PRE- AND POST-INFECTIONAL RESISTANCE OF SWEET POTATO TO *Meloidogyne incognita* and *M. javanica*

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ABSTRACT

Pre-infectional resistance was indicated by fewer nematodes which penetrated the resistant cultivars Jasper, Jewel and W-86 compared to those which entered the susceptible cultivars Binicol and UPR. Post-infectional resistance was shown by delayed or retarded development of nematodes after penetration in Jasper and Jewel or to non-development to maturity in W-86.

The number of eggs per egg mass and the size of egg-laying females in susceptible cultivars were significantly greater that those in resistant cultivars Jasper and Jewel.

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KEY WORDS: Sweet potato. Pre- and post-infectional resistance. *Meloidogyne incognita. M. javanica.*

INTRODUCTION

The use of resistant cultivars to check the root-knot nematode population in the soil is gaining popularity especially in low-value crops like sweet potato. It is more effective, economical and environmentally safer compared to the use of nematicides.

Several sweet potato cultivars have been confirmed to be resistant to root-knot nematodes (Weimer and Harter, 1925; Dean and Struble, 1953; Giamalva et al., 1960). Recently, Gapasin (1984) tested 52 sweet potato cultivars for resistance to *Meloidogyne* spp. and found that 28 and 47 cultivars were resistant to *Meloidogyne incognita* and *M. javanica,* respectively.

Pre-infectional resistance classified by Wallace (1973) as passive, pre-existing or natural, operates before the nematode penetrates the host. This type of resistance may be associated with root exudates that either repel the infective larvae from

roots or are toxic to them (Rohde, 1972). Post-infectional resistance is manifested after the nematode has penetrated the host tissues. According to Veech (1982), this type of resistance may involve constitutive morphological or biochemical factors or it may depend on the plant's responses to infection. The plant's response may either involve the production of morphological barriers that segregate the infecting organism or the synthesis of certain biochemicals that interfere with the subsequent development of the pathogens.

Very limited studies on the nature of resistance of sweet potato to the root-knot nematodes, *Meloidogyne* spp. have been conducted. Jatala and Russell (1972) proposed the presence of a root exudate repellent to *M. incognita* larvae as a basis for resistance in the sweet potato variety Nemagold. Dean and Struble (1953) observed that nematodes which entered the roots of resistant sweet potato varieties (Orlis, Oklahoma 46, Oklahoma 29) produced necroses of host tissues several days after inoculation as a resistant reaction. This was not observed in susceptible Allgold roots. A few nematodes developed to egg-laying maturity in all resistant lines but most larvae died and disappeared before reaching that stage.

The objective of this study is to determine whether pre- and post-infectional resistance to *M. incognita* and *M. javanica* occur in sweet potato.

MATERIALS AND METHODS

The sweet potato cultivars used were Binicol, Jasper, UPR, Jewel and W-86. The cultivars Binicol and UPR are susceptible to *M. incognita* and *M. javanica,* respectively while Jasper and Jewel are resistant to the two nematode species, respectively. W-86 was reported to be highly resistant to both nematode species (Gapasin, 1984). Twelve plants of each cultivar were planted in 7.5-cm dia clay pots filled with baked sandy loam soil. The plants of cultivars Binicol, Jasper and W-86 were inoculated with 100 larvae of *M. incognita* while those of cultivars UPR, Jewel and W-86 were inoculated with *M. javanica* 10 days after planting, following the procedure described by Gapasin (1984). The pots were arranged on benches outside the greenhouse in a completely randomized manner and each treatment was replicated 4 times.

After 1, 2 and 3 days from inoculation, four plants from each cultivar were uprooted and the roots were carefully washed with tap water. The roots were cut to a length of about 2.5 cm, placed in a 100-mL beaker, and stained with acid fuchsin lactophenol for 3 minutes. The stained roots were washed with water and destained with plain lactophenol for 24 hours. The nematodes in the roots of each cultivar were counted and their developmental stages were also determined.

A second experiment was conducted using the same cultivars for *M. incognita* and *M. javanica* as in the previous experiment. Twenty plants per cultivar were grown and after 7, 14, 21, 28 and 35 days from inoculation, four plants of each cultivar were uprooted and the roots were carefully washed with tap water. The rest of the procedures in the preceding experiment was followed.

The number of eggs per egg mass produced by a *Meloidogyne* female in each cultivar was determined by placing five randomly chosen egg masses from each replicate plant in a petri dish. Each egg mass was crushed with a dissecting needle and the eggs were then counted. The corresponding egg-laying female was teased out from the roots and its greatest body width was measured under a calibrated 'Microstar' H.P. microscope.

RESULTS AND DISCUSSION

The roots of resistant cultivars Jasper and W-86 were penetrated by significantly less *M. incognita* larvae than the roots of the susceptible Binicol cultivar (Table 1). However, the larvae that entered W-86 were significantly lesser than those which penetrated Jasper at 2 and 3 days after inoculation. After only one day, *M. incognita* larvae were able to enter the roots of Binicol and the number increased at 2 and 3 days after inoculation. Similar results were obtained from inoculation with *M. javanica* (Table 1).

The above findings show that the larvae of *M. incognita* and *M. javanica* were inhibited from penetrating the roots of resistant sweet potato cultivars. However, some nematodes successfully penetrated the roots of resistant cultivars although at very low numbers compared to those of the susceptible cultivars. The cultivar W-86 which was reported by Gapasin (1984) to have zero egg mass, gall index and nematode recovery in the roots was penetrated by few larvae of both test species at 2 and 3 days after inoculation (Table 1).

Pre-infectional resistance mechanism expressed as the failure of the nematode to penetrate the plant roots is usually associated with the effects of root diffusates (allelochemics) on nematode attraction, repulsion or toxicity (Veech, 1981). A root exudate repellent to *M. incognita* larvae has been proposed as possible basis for resistance to this pest in sweet potato (Jatala and Russell, 1972) and the same resistance mechanism may also be operating in this study.

The number of nematodes recovered in the roots of resistant and susceptible cultivars at 7, 14, 21, 28 and 35 days after inoculation with *M. incognita* and *M. javanica* is presented in Table 1. Significant differences in the number of nematodes recovered were noted between Binicol and Jasper, and also between Jasper and W-86 which are both resistant to *M. incognita*. Binicol supported significantly more nematodes. The same result was

Table 1. Number of nematode larvae/nematodes from fibrous roots of potted susceptible and resistant sweet potato cultivars inoculated with 100 larvae of *Meloidogyne incognita* and *M. javanica.*[1]

Nematode Species/ Sweet Potato Cultivar	Number of Larvae/Nematodes — Days After Inoculation							
	1	2	3	7	14	21	28	35
M. incognita								
Binicol (S)[2]	0.50	17.00a	30.75a	36.25a	55.50a	50.25a	65.25a	85.50a
Jasper (R)[3]	0.00	8.75b	9.75b	9.75b	11.25b	14.50b	14.00b	10.50b
W-86 (R)	0.00	2.00c	2.50c	2.00c	3.50c	4.25c	4.25c	2.00c
M. javanica								
UPR (S)	0.00	18.25a	22.00a	26.50a	33.75a	41.00a	51.75a	58.25a
Jewel (R)	0.00	7.25b	9.00b	9.75b	17.75b	16.75b	15.75b	11.50b
W-86 (R)	0.00	2.00c	2.25c	2.25c	2.75c	2.75c	3.25c	2.50c

[1]Data are means of four replicates. For each nematode species, means within a column with different letters are significantly different at 5% level, DMRT. Data were transformed to Log (X + 1) for statistical analysis.

[2]Susceptible cultivar

[3]Resistant cultivar

obtained with *M. javanica*. The number of nematodes recovered from susceptible UPR was significantly higher than those from resistant Jewel and W-86.

The failure of the host to supply some nutrients necessary for the survival of the parasite could be one basis for resistance. This may be true in the resistant cultivars Jasper, Jewel and W-86 which supported fewer nematodes than susceptible cultivars Binicol and UPR at 35 days after inoculation. This low nematode recovery from the roots may be due to death of some individuals which have successfully penetrated. Galls without nematodes and browning of cells have been observed in the resistant Jasper and Jewel cultivars (Fig. 1). This corroborated the findings of McClure et al. (1974) that some galls in resistant cotton plants contained no detectable trace of developing larvae. The decrease could also be attributed to stimulation of some nematodes to become male. This was exhibited in this experiment by the resistant cultivar W-86 (Fig. 2). There must have been less nutrients for the nematodes thereby stimulating them to become males. Depletion of nutrients has been reported to increase males in *Meloidogyne* spp. (Bird, 1960; McClure and Viglierchio, 1966; Davide and Triantaphyllou, 1967). Dropkin and Nelson (1960) also reported increased male to female ratio due to lack of suitable food.

The resistant cultivars affected the normal development of *M. incognita* and *M. javanica* inside the roots (Table 2). At 7 days after inoculation, second stage larvae (L_2 - developmental group A) of each test nematode species were observed in both resistant and susceptible cultivars. However in susceptible Binicol and UPR cultivars, the nematodes were already in the advanced second larval stage as shown by their different shapes (Fig. 3).

At 14 days after inoculation, most of the nematodes in the susceptible cultivars were in the third and fourth larval stages (L_3 and L_4 developmental group B) and some have become adults (developmental group C). In the resistant Jasper cultivar, few developed to L_3 and L_4 and no adults were observed. Both nematode species were still at L_2 in the resistant cultivar W-86 at 14 days after inoculation.

The number of adult egg-laying females was significantly greater in the susceptible cultivars than in the resistant ones (Table 2). It was also observed that in the Jasper and Jewel cultivars, the egg-laying females were smaller at 21 days after inoculation. In W-86 cultivar, both nematode species were unable to develop to L_3 and L_4 much less to young adult and egg-laying stages. Furthermore, necrosis was consistently associated with the nematodes in this cultivar (Fig. 4).

Only egg-laying (developmental group D) *M. incognita* females were observed in Binicol at 28 days after inoculation and the second generation L_2 (developmental group E)

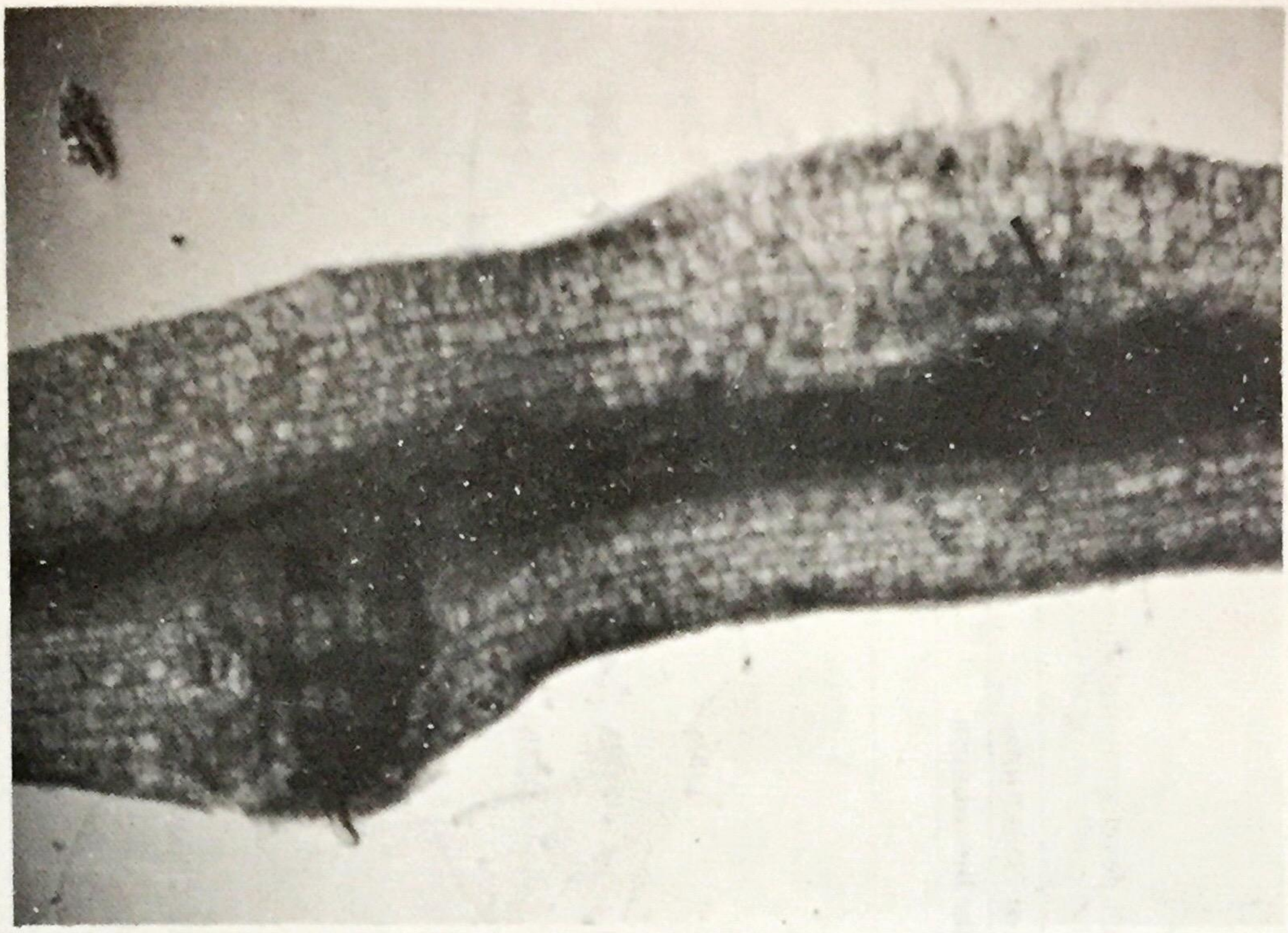

Figure 1. Browning of tissue (arrow) observed in resistant cultivar Jasper at 35 days after inoculation. Note the nematode (ne) that successfully penetrated and developed. 40x.

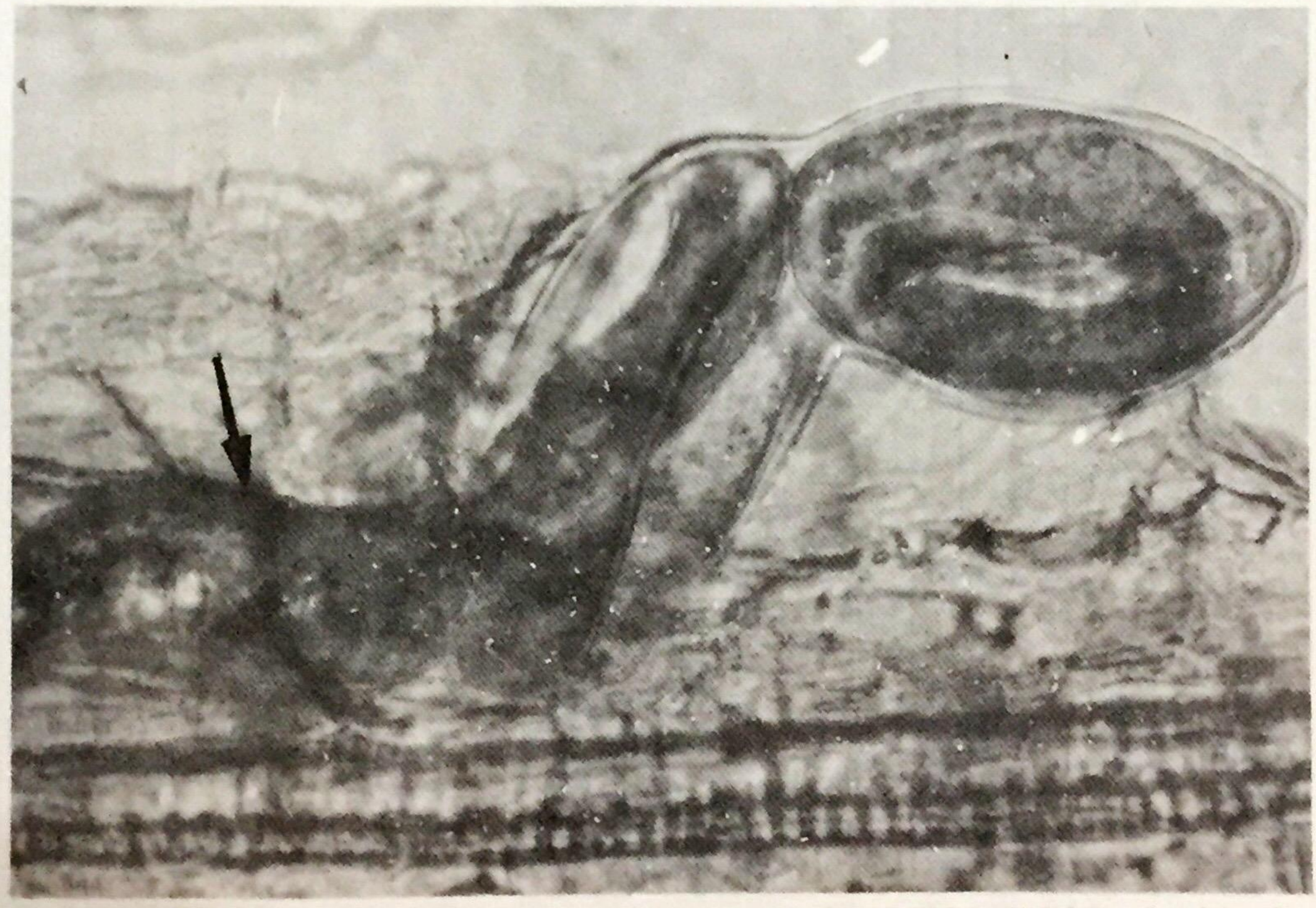

Figure 2. *Meloidogyne incognita* male found in resistant cultivar W-86 at 35 days after inoculation. Note the hypersensitive cells (arrow) at the head region of the nematode. 320x.

Table 2. Number of *Meloidogyne incognita* and *M. javanica* in each developmental stage in resistant and susceptible sweet potato cultivars.[1]

Nematode Species/ Sweet Potato Cultivar	Number of Nematodes — Days After Inoculation							
	7	14			21			
	A[2]	A	B	C	A	B	C	D
M. incognita								
Binicol (S)[3]	36.25c	5.75b	48.00c	1.75b	0.00a	4.75b	6.25b	39.25c
Jasper (R)[4]	9.75b	0.50a	10.75b	0.00a	0.00a	3.25b	5.25b	6.00b
W-86 (R)	2.00a	2.75b	0.00a	0.00a	4.25b	0.00a	0.00a	0.00a
M. javanica								
UPR (S)	26.50c	1.25a	37.25c	5.25b	0.00a	4.75b	19.75c	16.75c
Jewel (R)	9.75b	2.50a	15.25b	0.00a	0.50a	5.75b	6.25b	4.25b
W-86 (R)	2.25a	2.25a	0.00a	0.00a	2.75b	0.00a	0.00a	0.00a

Table 2. Continued . . .

Nematode Species/ Sweet Potato Cultivar	Number of Nematodes								
	Days After Inoculation								
	28				35				
	A	B	C	D	A	B	C	D	E
M. incognita									
Binicol (S)	0.00a	0.00a	0.00a	65.25c	0.00a	0.00a	0.00a	69.50c	16.00b
Jasper (R)	0.00a	1.50b	3.25b	9.25b	0.00a	0.00a	2.25b	8.25b	0.00a
W-86 (R)	4.00b	0.00a	0.00a	0.00a	1.00a	1.00a	0.00a	0.00a	0.00a
M. javanica									
UPR (S)	0.00a	0.00a	9.50b	41.50c	0.00a	0.00a	0.00a	42.25c	16.00b
Jewel (R)	0.00a	0.25a	5.25b	9.00b	0.00a	0.00a	3.25b	8.25b	0.00a
W-86 (R)	4.00b	0.00a	0.00a	0.00a	2.25a	0.25a	0.00a	0.00a	0.00a

[1]Data are means of four replicates. For each nematode species, means within a column with different letters are significantly different at 5% level, DMRT.

[2]Nematode developmental stages: A = second larval stage (L_2); B = third and fourth larval stages (L_3 and L_4); C = young adults (no eggs yet); D = egg-laying females; E = second generation L_2.

[3]Susceptible cultivar

[4]Resistant cultivar

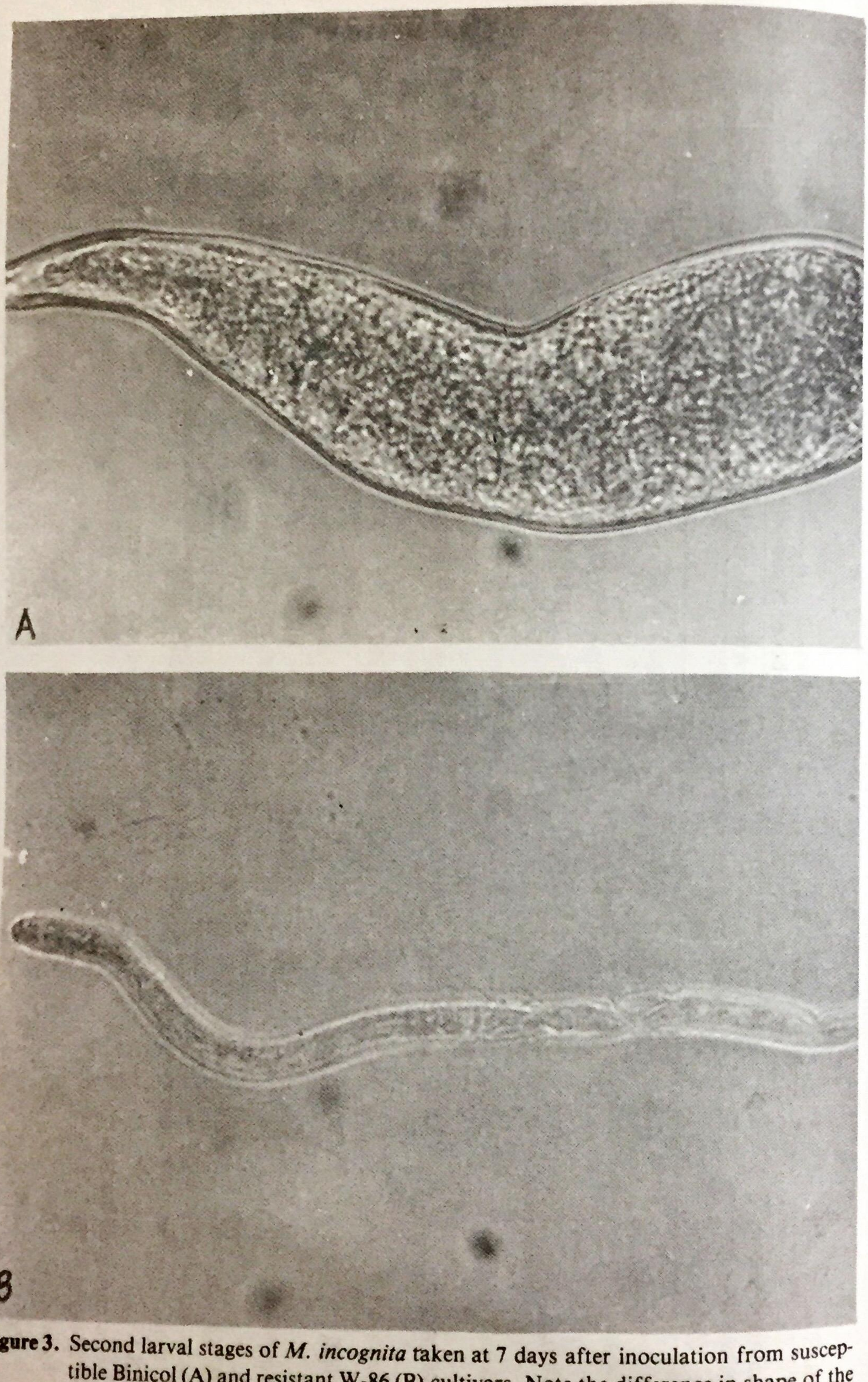

Figure 3. Second larval stages of *M. incognita* taken at 7 days after inoculation from susceptible Binicol (A) and resistant W-86 (B) cultivars. Note the difference in shape of the larvae. 112x.

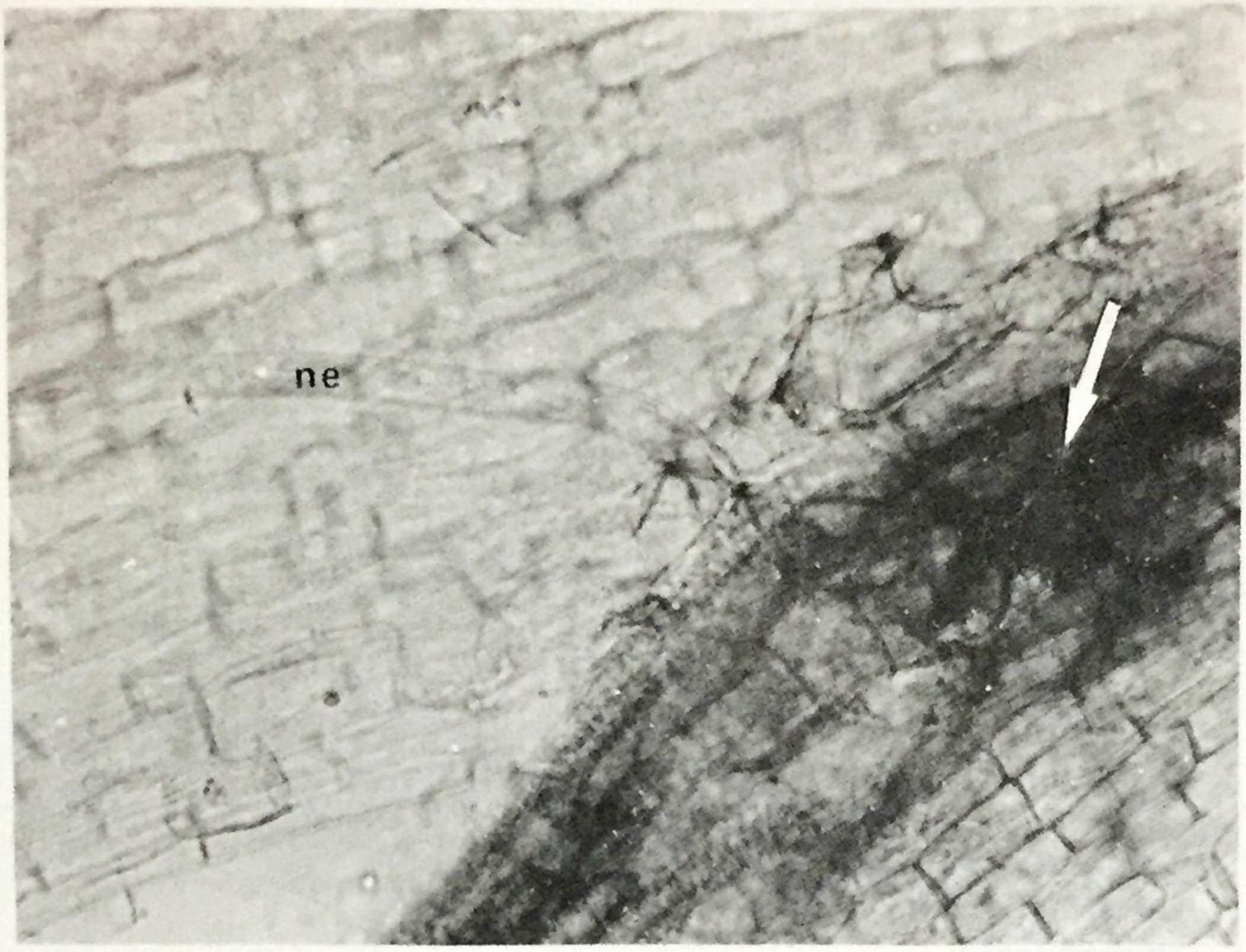

Figure 4. Necrotic cells (arrow) with one *Meloidogyne incognita* L_2 in feeding position in the root of resistant sweet potato cultivar W-86 at 21 days after inoculation. 265x.

was noted at 35 days after inoculation. The same trend was observed with *M. javanica* in the susceptible cultivar UPR. Very few females of both species developed into egg-laying adults at 28 and 35 days after inoculation in the resistant cultivars.

Significant differences in mean number of eggs per egg mass and size of egg-laying females were noted between resistant and susceptible cultivars at 35 days after inoculation with *M. incognita* and *M. javanica* (Table 3). The susceptible cultivars showed more eggs per egg mass as well as bigger-sized egg-laying females than the resistant ones.

These findings indicate that the development of both nematode species in resistant cultivars was either delayed or they did not develop at all to maturity. There appears to be a post-infectional resistance mechanism exhibited by Jasper, Jewel and W-86 against both nematode species. This resistance mechanism is usually associated either with a possible synthesis of toxic compounds by plants as a reaction to the penetrating nematodes or with lack of necessary nutrients for nematode growth and development.

McClure et al. (1974) reported that post-infectional resistance

Table 3. Number of eggs per egg mass and size of egg-laying adults of *Meloidogyne incognita* and *M. javanica* at 35 days after inoculation in resistant and susceptible sweet potato cultivars.[1]

Nematode Species/ Sweet Potato Cultivar	Number of Eggs Per Egg Mass	Size of Egg-Laying Female[2]
M. incognita		
Binicol (S)[3]	429.10a	461.08a
Jasper (R)[4]	187.45b	369.73b
M. javanica		
UPR (S)	275.90a	440.78a
Jewel (R)	132.45b	357.43b

[1]Data are means of four replicates, each with five samples. For each nematode species, means within a column with different letters are significantly different at 5% level, LSD.

[2]Greatest body width in microns (μ)

[3]Susceptible cultivar

[4]Resistant cultivar

mechanism in cotton plants resistant to *M. incognita* was partly due to reduction in virulence of the penetrating larvae caused by toxic substances. Resistance to *M. acrita* was attributed to conditions within the roots that prevented or delayed larval development and not to failure of nematodes to enter the roots (Minton, 1962). Furthermore, hypersensitivity of the root tips to the penetrating larvae resulted in plant tissue necrosis which inhibited larval development. The failure of root cells to favorably respond to the nematode also resulted in fewer nematodes developing to maturity.

In this study; the delayed development of the test nematodes, the fewer eggs per mass laid and the smaller egg-laying females in the resistant cultivars are manifestations of host unsuitability or resistance. These findings confirm the results of Christie (1946) and Tyler (1933). According to Christie, there is a direct correlation between suitability of the host, and rate of parasite development and egg production. When parasite development is only slightly retarded, the effect is a reduction in the number of generations that can occur in a given period. When development is

strongly retarded, many females may never reach maturity and the egg output of those that do may be reduced. Likewise, Tyler postulated that the number of eggs laid as well as the number, size and vigor of larvae are affected by the nutritional state of the host. He concluded that the healthy condition of the host is an important factor for the development of its parasite.

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