



# MANAGING FUSARIUM WILT OF 'CAVENDISH' BANANA USING MICROBIAL CONTROL AGENTS AND RESISTANT SOMACLONES

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# INTRODUCTION



## BANANA

- the world's leading fruit crop; the 5th most important agricultural crop in world trade (Aurore *et al.*, 2009).
- in the Philippines, banana is a national priority industry with Davao Region contributing 76% to total production (RDC X1, 2005-2010).
- the 'Cavendish' banana industry is the 2<sup>nd</sup>. biggest dollar earner next to coconut oil.
- generates annual export earnings of PhP 30B.
- employs 330,000 Filipinos





# INTRODUCTION



## Fusarium Wilt or Panama Disease

- a threat to global banana production



Field epidemic of Fusarium wilt , South China



Malaysia



Taiwan



South Africa



Marginal streaking on the leaves

Pseudostem splitting

Vascular discoloration

Streaking/bleeding



# *What causes Fusarium Wilt of 'Cavendish' banana?*

The disease is caused by the soil-borne fungus  
***Fusarium oxysporum* f. sp. cubense (Foc) TR4**



Three types of spores: (a) macrospores; (b) microspores and  
(c) chlamydospores - survival spores

# Four known races based on pathogenicity (Waite, 1963)

**race 1** – infects ‘Gros Michel’

**race 2** – infects Bluggoe; other cooking bananas

**race 3** – attacks *Heliconia*

**race 4** - infects Cavendish and hosts of races 1 and 2

## ***In the Philippines:***

- races 1, 2 and 4 affects banana
- Tropical Race 4- the most destructive





# INTRODUCTION

***Foc TR4* - is now a threat to the 400-million dollar banana export industry of the Philippines.**

## **Impacts:**

- 600 + hectares damaged in 2013 (DA R-X1)**
- damaged 15,507 hectares in Region XI alone, particularly in Davao del Norte and Compostela Valley Province (HVCDP–DA XI, 2016).**





# FOC TR4 CASES IN THE PHILIPPINES IN RECENT YEARS



**Calinan, Davao City**



**Buhangin, Davao City**



**Monkayo, Compostela Valley**



**Maco, Compostela, Valley**



**Balagunan, Sto Tomas**



**Licanan, Davao City**



**Kinamayan, Sto. Tomas**



**Pantaron, Sto. Tomas**

Source: Dr. B. Corcolon







# CURRENT MANAGEMENT STRATEGIES

Management of Fusarium wilt involves a combination of disease control strategies, since no single method is fully effective on its own.

These strategies concentrate on lowering the amount of inoculum in the field, while enhancing plant vigor and disease tolerance (Erwin, 1981).

Preventive measures include restriction of the introduction of disease, early detection of the disease, and effective quarantine and sanitation methods.

Eradicative measures : burning

Other cultural practices: Fallowing and crop rotation







# Why Biological Control Against Foc TR4?

## and why use resistant varieties?

Various reports had shown the potential of antagonistic microbes in controlling Fusarium wilt and other diseases of various crops.

The use of disease-resistant varieties, whenever available, remains to be the best and the most effective strategy in the control of plant diseases.

Hence, the use of microbial control agents and resistant banana somaclones was explored for the management of Fusarium wilt of 'Cavendish' banana.





# OBJECTIVES:

- To evaluate and determine the efficacy of commercially available microbial agents (*Trichoderma harzianum*, Vesicular-Arbuscular Mycorrhizae (VAM), and Effective Microorganisms (EM) against *Foc* TR4 applied singly and in combination under greenhouse and field conditions on susceptible Grand Nain;
- To determine their efficacy in combination with Giant Cavendish Tissue-Cultured Variants (GCTCV) 218 and 219; and
- To develop protocols for the application of effective microbial control agents on Grand Nain and the resistant somaclones.







## SIGNIFICANCE OF THE RESEARCH:

Identification of effective microbial control agents and their use in combination with resistant somaclones can be a potential component of an integrated disease management (IDM) strategy against Foc TR4 in 'Cavendish' banana especially in heavily infested areas.





# METHODOLOGY

## Microbial Control Agents Evaluated



Vesicular-Arbuscular  
Mycorrhizae (VAM)



Trichoderma  
harzianum



Effective  
Microorganism  
(EM)





# METHODOLOGY

## Single & combination trial of microbial agents

## Greenhouse experiment



VAM  
EMAS  
*Trichoderma harzianum*  
-and their combinations

7 days → Foc TR4

Post-planting application-EMAS & *T. harzianum*

## Field experiment

VAM  
EMAS  
*T. harzianum*  
-and their combinations in Grand Nain  
- Single application on GCTCV 218 & 219.

1 month →

Field Planting  
(application of microbial agents)

Post-planting  
EMAS, *T. harzianum*





# RESULTS (Greenhouse Experiment)

Table 1. Percent incidence, % corm with vascular discoloration and severity of infection of *Fusarium* wilt on 'Grand Nain' as affected by the application of the microbial agents under greenhouse condition.

MICROBIAL AGENTS	PERCENT INCIDENCE <sup>a</sup> ..	% CORM WITH VASCULAR DISCOLORATION <sup>b</sup> ..	DISEASE INFECTION INDEX <sup>c</sup> ..
Untreated, Uninoculated	0.00 <sup>a</sup>	0.00 <sup>a</sup>	1.00 <sup>a</sup>
VAM, w/o <i>Foc</i>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	1.00 <sup>a</sup>
EMAS, w/o <i>Foc</i>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	1.00 <sup>a</sup>
<i>Trichoderma harzianum</i> , w/o <i>Foc</i>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	1.00 <sup>a</sup>
Untreated, Inoculated with <i>Foc</i>	43.33 <sup>c</sup>	100.00 <sup>b</sup>	3.03 <sup>d</sup>
VAM + <i>Foc</i>	16.67 <sup>ab</sup>	93.33 <sup>b</sup>	2.44 <sup>bc</sup>
EMAS + <i>Foc</i>	46.67 <sup>c</sup>	100.00 <sup>b</sup>	2.98 <sup>cd</sup>
<i>T. harzianum</i> + <i>Foc</i>	33.33 <sup>bc</sup>	86.67 <sup>b</sup>	2.37 <sup>b</sup>
VAM + EMAS + <i>Foc</i>	43.33 <sup>c</sup>	96.30 <sup>b</sup>	2.58 <sup>bcd</sup>
VAM + <i>T. harzianum</i> + <i>Foc</i>	40.00 <sup>bc</sup>	96.67 <sup>b</sup>	2.87 <sup>bcd</sup>
EMAS + <i>T. harzianum</i> + <i>Foc</i>	40.00 <sup>bc</sup>	100.00 <sup>b</sup>	2.62 <sup>bcd</sup>
VAM + EMAS + <i>T. harzianum</i> + <i>Foc</i>	56.67 <sup>c</sup>	100.00 <sup>b</sup>	2.93 <sup>cd</sup>
CV (%) =	26.52	4.19	3.25

VAM significantly reduced *Fusarium* wilt incidence while VAM and *T. harzianum* applied singly reduced significantly severity of infection on Grand Nain due to *Foc* TR4.





Figure 2. Effect of microbial agents applied singly and in combinations on severity of infection of Foc TR4 on 'Cavendish' banana under greenhouse condition. a) untreated, uninoculated; b) VAM w/o Foc; c) EMAS w/o Foc; d) *T. harzianum* w/o Foc; e) untreated, inoculated with Foc; f) VAM with Foc; g) EMAS with Foc; h) *T. harzianum* Foc; i) VAM + EMAS with Foc; j) VAM + *T. harzianum* with Foc; k) EMAS + *T. harzianum* with Foc and l) VAM + EMAS + *T. harzianum* with Foc.





# RESULTS (Field Experiment-GN)

Table 2. Average Fusarium wilt incidence on 'Cavendish' banana cv. Grand Nain.

MICROBIAL AGENTS	AVERAGE ACROSS LOCATIONS	
	% Disease Incidence**	% Disease Reduction
UNTREATED	65.79 <sup>c</sup>	-
VAM	29.69 <sup>ab</sup>	54.87
EMAS	35.98 <sup>b</sup>	45.31
<i>T. harzianum</i>	30.16 <sup>ab</sup>	54.16
VAM + EMAS	30.04 <sup>ab</sup>	54.16
VAM + <i>T. harzianum</i>	26.10 <sup>a</sup>	60.33
EMAS + <i>T. harzianum</i>	31.76 <sup>ab</sup>	51.72
VAM + EMAS + <i>T. harzianum</i>	32.74 <sup>ab</sup>	50.24
CV (%) =	4.32	

VAM + *T. harzianum* significantly reduced Fusarium wilt incidence across locations with 60.33% disease reduction.





# RESULTS (Field Experiment-GCTCV 218)

Table 3. Average Fusarium wilt incidence on moderately resistant 'GCTCV 218.

TREATMENTS	AVERAGE ACROSS LOCATIONS	
	% Disease Incidence**	% Disease Reduction
UNTREATED GRAND NAIN	65.79 <sup>c</sup>	-
UNTREATED GCTCV 218	39.62 <sup>b</sup>	39.78
VAM	16.54 <sup>a</sup>	74.86
EMAS	13.40 <sup>a</sup>	79.63
<i>T. harzianum</i>	11.47 <sup>a</sup>	82.57
CV (%) =	7.14	

- All three microbial agents significantly reduced Fusarium wilt incidence on GCTCV 218 with disease reductions ranging from 74.86 to 82,57%.

\* Untreated GCTCV 218 reduced disease by 39.78%.





# RESULTS (Field Experiment-GCTCV 219)

Table 4. Average Fusarium wilt incidence on highly resistant 'GCTCV 219.

TREATMENTS	AVERAGE ACROSS LOCATIONS	
	% Disease Incidence	% Disease Reduction
UNTREATED GRAND NAIN	65.79 <sup>c</sup>	
UNTREATED GCTCV 219	6.25 <sup>a</sup>	90.50
VAM	0.58 <sup>a</sup>	99.12
EMAS	0.65 <sup>a</sup>	99.01
<i>T. harzianum</i>	0.00 <sup>a</sup>	100.00
CV (%) =	12.60	

- \* All microbial agents significantly reduced Fusarium wilt incidence. Disease reductions ranged from 99.01-100%.
- \* Untreated GCTCV 219 reduced disease by 90.50%.



# COMPARATIVE COST ANALYSIS (GN)

Table 6. Comparative cost of application of microbial control agents in one hectare Grand Nain.

TREATMENT	% FW**	% Survived Plants	Actual # of survived plants	Average net bunch wt (across sites) in kg <sup>ns</sup>	Yield in kg/ha based on # of survived plants**	Number of boxes at 13.5 kgs/box	Price/box at 4.10 US Dollar/box (=P184.50/box)	Cost of application of MCAs (materials and labor)	Income minus added cost
Control (Untreated)	65.79 <sup>c</sup>	34.21	684	13.92	9521.28 <sup>c</sup>	705	₱130,072.50	0	₱130,072.50
VAM	29.69 <sup>ab</sup>	70.31	1,406	14.18	19937.08 <sup>ab</sup>	1,476	₱272,322.00	₱3,000.00	₱269,322.00
EMAS	35.98 <sup>b</sup>	64.02	1,280	14.39	18419.20 <sup>b</sup>	1,364	₱251,658.00	₱50,542.00	₱201,116.00
<i>Trichoderma harzianum</i>	30.16 <sup>ab</sup>	69.84	1,397	15.20	21234.43 <sup>ab</sup>	1,572	₱290,034.00	₱34,080.00	₱255,954.00
VAM + EMAS	30.04 <sup>ab</sup>	69.96	1,399	14.71	20579.29 <sup>ab</sup>	1,524	₱281,178.00	₱53,542.00	₱227,636.00
VAM + <i>T. harzianum</i>	26.10 <sup>a</sup>	73.90	1,478	15.34	22672.52 <sup>a</sup>	1,679	₱309,775.50	₱37,080.00	₱272,695.50
EMAS + <i>T. harzianum</i>	31.76 <sup>ab</sup>	68.24	1,365	15.12	20638.80 <sup>ab</sup>	1,528	₱281,916.00	₱84,622.00	₱197,294.00
VAM + EMAS + <i>T. harzianum</i>	32.74 <sup>ab</sup>	67.26	1,345	15.54	20901.30 <sup>ab</sup>	1,548	₱285,606.00	₱87,622.00	₱197,984.00

No. of plants/ha=2,000







# COMPARATIVE COST ANALYSIS (GCTCV 218)

Table 6. Comparative cost of application of microbial control agents in one hectare GCTCV 218.

TREATMENT	% FW	% Survived Plants	Actual # of survived plants	Average net bunch wt (across sites) in kg	Yield in kg/ha based on # of survived plants	Number of boxes at 13.5 <del>kg</del> /box	Price/box at 4.10 US Dollar/box (=P184.50/box)	Cost of application of MCAs (materials and labor)	Income minus added cost
Untreated Grand Nain	65.79 <sup>c</sup>	34.21	684	13.92	9,521.28 <sup>c</sup>	705	P130,072.50	0	P130,072.50
Untreated GCTCV 218	39.62 <sup>d</sup>	60.38	1,208	15.69	18,953.52 <sup>d</sup>	1,403	P258,853.50	0	P258,853.50
VAM	16.54 <sup>a</sup>	83.46	1,669	16.37	27,321.53 <sup>a</sup>	2,023	P373,243.50	P3,000.00	P370,243.50
EMAS	13.40 <sup>a</sup>	86.60	1,732	15.28	26,464.96 <sup>a</sup>	1,960	P361,620.00	P39,482.00	P322,138.00
<i>Trichoderma harzianum</i>	11.47 <sup>a</sup>	88.53	1,771	14.33	25,378.43 <sup>a</sup>	1,879	P346,675.50	P20,480.00	P326,195.00

Number of plants /ha= 2,000; VAM= P 120/kg at 10g/plan in split application applied before planting and basally at planting; *T. harzianum* in composted sawdust or sachet of pure culture at P 8.00/kg or per sachet applied monthly at 100g/plant until harvest; EM-1 at P 600/L EM-1; to prepare EMAS, use 30 ml EM-1/L of EMAS preparation and 30 ml molasses/L ~~wate~~ (Cost of molasses is P450/container of 20L. or P22.50/L molasses). Apply 40 ml EMAS/L solution at weekly interval for the 1st three months and every two weeks thereafter until harvest.



# COMPARATIVE COST ANALYSIS (GCTCV 219)

Table 6. Comparative cost of application of microbial control agents in one hectare GCTCV 219.

TREATMENT	% FW	% Survived Plants	Actual # of survived plants	Average net bunch wt (across sites) in kg	Yield in kg/ha based on # of survived plants	Number of boxes at 13.5 kg/box	Price/box at 4.10 US Dollar/box (=P184.50/box)	Cost of application of MCAs (materials and labor)	Income minus added cost
Untreated Grand Nain	65.79 <sup>c</sup>	34.21	684	13.92	9,521.28 <sup>b</sup>	705	P130,072.50	0	P130,072.50
Untreated GCTCV 219	6.25 <sup>d</sup>	93.75	1,875	13.56	25,425.00 <sup>a</sup>	1,883	P347,413.50	0	P347,413.50
VAM	0.58 <sup>a</sup>	99.42	1,988	13.91	27,653.08 <sup>a</sup>	2,048	P377,856.00	P3,000.00	P374,856.00
EMAS	0.65 <sup>a</sup>	99.35	1,987	13.20	26,228.4 <sup>a</sup>	1,942	P358,299.00	P39,482.00	P318,817.00
<i>Trichoderma harzianum</i>	0.00 <sup>a</sup>	100.00	2,000	13.24	25,480.00 <sup>a</sup>	1,961	P361,804.50	P25,080.00	P336,724.50

Number of plants /ha= 2,000; VAM= P 120/kg at 10g/plan in split application applied before planting and basally at planting; *T. harzianum* in composted sawdust or sachet of pure culture at P 8.00/kg or per sachet applied monthly at 100g/plant until harvest; EM-1 at P 600/L EM-1; to prepare EMAS, use 30 ml EM-1/L of EMAS preparation and 30 ml molasses/L water (Cost of molasses is P450/container of 20L. or P22.50/L molasses). Apply 40 ml EMAS/ L solution at weekly interval for the 1st three months and every two weeks thereafter until harvest.



# CONCLUSIONS:

Based on the results of the **greenhouse experiment**, **VAM** and ***Trichoderma harzianum*** applied singly as pre-treatment microbial control agents can reduce incidence and severity of Fusarium wilt on susceptible **Grand Nain** due to *Foc* TR4.

In **field experiments**, **VAM + *T. harzianum*** and **VAM only** are potential microbial control agents against Fusarium wilt in susceptible **Grand Nain**. For **GCTCV 218** and **219**, ***T. harzianum***, **EMAS** and **VAM** are potential microbial control agents. Lowest incidence and highest disease reduction can be obtained with ***T. harzianum* application**.

Based on comparative cost analyses, highest return can be realized with **VAM + *T. harzianum*** followed by **VAM only** in susceptible **Grand Nain**. For **GCTCV 218** and **219**, highest return can be realized with **VAM application**.







# RECOMMENDATIONS

- Evaluation of different delivery systems to further enhance efficacy of **VAM** and ***T. harzianum*** and reduce the cost of ***T. harzianum*** application.
- Enhance the efficacy of VAM and ***T. harzianum*** by combining them with growth-promoting organic formulations/products.
- Validation trial in bigger plots on the use of the best delivery systems for **VAM** and ***Trichoderma harzianum*** in **Grand Nain** and **GCTCV 218**.
- Use Resistant somaclones in combination with **microbial control agents** in heavily infested areas.





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# Source of Information:

## Panama Project 2: Development of Biological Control Strategies Against *Foc* Tropical Race 4 (TR4)

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