VARIETAL RESISTANCE AND NON-FUNGICIDAL CONTROL TO BANANA FRUIT ROTS FUNGI

BY

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ABSTRACT

Botryodiplodia theobromae, Fusarium semitectum, Fusarium oxysporum, Verticillium theobromae, Alternaria alternata and *Aspergillus niger* were recovered from samples of banana fruits, showed symptoms of banana fruit rots, collected from markets in different localities in El-Behera Governorate during 1999/2000 period. These fungi were recovered in frequencies of 52%, 56%, 19%, 23%, 72% and 21%, respectively. *B. theobromae, F. semitectum,* and *F. oxysporum* were significantly pathogenic and incited rots ranged between 9.4 mm and 78 mm on the tested banana cultivars (Hindi, Baiadi, Williams, and Paradica). *V.theobromae* was only pathogenic to cv. Hindi and did not incite a significant rot on the other banana cvs. *Alternaria alternata* and *Aspergillus niger,* however, failed to induce rot on any of the tested banana cvs. Hindi fruits were extremely susceptible to the tested banana fruit rots fungi. Williams and Paradica were moderately susceptible while Baladi fruits exhibited the highest resistance. That resistance was linked to the high firmness of fruits, high wax content on peels, high phenolics and starch content, but low sugars content. Salicylic acid (5000 ppm), acetic acid (100 ppm), lactic acid (10000 ppm), hydrogen peroxide (10000 ppm), sodium hypochlorite (5000 ppm), and calcium chloride ($15x10^4$ ppm), as dipping treatments, significantly decreased amount of rots (75-95%) developed on banana fruits. Such non-fungicidal, non-residual treatments should be considered for a safer control of banana fruit rots fungi.

Key words: Banana, fruit rot, *Botryodiplodia sp, Fusarium spp, Verticillium sp.*

INTRODUCTION

Losses due to post-harvest and fruit rots of banana ranged between 10% and 30% with much bigger figures in the developing countries (Bourne, 1981). No accurate data are available concerning losses due to post-harvest banana fruit rots in Egypt (Nour El-Din, 1985). Several fungal pathogens were reported to be associated with banana fruit rots around the world. That included species of *Fusarium, Botryodiplodia, Verticillium, Colleiotrichum, Cladosporium, Cephalosporium, Nigrospora, Phomopsis,*

Cylindrocarpon, Alternaria, Penicillium, Aspergilllus, Rhizopus, and *Mucor* (Griffee, 1976; Shillingford, 1976; Knight *et.al.,* 1977; Knight, 1982; Slabaugh and Grove, 1982; Vesonder *et.al.,* 1995). Physical and chemical characteristics of banana fruits were found to be affecting varietal susceptibility to fruit rots fungi (Nour El-Din, 1985; Wasef and Naseria, 1990; Singh, 1993; Oh *et.al.,* 1999; Modafar *et.al.,* 2000). A number of fungicides such Benomyel and Topsin-M where successfully used to control banana fruit rots. However, toxicity, safety and residues were always considered (Eckert, 1990). A number of non-residual, non-fungicidal more safer chemicals were recently introduced to control a variety of post-harvest diseases. That chemicals were such salicylic acid, acetic acid, lactic acid, hydrogen peroxide, sodium hypochlorite, and calcium chloride (Helton and Dilbeck, 1982; Link and Riley, 1988; Michail *et.al.,* 1988; Conway *et.al.,* 1992&1994; Al-Zaemey *et.al.,* 1994; Frey and Carver, 1998; Hussain *et.al.,* 2002).

Consequently, the present study was conducted to focus on banana fruit rots in El-Behera Governorate through the following approaches: a). Isolation and identification of the pathogens responsible for banana fruit rots. b). Studying the varietal resistance to banana fruit rots fungi. c). Studying the efficacy of some newly introduced non-fungicidal chemicals to control banana fruit rots fungi.

MATERIALS AND METHODS

Isolation and identification of the causal organisms:

Banana fruits, showing rot symptoms were sampled from markets in different localities in El-Behera Governorate during the 1999-2000 period. Banana fruits were washed in tap water and surface sterilized with 95% ethyl alcohol. Small portions of the inner rotted tissues were transferred onto PDA plates and incubated at 24^0C for five days. Pure cultures of the recovered fungi were obtained by the hyphal tip technique. Identification of the isolated fungi were conducted according to Barnett and Hunter (1972), and Booth (1977).

Pathogenicity tests :

Green mature fruits of Hindi, Williams, Paradica and Baladi banana cultivars were obtained from orchards in El-Behera Governorate. Fruits

were in a good physical conditions, uniform in size and in the second stage of maturity which is green, trace of yellow (Nour El-Din, 1985). Fruits were ripened by dipping in 1000 ppm acetylene solutions for five mins, rinsed in sterile distilled water and kept to dry in air. Pores of 5-mm in diameter were prepared in banana fruits using a sterilized cork borer. Inocula of 4-mm discs were taken from the advancing margin of 7-day-old PDA cultures of the tested fungi and inserted into fruit tissues through the prepared pores and covered with peel plugs. Then, inoculated tissues were sealed with a thin layer of wax to avoid contamination. Each treatment was consisted of five replicate fruits and incubated at 24^0C. Maximum diameters of rotted areas developed on banana fruits of the tested cultivars were recorded in mm, ten days after inoculation.

Physical characteristics associated with varietal resistance to banana fruit rots fungi :

That was assessed in randomly selected healthy fruits in five replicate fruits for each tested cultivar as follows:

- Firmness, was measured according to Youn and Howard (1999) using the 5/16 Effegi-Plunger pressure tester (Italy) and expressed as pound/inch^2.
- Wax content, was determined on peels of the tested banana cultivars according to Freeman and Turner (1985) as :

$$\text{WAX CONTENT (g/cm}^2\text{)} = \frac{\text{WAX CONTENT OF PEEL SURFACE (g)}}{\text{PEEL SURFACE AREA (cm}^2\text{)}}$$

- Acidity of peel and pulp, was determined as pH values using the Digital-Jenco meter (Model 5001, USA) according to Nour El-Din (1985).

Chemical characteristics associated with varietal resistance to banana fruit rots fungi :

Fresh samples were taken from peel and pulp of the tested banana cvs non-inoculated and inoculated with *B. theobromae, F. semitectum,* and *F. oxysporum*, ten dayes after inoculation, for the chemical composition determination as follows:

- Total phenolics content, was determined in fresh samples of peel tissues according to Johnson and Schall (1957).
- Total sugars content, was determined in fresh pulp samples according to the Association of Official Analytical Chemists, USA, methods (1980).

- Starch content, was determined in fresh pulp samples according to El-Shennawi (2000).

Chemical control :

A variety of chemicals recently introduced to control post-harvest diseases were tested in the present study to control banana fruit rots and their causal organisms. The obtained effects were compared with the commonly used Topsin-M fungicide. The tested chemicals, their sources, and concentrations tested, were as follows, salicylic acid (99%), El-Nasr, company (1000, 3000, 5000 ppm); acetic acid (99.5%), El-Nasr company (10, 50, 100 ppm); lactic acid (88%), El-Nasr company (1000, 5000, 10000 ppm); hydrogen peroxide (33.3%), El-Gomhouria company (100, 1000, 10000 ppm); sodium hypochlorite (Chlorax, 0.05%), El-Gomhouria company (100, 1000, 5000 ppm); calcium chloride (95%), El-Gomhouria company (5,10,15 $x10^4$), and Topsin-M (70%), Kafer El-Zayat company (1, 10, 50 ppm).

***In vitro* tests:** The above mentioned chemicals and concentrations were *in vitro* screened for the most effective ones to be used in the *in vivo* tests. Concentrations were freshly prepared in sterile distilled water and incorporated into PDA just before pouring the medium. Discs 5-mm in diameter were taken from advancing margins of PDA cultures of the tested fungi and transferred onto PDA medium supplemented with different concentrations of the tested chemicals. Check treatment without chemicals was performed. Each treatment was conducted in five replicate plates and incubated at 28^0C. Plates were monitored until an isolate colonized the whole plate, then, radial growth rate of the tested fungi was calculated in mm.

***In vivo* tests:** Mature banana fruits of cv. Hindi were prepared in five replicate fruits for each treatment and inoculated with *B. theobromae, F. semitectum,* and *F. oxysporum* isolates as described in pathogenicity tests, no wax sealing was performed for the inoculation sites. Fruits were dipped in the required concentrations, freshly prepared in sterile distilled water according to (Michail *et.al.,* 1988). Similar inoculated fruits were immersed in sterile distilled water and served as a control. Treated fruits were kept at room temperature (20-26^0C) for ten days, then, maximum diameters of the rotted areas developed on the fruits were measured in mm, ten days after inoculation.

Statistical analysis: The obtained data were statistically analyzed according to the Gomez and Gomez (1984) Costat computer program. Means were compared using LSD test at the 0.05 level of probability.

EXPERIMENTAL RESULTS

The recovered isolates :

Different fungi were recovered from the surveyed banana samples (Table 1). *Fusarium spp* were most prevalent as recovered from 75% of the plated samples. *F. semitectum* constituted 56% while *F. oxysporum* constituted 19%. *Alternaria alternata* was recovered at a high frequency of 72%, while *Botryodiplodia theobromae* was recovered at a frequency of 52%. *Verticillium theobromae* and *Aspergillus niger* were also recovered but at lower frequencies of 23% and 21% respectively (Table 1).

Table (1): Frequency of fungi recovered from banana fruits, showed symptoms of banana fruit rots, collected from different localities in El-Behera Governorate during 1999-2000 seasons.

Fungi	Frequency*
Botryodiplodia theobromae	52
Fusarium semitectum	56
Fusarium oxysporum	19
Alternaria alternata.	72
Verticillium theobromae	23
Aspergillus niger	21

* Number of isolates recovered from 100 samples plated on PDA.

Pathogenicity tests :

Pathogenicity tests showed that *B. theobromae* and *Fusarium spp* isolates were pathogenic to all tested banana cultivars *i.e.*, Hindi, Baladi, Williams, and Paradica and incited rots on banana fruits ranged between 9.4 mm and 78 mm (Table 2). Rotted area, however, was greater (12-78 mm) for *B. theobromae. Verticillium theobromae* was only pathogenic to cv. Hindi and did not incite a significant rot on the other banana cvs. *Alternaria alteranata* and *Aspergillus niger*, however, failed to induce a significant rot on any of the tested banana cultivars.

Hindi was the most susceptible banana cultivar to infection with the tested banana fruit rots fungi, while Baladi was the most resistant as mean of the rotted areas developed were 28.7 mm and 5.4 mm respectively. Williams and Paradcia, however, intermediately reacted (Table 2).

Table (2): Maximum diameter of the rotted areas (mm) developed on banana fruits of the tested cultivars, ten days after inoculation.

Fungi	cultivars				Means
	Hindi	Williams	Paradica	Baladi	
B. theobromae	78*	25	22	12	34.2 A
F. semitectum	43	15	18	9.7	21.4
F. oxysporum	37	10	14	9.4	11.93
V. theobromae	11	0.8	0.7	0.6	3.3 D
Alternaria alternata	2.3	0.0	1.1	0.0	0.85 D
Aspergillus niger	1.3	0.2	0.9	1.0	0.85 D
Control (non-inoculated)	3.4	0.0	2.0	0.0	1.35 D
Means (inoculated).	28.7 A	8.5 B	9.4 B	5.4 C	

LSD of varieties at 0.05 = 2.1 LSD of fungi at 0.05 = 2.2

*Data are average of rotted areas developed on five replicate fruits. Values sharing a common letter in the same column or row are not significantly different at 0.05 level of probability.

Physical and chemical characteristics associated with varietal resistance to banana fruit rots fungi :

Baladi and Williams cultivars (Table 3) exhibited the highest fruit firmness *i.e.*, 3.3 and 3.5 pound/inch^2 respectivily, while cv. Hindi had the lowest firmness *i.e.*, 2.6 pound/inch^2. Meantime, cv. Baladi had the highest content of wax on peel surface (300 µg/cm^2) followed by cv. Williams (260 µg/cm^2), cv. Hindi (90 µg/cm^2) and cv. Paradica (43 µg/cm^2). No obvious variations were detected for acidity (as pH values) of peel and pulp of the tested cultivars of the ripe banana fruits (Table 3).

Table (3): Physical characteristics associated with resistance of tested banana cultivars to banana fruit rots fungi.

Banana cvs.	Firmness pound/inch^2	Wax content µg/cm^2	Acidity **	
			Peel	Pulp
Hindi	2.6 ± 0.1*	90.0 ± 2.0	6.5± 0.4	5.3±0.4
Williams	3.5 ± 0.2	260 ± 5.0	6.1 ± 0.6	5.1±0.3
Paradica	3.0 ± 0.5	43.0 ± 2.0	6.1 ± 0.5	5.1±0.3
Baladi	3.3 ± 0.1	300 ± 10.0	6.1 ± 0.3	5.1±0.2

* Standard Deviation value. ** Measured as pH values.

Meantime, cv. Baladi exhibited the highest total phenolics content in both non-inoculated and inoculated banana fruits while cv. Hindi had the lowest (Table 4). Williams and Paradica, however, were of intermediate phenolics contents. Besides, cv. Hindi exhibited the highest total sugars content but lowest starch content in both non-inoculated and inoculated banana fruits, and on the contrary were Baladi and Paradica. Williams, however, was of intermediate values (Table 4).

A reversible relationship was detected between severity of rots developed on banana fruits and firmness of the fruits, the wax content on peels, and the phenolics content, and on the contrary was the relationship between rots severity and the total sugars content. For the starch content, a proportional relationship was revealed in the non-inoculated banana fruits while in the inoculated ones a reversible relationship was obtained with much higher regression value (Fig. 1).

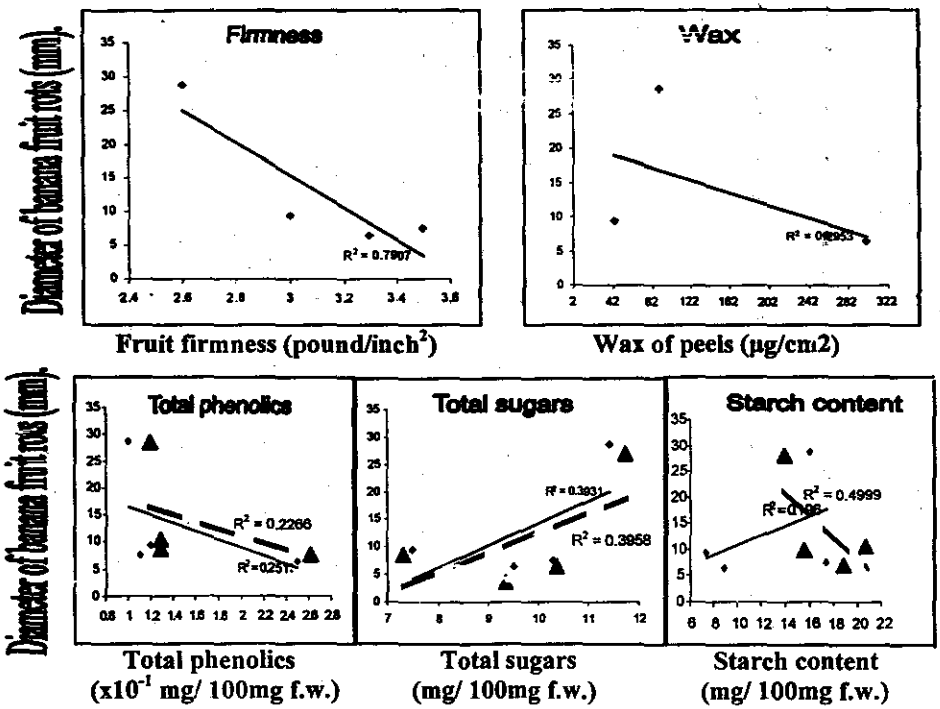

Fig. (1): Relationship between physical and chemical characteristics of banana fruits, of the tested cultivars, and severity of fruit rots developed due to artificial inoculation with the tested banana fruit rots fungi. ◆ & —— = non-inoculated. ▲ & -- = inoculated.

Table (4): Chemical constituents of the tested cultivars of banana fruits non-inoculated and inoculated with banana fruit rots fungi, ten days after inoculation.

Tested fungi / Banana cultivars	Chemical constituents														
	Phenolics content (x 10^{-1} mg/100mg f.w.)					Total sugars content (mg / 100mg f.w.)					Starch content (mg / 100 mg f.w.)				
	Control (non-inoculated)	*B.theobromae*	*F. semitectum*	*F. oxysporum*	Means	Control (non-inoculated)	*B.theobromae*	*F. semitectum*	*F. oxysporum*	Means	Control (non-inoculated)	*B.theobromae*	*F. semitectum*	*F. oxysporum*	Means
Hindi	1.0*	1.1	1.6	1.3	1.2B	11.4	10.6	10.9	11.0	10.9A	16	13.3	14.4	13.7	14.3D
Williams	1.1	1.2	1.5	1.3	1.3 B	10.3	10.0	9.9	10.2	10.1B	17.4	14.8	15.5	15.9	15.8C
Paradica	1.2	1.2	1.6	1.2	1.3B	7.5	7.2	7.3	7.5	7.4D	22.6	18.7	20.1	20.7	20.5A
Baladi	2.5	2.7	2.9	2.8	2.7A	9.5	8.7	9.4	8.9	9.1C	20.7	19.3	18.8	16.5	18.8B
Means*	1.5C	1.5C	1.9A	1.7B		9.7A	9.1C	9.4B	9.4B		19.2A	16.5C	17.2B	16.7C	

* Data are average of five replicate fruits ** Means followed by the same letter in the same row or column, for each chemical constituent, are not significantly different at 0.05 of probability.

LSD of phenolics content for cultivars =$0.12x10^{-1}$, for fungi = $0.14x10^{-1}$.

LSD of total sugars content for cultivars = 0.12, for fungi = 0.14.

LSD of starch content for cultivars = 0.24, for fungi = 0.24.

Chemical control:

The *in vitro* screening of the tested chemicals and concentrations revealed that salicylic acid, acetic acid, lactic acid, hydrogen peroxide, sodium hypochlorite, and calcium chloride were effective and inhibited mycelial growth of the tested fungi at 5000, 100, 10000, 10000, 5000, and $15x10^4$ ppm, respectively (Table 5).

The *In vivo* tests proved that the effective concentrations revealed in the *in vitro* tests were still effective when, applied as dipping treatments, against the tested banana fruit rots fungi. Severity of rots developed significantly decreased compared to the untreated control. The obtained effects, however, were lower than that of Topsin-M fungicide (Table 6).

DISCUSSION

Several fungal pathogens were found to be associated with banana fruit rots in El-Behera Governorate. *Alternaria alternata, Fusarium semitectum, Botryodiplodia theobromae* were recovered in high frequencies of 72%, 56%, and 52% respectively. *Verticillium theobromae, Fusarium oxysporum* and *Aspergillus niger* were also recovered but at lower frequencies of 23%, 19%, and 21%, respectively. These results are in agreement with reports from Egypt and other parts of the world (El-Helaly *et.al.*, 1955; Abo El-Dahab and El-Goorani, 1969; Lantican and Quimio, 1976; Shillingford, 1976; Knight *et.al.*, 1977; Nour El-Din, 1985; Wasef and Naseria, 1990; Johnson and Blazques, 1992; Singh, 1993; Vesonder *et.al.*, 1995; Oh *et.al.*, 1999; Modafar *et.al.*, 2000). However, *B.theobromae, F.semitectum*, and *F.oxysporum* were highly pathogenic and incited significant rots (9.4-78 mm) on banana fruits of the tested banana cultivars *i.e.*, Hindi, Williams, Paradica, and Baladi. *V. theobromae* was only pathogenic to cv. Hindi and did not incite a significant rot on the other banana cultivars. *Alternaria alternata* and *Aspergillus niger*, however, failed to induce rot on any of the tested banana cvs. Potential of *B. theobromae* and *Fusarium spp* in inducing banana fruit rots could be due to production and activity of macerating enzymes such pectin methyl esterase (PME) and polygalacturanase (PG) produced by *B.theobromae* and *Fusaruim spp.* (Ali, 1977; Shillingford and Sinclair, 1980). Hindi fruits were extremely susceptible to the tested banana fruit rots fungi, Williams and Paradica were moderately susceptible while Baladi fruits, surprisingly, exhibited the highest resistance. That variation could be due to one or more of the physical and chemical characteristics of banana cvs. The highest firmness of banana fruits and the high content of wax on peels were linked to the resistant cv. Baladi, while the lowest firmness and the low content of

Table (5): *In vitro* effects of different concentrations of certain non-fungicidal chemicals and Topsin-M fungicide on radial growth rate (mm/day) of the tested banana fruit rots fungi.

Conc.* / Fungi	Tested chemicals																					
	Cont.	Topsin-M			Salicylic acid			Acetic acid			Lactic acid			Calcium chloride ($x10^4$)			Hydrogene peroxide			Sodium hypochlorite		
	0.0	1	10	50	1000	3000	5000	10	50	100	1000	5000	10000	5	10	15	100	1000	10000	100	1000	5000
B.theobromae	33**	0.0	0.0	0.0	30	15	0.0	29	24	0.0	28	13	0.0	21	3.0	0.0	12	2.0	0.0	24	7.0	0.0
F.semitectum	26	18	6.0	0.0	24	16	0.0	22	19	0.0	13	8.0	0.0	8.0	4.0	0.0	18	10	0.0	24	14	0.0
F. oxysporum	28	9.0	3.0	0.0	23	21	0.0	20	18	0.0	15	10	0.0	10	3.0	0.0	25	21	0.0	19	13	0.0

* Concentrations of the tested chemicals expressed as ppm. ** Data are average of five replicate PDA plates.

Table (6): Maximum diameter of rotted areas (mm) developed on cv. Hindi banana fruits, artificially infected with banana fruit rots fungi and treated with certain non-fungicidal chemicals, ten days after inoculation.

Treatments & Conc. / Fungi	Control (Untreated).	Topsin-M 50 ppm	Salicylic acid 5000 ppm	Acetic acid 100 ppm	Lactic acid 10000 ppm	Calcium chloride $15X10^4$ ppm	Hydrogene peroxide 10000 ppm	Sodium hypochlorite 5000 ppm
B. theobromae	70*	0.0	3.0	9.0	18	3.6	3.1	4.4
F. semitectum	56	0.0	3.0	3.0	14.2	2.8	2.7	2.8
F. oxysporum	61	0.0	2.0	3.0	13.7	3.0	2.5	3.6
Means **	62 A	0.0 E	2.6 D	5.0 C	15.3 B	3.1 CD	2.8 D	3.6 CD

.* Data are average of five replicate fruits.

** Means followed by the same letter are not significantly different at 0.05 level of probability.

LSD for fungi = 0.5 LSD for treatments = 1.67.

wax were linked to the susceptible cv. Hindi. Firmness of peel tissues were taken as a parameter for softening of banana fruits and consequently, its susceptibility to post-harvest pathogens invasion (Youn and Howard, 1999). Meantime, cuticle was generally accepted as a physical barrier (Martin, 1964). Waxes on cuticle prevent the penetration by the fungi or it might contain substances that inhibit fungal growth, or, both factors might be operative (Oh *et.al.,* 1999). Acidity of peel and pulp, however, was not found to play a significant role in this respect. It has been indicated by Lakshmann and Mohan (1992) that the more starchy fruits the less susceptible, while the sweet varieties were more susceptible to fruit rots fungi. The obtained results confirmed that hypothesis as the susceptible Hindi cultivar had the highest level of total sugars and the lowest level of starch and on the contrary was the resistant cv Baladi. Sugars content, however, decreased when fruits showed symptoms of rots, probably because of the sugar consumption by the invading fungi. Meantime, the resistant cv. Baladi had a total phenolics content greater than the susceptible cv. Hindi. Moreover, total phenolics significantly accumulated in the resistant Baladi fruits as a response to the artificial infection with banana fruit rots fungi. These results are in harmony with Johnson and Schall (1957), Griffee (1976), Lantican and Quimio (1979), Knight (1982), Freeman and Turner (1985), Nour El-Din (1985), Brown (1989), Wasef and Naseria (1990), Singh (1993), Meyer *et.al.* (1997), Youn and Howard (1999), and Modafar *et.al.* (2000).

For the control of a number of post-harvest diseases salicylic acid was introduced (Mills and Wood, 1984). Salicylic acid had long been known as an exogenous inducer for the systemic acquired resistance (Frey and Carver, 1998). The present study supported that proposal; dipping of the artificially infected banana fruits (cv Hindi) in 5000 ppm salicylic acid significantly controlled banana fruit rots. Acetic acid and lactic acid, were thought to have antiseptic effects against pathogens of the post-harvest diseases (Michail *et.al.,* 1988; Al-Zaemey *et.al.,* 1994). Acetic acid at 100 ppm and lactic acid at 10000 ppm, surprisingly, controlled rots of the artificial infection with banana fruit rots fungi. Similarly, hydrogen peroxide and sodium hypochlorite were known of having antiseptic effects against a wide range of plant pathogens (Helton and Dilbeck, 1982; Link and Riley, 1988). The present study confirmed that hypothesis. Treatment of banana fruits as dipping in 10000 ppm hydrogen peroxide, or 5000 ppm sodium hypochlorite significantly decreased amount of rots developed in the artificially infected banana fruits and similarly did the treatment with calcium chloride at $15x10^4$ ppm. Calcium effect was probably due to the

complexity of calcium ions with the cell wall of fruit peels that may reflect in more firmness and a consequent less rot (Conway *et.al.*, 1992). These findings are in harmony with Nour El-Din (1985), Michail *et.al.* (1988), Al-Zaemey *et.al.* (1994), Conway *et.al.* (1994), Frey and Carver (1998), and Youn and Howard (1999). Consequently, such non-fungicidal, non-residual treatments should be considered for a safer control against banana fruit rots fungi.

REFERENCES

Abo-El-Dahab, M. K. and M. A. El-Goorani (1969). A *Fusarium* fruit rot of banana. Phytopathol. Mediter., 6 : 83- 86.

Ali, S. S. (1977). Synergistic action of pectin-methyl estrase and poly galacturonase during pathogenesis by *Botryodiplodia theobromae* Pat. J. Ind. Bot. Soc., 56 : 86-89.

Al-Zaemey, A.B, N. Magan, and A.K. Thompson (1994). Studies on the effect of fruit-coating polymers and organic acids on growth of *Colletotrichum musae in vitro* and on post-harvest control of anthracnose of banana. Mycol. Res., 98:1463-1468.

Association of Official Agricultural Chemists (1980). Official methodes of analysis associated with official agricultural chemists. Washington, USA.

Barnett, H. L. and B.H. Hunter (1972). Illustrated Genera of Imperfect fungi 3rd Burgess Publishing Co., Minneapolis.

Booth, C. (1977). *Fusarium* laboratory guide to the identification of the major species. Common. Mycol. Inst., Kew, England.

Bourne, H. C. (1981). The world problem of post harvest food losses. Environmental Industry, 4 : 3-5.

Brown, G. E. (1989). Host defences at the wound site on harvest crops. Phytopothology, 79 : 1381-1384.

Conway, W. S., C. E. Sams, C. Y. Wang, and J. A. Abbott (1994). Additive effects of post-harvest calcium and heat treatment on reducing decay and maintaining quality in apples. J. Amer. Soc. Hort. Sci., 119 : 49-53.

Conway, W. S., C. E. Sams, R. G. McGuire and A. Kelman (1992). Calcium treatment of apples and potatoes to reduce post-harvest decay. Plant Dis., 76 : 329-334.

Eckert, J. W. (1990). Recent developments in the chemical control of post-harvest diseases. Acta Hort., 269 : 477- 494.

El-Helaly, A. F., I. A. Ibrahim, and H. M. El-Arosi (1955). Studies on *Botryodiplodia* fruit rots of banana in Egypt. Alex. J. Agric. Res., 3 : 109-121.

El-Shennawi, M.R. (2000). Effect of nitrogen and potassium fertilization on growth yield, fruit quality and leaf mineral content of Williams banana grown in calcareous soil. Ph.D. Thesis, Fac. of Agric., Alex. Univ.

Freeman, B. and D. W. Turner (1985). The epicuticular waxes on different varieties of banana (*Musa. sp*). Aust. J. Bot., 33 : 393-408.

Frey, S. and T. L. Carver (1998). Induction of systemic resistance in pea to pea powdery mildew by exogenus application of salicylic acid. J. Phytopathol., 146 : 239-245.

Gomez, K. A and A. A. Gomez (1984). Statistical procedures for agricultural research. 2nd ed, John Wiley and Sons, Inc. New York. USA.

Griffee, P. J. (1976). Pathogenicity of some fungi isolated from diseased crown of banana hands. Phytopathol. Z., 85 : 206- 216.

Helton, A. W. and R. Dilbeck (1982). Effect of hydrogene peroxide seed disinfestation treatments on germination and development of *Pisum sativum*. Plant Dis., 66 : 784-785.

Hussain, N. A., A. A. El-Banan, N. A. Abdel-Aziz, and A. A. Galal (2002). Effect of calcium salts on growth, polygalacturonase activity and infection of bean pods by *Sclerotinia sclerotiorum*. Minia J. Agric. Res. Develop., 22 : 243-254.

Johanson, A. and B. Blazquez (1992). Fungi associated with banana crown rot on field-packed fruit from the Windward Islands and assesment of their sensitivity to the fungicides, thiobendazole, prochloraz and imazalil. Crop Protection, 11 : 79-83.

Johnson, G. and L. A. Schall (1957). Accumulation of phenolic substances and ascorbic acid in potato tuber tissue upon injury and their possible role in disease resistance. Amer. Potato J., 34 : 220-209.

Knight, C. (1982). Pathogenicity of some fungi associated with crown rot of banana. Phytopathol. Z., 104 : 13-18.

Knight, C., D. Cuttes, and J. Colhoum (1977). The role of *Fusarium semitectum* in casing crown rot of banana. Phytopathol. Z., 89, 170-176.

Lakshmann, P., and S. Mohan (1992). Studies on rhizome rot and tip-over disease of banana. Madras Agric. J., 79 : 56- 57.

Lantican, M. T. and T. H. Quimio (1976). Pathogenicity and cultural characteristic of *Botryodiplodia* spp causing fruit rots. Phillippine Phytopathol., 12: 66-74.

Link, E. M. and P. A. Riley (1988). Role of hydrogene peroxide in the cytotoxicity of the xanthine oxidase system. Biochem. J., 249 : 391-399.

Martin, J. T. (1964). Role of cuticule in the defence against plant disease. Annu. Rev. Phytopathol., 2: 81-100.

Meyer, V., S. Michalek, D. Treutter, and W. Feucht (1997). Phenolic compound of apple and their relationship to scab resistance. J. Phytopathol., 145 : 69-75.

Michail, S. H., A. M. Hussein, A. M. Kamara, and M. S. El-Din (1988). Non-fungicidal control of certain post-harvest disease of banana fruits. Acta Phytopathologica et Entomologica Hungarica, 23 : 413-421.

Mills, P.R., K.S. Wood (1984). The effect of polyacrylic acid, acetyl salicylic acid, and salicylic acid on resistance of cucumber to *Colletotrichum lagenarium*. Phytopathol. Z., 111:209-216.

Modafar, C., A. Tantaoui, and E. El-Boustani (2000). Changes in cell-wall banana phenolic compounds and lignin in roots of date palm cultivars differing in susceptibility to *Fusarium oxysporum* F. sp *albdinis*. J. Phytopathol., 148 : 405-411.

Nour El-Din, Mona. M. (1985). Post-harvest pathology of banana fruits. M.Sc. Thesis, Fac. of Agric., Alex. Univ.

Oh, B. J., K. D. Kim, and Y. S. Kim (1999). Effect of cuticular wax layer of green and red pepper fruits on infection by *Colletotrichum gloeosprioides*. J. Phytopathol., 147: 547-552.

Shillingford, C. A. (1976). Occurrence of banana fruit rot in Jamaican boxing plants. Plant Dis. Reptr., 60 : 788-793.

Shillingford, C. A., and J. B. Sinclair (1980). Macerating enzymes production by *Colletotrichum musae* and *Fusaruim semitectum* incitants of banana fruit decay. Phytopathol. Z., 97:127-135.

Singh, H. (1993). Changes in sugar and vitamin C in banana fruits during pathogenesis. Advan. Plant Sci., 6 : 33-36.

Slabaugh, W. R., and M. D. Grove (1982). Post-harvest diseases of banana, and their control. Plant Dis., 66 : 746-750.

Vesonder, R., A. logrieco, A. Botta lico, C. Altomane, and S. peterson. (1995). *Fusarium* species associated with banana fruit rot and their potential toxigenicity. Mycotoxin Res., 11 : 93-98.

Wasef, R. A. and F. K. Naseria (1990). Physio-chemical properties of Hindi banana during ripening and processing. Agric. Res. Rev., 68 : 999-1011.

Youn, L. and L. Howard (1999). Firmness and phyto-chemical losses in yellow peppers (*Capsicum annuum*) as affected by calcium choride and storage. J. Agric. Food Chem., 47: 700-703.

الملخص العربي

إستخدام الأصناف المقاومة وبدائل المبيدات الفطرية لمقاومة فطريات أعفان ثمار الموز

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تم عزل فطريات بوتريوديبلوديا ثيوبرومي، فيوزاريوم سميتيكتم، فيوزاريوم اوكسيسبورام، فيرتيسيليوم ثيوبرومي، الترناريا الترناتا، اسبيرجيلس نيجر ، وذلك من ثمار موز مصابة بالأعفان تم جمعها من مناطـــق مختلفة بمحافظة البحيرة ، عزلت هذه الفطريات بنسبة ٥٢% ، ٥٦% ، ١٩% ، ٢١%، ٧٢%، ٢١% من العينات المصابة علي التوالي. كانت الفطريات بوتريوديبلوديا ثيوبرومي ، فيوزاريوم سميتيكتم، فيوزاريوم اوكسيسبورام هي الأكثر قدرة علي إحداث أعفان الثمار حيث تراوح نصف قطر العفن الناتج بين ٩,٤ ، ٧٨ ملليمتر علي أصناف الموز المختبرة، وهي صنف هندي، بلدي، ويليامز، باراديكا. وأظهر الفطر فيرتيسيليوم ثيوبرومي قدرة مرضية علي الصنف هندي فقط دون بقية الأصناف، بينما الفطر الترناريا الترناتا والفطر أسبيرجيلس نيجر ، لم يحدثا إصابة معنوية علي أي من الأصناف المختبرة. كانت ثمار الصنف هندي هي الأكثر قابلية للإصابة بفطريات الأعفان المختبرة بينما كانت ثمار الصنف ويليامز والصنف باراديكا متوسطي القابلية للإصابة وكان الصنف بلدي الأكثر مقاومة. وقد إرتبطت المقاومة لفطريات الأعفان في أصناف الموز المختبرة بقيمة عالية لصلابة الثمار والمحتوي المرتفع من الشموع علي سطح قشرة الثمار وكذلك المحتوي المرتفع من الفينولات والنشا، والمحتوي المنخفض من السكريات الكلية. أظهرت معاملة ثمار الموز المعداة بفطريات أعفان الموز المختبرة والمعاملة بحمض السلسيليك (٥٠٠ جزئ في المليون) أو حمض الخليك (١٠٠ جزئ في المليون) أو حمض اللاكتيـــك (١٠٠٠٠ جزئ في المليون) أو فوق أكسيد الهيدروجين (١٠٠٠٠ جزئ في المليون) أو هيبوكلوريت الصوديـــوم (٥٠٠٠ جزئ في المليون) أو كلـــوريد الكالسيوم (١٥×١٠^{٤} جزئ في المليون) فعالية معنوية في تخفيض شدة الأعفان الناتجة علي ثمار الموز المعداة مما يشير إلى أن مثل هذه المعاملات عديمة الأثر الباقي يجب تطبيقها من أجل مقاومة آمنة لفطريات أعفان ثمار الموز.