Screening for Resistance to Cassava Bacterial Blight

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ABSTRACT

Lozano, J. C., and Laberry, R. 1982. Screening for resistance to cassava bacterial blight. Plant Disease 66:316-318.

Resistance to *Xanthomonas campestris* pv. *manihotis* in cassava (*Manihot esculenta*) was identified during four cycles of field evaluation in an area where cassava bacterial blight is endemic. Some genotypes that were rated resistant based on foliar symptoms produced under controlled conditions were eliminated because of infection after two, three, or four cycles of continuous cultivation.

Resistance is the best way to control cassava bacterial blight, caused by *Xanthomonas campestris* pv. *manihotis* (Berthet & Bondar 1915) Dye 1978 (6,9). Resistance to this bacterium and to any cassava (*Manihot esculenta* Crantz) pathogen or pest must be correctly identified for the following reasons. The vegetative cycle of cassava is sufficiently long (8–24 mo) to allow severe epidemics to develop on susceptible cultivars when environmental conditions favor disease or pest establishment. Cassava is propagated vegetatively; the quality of the stem cuttings determines to a great extent the overall success in achieving optimal yields. Quality is determined by stem size, age, lignification, number of nodes, and the presence of systemic pathogens or localized pathogens or pests (mites and insects) (10). This quality should be maintained after each production cycle by cultural practices and cultivar resistance to the constraints acting in each ecosystem (7). In most regions, cassava production is continuous or nearly continuous. Consequently, in most ecosystems, cultivars that are susceptible to biotic problems could be present throughout the year. Cassava also has a long genetic cycle (up to 3 yr), which delays development of new, improved cultivars that are resistant to specific problems and greatly limits the ability of breeders to respond to changing host-pathogen interactions (7,8). Most cassava growers are small farmers (11) with traditional technical know-how and few economic resources. They usually have no alternative to producing their own planting material, which should therefore be resistant if possible.

Resistance to diseases is commonly identified by selecting genotypes according to plant reaction after a production cycle. In cassava, however, disease resistance to systemic pathogens (6,12) should be identified after evaluating plant reaction and planting material during each of several succeeding generations exposed to the causal agents. That is, resistance is measured over time at increasing levels of infection. Results of this approach with respect to cassava bacterial blight are presented here for a 5-yr period of greenhouse and field evaluations.

Accepted for publication 11 June 1981.

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0191-2917/82/04031603/$03.00/0

MATERIALS AND METHODS

At least 10 plants of each of 1,800 cassava cultivars from CIAT's germ plasm collection were evaluated for resistance to bacterial blight under controlled conditions (80–90% relative humidity; day-night temperatures of 30-18 C; and a 12-hr photoperiod at 6 klux). The leaf-clipping inoculation technique was used (each leaf lobe was clipped in half with scissors that had been dipped in a bacterial suspension of 1×10^9 to 3×10^9 cells per milliliter of sterile, distilled water (1). We used the highly virulent strain 1060 from the CIAT collection of *X. campestris* pv. *manihotis* (4). The isolate was grown for 36 hr on Kelman's agar (5) without tetrazolium chloride, and the cell suspension was adjusted turbidimetrically to approximately 1×10^8 cells per milliliter. Plants were rated as resistant (angular leaf spots or leaf blight), intermediate-resistant (leaf symptoms and stem cankers and/or gum exudation), or susceptible (dieback, death), following the CIAT cassava bacterial blight rating scale for the leaf-clipping inoculation system (1).

The same cultivars were also planted in the Carimagua ecosystem (eastern plains of Colombia), where the disease is endemic and causes severe epidemics during rainy seasons (2,3,8). Cultivars were planted in blocks of five cuttings, each replicated twice at random, using

planting material produced at CIAT in Cali, Colombia. Subsequent cycles consisted of 15–30 plants per plot for surviving cultivars, with at least two replicates of each cultivar. All planting material used in these cycles was produced in the evaluation plots at the Carimagua testing site. In all cycles, natural epidemics developed. Disease rating and number of cuttings yielded per cultivar were recorded for each cycle and used as an index of resistance.

RESULTS AND DISCUSSION

Plant reactions to cassava bacterial blight infection under controlled conditions and during the first cycle of field testing were very similar (Table 1). The rate of pathogen recovery from susceptible genotypes was greater than that from resistant or intermediate-resistant genotypes; however, the pathogen was also found to invade the stem 5 cm above ground level on resistant and intermediate-resistant genotypes after they were inoculated by the leaf-clip method (Table 1). Although bacterial invasion of the vascular system is correlated ($r = 0.914$ for greenhouse reaction and 0.927 for field reaction, both significant at the 0.1% level) with susceptibility as evaluated by external leaf and stem symptoms, several exceptions were noted (Table 1 and Fig. 1), in which apparently resistant plants were systemically infected.

Systemically infected, apparently resistant plants are not desirable in an endemic cassava bacterial blight area. Because the pathogen has poor pectinase activity (6,9), mature, diseased stem tissue appears symptomless. Bacteria surviving in invaded xylem vessels of the mature stem spread systemically through young plants, which then serve as sources of inoculum for subsequent epidemics (6,9). Consequently, the proportion of infected cuttings increases after several cycles of continuous cultivation of systemically infected, apparently intermediate-resistant or resistant genotypes when these classifications are assigned after one greenhouse or field cycle evaluation. The results of using such systemically infected, apparently resistant material on a continuous basis would be a progressive decline in stand density from lack of bud germination (6,9); a decrease in plant vigor because of bacterial rotting (6); and earlier, more severe epidemics.

The greenhouse results were corroborated by results obtained after planting several genotypes at Carimagua (Fig. 1) for four cycles. Because of the poor nutritional condition of the soil in this region, the production of planting material is about 60% of CIAT production. However, resistant genotypes (Table 1, group I), in which bacterial infection in the stem was very low or absent, produced about the same percentage of cuttings during each of the four cycles (Fig. 1), while other apparently resistant genotypes (Table 1, groups II and III) survived for only two or three cycles (Fig. 1). Susceptible genotypes (groups IV and V) were eliminated during the first or second cycle (Fig. 1).

The data indicate the existence of cassava blight bacterium-resistant genotypes in *M. esculenta* and the need for

Table 1. Reactions of cassava cultivars to *Xanthomonas campestris* pv. *manihotis*[a]

Group[b]	Cultivar	Disease rating[c]		Days after inoculation				
		Greenhouse[d]	Field[e]	45	60	75	90	120
I	CMC 40	IR	IR	23[f]	15	17	18	9
	M Ecu 82	R	R	0	3	0	0	0
	M Col 1916	R	R	0	1	3	0	0
	M Pan 19	R	R	1	0	0	1	0
	M Pan 12B	R	R	2	0	0	3	0
II	M Col 636	R	R	2	8	15	6	12
	M Col 638	R	R	3	16	12	17	10
	M Pan 90	R	R	5	12	9	10	12
	M Col 647	R	R	0	13	8	16	0
III	M Col 170	R	R	12	15	35	40	42
	M Ven 33	R	IR	19	20	25	26	35
	Llanera	IR	IR	33	36	56	61	34
	M Col 1684	R	IR	13	18	12	20	16
	M Ven 38	R	R	16	19	13	12	19
IV	M Pan 101	S	S	75	63	78	56	60
	M Col 113	S	S	95	83	89	85	80
	M Col 22	S	S	81	87	73	84	86
	M Mex 59	S	S	87	56	83	44	91
	M Bra 22	S	S	34	56	23	70	38
V	M Col 62	S	S	56	83	76	53	75
	M Col 162	IR	S	68	80	73	64	68
	M Col 493	S	S	75	86	74	90	75
	Secundina	S	S	86	90	73	80	76
	M Ven 19B	S	S	70	74	83	40	63

[a] Percentage of plants invaded by the bacterium at 5 cm above ground level after inoculation by the leaf-clipping method and incubation in a greenhouse at 80% relative humidity and 23 ± 5 C. The pathogen was isolated by sap streaking on Kelman's tetrazolium chloride medium (5).
[b] Groups were designated according to field resistance: group I lasted for only one cycle; group V continued to produce adequate, high-quality material during four cycles.
[c] R = resistant; I = intermediate-resistant; S = susceptible.
[d] Disease reaction under controlled conditions.
[e] Disease reaction in Carimagua field tests during the first cycle.
[f] Rate of pathogen recovery as a percentage of 50 plants inoculated per cultivar.

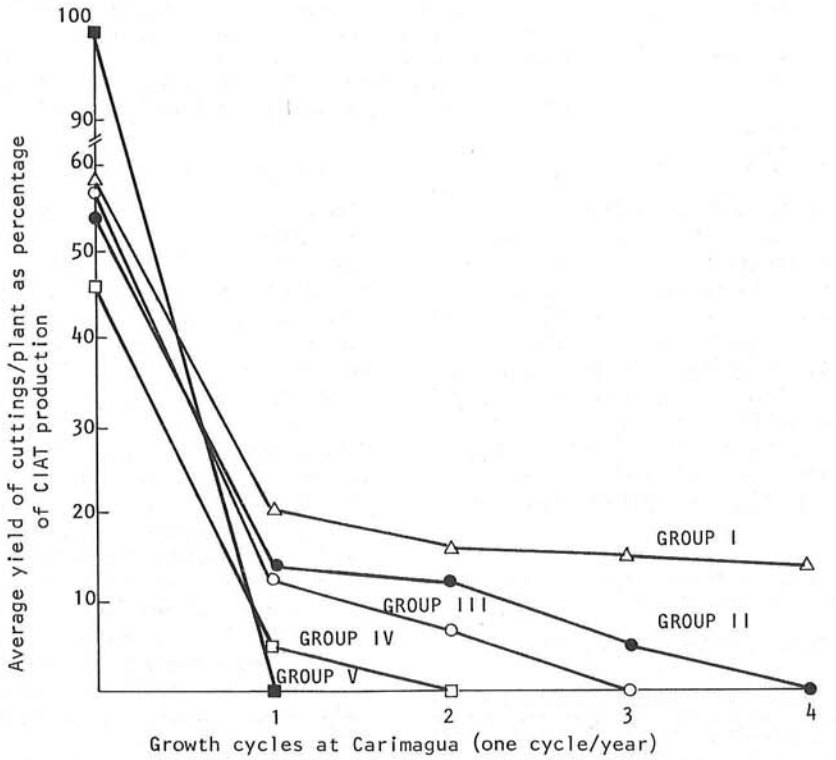

Fig. 1. Survival of five groups of cassava genotypes (average yield of cuttings produced per plant as a percentage of CIAT production) after four cycles of continuous cultivation in the Carimagua ecosystem (eastern plains of Colombia), using planting material produced at the testing site.

field evaluation of testing material for several continuous cycles in areas where the disease is epidemic to accurately identify genotypes resistant to *X. campestris* pv. *manihotis*. Planting material for each successive cycle must be produced in an endemic test area; otherwise, investigators will not be able to distinguish resistant types I, II, and III, with potentially serious consequences in growers' fields. Final resistance evaluation should be the result of integrating data on plant reaction, production of cuttings, and quality of propagating material.

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