RESEARCH NOTE/NOTA DE INVESTIGACIÓN

SCREENING OF WILD COFFEE (*COFFEA* SPP.) FOR RESISTANCE TO *MELOIDOGYNE INCOGNITA* RACE 1

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ABSTRACT

Aribi, J., W. Ribière, L. Villain, and F. Anthony. 2018. Screening of wild coffee (Coffea spp.) for resistance to *Meloidogyne incognita* race 1. Nematropica 48:5-14.

One hundred and forty six cuttings representing duplicates of 73 wild accessions from 16 coffee species were evaluated for resistance to *Meloidogyne incognita* race 1. Five species were subdivided on the basis of geographical origin because morphological differences were previously observed. Two well-characterized susceptible and resistant cultivars were used as comparative controls. The experiments were conducted in a greenhouse using a clonal population of *M. incognita* from Brazil. The reproduction factor (RF) was used to evaluate the resistance (RF<1) or susceptibility (RF>1) to the nematode infection. Plants of both controls were discriminated on the basis of RF values. Both duplicate cuttings of the wild accessions were identically classified as resistant or susceptible. Eight species displayed a resistant reaction, one species was considered to be susceptible, and seven species presented both susceptible and resistant accessions. Resistance *to M. incognita* appeared to be a more frequent character than susceptibility within the gene pool of wild coffee. These results provide coffee breeders with material whose resistance can be transferred into commercial cultivars.

Key words: *Coffea*, coffee, *Meloidogyne incognita*, resistance, root-knot nematode

RESUMEN

Aribi, J., W. Ribière, L. Villain, y F. Anthony. 2018. Cribado de café silvestre (*Coffea* spp.) Para resistencia a *Meloidogyne incognita* raza 1. Nematropica 48:5-14.

Ciento curaenta y seis estacas de 73 accesiones silvestres perteneciendo a 16 especies de café fueron evaluadas para su resistencia a *Meloidogyne incognita* raza 1. Se subdividió cinco especies según su origen geográfico en base a diferencias morfológicas previamente observadas. Los experimentos fueron realizados en invernadero con una población clonal de *M. incognita* colectada en Brasil. Las resistencia y susceptibilidad a este nematodo fueron evaluadas mediante el factor de reproducción (FR). Las plantas de los dos testigos fueron discriminadas en base a los valores del FR. Se observó siempre la misma clasificación como resistente o susceptible de las dos estacas de cada una de las accesiones silvestres evaluadas. Ocho especies mostraron una respuesta de resistencia; una especie fue considerada como susceptible y siete especies presentaron algunas accesiones susceptibles y otras resistentes. La resistencia a *M. incognita* parece ser más frecuente que el carácter de susceptibilidad dentro de la base genética de los cafetos silvestres. Los presentes resultados proveen a los fitomejoradores de café material vegetal cuya resistencia puede ser transferida a cultivares comerciales.

Palabras claves: café, *Coffea*, *Meloidogyne incognita*, nematodos de agallas, Resistencia

Root-knot nematodes (RKNs) of the genus *Meloidogyne* are more widely distributed throughout the world in coffee plantations than any other major group of plant-parasitic nematodes (Campos and Villain, 2005). In Latin American countries, they constitute the main limitation in the development of coffee production because of large diffusion in plantations and abundance in soils (Campos *et al*., 1990). So far, more than 17 species of RKNs have been reported as pathogens of coffee (Carneiro and Cofcewicz, 2008) and new species are still discovered (Humphreys-Pereira *et al*., 2014). The taxonomy remained unclear until recent time. *M. paranaensis* was mistaken as *M. incognita* for more than 20 years in Brazil (Carneiro *et al*., 1996). Consequently, publications prior to the description of *M. paranaensis* in 1996, and a few after it, should be reinterpreted.

Meloidogyne incognita (Kofoid & White) Chitwood is one of the most damaging species on coffee according to the symptoms and the severity of damage (Bertrand and Anthony, 2008). Four races were identified in Brazil and distinguished by a differential host test (Taylor and Sasser, 1978; Carneiro *et al*., 1992). The races 1, 2, and 3 have been considered to be the most aggressive (Albuquerque *et al*., 2010). The race 1 induces a hypersensitive-like response in coffee (Albuquerque *et al*., 2010), similarly to that induced by *M. exigua* infection (Anthony *et al*., 2005). These histological studies suggest that coffee resistance to RKNs may be mediated by a *R*-gene based immunity system.

Commercial coffee production relies on two species, *Coffea arabica* and *C. canephora*. Modern *C. arabica* cultivars are susceptible to many pests and diseases, including RKNs, while *C. canephora* cultivars possess *R* genes that reduce pathogen attacks (Anthony *et al*., 1999; Bertrand and Anthony, 2008). Beside the cultivated species, more than 120 wild species are known in the genus *Coffea* L., which now includes the related species of the genus *Psilanthus* Hook.f (Davis *et al*., 2011). Up to now, very few accessions have been tested for resistance to RKNs. Accessions resistant to *M. incognita* race 1 were identified *in C. canephora* (Gonçalves *et al*., 1996). Resistance to *M. incognita* race 3 was identified in *C. canephora* and (*C. canephora* x *C. congensis*) hybrids initially identified as *C. congensis*, but not in *C. arabica* (Gonçalves and Ferraz, 1987). Moderate resistance based on an 86% reduction of the reproduction factor eight months post-inoculation was recorded to races 1, 2, and 3 in accession UFV408-28 (Albuquerque *et al*., 2010), including the race 1 used in the screening described in this paper.

Similar to what occurs with other perennial crops, RKN control is uncertain in coffee plantations. These parasites destroy the plant root system, are easily disseminated, persist for a long time in the soil in the absence of transitional hosts, and are not efficiently controlled by nematicides (Campos and Silva, 2008). As for most RKNs, *M. incognita* has a wide range of hosts, infecting vegetable, grain, and fruit crops, weeds, and ornamental plants (Ponte, 1977; Nickle, 1984; Luc *et al*., 2005). Because of this situation, genetic control of RKNs has become a major goal in coffee-producing countries, particularly in Latin America (Bertrand *et al*., 2001; Bertrand and Anthony, 2008). This is an essential part of integrated control, as the use of resistant cultivars or rootstocks constitutes an easy, inexpensive, non-polluting method of control, usually requiring no change in cultural practices (Luc and Reversat, 1985). The objective of the present study was to contribute to genetic control to *M. incognita* in coffee, by screening for the first time some accessions from the largest collection of wild coffee worldwide (Dulloo *et al*., 2009; Herrera *et al*., 2011) for their resistance to *M. incognita*. This collection (30 species, 8,000 genotypes) was established in Ivory Coast by IRD in the 70s and 80s (Anthony, 1992). A core collection was then introduced in greenhouses and *in vitro* at Montpellier (Dussert *et al*., 1997).

The plant material consisted of cuttings from 16 coffee species covering the coffee distribution area in Africa (Table 1). Five species (*C. anthonyi*, *C. canephora*, *C. congensis*, *C. liberica*, and *C. stenophylla*) were subdivided on the basis of geographical origin because genetic differentiation was previously observed between these geographical groups (Berthaud *et al*., 1984; Berthaud, 1986; Bridson, 1985; Anthony, 1992; Dussert *et al*., 2003; N'Diaye *et al*., 2007). A new species (*Coffea* sp. 'Congo') from Congo (de Namur *et al*., 1987) was included in the study. Three vigorous genotypes by species or geographical subgroups were selected in the gene bank maintained in greenhouses at Montpellier (France) (Herrera *et al*., 2011). At least two cuttings were produced for each genotype. Two cultivars well known for their host status for *M. incognita*, *C. arabica* cv. Caturra and *C. canephora* cv. Nemaya, were used as susceptible and resistant controls, respectively. The cuttings were cultivated in 8.7 x 11.3 cm plastic pots containing commercial organic soil (®Neuhaus N2) in greenhouse maintained at 24-26°C and 70-80% relative humidity. Basal application of fertilizer was carried out on the plots two weeks after planting, using NPK (17:11:11) (®Fertil).

The *Meloidogyne* population used in the screening tests has been previously used to study the histological response to *M. incognita* in coffee (Albuquerque *et al*., 2010). It was identified as belonging to the race 1.A clonal population, which

Table 1. Origin of the coffee species used in the screening. The geographical subdivisions correspond to genetic differentiation that were observed previously within *C. anthonyi* (Anthony, 1992), *C. canephora* (Berthaud *et al.*, 1984; Berthaud, 1986; Dussert *et al*., 2003), *C. congensis* (Anthony, 1992), *C. liberica* (Bridson, 1985; N'Diaye *et al*., 2007) and *C. stenophylla* (Berthaud *et al.*, 1989).

Species	Origin	Code	Number of genotypes
C. anthonyi	Cameroon	OD	3
	Republic of Congo	OE	3
C. arabica	Ethiopia	Ar	4
C. brevipes	Cameroon	JB	3
C. canephora	Ivory Coast	BA	3
	Central African Republic	BB	3
	Caféier de la Nana	BC	3
	Cameroon	BD	3
C. congensis	Central African Republic	CA	3
	Cameroon	CB	3
	Republic of Congo	CC	3
C. costatifructa	Tanzania	08/OH	3
C. heterocalyx	Cameroon	JC	3
C. humilis	Ivory Coast	G	3
C. liberica	Ivory Coast	EA	3
	Central African Republic	EB	3
C. pocsii	Tanzania	PB	3
C. pseudozanguebariae	Kenya	H	3
C. racemosa	Mozambique	IA/IB	3
C. salvatrix	Mozambique	LA/LB	3
C. sessiliflora	Kenya	PA	3
C. stenophylla	Ivory Coast (Ira population)	FA	3
	Ivory Coast (Assabli population)	FB	3
Coffea sp. 'Congo'	Republic of the Congo	OB	3

was established from a single egg-mass to ensure repeatability of evaluations (Bertrand and Anthony, 2008). This clonal population was reared on the susceptible cv. Caturra in the greenhouse. When the plants presented two pairs of fully-expanded leaves, single plants were inoculated with about 2,500 second-stage juveniles (J2s) into four 1-cm deep holes around the collar region.

Two months after inoculation, plants were removed carefully from the pots. The root systems were washed with tap water and weighed. J2s were extracted by nebulization in a mist chamber

(Barker, 1985). The J2s extracted by this method are very active and easy to count, allowing a precise quantification and a high quality of the inoculum (Bertrand and Anthony, 2008). They were counted three times, one week apart using a Peter slide under light microscope to estimate the final populations (Pf). Nematode reproductive factors (RF=Pf/2,500) were then calculated. RFs were characterized as showing resistance when RF < 1 or susceptibility when RF > 1. Evaluation of coffee cuttings was divided into six batches according to plant development. Each batch was composed of well-developed plants with two pairs of fully-expanded leaves. Two plants of both controls (resistant and susceptible) were systematically included in each batch. Nematode numbers per plant and per g of roots were transformed to *log*(x+1) to normalize the variance prior to statistical analysis (Proctor and Marks, 1974).

Root weights of both controls were variable although all evaluated plants presented two pairs of fully-expanded leaves (Table 2). No relation was observed between root weight and extracted nematode number in the susceptible control. Plants of both controls were discriminated by RF ($P < 0.0000001$), ranging from 0 to 0.1 in cv. Nemaya and from 1.8 to 5.8 in cv. Caturra. They were also discriminated by the total number of extracted J2s ($P < 0.0000001$) and by the number of J2s per root g ($P < 0.034$).

A total of 146 cuttings representing 73 wild coffee accessions were evaluated (Table 3). Both cuttings of each accession were identically classified as resistant or susceptible based on their RF values. Nine species presented a homogeneous response to *M. incognita* race 1 inoculation, with eight species (*C. anthonyi*, *C. brevipes*, *C. heterocalyx*, *C. liberica*, *C. racemosa*, *C. salvatrix*, *C. stenophylla*, *Coffea* sp. 'Congo') displaying a resistant response and one species (*C. humilis*) a susceptible response. However, the significance of classifying the species as resistant or susceptible is limited because of the low number of evaluated accessions for each species, except for those that were represented by several geographic groups (*C. anthonyi*, *C. canephora*, *C. congensis*, *C. liberica*, *C. stenophylla*). *Coffea racemosa* was already known to have some accessions resistant to M. exigua (Fazuoli, 1975; Anthony *et al*., 2003). Considering the number of species that gave variable responses to *M. incognita* race 1 inoculation (*C. arabica*, *C. canephora*, *C. congensis*, *C. costatifructa*, *C. pocsii*, C. *pseudozanguebariae*, *C. sessiliflora*), most accessions (54/74) were classified as resistant (Table 3). Resistance to *M. incognita* thus appeared overall to be a more frequent character than susceptibility within the gene pool of wild coffee analyzed in this work.

Here is the first report on resistance to *M. incognita* in non-cultivated coffee species. Reactions of these species to RKN inoculations are weakly documented because of recentness of collects, difficult access to the genetic resources, and low interest for breeders. By contrast, resistance of the cultivated species has been tested against different RKNs, and *C. canephora* appears to present a greater number of RKN resistances than *C. arabica*. Among *C. canephora* accessions, resistances have been identified against *M. arabicida* (Bertrand *et al*., 2002; Anthony *et al*., 2003), *M. exigua* (Curi *et al*., 1970; Gonçalves *et al*., 1996; Anthony *et al*., 2003), *M. incognita* race 1 (Gonçalves et al., 1996) and *M. paranaensis* (Bertrand *et al*. 2000) originally named *Meloidogyne* sp. (Bertrand and Anthony, 2008) while among *C. arabica* accessions, resistances are only known against *M. arabicida* (Bertrand *et al*., 2002; Anthony *et al*., 2003) and *M. paranaensis* (Anzueto *et al*., 2001; Anthony *et al*., 2003; Boisseau *et al*., 2009) originally identified as *M. incognita* (Bertrand and Anthony, 2008). Up to now, only three *R* genes have been identified and mapped in wild coffee germplasm: the *Mex-1* gene of resistance to *M. exigua* from *C. canephora* (Noir *et al*., 2003); the *T* gene of resistance to coffee berry disease from *C. canephora* (Gichuru *et al*., 2008); and the SH3 gene of resistance to coffee leaf rust from C. liberica (Prakash *et al*., 2004). New opportunities have been opened in coffee genomics and breeding since the *C. canephora* genome was recently sequenced (Denoeud *et al*., 2014). An expansion of nucleotide binding site (NBS) resistance-genes was highlighted in the coffee genome and a list of 561 NBS genes was established. They represent valuable candidate genes in order to localize the genomic region(s) involved in the coffee response to infection by *M. incognita* or other RKNs.

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Table 2. Evaluation of resistance to *M. incognita* race 1 in the susceptible and resistant controls.

Control accession	Batch	Root wt (g)	J2 total	J2/root g	RF	Status[z]
C. arabica cv. Caturra	1	4.4	3,525	801	1.8	S
C. arabica cv. Caturra	1	4.1	4,000	976	2.0	S
C. arabica cv. Caturra	2	4.6	6,875	1,495	3.4	S
C. arabica cv. Caturra	2	4.7	10,700	2,277	5.4	S
C. arabica cv. Caturra	3	5.1	4,300	843	2.2	S
C. arabica cv. Caturra	3	4.4	6,975	1,585	3.5	S
C. arabica cv. Caturra	4	4.8	3,785	789	1.9	S
C. arabica cv. Caturra	4	6.9	5,875	851	2.9	S
C. arabica cv. Caturra	5	3.9	3,595	922	1.8	S
C. arabica cv. Caturra	5	10.2	9,775	958	4.9	S
C. arabica cv. Caturra	6	6.9	9,600	1,391	4.8	S
C. arabica cv. Caturra	6	7.0	11,675	1,668	5.8	S
C. canephora cv. Nemaya	1	6.9	125	18	0.1	R
C. canephora cv. Nemaya	1	5.0	15	3	0.0	R
C. canephora cv. Nemaya	2	4.4	250	57	0.1	R
C. canephora cv. Nemaya	2	3.5	0	0	0.0	R
C. canephora cv. Nemaya	3	1.0	2	2	0.0	R
C. canephora cv. Nemaya	3	5.2	26	5	0.0	R
C. canephora cv. Nemaya	4	5.2	57	11	0.0	R
C. canephora cv. Nemaya	4	4.8	95	20	0.0	R
C. canephora cv. Nemaya	5	5.2	125	24	0.1	R
C. canephora cv. Nemaya	5	1.6	39	24	0.0	R
C. canephora cv. Nemaya	6	1.8	7	4	0.0	R
C. canephora cv. Nemaya	6	2.3	72	31	0.0	R

[z]R = resistant; S = susceptible

Table 3. Evaluation of resistance to *M. incognita* race 1 in various coffee species.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status[z]
C. anthonyi	OD53	1	1.2	1	1	0.0	R
C. anthonyi	OD53	2	0.9	9	10	0.0	R
C. anthonyi	OD60	1	1.8	7	4	0.0	R
C. anthonyi	OD60	2	1.1	8	7	0.0	R
C. anthonyi	OD72	1	1.2	5	4	0.0	R
C. anthonyi	OD72	2	1.4	6	4	0.0	R
C. anthonyi	OE54	1	2.0	5	3	0.0	R
C. anthonyi	OE54	2	2.3	4	2	0.0	R
C. anthonyi	OE56	1	2.5	8	3	0.0	R
C. anthonyi	OE56	2	2.1	6	3	0.0	R
C. anthonyi	OE57	1	1.4	1	1	0.0	R
C. anthonyi	OE57	2	1.9	3	2	0.0	R
C. arabica	Ar15	1	6.6	121	18	0.0	R
C. arabica	Ar15	2	4.4	12	3	0.0	R
C. arabica	Ar25B	1	5.0	129	26	0.1	R
C. arabica	Ar25B	2	5.5	775	141	0.3	R
C. arabica	Ar57	1	9.4	102	11	0.0	R
C. arabica	Ar57	2	7.8	6	1	0.0	R
C. arabica	Ar59	1	8.1	2,775	343	1.1	S
C. arabica	Ar59	2	4.3	2,590	602	1.0	S
C. brevipes	JB56	1	3.4	875	257	0.3	R
C. brevipes	JB56	2	2.9	265	91	0.1	R
C. brevipes	JB65	1	1.8	124	69	0.0	R
C. brevipes	JB65	2	2.7	19	7	0.0	R
C. brevipes	JB70	1	3.3	81	25	0.0	R
C. brevipes	JB70	2	3.5	212	61	0.1	R

Table 3. Continued.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status[z]
C. canephora	BA53	1	12.3	125	10	0.1	R
C. canephora	BA53	2	8.7	15	2	0.0	R
C. canephora	BA58	1	6.9	7,000	1,014	2.8	S
C. canephora	BA58	2	7.1	5,650	796	2.3	S
C. canephora	BA59	1	4.0	7,275	1,819	2.9	S
C. canephora	BA59	2	6.4	7,850	1,227	3.1	S
C. canephora	BB68	1	3.8	225	59	0.1	R
C. canephora	BB68	2	7.0	400	57	0.2	R
C. canephora	BB69	1	8.6	4,800	558	1.9	S
C. canephora	BB69	2	7.8	5,375	689	2.1	S
C. canephora	BB70	1	3.5	775	221	0.3	R
C. canephora	BB70	2	6.1	175	29	0.1	R
C. canephora	BC53	1	4.8	2	0	0.0	R
C. canephora	BC53	2	3.8	5	1	0.0	R
C. canephora	BC54	1	1.5	975	650	0.4	R
C. canephora	BC54	2	1.8	1,175	653	0.5	R
C. canephora	BC62	1	2.5	925	370	0.4	R
C. canephora	BC62	2	3.3	10	3	0.0	R
C. canephora	BD54	1	2.7	153	57	0.1	R
C. canephora	BD54	2	2.5	3	1	0.0	R
C. canephora	BD68	1	2.6	575	221	0.2	R
C. canephora	BD68	2	3.2	125	39	0.1	R
C. canephora	BD69	1	3.6	125	35	0.1	R
C. canephora	BD69	2	4.8	650	135	0.3	R
C. congensis	CA54	1	4.0	9,400	2,350	3.8	S
C. congensis	CA54	2	2.0	4,200	2,100	1.7	S
C. congensis	CA58	1	2.2	4	2	0.0	R
C. congensis	CA58	2	2.3	0	0	0.0	R
C. congensis	CA61	1	2.8	6	2	0.0	R
C. congensis	CA61	2	1.9	5	3	0.0	R
C. congensis	CB61	1	2.6	3	1	0.0	R
C. congensis	CB61	2	1.8	2	1	0.0	R
C. congensis	CB67	1	1.9	2	1	0.0	R
C. congensis	CB67	2	1.7	363	214	0.1	R
C. congensis	CB70	1	1.7	6	4	0.0	R
C. congensis	CB70	2	1.8	5	3	0.0	R
C. congensis	CC51	1	2.5	376	150	0.2	R
C. congensis	CC51	2	2.3	668	290	0.3	R
C. congensis	CC54	1	1.9	7,025	3,697	2.8	S
C. congensis	CC54	2	3.2	5,550	1,734	2.2	S
C. congensis	CC65	1	2.1	65	31	0.0	R
C. congensis	CC65	2	1.3	402	309	0.2	R
C. costatifructa	08.126	1	4.5	3	1	0.0	R
C. costatifructa	08.126	2	2.2	10	5	0.0	R
C. costatifructa	OH54	1	0.7	7	10	0.0	R
C. costatifructa	OH54	2	0.7	74	106	0.0	R
C. costatifructa	OH62	1	6.8	7,715	1,135	3.1	S
C. costatifructa	OH62	2	3.7	4,879	1,319	2.0	S
C. heterocalyx	JC63	1	2.0	138	69	0.1	R
C. heterocalyx	JC63	2	3.4	4	1	0.0	R
C. heterocalyx	JC65	1	1.7	64	38	0.0	R
C. heterocalyx	JC65	2	1.4	13	9	0.0	R
C. heterocalyx	JC68	1	1.1	30	27	0.0	R

Table 3. Continued.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status[z]
C. heterocalyx	JC68	2	1.8	5	3	0.0	R
C. humilis	G52	1	2.5	3,125	1,250	1.3	S
C. humilis	G52	2	3.4	3,875	1,140	1.6	S
C. humilis	G56	1	1.9	5,875	3,092	2.4	S
C. humilis	G56	2	3.3	9,910	3,003	4.0	S
C. humilis	G68	1	2.7	4,850	1,796	1.9	S
C. humilis	G68	2	4.2	11,620	2,767	4.6	S
C. liberica	EA63	1	4.1	1,125	274	0.5	R
C. liberica	EA63	2	7.4	285	39	0.1	R
C. liberica	EA64	1	8.8	898	102	0.4	R
C. liberica	EA64	2	6.8	1,334	196	0.5	R
C. liberica	EA70	1	4.0	4	1	0.0	R
C. liberica	EA70	2	3.1	237	76	0.1	R
C. liberica	EB51	1	3.9	28	7	0.0	R
C. liberica	EB51	2	4.0	550	138	0.2	R
C. liberica	EB52	1	11.9	539	45	0.2	R
C. liberica	EB52	2	6.4	25	4	0.0	R
C. liberica	EB68	1	3.1	158	51	0.1	R
C. liberica	EB68	2	4.9	111	23	0.0	R
C. pocsii	PB58	1	2.2	4,500	2,045	1.8	S
C. pocsii	PB58	2	1.8	5,900	3,278	2.4	S
C. pocsii	PB61	1	0.7	76	109	0.0	R
C. pocsii	PB61	2	0.8	6	8	0.0	R
C. pocsii	PB70	1	1.5	140	93	0.1	R
C. pocsii	PB70	2	0.6	4	7	0.0	R
C. pseudozanguebariae	H53	1	2.6	3,100	1,192	1.2	S
C. pseudozanguebariae	H53	2	2.6	3,540	1,362	1.4	S
C. pseudozanguebariae	H63	1	1.2	81	68	0.0	R
C. pseudozanguebariae	H63	2	0.5	8	16	0.0	R
C. pseudozanguebariae	H65	1	3.8	42	11	0.0	R
C. pseudozanguebariae	H65	2	2.3	200	87	0.1	R
C. racemosa	IA51	1	2.6	78	30	0.0	R
C. racemosa	IA51	2	3.5	250	71	0.1	R
C. racemosa	IB55	1	2.0	325	163	0.1	R
C. racemosa	IB55	2	3.3	18	5	0.0	R
C. racemosa	IB62	1	2.9	16	6	0.0	R
C. racemosa	IB62	2	2.2	64	29	0.0	R
C. salvatrix	LA51	1	1.9	32	17	0.0	R
C. salvatrix	LA51	2	1.1	25	23	0.0	R
C. salvatrix	LB53	1	1.8	264	147	0.1	R
C. salvatrix	LB53	2	1.6	20	13	0.0	R
C. salvatrix	LB66	1	4.8	125	26	0.1	R
C. salvatrix	LB66	2	4.8	4	1	0.0	R
C. sessiliflora	PA60	1	2.6	325	125	0.1	R
C. sessiliflora	PA60	2	2.8	686	245	0.3	R
C. sessiliflora	PA63	1	2.5	29	12	0.0	R
C. sessiliflora	PA63	2	0.3	300	1,000	0.1	R
C. sessiliflora	PA64	1	6.8	7,800	1,147	3.1	S
C. sessiliflora	PA64	2	5.4	9,050	1,676	3.6	S
C. stenophylla	FA51	1	3.0	142	47	0.1	R
C. stenophylla	FA51	2	1.2	12	10	0.0	R
C. stenophylla	FA53	1	0.9	14	16	0.0	R
C. stenophylla	FA53	2	0.8	60	75	0.0	R

Table 3. Continued.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status[z]
C. stenophylla	FA56	1	3.5	306	87	0.1	R
C. stenophylla	FA56	2	2.5	0	0	0.0	R
C. stenophylla	FB57	1	1.9	19	10	0.0	R
C. stenophylla	FB57	2	1.0	725	725	0.3	R
C. stenophylla	FB58	1	0.5	4	8	0.0	R
C. stenophylla	FB58	2	0.8	11	14	0.0	R
C. stenophylla	FB61	1	1.0	54	54	0.0	R
C. stenophylla	FB61	2	0.8	9	11	0.0	R
Coffea sp. 'Congo'	OB56	1	2.2	1,000	455	0.4	R
Coffea sp. 'Congo'	OB56	2	1.2	1,225	1,021	0.5	R
Coffea sp. 'Congo'	OB58	1	1.3	10	8	0.0	R
Coffea sp. 'Congo'	OB58	2	1.5	27	18	0.0	R
Coffea sp. 'Congo'	OB60	1	0.7	27	39	0.0	R
Coffea sp. 'Congo'	OB60	2	0.4	9	23	0.0	R

[z]R = resistant; S = susceptible

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