBH	T1	4.76 d	11.10 o	66.52 k	0.12 b	102.56 c
	T2	4.58 c	10.10 j	70,57 q	0.15 c	68.63 b
	T3	4.60 c	10.20 j	64.63 g	0.12 b	90.31 c
	T4	4.70 d	8.80 f	66.92 l	0.11 a	90.53 c
	T5	4.33 a	7.00 c	63.70 e	0.12 b	60.07 b
	T6	4.60 c	10.10 j	67.48 o	0.11 a	98.86 c
	T7	4.45 b	10.90 n	63.94 f	0.12 b	100.69 c
	T8	4.67 d	10.30 k	73.20 t	0.11 a	97.26 c
	T9	4.83 d	11.80 r	70.58 q	0.12 b	104.59 c
	T10	4.69 d	11.50 q	63.97 f	0.10 a	135.06 c
	T11	4.50 b	12.40 t	70.85 r	0.12 b	106.70 c
AH[2]	T1	4.79 d	10.30 k	67.07 m	0.17 d	62.28 b
	T2	4.41 a	9.80 i	74.45 u	0.15 c	69.38 b
	T3	4.47 b	10.20 j	82.12 x	0.13 b	80.55 b
	T4	4.49 b	10.20 j	64.59 g	0.10 a	111.85 c

T5	4.47 b	10.90 n	78.62 w	0.12 b	100.69 c
T6	4.25 a	7.90 e	60.95 c	0.16 d	50.15 a
T7	4.49 b	9.00 g	65.23 h	0.13 b	72.75 b
T8	4.70 d	11.00 o	67.22 n	0.17 d	67.75 b
T9	4.56 c	10.90 n	66.54 k	0.15 c	74.08 b
T10	4.50 b	11.20 p	58.21 b	0.11 a	109.72 c
T11	4.44 b	12.40 t	66.00 i	0.12 b	114.72 c
C.V%	8.13	3.75	5.60	6.45	15.85

* Treatament: T1 = Bion®, 0.15 g L^{-1}; T2 = Bion®, 0.30 g L^{-1}; T3 = Nutri Phite®, 3 mL L^{-1}; T4 = Nutri Phite®, 6 mL L^{-1}; T5 = Reforce®, 3 mL L^{-1}; T6 = Reforce®, 6 mL L^{-1}; T7 = Reforce®+SA, 3 mL L^{-1}; T8 = Reforce®+SA, 6 mL L^{-1}; T9 = Ridomil Gold®, 2 g L^{-1}; T10 = Testemunha (+); (1) Days before harvest; (2) After harvest. (3)hydrogenionic potential; (4)SST= Total soluble solids (°Brix); (5)VC= Ascorbic acid (mg 100 g^{-1}); (6)ATT= Total titratable acidity (g 100 g^{-1}); (7)SST/ATT= ratio of total soluble solids / total titratable acidity; Values followed by the same lowercase letter in each column did not differ (Scott-Knott test, P≤0,05).

The pH ranged from 4.59 to 4.99 when phosphites were applied 6 DBH (Table 3), from 4.83 to 4.33 when applied 3 DBH, and, 4.25 to 4.79, when applied AH among treated fruits. Small variations in this feature can cause changes in the fruit flavor. The sugar content, as well as the pH, can be used as an index of maturation for papaya fruit. Papaya fruits are usually acidic, with a pH of up to 5.59 (MAIA, 2007).

The levels of Ascorbic acid (AA) in 100 g of pulp (mg $100g^{-1}$) in fruits treated ranged from 52 to 75.34 mg, when applied 6 DBH; 63.7 to 73.2 mg when applied 3 DBH and 60.95 to 82.12 mg, when applied AH (Table 3). The AA values obtained are within the acceptable range for fruit ranging from 43.9 to 89.61 mg $100g^{-1}$ (JAGTIANI, 1988).

For the TSS/ATT ratio, variations from 35.51 to 103.18 were observed when products were applied 6 DBH (Table 2), from 60.07 to 104.59 when applied 3 DBH, and, from 50,15 to 111,85 DAH, when applied DAH. According to Chitarra & Chitarra (2005), the TSS/ATT ratio is one of the most used ways to evaluate flavor, being more representative than the isolated measurement of sugar or acidity, showing a balance between these two components. This high ratio contributes with a sweet taste in fruit, making it more pleasant to the palate.

As for the chemical characteristics, treatments with phosphite, mainly the Reforce® + AS at both doses tested (T7 and T8) when applied 6 DBH, had significant effect on the variables studied, promoting physiological changes in fruits. However, at eight days after incubation (DAI) for these treatments, a delay in maturation of fruits in T7 and T8 was noticed, what possibly hindered the infection of *P. palmivora* on fruits due to the uninjured maintenance of the cell wall as well as the associated pectin derived substances (Table 3) (CHEN et al., 2007; MACEDO et. al., 2005; UENOJO; PASTORE, 2007).

In T7 and T8 were found normal fruit ripening to day 18, showing chemical characteristics within the acceptable range (Table 4 and Figure 1).

Table 4. Chemical characteristics of papayas inoculated with *Phytophthora palmivora* and treated 6 d before harvest, with Reforce® + salicylic acid, at 8 and 18 d after incubation.

Trt(1)	**pH(2)**		**SST(3)**		**VC(4)**		**ATT(5)**		**SST/ATT(6)**	
	8 DI(7)	**18 DI**	**8 DI**	**18 DI**	**8 DI**	**18 DI**	**8 DI**	**18 DI**	**8 DI**	**18 DI**
T7	5.0(8) aA	4.6 aA	5.0 aA	8.0 aB	61.3 aA	69.2 aB	0.14 aA	0.14 aA	35.5 aA	88.7 aB
T8	4.8 aA(9)	4.6 aA	4.8 aA	8.1 aB	52.0 bA	70.9 bB	0.14 aA	0.13 aA	36.4 aA	97.5 aB
C.V%	7.9		4.4		3.0		9.0		13.7	

(1)T7- 240 g L^{-1} K_2O, 340 g L^{-1} P_2O_5 e 5 + % de $C_7H_6O_3$ (3 mL L^{-1}), and, T8- 240 g L^{-1} K_2O, 340 g L^{-1} P_2O_5 + 5% $C_7H_6O_3$ (6 mL L^{-1}); (2)pH= hydrogenionic potential; (3)SST= Total soluble solids [20°C(°Brix)]; (4)VC= Ascorbic acid (mg $100g^{-1}$); (5)ATT= Total titratable acidity (g 100 g^{-1}); (6)SST/ATT= ratio of total soluble solids / Total titratable acidity; (7)DI = Days after incubation; Values followed by the same lowercase letter in the column and the same capital letter on the line, do not differ statistically, according to the test of Scott-Knott (P≤0,05).

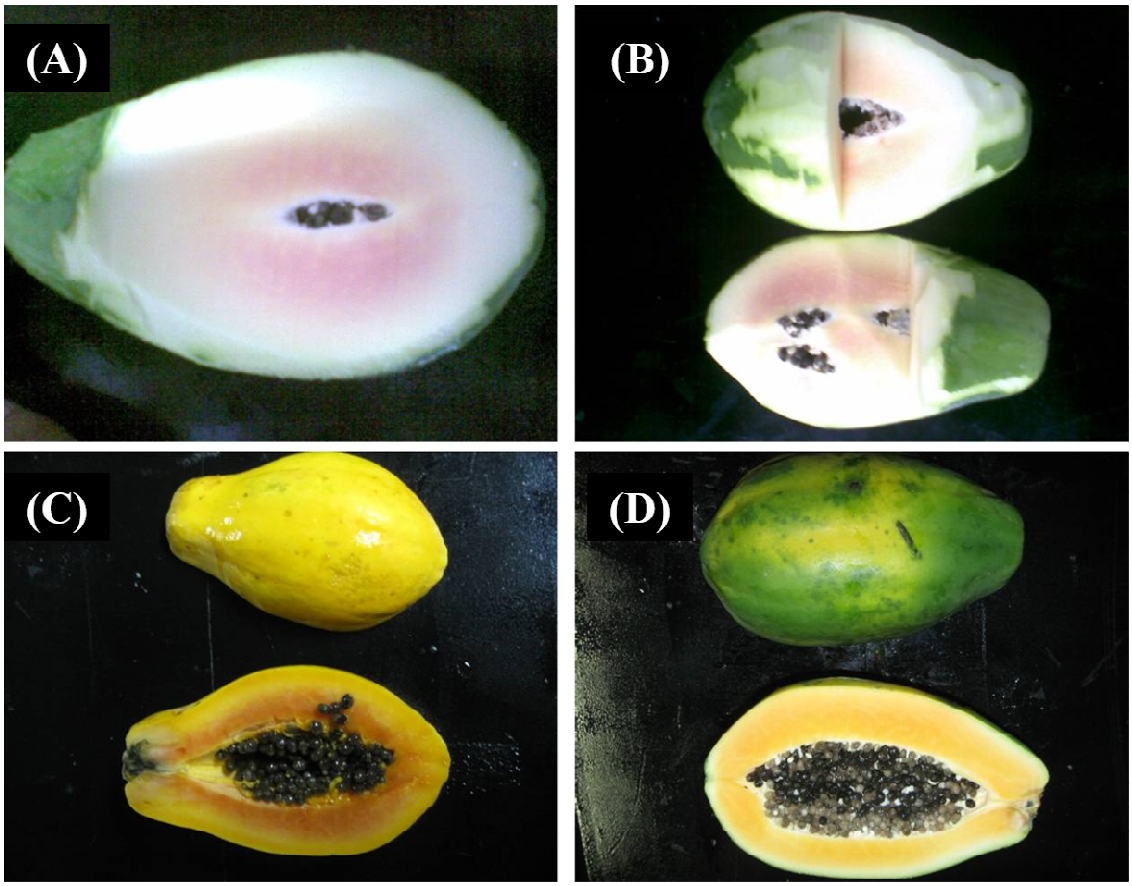

Figure 1. Effect of Reforce®+AS on delay of maturation of papaya 'Sunrise Solo' applied 6 d before harvest. A) Physiological characteristics of fruits 8 d after incubation using Reforce®+AS, 3 mL L^{-1}-B) Physiological characteristics of fruits 8 d after incubation using Reforce®+AS,6 mL L^{-1}; C) Physiological characteristics of fruits 18 d after incubation using Reforce®+AS, 3 mL L^{-1}; D). Physiological characteristics of fruits 18 d after incubation using Reforce®+AS, 6 mL L^{-1}.

Wall (2006) reported that soluble solids can be used as an index of maturation, since there is a directly proportional relationship between the formation of Ascorbic acid and total soluble solids. It occurs due to an increase in ascorbic acid content as the ripening of fruit. Changes during ripening of papaya can be easily identified due to obvious changes in color, aroma, flavor and texture of these fruits. These changes correspond to the major biochemical transformations of commercial interest, which occur with pigments, volatile compounds, organic acids and carbohydrates of these fruits (MELGAREJO; ARTES, 2000). Papaya is considered a fruit postharvest life too short, susceptible to attack by pathogens. Brummell & Harpster (2001) informed that, the ability to maintain their ripening after harvest is about a week, when starting the cell wall degradation by hydrolytic enzymes, including the pectin lyases, polygalacturonase and pectin methylesterase.

CONCLUSIONS

The application of Reforce® + salicylic acid to 6 d before harvest was efficient in the control of the disease and delay ripening of the fruit, for the doses tested (3; 6 mL L^{-1});

The application of Acibenzolar-S-Methyl after harvest (0.15; 0.30 g L^{-1}) was effective against fruit rot.

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RESUMO: A podridão dos frutos do mamoeiro (*Phytophthora palmivora*) é responsável por perdas significativas e para minimizar a doença, principalmente em locais com clima favorável ao patógeno, medidas de controle químico são adotadas. Porém, estas medidas podem elevar o custo da produção e causar severos impactos ambientais. Alternativamente, existem produtos como os fosfitos de potássio (K) e acibenzolar-S-metil (ASM) que podem ser eficientes no controle de doenças e menos agressivos ao ambiente. Fosfitos de K e ASM foram avaliados neste trabalho quanto à eficácia do controle da podridão de frutos de mamão 'Sunrise Solo' tipo exportação, cultivados no Sul da Bahia, em diferentes doses e formulações comerciais na pré e pós-colheita. Para cada tratamento foi avaliada a severidade da doença e o percentual de controle da doença, sendo também verificada a influência nas características fisioquímicas na fruta. Para os tratamentos pré-colheita, aplicados aos seis dias antes da colheita, o fosfito de K [240 g L^{-1} K_2O, 340 g L^{-1} P_2O_5 e 50 g L^{-1} $C_7H_6O_3$ (Reforce® + Ácido Salicílico)] a 3 ou 6 mL L^{-1} reduziu significativamente a doença, e influenciou diretamente no atraso da maturação da fruta. Na pós-colheita, ASM incitou redução na severidade da doença. Todos os tratamentos não alterarão as características fisioquímicas da fruta.

PALAVRAS-CHAVE: Controle alternativo. atraso na maturação. podridão do mamão

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