Original Research Article
CONTROL OF PEDUNCULAR ROT IN POST-HARVEST MANGO FRUITS WITH HYDROTHERAPY AND REFRIGERATION

ABSTRACT

Aims: The objective of this study was to evaluate the use of hydrotherapy in the curative control of peduncular rot of mango cv. Tommy Atkins.
Place and Duration of Study: Phytopathology laboratory of the Agricultural Sciences Center of the Federal University of Alagoas - CECA / UFAL - Delza Gitaí Campus - Rio Largo - AL, Brazil, from June to December 2018.
Study design: The experimental design was completely randomized with 15 treatments, in a factorial scheme 5 x 3, represented by the 5 temperatures and 3 times of immersion of the fruits in heated water. For statistical evaluation, the Sisvar ver 5.6 computer program was used, data were submitted to analysis of variance (ANOVA) and means were submitted to regression analysis. The data regarding the severity of the disease were collected using an adapted diagrammatic scale, later analyzed.
Results: The results show that hydrotherapy associated with refrigeration is able to control peduncular rot in mango fruits. The temperatures of 50, 55 and 60 ºC in the time of 9 minutes of fruit immersion showed 100% control of the disease, in the time of 1 minute only the temperature of 60 ºC presented control superior to 90% of the disease, the temperatures of 45 , 50 and 55 presented control of 74.6, 76.2 and 89%, respectively. In the time of 5 minutes, the temperatures of 55 and 60 ºC were the best with control superior to 90% of the disease. In all immersion times, the equation that best fit the data was the 3rd degree polynomial. The temperature of 40ºC, in all evaluated times, was the only one that presented control of the disease inferior to 20%.
Conclusion: Thermotherapy associated with refrigeration promotes the curative effect of pedicle rot caused by *Lasiodiplodia theobromae* on Tommy Atkins cv mango fruits. The immersion of the mangoes in water heated at 50 °C, 55 °C and 60 °C for 9 minutes, followed by refrigeration of the fruits at 20 °C, is able to control peduncular rot in 100%.

Keywords: Alternative control, *hydrotherapy, Lasiodiplodia theobromae, Mangifera indica,* peduncle rot.

1. INTRODUCTION

The mango tree (*Mangifera indica* L.), introduced in Brazil by the Portuguese in the 16th century, was planted in Rio de Janeiro, from where it spread throughout the country [1]. According to [2], this fruit is subject to loss of quality, influenced by several post-harvest factors, among which are diseases caused by phytopathogens, which may develop after harvesting, especially in the ripening phase, when not receives the necessary care and has not undergone phytosanitary treatment. The pathogenic rot caused by *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl, occurring in all the producing regions of the world,

stands out among post-harvest diseases of the mango, for damage caused, in the order of 40 to 50% when the fruit peduncle is infected [3]. The source of the pathogen's inoculum is produced in rotted fruit on the tree or on the ground. Once the plant is infected, the fungus can remain in the vascular tissues for years until the tissue dies. Spreading occurs through winds, pruning instruments and penetration into the plant occur through natural openings or wounds, and the infection can occur in the fruits, in the field and in the harvest phase [4]. Most of the time, the fruit is already infected from the field where the etiological agent (*L. theobromae* (*Botryodiplodia theobramae* (Pat.)) Remains in the quiescent fruit until the appearance of favourable conditions for its development [5]. The peduncular rot in mango culture develops in post-harvest in a period of three to 12 days, in fruits stored at room temperature. However, once the process has started rotting occurs in all fruits within two to three days [6]. Among the recommendations for controlling the disease are preventive sprays of fungicides. However, the forms of control are increasingly evolving. In addition to this, population thinking that seeks not only a healthier consumption of food but also the maintenance of the environment, has required less aggressive and economically viable methods to combat diseases, among which the use of various forms of energy [7]. The use of thermotherapy and refrigeration are alternative methods, widely used to control post-harvest rot, and are capable of eradicating or weakening the pathogen [8]. The objective of this study was to verify the efficiency of physical control in the management of peduncular rot (*L. theobromae*) in Tommy Atikns mangoes through the use of hydrotherapy and refrigeration.

2. MATERIAL AND METHODS

The experiment was conducted at the phytopathology laboratory of the Agrarian Sciences Center of the Federal University of Alagoas - CECA / UFAL - Campus Delza Gitaí - Rio Largo - AL, from June to December 2018.

Mango fruits at the E1 maturation stage were obtained from the Agricultural Sciences Center of UFAL and after harvesting, only those fruits that had no disease caused by phytopathogens were selected.

The fruits were then disinfected with 1% sodium hypochlorite for 10 minutes and washed in running water and dried at room temperature, after which they were submitted to hydrothermal treatment, using a CT 245 water bath, immersing the fruits in water heated at 40, 45, 50, 55 and 60 ° C for 1, 5 and 10 minutes (figure 1), 24 hours after inoculation of the fruits with the *Lasiodiplodia theobromae* (10^6 con.mL^{-1}) inoculum suspension, cultivated in BDA (potato-dextrose-agar) culture medium, aiming to evaluate the curative effect of hydrotherapy on peduncular rot in mango fruits.

After receiving the treatments, the fruits were placed on refrigeration at 20 ºC for 5 days in a BOD incubator model CE-300, when they were evaluated, in relation to the severity of the disease.

For the evaluation of severity, a diagrammatic scale adapted from [9], was used to quantify the severity of anthracnose in passion fruit, Figure 2. Severity data were transformed into disease control by the formula C = (100% - severity) since that control is the inverse of severity.

The experimental design was completely randomized with 15 treatments, in a factorial scheme 5 x 3, represented by the 5 temperatures and 3 times of immersion of the fruits in

heated water. For statistical evaluation, the Sisvar ver 5.6 computer program was used, the data were submitted to analysis of variance and the means submitted to regression analysis.

Fig. 1. Mango fruits in a water bath, 24 hours after inoculation, at a predetermined temperature.

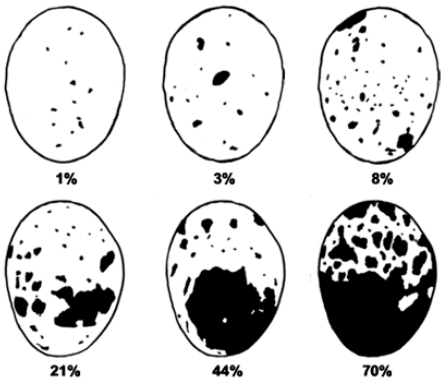

Fig. 2. The scale of notes used in the experiment for disease severity.

3. RESULTS AND DISCUSSION

Hydrotherapy reduced the severity of peduncular rot in mango fruit cv. Tommy Atkins. The level of control varied according to the temperature and the exposure time employed figure 3. Only the immersion of the fruits in the temperature of 40 ºC for 1, 5 and 9 minutes presented control inferior to 20%, the other treatments presented control superior to 70%.

According to the test F (table 1), there was a significant difference in the level of 1% probability in the interaction between temperature and time factors, indicating that the percentage of control of peduncular rot in mango fruits caused by *L. theobromae* submitted to different depends on the time of immersion of the respective fruits in heated water.

In the unfolding of the interaction, there was a significant difference between the temperatures, at the 1% probability level, within the time of 1, 5 and 9 minutes in relation to the control percentage of peduncular rot in mango fruits. At all times the equation that best fit the data was the polynomial of 3rd degree. In the 1 minute time, the maximum control point was 90.2%, corresponding to the temperature of 60 ^{0}C, in the time of 5 minutes the maximum of control was obtained, also, with the temperature of 60 ^{0}C being of 95% control followed by 91.8 and 81.6% for temperatures of 55 and 50 ^{0}C in this order, with an increase

in the control of the disease when the temperature is increased, but a 100% control of the disease was not obtained in the times of 1 and 5 minutes immersion.

The immersion of the fruits in water heated for 9 minutes at temperatures of 50, 55 and 60 ^{0}C followed by refrigeration at 20 ^{0}C, showed 100% control of the peducular rot in mango fruit caused by *L. theobromae*. the temperature of 45 ^{0}C showed control of 81.6% and the temperature of 40 ^{0}C showed a control lower than 20% indicating that this temperature is inefficient to denature the reproductive structures of the pathogen.

Some researchers state that hydrotherapy has not demonstrated efficiency in the control of fungi when used alone: [10] observed this in post-harvest diseases of papaya culture; in the banana, [11] found that heat treatment alone was not efficient in the control of post-harvest anthracnose of banana 'Prata anã' and [12], evaluating the effect of hydrotherapy on the severity of peduncular rot (*L. theobromae*) in fruits mango cv Tommy Atkins, with temperatures of 53, 55 and 57 ºC for 4 and 5 minutes, found no efficiency in controlling this disease. In a way, these observations reinforce the results found in this study, since hydrotherapy associated with refrigeration was used. It was observed that the temperatures of 50, 55 and 60 ºC for 9 minutes associated with fruit refrigeration, showed efficiency in reducing the severity of peduncular rot in cv. Tommy Atkins.
Other studies corroborate the results found in this research: [13] obtained the control of anthracnose (*C. gloesporioides*) in post-harvest mango cv Espada (94%), using hydrotherapy (53 ° C for 5 minutes), thus like [14] who obtained control of *C. gloeosporioides* in post-harvest passion fruit (85%), using the same method of inoculation by [13].

The thermotherapy or hydrotherapy has as a prerogative that the treatment cannot affect the physical-chemical properties of the fruits. In this work, the exposure of Tommy Atkins mango fruits at temperatures of 55 ºC for 5 and 9 minutes did not affect the physicochemical properties of these fruits, which presented consistency, colour and flavour unchanged. Similar results were observed by [15], who verified that 5 minutes at 55 ºC, used to reduce the severity of the anthracnose in mango, did not affect the physical-chemical properties of the fruits.

In this work the direct effect of hydrotherapy and refrigeration on peduncular rot in mango fruits was demonstrated, evidencing the importance and efficiency of this method in the control of post-harvest disease of fruits.

Table1. Variance analysis (ANOVA) showing significant results

FV	GL	SQ	QM	Fc	Pr>Fc
TEMPERATURE	4	6.476885	1.619221	2747.548	0.0000
TIME	2	0.169523	0.084761	143.826	0.0000
TEMPERATURE*TIME	8	0.053531	0.006691	11.354	0.0000
error	60	0.035360	0.000589		
Total corrected	74	6.735299			

CV (%) = 3.28
Overall average: 0.7401333 Number of observations: 75

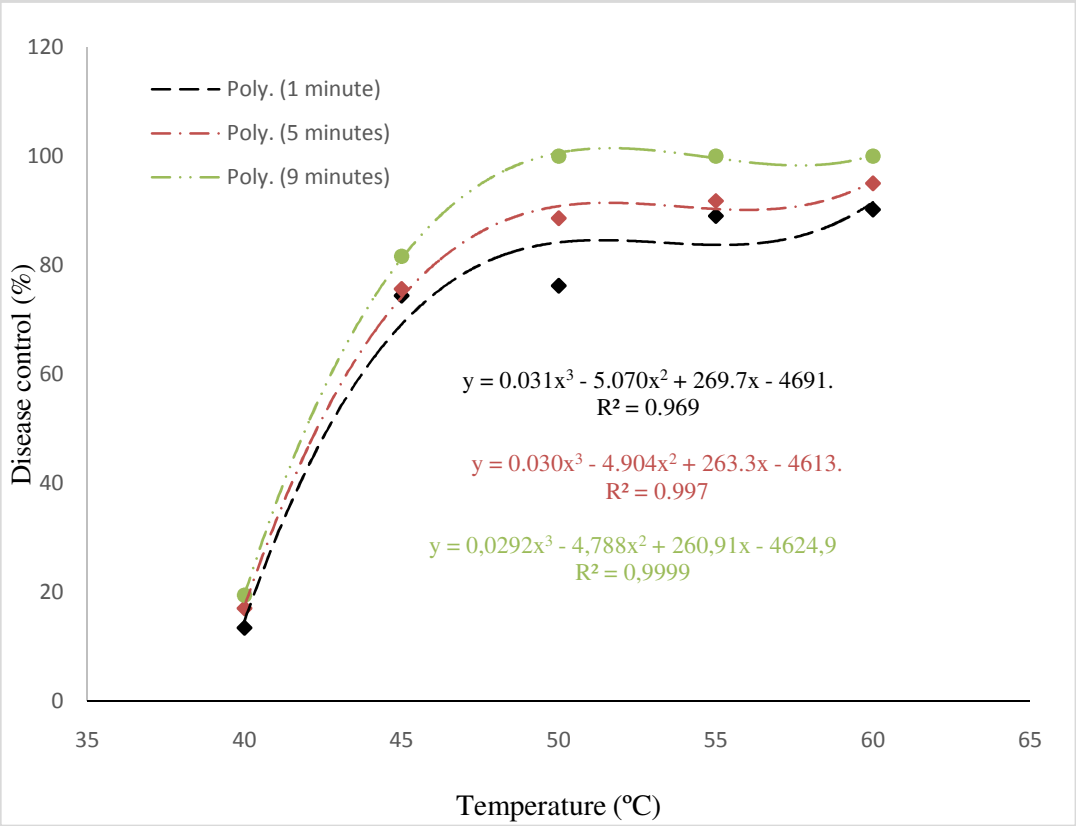

Fig. 3. Effect of therapy and refrigeration on the control of peduncular rot in mango fruits.

4. CONCLUSION

Thermotherapy associated with refrigeration promotes the curative effect of Tommy Atkins mango fruits on peduncular rot (*Lasiodiplodia theobromae*). The immersion of Tommy Atkins cv mango fruits in warm water at 50 ºC, 55 ºC and 60 ºC for 9 minutes, followed by refrigeration of the fruits at 20 ºC is able to control peduncular rot. Competing interests.

REFERENCES

1. Nascimento A. S. MANGA: FITOSSANIDADE. 1 ED. Brasília: Embrapa Communication for Technology Transfer, 2000. p. 104.

2. Chitarra M. I. F, Chitarra A. B. Post-harvesting of fruits and vegetables: physiology and handling. 2. ed. Lavras: UFLA, 2005. 785 p.

3. Angel N. D. et al. Mango diseases. In: Oliveira, S.M. et al. (Ed ..). Post-harvest pathology: tropical fruits, oleractic and ornamental. Brasília, DF: EMBRAPA. Information Technology, 2006. p.733-774.

4. Zambolim L, Junqueira N.T.V. Integrated Mangement Management. In: ROZANE, D.E.; Darezzo, R.J.; Aguiar, R.L.; Aguilera, G.H.A.; Zambolim, L. (Ed.). Manga: integrated production, industrialization and commercialization. Viçosa: Federal University of Viçosa, 2004. v.1, p.391-408.

5. Lins S. R. O. Investigation of peduncular rot in mango. 174 p. Thesis (PhD in Phytopathology) - Federal Rural University of Pernambuco. Recife, 2010.

6. Diedhiou P. M. Alteration of post harvest diseases of mango Mangifera indica through production practices and climatic factors. African journal of Biotechnology. Bowien, v. 6, n. 9, p. 1087-1094, 2007.

7. Amorim E. P. R, Peixinho G. S, Ribeiro V. G. Alternative products in post-harvest handling grapevine cv. Italy. 1. ed. NEA New Academic Editions, 2017. v. 1. 187p.

8. Golan R. B, Philips D.J. Postharvest heat treatment of fresh fruits and vegetables for decay control. Plant Disease, St Paul. v. 75, p.1085-1089. 1991.

9. Fischer I. H, Alves S. A. M, Almeida A. M, Arruda M. C, Bertani R. M. A , Garcia M. J. M. Elaboration and validation of a diagrammatic scale for the quantification of anthracnose severity in yellow passion fruit fruits.. Summa Phytopathol, Botucatu, v. 35, n. 3, p. 226-228, 2009

10. Bleinroth E. W, Sigrist J. M. M. Raw material. In: Papaya: Culture, raw material, processing and economic aspects. Campinas, Ital. p. 227-236. 1989.

11. Silva J. C. Use of essential oils, plant extracts and resistance inducers in the alternative control of banana malaria. 66 p. Dissertation (Master's). Center of Agrarian Sciences, Federal University of Alagoas. Rio Largo, 2007.

12. Barbosa L. F. Control of Mango Peduncular Rot (*Lasiodiplodia theobromae* (PAT.) GRIFFON & MAUBL), using plant extracts, essential oils and hydrotherapy 110 p. Dissertation (Master's Degree in Plant Protection) - Federal University of Alagoas. Rio Largo, 2011.

13. Amorim S. R. Integrated control of *Colletotrichum gloeosporioides* Penz. in mango fruits (*Mangifera indica L.*) 54 p. Dissertation (Master in Agronomy) - Federal University of Alagoas. Rio Largo, 2003.

14. Peruch L. A. M, Schroeder A. L, Tschoeke P. H, Schroeder A. L, Tschoeke P. H. Effect of thermotherapy on the viability of Colletotrichum gloeosporioides conidia and post-harvest control of yellow passion fruit anthracnose. Brazilian Phytopathology, Brasília, v. 24, p. 316, 1999 Supplement.

15. Lima, L.C.; Dias, M.S.C.; Castro, M.V.; Ribeiro Júnior, P.M.; Silva, E.B. Control of anthracnose and mango quality (Mangifera indica L.) cv. Haden, after hydrothermal treatment and refrigerated storage under modified atmosphere. Science and Agrotechnology, Lavras, v.31, n.2, p.298-304, 2007.