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RESISTANCE AND SCOUTING IN THE CONTROL OF YAM ANTHRACNOSE OF THE WINGED YAM (*Dioscorea alata*)

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ABSTRACT

Anthracnose (*Colletotrichum gloeosporioides*) is a major obstacle to economic production of winged yams (*D. alata*) in the Caribbean. We evaluated varietal resistance and disease scouting combined with fungicide for control of anthracnose. On Gunung, a high yielding introduction anthracnose severity never exceeded 15 % necrotic foliage and economic losses were not observed. Kinabayo and Kabusah were more anthracnose susceptible than Gunung but did not suffer economic losses. Binugas, a high yielding cultivar, has never shown over 25 % anthracnose losses detected once in 4 years. Florido, Forastero, and Leon Globe were always damaged with over 25 % yam anthracnose necrosis. Purmay, Gemelos, and Moresby were intermediately susceptible and usually showed yield and quality losses. Chemical control of anthracnose by preventive sprays required monthly applications (6 or more) during the rainy season. During 1986-87 and 1987-88, we tested the application of fungicide (benomyl + mancozeb) only when a 5 % increase in anthracnose over any month was found in susceptible varieties : no sprays were applied in 1987-88 in Mayaguez, and Isabela, and 3 sprays were applied in Isabella in 1986-87. Susceptible cultivars generally showed 15 % or more increase in tuber yield with fungicide protection.

RESUME

VARIETES RESISTANTES ET PRE-EVALUATION DE LA MALADIE DANS LA LUTTE CONTRE L'ANTHRACNOSE DE *D.ALATA*

L'Anthracnose (*Colletotrichum gloeosporioides*) est un obstacle majeur à la production économique de l'igname ailée (*D. alata*) dans la Caraïbe.

Nous avons évalué la résistance variétale et l'évolution de la maladie associée à un fongicide dans la lutte contre l'anthracnose. Sur GUNNUNG, une introduction à haut rendement, l'attaque d'anthracnose ne dépasse jamais 15 % en nécrose du feuillage et il n'y a pas de réduction du rendement commercial. Kinabayo et Kabusah étaient plus sensibles mais ne présentaient pas de réduction de rendement commercial. BINUGAS, un cultivar à haut rendement, n'a jamais dépassé 25 % de nécrose due à l'anthracnose. PURMAN, GEMELOS et MORESBY de sensibilité intermédiaire éprouvaient généralement une perte de rendement et qualité. La lutte chimique contre l'anthracnose par pulvérisation préventive nécessite des traitements mensuels (6 ou davantage) pendant la saison des pluies. En 86-87 et 87-88 nous avons testé l'application de bénomyl + mancozeb seulement quand on observait d'un mois au suivant un accroissement de 5 % de l'anthracnose chez les variétés sensibles : aucun traitement ne fut nécessaire à Mayaguez en 1986-87, deux le furent en 87-88 à Mayaguez et Isabela, et 3 furent faits à Isabela en 86-87. Les cultivars sensibles montrent généralement un accroissement de rendement de 15 % avec le traitement fongicide.

INTRODUCTION

Yams (*Dioscorea* spp.) are extensively planted in the Caribean, where they are a popular food, and in West Africa, where they are staples. However, in the Caribbean, diseases often limit production of yams and other root crops (Ferguson, 1986). Anthracnose (*Colletotrichum gloeosporioides* Penz.), one of the most devastating yam diseases, mainly affects winged yams (*D. alata*) (Mignucci, et al, 1982). Anthracnose-diseased tissues die, giving plants a burnt appearance. This premature defoliation leads to sizable losses in tuber yield an quality. In Puerto Rico, where the disease is known as «Candelilla,» severe anthracnose has led to the disappearance of *D. alata* cv. Florido and its replacement by the African yam, *D. rotundata* cv. Habanero. Winged yams have greater resistance to storage and nematode damage than the African yams. Their continued cultivation is highly desirable if yam anthracnose can be controlled economically.

Fungicides can be used to reduce yam anthracnose (Mignucci et. al., 1981) ; however, generally recommended monthly or biweekly applications are costly to producers. They also can lead to pathogen tolerance or resistance to fungicides, and result in high exposure of applicators and the environment to the pesticides. Spraying only after anthracnose thresholds are reached could reduce fungicide applications while maitaining sufficient control for high economic yields. With this approach, anthracnose scouting is necessary to determine when fungicide should be applied.

The development and testing of an anthracnose scouting and control system for winged yams is outlined here.

MATERIALS AND METHODS

The experiments were conducted in western Puerto Rico at the Isabela and Mayaguez farms of the Tropical Agriculture Research Station, U.S. Department of Agriculture. Isabela and Mayaguez receive mean annual precipitation of 1,675 and 2,158 mm, respectively, having tropical oceanic lowland climates classified as subhumid and humid, respectively. The Isabela soil is a sandy loam oxisol and the Mayaguez site has a heavy clay ultisol.

Yams plots were established during the months of March to May in 1987 and 1988 using 100 g tuber pieces. Ten cultivars were planted on 0.75 m ridges with a 1 m by 0.7 m arrangement. Fifteen yams were planted per row with 3 rows per replicate. Plots were replicated 4 times using a randomized complete block design which was split into sprayed and nonsprayed subplots.

After plant emergence, anthracnose severity was rated monthly. The percentage of diseased foliage area was determined visually and recorded. When a 5 % increase in necrosis occurred in any month on any variety, fungicide was applied to half of all plots. The fungicide treatment consisted of a combination of Benlate 50 W (benomyl) (1 kg a.p./ha) and Dithane M45 (mancozeb) (3 kg a.p./ha) diluted
with water and applied foliarly until run-off. Three applications (mid-june, mid-August, and mid-September) were used in Isabela in 1987, but none were needed in Mayaguez in that year. In 1988, two applications (mid-August and mid-September) were made in Isabela and Mayaguez.

Yams were harvested for yield in january, 1988 and 1989.

RESULTS AND DISCUSSION

Foliar anthracnose readings in mid-October, 1988, for the yam cultivars in Isabela and Mayaguez are reported in Table 1. Anthracnose levels were generally lower than those found by Hepperly and Vazquez (1989) or by Mignucci, et al. (1982). Gemelos (34.3 %) and Leone Globe (35.0 %) had the highest anthracnose in Isabela and Mayaguez, respectively. Varieties were similarly susceptible across sites, with significant rank correlations ($r = 0.76$). Gunung had the lowest level of anthracnose severity (<2%) and disease was not significantly reduced by fungicide treatments. Low levels of anthracnose

Table 1 : Anthracnose severity in 10 winged yam cultivars evaluated in mid-October, 1988, in Isabela and Mayaguez, Puerto-Rico

	Anthracnose Severity (%)			
	Isabela		Mayaguez	
Cultivar	Treated[1]	Nontreated[2]	Treated	Nontreated
Leone Globe	5,8[3]	10,3	9,5	35
Forestera	8,3	23	13,8	32
Gemelos	15	34,3	10	17,5
Purmay	5,3	9	7,5	15,8
Moresby	5,8	9,3	13,3	19
Florido	12,5	25	9,5	16,5
Kinabayo	6,8	10,5	6,8	13
Binugas	2,8	3,5	4,8	8
Kabusah	2,8	8	3,5	7,3
Gunung	1,3	1,5	1,3	1,3

1 Two applications (mid-August and mid September based on anthracnose severity) of foliar fungicide (1kg a.p./ha Benlate 50 W and 3 kg a.p./ha Dithane M45), using a hand-pumped backpack sprayer.

2 Rank correlation of anthracnose severity in non treated plots was significant (r=0,76. P=0,05).

3 Means from 4 replications.

on Gunung were previously reported by Hepperly and Vazquez (1989). In this study, all cultivars except Gunung showed about 50 % reduction of anthracnose following fungicide treatment.

In the 1987-88 crop, fungicide was applied 3 times in Isabela but was not applied in Mayaguez. Mean yields in Mayaguez ranged from 4,500 to 29,100 kg/ha (Table 2). In 7 of 10 cultivars tuber yields were higher after fungicide treatment. Yields ranged from 2,600 to 34,300 kg/ha in the nontreated plots and 6,300 to 39,500 kg/ha in the fungicide treated plots.

In the 1988-89 crop, fungicide was applied twice in both Isabela and Mayaguez. After fungicide application, five cultivars gave higher yields at both sites (Table 3). Yield responding varieties Leone Globe, Forastero, Purmay, and Moresby are consistently susceptible to anthracnose and generally show more severe foliar damage anthracnose than the nonresponsive varieties. Isabela yields were lower than in previous seasons probably because of a severe summer drought. When other yield limiting factors, such as adverse weather are present, yam response to anthracnose control may be reduced.

Because yam foliage develops over a 6 to 12 month period, chemical control requires 8 or more sprays of benomyl having 3-week activity, or 16 or more sprays of protectant fungicide used at 10-days intervals. By applying fungicide only during critical periods when a significant increase in anthracnose was noted during scouting, a 62-100 % reduction in spraying was possible. The control plan led to increased yields and tuber size in most of the susceptible varieties tested.

In the 1988-89 crop, measurements were taken on mean tuber weights in Mayaguez (Table 4). After fungicide treatment, tuber weights increased in 7 of the 10 cultivars. In general, fungicide responsive varieties were more susceptible to anthracnose than the nonresponsive ones. Mean tuber weight of Leone Globe, Forastero, Gemelos, Purmay, and Moresby was 0.76 kg/tuber for fungicide-treated plots and 0.56 kg/ha for the nontreated controls.

Yam anthracnose mainly reduces leaf activity, decreasing photosynthate available for tuber development. The small tubers of anthracnose-infected plants are often unmarketable because of their size. Mignucci, et al (1981) did an in-depth study of the effect of benomyl on yam anthracnose using *D. alata* cv. Florido. They found tuber size was the yield and quality component most reduced by anthracnose. In anthracnose susceptible yams, effective fungicide treatment will increase the proportion of marketable yams by increasing size.

Table 2. Mean tuber yields, 1987-88 crop, of 10 winged yam cultivars treated 3 times with foliar fungicide in Isabela or not treated in Mayaguez and Isabela, Puerti-Rico.

	Tuber Yield (1 kg/ha)			
	Isabela			Mayaguez
Cultivar	Treated[1]		Nontreated	Nontreated
Leone Globe	7,6[2]	*[3]	5,9	16,3
Forestera	11,2	*	2,6	18,2
Gemelos	9,8		9	4,5
Purmay	10,4	*	6,9	7,2
Moresby	6,3	*	5,2	6,4
Florido	7,6		8,5	14,3
Kinabayo	22,8	*	9,6	29,1
Binugas	39,5	*	34,3	23,4
Kabusah	12,9	*	10	10,5
Gunung	12,5		18,5	21,8

1 Foliar fungicide (1 kg a.p./ha Benlate 50 W and 3 kg a.p./ha Dithane M45) applied based on anthracnose severity using a hand-pumped backed sprayer at mid-June, mid-August, and mid-September, 1987.

2 Means from 4 replicates

3 Significant increase by treatment according to paired t- test (P=0,05).

Table 3. Mean tuber yields, 1988-89 crop, of 10 winged yam cultivars treated 2 times with foliar fungicide in Isabela or not treated in Mayaguez and Isabela, Puerto-Rico.

	Tuber Yield (1 kg/ha)					
	Isabela			Mayaguez		
Cultivar	Treated[1]		Nontreated	Treated		Nontreated
Leone Globe	1,8[2]	*[3]	7,4	13	*	9,5
Forastero	14,6	*	13,1	11	*	8,7
Gemelos	4,7		5,8	11,9	*	9,8
Purmay	8,5	*	5,1	5	*	3,6
Moresby	6,7		6	6,6	*	4,2
Florido	6,3		6,5	8,1		8,5
Kinabayo	12,2		11,6	14,5		14,1
Binugas	28		25,5	18,6		20,7
Kabusah	6		5,5	6,8		9,5
Gunung	11,7		11,4	16,6		22,5

1 Foliar fungicide (1 kg a.p./ha Benlate 50 W and 3 kg a.p./ha Dithane M45) applied based on anthracnose severity at mid-August and mid-Septembe, 1988, using a hand-pumped backpack sprayer..

2 Means from 4 replicates

3 Significant increase by treatment between paired means based on paired t-test (P=0,05).

Table 4 : Mean tuber weights, 1988-89 crop, of 10 winged yam cultivars either treated with foliar fungicide for anthracnose control or not treated in Mayaguez, Puerto-Rico.

	Mean Tuber Weight (kg/tuber)		
Cultivar	Treated[1]	*	Nontreated
Leone Globe	0,97[2]	*[3]	0,8
Forastero	1,29	*	0,9
Gemelos	0,59	*	0,49
Purmay	0,5	*	0,34
Moresby	0,44	*	0,26
Florido	0,53	*	0,43
Kinabayo	1,9	*	1,3
Binugas	1,31	*	1,82
Kabusah	0,75		0,89
Gunung	1,38		1,58

The reduction of tuber size in the more resistant varieties after fungicide treatments may be evidence of a phytotoxic reaction which could distort disease loss assessments to some extent. Gunung, the most resistant variety, had decreased yield and tuber size after fungicide application.

Table 5 presents the increases in estimated gross returns in the yam cultivars responding positively to fungicide treatments. favorable returns were obtained by the majority of the most susceptible yam cultivars using the control system. Returns after fungicide use were probably more favorable than estimated because tuber size was not taken into consideration, in our estimates.

Cultivars with anthracnose resistance tend to outyield anthracnose-susceptible varieties whether anthracnose is present or not. However, the acceptance of some of the resistant varieties has been limited by their odd, lobed appearance, which is not appealing to most local consumers.

Despite the devastating effect of anthracnose, integrated control measures should allow for the continued cropping of winged yams in the Caribbean. Foliar fungicide application in conjunction with a scouting system, can control yam anthracnose effectively and economically. However, the most important long-term goal for yam anthracnose control should be the transfer of resistance from Gunung to susceptible varieties with superior appearance and marketability. Since winged yams have not been bred, novel techniques of gene isolation and transfer should be attempted to deal with this problem.

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Table 5 : Influence of chemical control of anthracnose on estimated gross returns of 1987-88 and 1988-89 crops of winged yam in Isabela and 1988-89 crop in Mayaguez, Puerto-Rico.

		Isabela				
		Yield (1 kg/ha)				
Cultivar	Year	Treated[1]	Control	Diff.	% Incr.	$ Incr./hectare [2,3]
Leone Globe[4]	87-8	7,6[5]	5,9	1,7	28,8	850-1,700
	88-9	11,8	7,4	4,4	59,5	2,200-4,400
Forastero	87-8	11,2	2,6	8,6	330,8	4,300-8,600
	88-9	14,6	13,1	1,5	11,5	750-1,500
Purmay	87-8	10,9	6,9	4	58	2,00-4,00
	88-9	8,5	5,1	3,4	66,7	1,700-3,400
Moresby	87-8	6,3	5,2	1,1	21,2	550-1,100
	88-9	6,7	6	0,7	11,7	375-750
Kinabayo	87-8	22,8	9,6	13,2	137,5	6,600-13,200
	88-9	12,2	11,6	0,6	6,5	300-600
Binugas	87-8	39,5	34,3	5,2	15,2	2,600-5,200
	88-9	28	25,5	2,5	9,8	1,250-2,500
Kabusah	87-8	12,9	10	2,9	29	1,450-2,900
	88-9	6	5,5	0,5	9,1	250-500

	Mayaguez 1988-89[6]				
	Yield (1 kg/ha)				
Cultivar	Treated	Control	Diff.	% Incr.	$ Incr./ha
Leone Globe	13	9,5	3,5	36,8	1,750-3,500
Forastero	11	8,7	2,3	26,4	1,150-2,300
Gemelos	11,9	9,8	2,1	21,4	1,050-2,100
Purmay	5	3,6	1,4	38,9	700-1,400
Moresby	6,6	4,2	2,4	57,1	1,200-2,400

1 Foliar fungicide (1kg a.p./ha Benlate 50 W and 3 kg a.p./ha Dithane M45) applied 3 times in Isabela in 1987-88 and 2 times in Isabela and Mayaguez in 1988-89 based on anthracnose severity.

2 Labor and pecticide costs for 2 and 3 sprays were $ 355,68 and $543,52/ha, respectively.

3 Increase in gross returns from fungicide treatment based on farmer price of $0,50 to $1 kg ($0,22 to $0,45/1b) of yams.

4 Estimates are only for the cultivars reacting postively to fungicide applications.

5 Means from 4 replications.

6 Estimates are only for the 1988-89 crop since the 1987-88 crop was not sprayed.