Preliminary Evidence of Correlation between Foliar and Root Resistance to Root Rot caused by *Phytophthora tropicalis* in Cassava

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Introduction

Phytophthora root rot affects cassava (*Manihot esculenta* Crantz) in different production areas and attacks all the plant's major organs, that is, roots, stems, and, sometimes, leaves. Farmers use several methods to control this economically significant disease, but ecological management by host-plant resistance is the preferred method (Alvarez et al. 2003). Root and leaf resistance to *Phytophthora tropicalis* was determined in 22 cassava clones, both during penetration of the pathogen through the peel (infection phase) and after infection in the parenchyma.

Materials and Methods

Plant materials and the pathogen. Cassava roots and young leaves belonging to 22 genotypes were evaluated for resistance to *P. tropicalis,* using isolate 44, which was obtained from cassava infected with root rot in Barcelona (Quindío, Colombia). The inoculum was cultured in medium (root inoculation) or leaf discs (leaf inoculation) and incubated between 20°C and 26°C for 4 to 7 days (Loke 2004).

Inoculations. Roots were inoculated by either perforating the peel or placing an agar disk containing mycelia at 4 to 9 points on each of nine roots per genotype. Once inoculated, the roots were deposited in plastic bags containing moisture, and left at 22°C in darkness for 6 days (Figure 1). Leaflets were inoculated by either perforating (1-mm holes) in 5-cm-long fragments of leaflet or inoculating leaflets with zoospores (1.0×10^4 mL^{-1}). They were left to incubate in petri dishes at 25°C to 28°C, with 12 h daylight and 12 h darkness (Figure 1). Eight leaflets per genotype were evaluated.

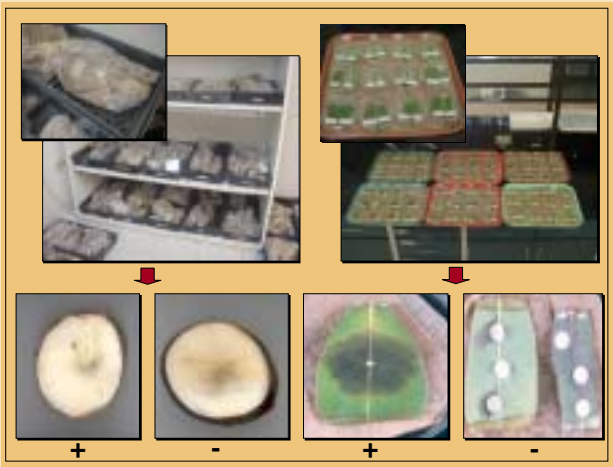

Figure 1. Symptoms obtained by inoculating roots and leaves, by either perforating (+) or not perforating (-) plant tissue.

Evaluations and data analyses. At 6, 9, and 12 days after inoculation of roots from 22 clones, the number of infected inoculation points and the area infected by the pathogen (%) were determined. After 72, 96, 120, and 144 h of incubation, leaflets were evaluated by recording the number of infected inoculation points and severity according to a semi-quantitative scale. To determine the significance of differences between clones in resistance reactions, analyses of variance and regression were made, using the analytical package STATISTIX 8.0 (1985-2003, Analytical Software).

Results and Discussion

We observed significant ($P < 0.05$) clonal differences for root and leaf resistance at the two stages of infection (penetration and post-penetration).

Root resistance. Results indicated that *P. tropicalis* is able to infect healthy roots,without wounds (Figure 1; Table 1). A correlation of +0.28 (r^2 = 0.08) between resistance during (in the peel) and after infection (in the parenchyma) was observed for the roots, indicating that the association between these two types of resistance is low, and therefore should be determined separately. The relationship between iron and manganese is possibly responsible for differences in varietal reaction of the root to infection during penetration (Loke 2004).

Leaf resistance. Resistance was not observed in the leaf, with all the clones showing high susceptibility. Correlation (r = -0.01) was not detected between reactions appearing during penetration and after penetration of the pathogen in the leaf.

Table 1. Resistance to penetration of the pathogen and resistance of tissue in roots and leaves of 22 cassava clones after inoculation with *P. tropicalis*.

Clone	Roots		Leaves	
	Resistance to penetration (% of lesions)	Resistance of the tissue (lesion size, %)	Resistance to penetration (% of lesions)	Resistance of the tissue (1-5)[a]
SM 1219-9	23.8	21.0	64.6	2.7
M Col 2760	28.8	40.8	66.0	3.1
SM 1855-15	31.9	19.4	81.3	3.6
HMC 1 (Manihoica P-13)	38.2	-	36.8	3.1
SM 2211-3	36.4	32.7	69.4	4.0
SM 2073-1	36.9	76.8	56.3	2.7
M Per 183 (Peruana)	42.2	46.8	72.9	3.0
SM 2085-7	47.5	70.9	72.9	2.4
CM 7951-5	57.0	25.6	84.1	2.5
SM 2198-4	55.6	56.4	72.9	2.9
SM 2160-2	59.8	64.3	72.9	2.7
SM 1871-33	59.8	54.0	100.0	3.2
M Tai 8	59.8	41.3	86.8	3.2
SM 2058-2	61.7	43.1	64.6	3.5
SM 1965-1	64.0	46.0	64.6	3.3
CM 523-7 (ICA Catumare)	66.2	58.5	81.3	3.4
CM 8370-10	65.2	50.6	66.9	3.2
CM 6660-21	67.3	33.4	99.6	3.6
SM 1779-7	68.5	50.4	46.3	3.6
SM 1660-4	72.3	42.7	92.4	3.3
CM 7463-2	79.8	69.0	86.5	2.4
SM 1642-22	97.3	46.2	77.9	2.8
Minimum	23.8	19.4	36.8	2.4
Maximum	97.3	76.8	100.0	4.0
Average	52.8	46.1	73.5	3.1
Standard deviation	18.9	16.8	15.6	0.4

[a] 1 = healthy, 5 = severely affected.

Relationship between the two phases of resistance. The two forms of resistance within each tissue (root or leaf lobe) are apparently independent, suggesting that resistance to penetration of the pathogen cannot be predicted by checking tissue resistance.

Relationship between resistance in roots and leaves. The correlation between leaf resistance (% of lesions 72 h after inoculation) and root resistance (% of lesions 10 days after inoculation) of the 22 clones was intermediately positive for pathogen penetration (r = +0.37, r^2 = 0.14). This relationship indicates that most of the clones (15 of 22 clones, 68%) have similar degrees of resistance to penetration in the leaf and root peel.

The moderately positive correlation calculated between the leaves and roots suggests that leaves can be used to predict resistance in roots of cassava populations. Iwaro et al. (1997) reported similar results for cacao. To validate the use of leaf reaction as an indicator of resistance to *P. tropicalis*, a representative cassava population needs to be evaluated.

Conclusions

- To screen for resistance to *P. tropicalis*, the phases of penetration and post-penetration of the pathogen must be evaluated independently, so that its combination can be used in crop improvement to increase the existing levels of resistance in cassava.

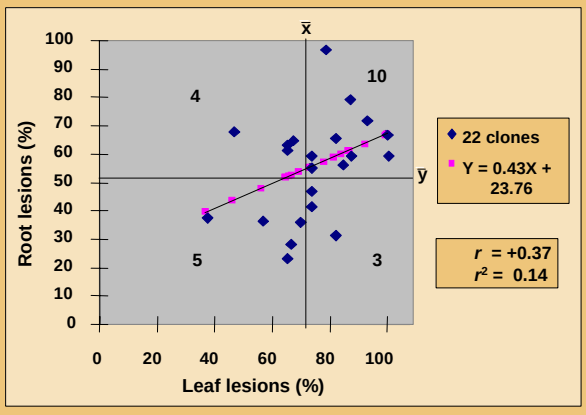

Figure 2. Relationships between percentage of root lesions and percentage of leaf lesions in 22 cassava clones inoculated with *P. tropicalis*. The number in each quadrant indicates the number of clones.

- Resistance in cassava root peel is an important component of resistance to root rot caused by *P. tropicalis*.
- The intermediately positive correlation between leaves and roots suggest that leaves can be used to predict resistance in cassava populations. This discovery will speed up the preselection of clones because the parenchyma does not need to be inoculated with *P. tropicalis*.
- Resistance to *P. tropicalis* as determined in root parenchyma in the evaluated clones is not based on major genes but is quantitative, making reference to the genetic form of inheritance.

References

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