Observations on a resistant and a susceptible variety of tomato in a field heavily infested with *Meloidogyne* in Senegal *

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ABSTRACT

Development of root-knot nematodes in a resistant variety of tomato, Rossol, and a susceptible variety, Roma, were compared after 10, 20, 30 40 and 50 days in an infested field in Senegal. In the susceptible Roma almost all infection sites were galled and contained giant cells ; no necrosis was observed. In the resistant Rossol galling and giant cell formation were rare ; necrosis occurred at a high percentage of infection sites. Second-stage juveniles penetrated the susceptible Roma readily and in large numbers ; mature females were found within 30 days. Fewer 2nd-stage juveniles penetrated the resistant Rossol and very few exhibited development even after 50 days ; partially embedded 2nd-stage juveniles were commonly observed. The occasional occurrence of mature females with egg masses on Rossol is attributed to the presence of resistance breaking biotypes (B-races).

RÉSUMÉ

Le développement de Meloidogyne *sur une variété résistante de tomate, Rossol, et sur une variété sensible, Roma, a été comparé après 10, 20, 30, 40 et 50 jours dans un champ infesté, au Sénégal. Dans la variété sensible Roma, des galles et des cellules géantes se sont formées dans presque tous les points d'infection ; aucune nécrose n'a été observée. Dans la variété résistante Rossol, la formation de galles et de cellules géantes est rare ; des nécroses sont apparues dans un fort pourcentage de points d'infection. Les juvéniles de deuxième stade ont pénétré facilement et en grand nombre dans la variété susceptible Roma ; des femelles mûres ont été trouvées en 30 jours. Les juvéniles de deuxième stade ont pénétré la variété résistante Rossol, en plus petit nombre et très peu s'étaient développés même après 50 jours ; des juvéniles de deuxième stade partiellement engagés dans les racines ont été souvent observés. La présence occasionnelle de femelles, avec masses d'œufs, sur Rossol est attribuée à la présence de biotypes brisant la résistance (races B).*

INTRODUCTION

Resistance to *Meloidogyne* spp. was originally found in *Lycopersicon peruvianum* L. (P.I. 128657), and Smith (1944), employing embryo culture techniques, sucessfully made a hybrid between *L. peruvianum* and the commercial tomato, *L. esculentum* L. WATTS (1947) backcrossed this hybrid with several lines of *L. esculentum* and obtained a clone which was resistant to *Meloidogyne* and self-fertile. FRAZIER and DENNETT (1949) crossed this clone with a breeding line resistant to three fungal diseases and selected several lines with *Meloidogyne*-resistance. They suggested that the possibilities were excellent for developing a commercial tomato variety resistant to *Meloidogyne*. Crossing of the resistant line with commercial tomatoes was continued by GILBERT and MCGUIRE (1952, 1956). They concluded that resistance to *M. incognita* was dominant and controlled by a single gene that they termed *Mi*. BARHAM and SASSER (1956) reported that tomatoes with the *Mi*-gene were also resistant to *M. javanica* and *M. arenaria* but susceptible to *M. hapla*. However, BARHAM and WINSTEAD (1957) demonstrated that the *Mi*-gene was incompletely dominant. LATERROT (1973) recently published a review on resistance in tomato.

FRAZIER and DENNETT (1949) reported heavy invasion of roots of both resistant and susceptible tomato lines by 2nd-stage juveniles of *Meloidogyne*. DEAN and STRUBLE (1953) reported that fewer 2nd-stage juveniles, "usually half or less", invaded roots of *L. peruvianum* and an *L. peruvianum* hybrid than roots of a susceptible tomato variety. They also described extensive necrosis around 2nd-stage juve-

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niles in resistant roots and stated that there was no development of 2nd-stage juveniles. LIAO and DUNLAP (1950) reported that 2nd-stage juveniles were abundant in the roots of susceptible tomato but in resistant lines only a few 2nd-stage juveniles had penetrated and some were only partially embedded in the root. Penetration was arrested when about one half of a 2nd-stage juvenile had enterd the root. RIGGS and WINSTEAD (1959) reported that there was no difference in penetration rates of 2nd-stage juveniles of *M. incognita* in resistant and susceptible tomatoes. They also noted no difference in partial penetration of 2nd-stage juveniles between resistant and susceptible lines. Using excised root tips of *L. peruvianum* and *L. esculentum*, PEACOCK (1959) demonstrated that 2nd-stage juveniles were attracted to *L. peruvianum* root tips less strongly than to *L. esculentum* and they penetrated *L. peruvianum* in smaller numbers.

RIGGS and WINSTEAD (1959) reported that there was some reproduction of *Meloidogyne* spp. on resistant tomato and repeated inoculation of the resistant tomato developed populations as virulent on the resistant tomatoes as on the susceptible tomatoes. These « B-populations », as there were termed, were genetically stable and did not loose their ability to attack resistant tomatoes even after being cultured on susceptible tomatoes for up to nine months. SAUER and GILLES (1959) reported that after repeated cropping with a resistant tomato in a field heavily infested with *M. javanica* it was as badly damaged as a susceptible variety. They suggested that this was due to the selection of an aggressive strain of *M. javanica* by the resistant variety. BARRIGA and MARIN (1966) also reported reproduction of *Meloidogyne* sp. on resistant tomato varieties. NETSCHER (1970) reported the occurrence of an isolate of *M. javanica* and one of *M. incognita* capable of breaking resistance of the tomato Ronita.

Studies on resistant and susceptible tomatoes have been made in laboratory, greenhouse, and field experiments. Emphasis has been placed on the host-parasite relationships at either a very early stage (DEAN and STUBLE, 1953, for example) or after prolonged tomato growth (BARRIGA and MARIN, 1966). No studies are known in which the host-parasite relationships of resistant and susceptible tomatoes have been compared at regular intervals under field conditions. It was the purpose of this study to compare nematode development and host reaction in a resistant and a susceptible variety of tomato 10, 20, 30, 40, and 50 days after transplantation into a field heavily infested with *Meloidogyne* spp.

MATERIALS AND METHODS

Seeds of the tomato variety Rossol, carrying the *Mi*-gene for *Meloidogyne* resistance, and a comparable susceptible variety, Roma, were planted in sterile soil. Seedlings were grown until a height of 15 cm was attained at which time they were transplanted to a field at the Centre pour le Développement de l'Horticulture (F.A.O.), Cambérène, Dakar, Sénégal, heavily invested with *Meloidogyne incognita* (KOFOID and WHITE, 1919) Chitwood, 1949, *M. javanica* (TREUB, 1885) Chitwood, 1949, *M. arenaria* (NEAL, 1889) Chitwood, 1949 and other unidentifiable forms. Twelve seedlings of each variety were planted in two parallel rows in each of six plots. Ten days after transplanting all of the tomato plants from one plot were carefully dug, labeled as to variety and taken to the laboratory. A minimum of 10 roots from each plant were selected and then stained in acid fuchsin lactophenol for 1-3 minutes depending on the diameter of the root. Plants were dug from the other plots, 20, 30, 40 and 50 days after transplanting and their roots treated as described above. Examinations of nematode development and host reactions were made with a dissecting microscope. For making accurate counts of heavily invaded roots, the roots were mounted between two pieces of glass and pressure applied to flatten them. To determine certain developmental stages, especially 3rd and 4th stage juveniles, nematodes were dissected from the roots, mounted in lactophenol and examined with a compound microscope.

RESULTS

Results of this experiment are summarized in Tables I-VI.

Galling at infection sites (table I). In the susceptible variety, Roma, galling at sites of infection was between 99 and 100%. In the resistant Rossol, a maximum of 9% galled infection sites was recorded 10 days after transplantion. Between 20 and 50 days after transplanting the galling ranged between 0.5 and 4%.

TABLE I

PERCENTAGE AND ACTUAL NUMBER OF INFECTION SITES EXHIBITING GALLING

Number of days after transplanting	*Roma (Susceptible)*		*Rossol (Resistant)*	
	Percentage	*Actual*	*Percentage*	*Actual*
10	99	103/104*	9	18/214
20	100	110/110	1	4/473
30	100	120/120	2	5/247
40	100	120/120	4	5/140
50	100	120/120	0.5	1/202

* The first number indicates the actual number of positive observations of galling, and the second the total number of infection sites observed based upon ten roots each of 12 plants.

Infection sites with giant cells (table II). After 20 days almost all infection sites in the susceptible variety Roma had giant cells. In the resistant variety Rossol, giant cells were rarely observed at infection sites.

TABLE II

PERCENTAGE AND ACTUAL NUMBER OF INFECTION SITES CONTAINING GIANT CELLS

Number of days after transplanting	*Roma (Susceptible)*		*Rossol (Resistant)*	
	Percentage	*Actual*	*Percentage*	*Actual*
10	57	59/104*	4	8/214
20	99	109/110	0.2	1/473
30	100	120/120	2	5/247
40	100	120/120	3	5/140
50	100	120/120	0.5	1/202

* The first number indicates the actual number of sites with giant cells, and the second the number of infection sites observed based upon 10 roots each of 12 plants.

Infection sites with necrosis (table III). In the susceptible variety Roma not a single case of a necrotic infection site was observed. However, in the resistant variety Rossol most infection sites were necrotic.

TABLE III

PERCENTAGE AND ACTUAL NUMBERS OF INFECTION SITES EXHIBITING NECROSIS

Number of days after transplanting	*Roma (Susceptible)*		*Rossol (Resistant)*	
	Percentage	*Actual*	*Percentage*	*Actual*
10	0	0/104*	73	157/214
20	0	0/110	99	470/473
30	0	0/120	98	242/247
40	0	0/120	96	135/140
50	0	0/120	99	201/202

* The first number indicates the actual number of necrotic infection sites observed, and the second the total number of infection sites observed based upon 10 roots each of 12 plants.

Incomplete 2nd-stage juvenile penetration (table IV). Figure 1 shows a 2nd stage juvenile incompletely penetrated in a root of Rossol. In the susceptible variety Roma no 2nd-stage juveniles were observed to be partially embedded in root tissue. In the resistant variety Rossol, incompletely penetrated 2nd-stage juveniles were observed after every time interval and particularly after 10 days when 23 per cent of the 2nd-stage juveniles observed were partially embedded in the root tissue.

TABLE IV

PERCENTAGE AND NUMBER OF 2nd-STAGE JUVENILES INCOMPLETELY PENETRATED

Number of days after transplanting	*Roma (Susceptible)*		*Rossol (Resistant)*	
	Percentage	*Actual*	*Percentage*	*Actual*
10	0	0/1200*	23	79/349
20	0	0/1374	11	131/1160
30	0	0/625	4	10/273
40	0	0/1457	4	7/167
50	0	0/529	3	6/228

* The first number indicates the actual number of incompletely penetrated 2nd-stage juveniles observed, and the second the total number of 2nd-stage juveniles observed based upon 10 roots each of 12 plants.

Meloidogyne development (table V). In the susceptible variety Roma the majority of individuals were observed to be developing ; whereas in Rossol only a very small number developed beyond the infective stage. After 30 days 37 per cent of the individuals were adult females in Roma, whereas the comparable figure for Rossol was 0.4%. After 40 days in Roma, all individual were adult and 50% had produced egg masses. In Rossol only 5 individuals were adult and no egg masses were observed.

TABLE V

NUMBER OF *MELOIDOGYNE* INDIVIDUALS EXHIBITING DEVELOPMENT

Number of days after transplanting	*Roma (Susceptible)*	*Rossol (Resistant)*
10	88/1200*	6/349
20	1064/1374	1/1160
30	625/625	4/273
40	1457/1457	5/169
50	529/529	1/228

* The first number indicates the number of individual exhibiting development, and the second the number of individuals observed in 10 roots each of 12 plants.

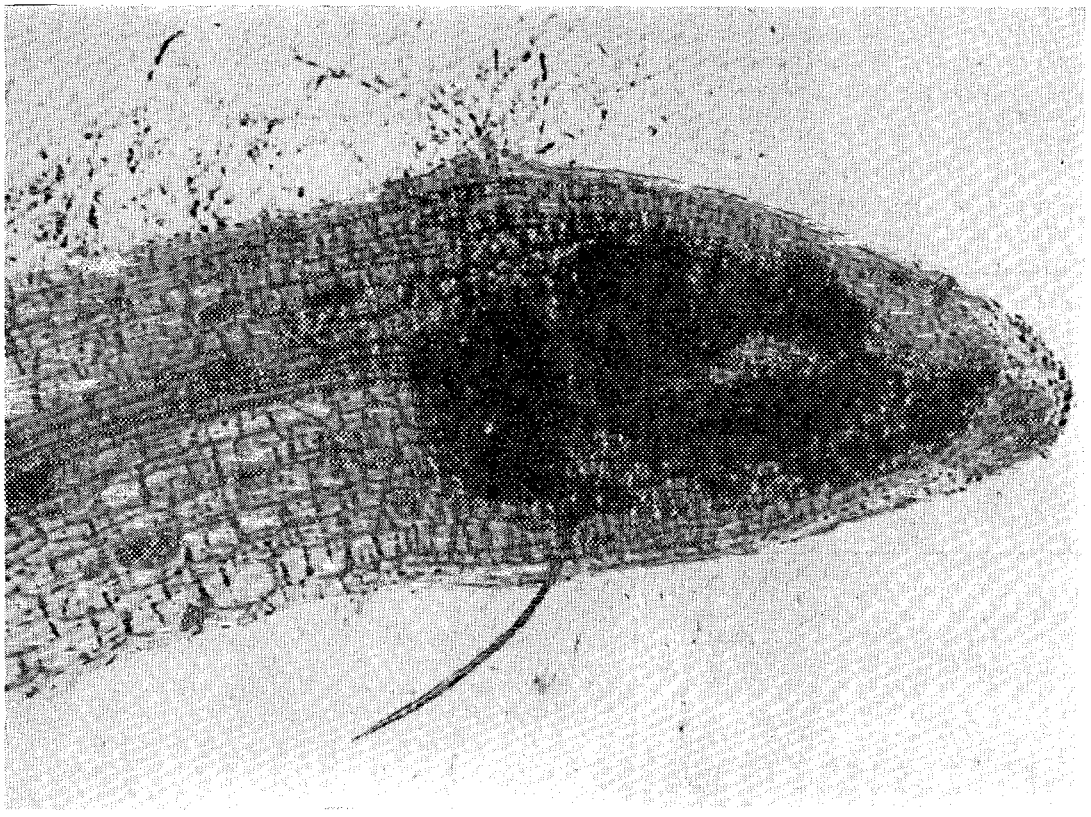

Fig. 1. — Root of the resistant tomato variety Rossol with a 2nd-stage juvenile of *Meloidogyne* sp. partially embedded in the root. Note also the extensive necrosis at and near the infection site

Mean number of nematodes per infection site (table VI). At every time interval the mean number of individuals per infection site was higher in the susceptible variety Roma than in Rossol.

TABLE VI

MEAN NUMBER
OF NEMATODES PER INFECTION SITE

Number of days after transplanting	*Roma (Susceptible)*	*Rossol (Resistant)*
10	11.5	1.6
20	12.5	2.5
30	5.2	1.1
40	12.1	1.2
50	4.4	1.1

DISCUSSION

On the basis of these observations the reactions of these two tomato varieties can be characterized as follows : Roma (susceptible) — very high percentage of infection sites galled and containing giant cells with no root necrosis observed. Infective 2nd-stage juveniles entered the roots completely and in relatively larger numbers and all nematodes observed had reached the adult stage within 30 days ; Rossol (resistant) — an extremely low percentage of infection sites were galled and contained giant cell development and a high percentage of infection sites were necrotic. Many 2nd-stage juveniles were unable to enter the roots completely and few exhibited development.

The necrotic reaction of *L. peruvianum* and tomato varieties carrying the *Mi*-gene has been consistantly reported by other workers, whereas susceptible tomatoes react to infection with the production of giant cells upon which the nematodes feed as they develop.

The observation of incomplete penetration of 2nd-stage juveniles into roots of the resistant variety in

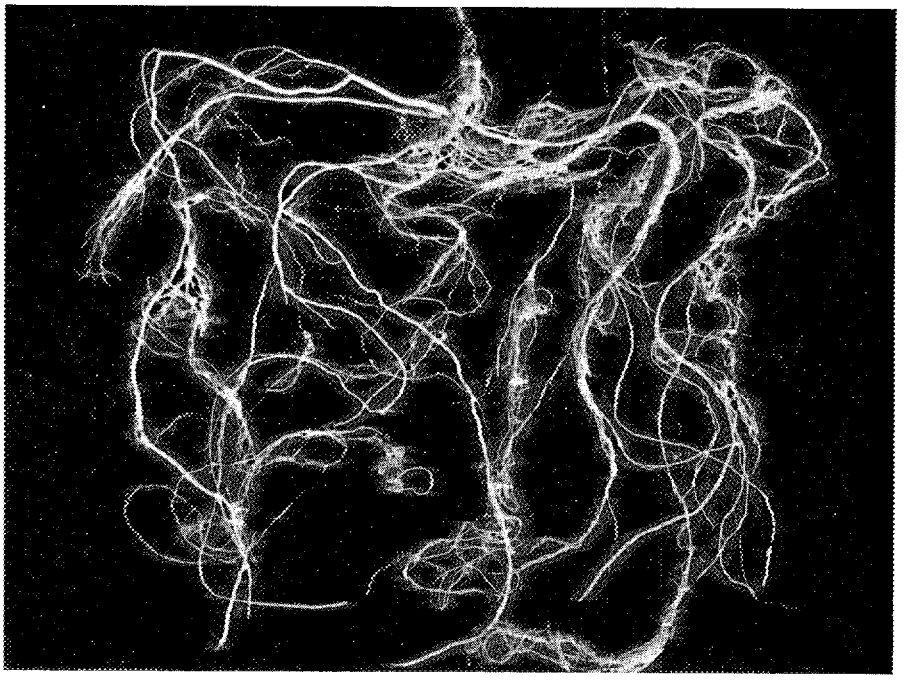

Fig. 2. — Root system of the resistant tomato variety Rossol 60 days after transplanting to a field heavily infested with *Meloidogyne* spp

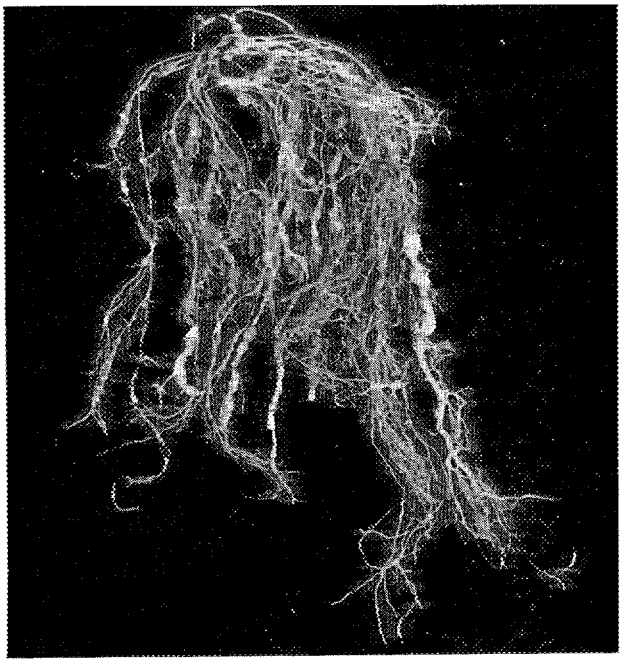

Fig. 3. — Root system of the susceptible tomato variety Roma 60 days after transplanting to a field heavily infested with *Meloidogyne* spp.

this study is in agreement with the report of LIAO and DUNLAP (1950) but conflicts with those of RIGGS and WINSTEAD (1959). The latter reported no difference in the number of incompletely penetrated 2nd-stage juveniles in susceptible and resistant varieties. In this study 574 infection sites were observed on susceptible tomato and over 5000 2nd-stage juveniles were examined without observing a single case of incomplete penetration ; whereas a total of 233 incompletely penetrated 2nd-stage juveniles were observed among the 2179 observed in the resistant variety. Thus, it appears that this phenomenon was specific to the resistant variety under the conditions of this study.

Under these conditions fewer 2nd-stage juveniles of *Meloidogyne* penetrated the roots of the resistant variety of tomato than entered the roots of the susceptible. This is most clearly seen when the average numbers of nematodes per infection site are compared. DEAN and STRUBLE (1953) and PEACOCK (1959) also reported a larger penetration of 2nd-stage juveniles into roots of susceptible tomato than into *L. peruvianum* and hybrids carrying the *Mi*-gene. However RIGGS and WINSTEAD (1959) did not observe such differences. Such discrepancies might be explained by the nematode populations used, the tomato varieties studied, or differences in climatic factors during the various experiments.

In observations after each time interval some devel-

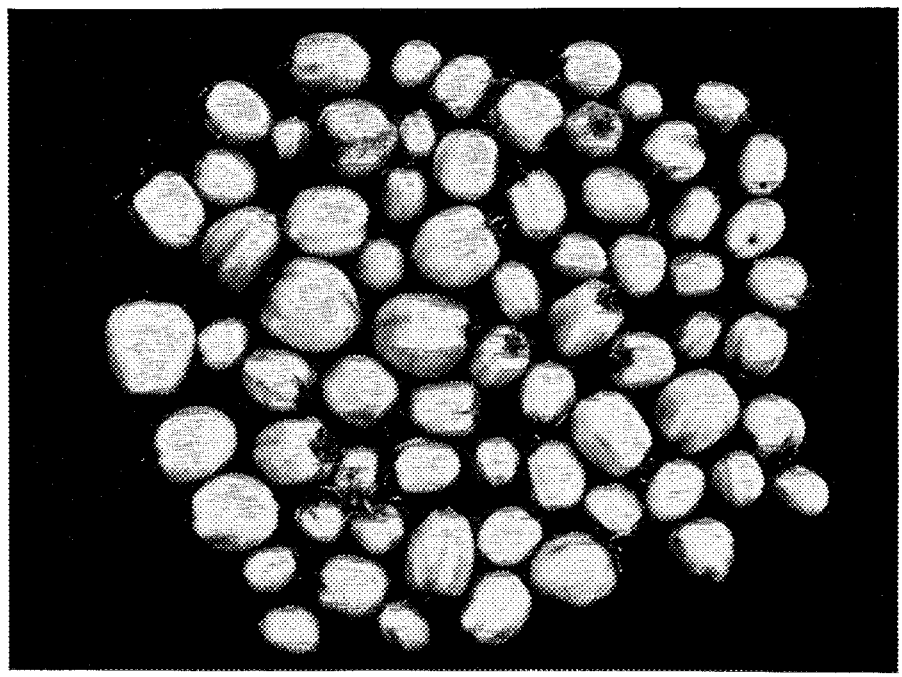

Fig. 4. — Total fruit production of the resistant tomato variety Rossol 60 days after transplanting into a field heavily infested with *Meloidogyne* spp.

opment of *Meloidogyne* juveniles was observed in the resistant tomato variety and after 30, 40, and 50 days adult females were occasionally observed. Eggs from these and other females developed on Rossol have been reinoculated onto Rossol and many of the populations have increased. Thus, it can be assumed that resistance breaking biotypes, the « B-populations » of RIGGS and WINSTEAD (1959), occurred naturally in the *Meloidogyne* population used in this study. During the short course of this experiment no increase in the number of resistant breaking biotypes was observed ; however, it is possible that repeated planting of resistant varieties on soils containing this biotype might select a population highly virulent to the resistant variety as has been reported from Australia (SAUER and GILES, 1959). However, examination of the sixth plot 60 days after transplanting revealed that the root systems of Rossol were essential root-knot free while those of Roma were badly affected (Fig. 2 and 3). Fruits harvested from one plant each of Rossol and Roma 60 days after transplantation (Figures 4 and 5) show the potential increase in yield obtainable in heavily infested soils by planting resistant varieties. Thus, it seems that the growth of resistant varieties should be encouraged providing that attention is directed to the possible development of resistance breaking biotypes.

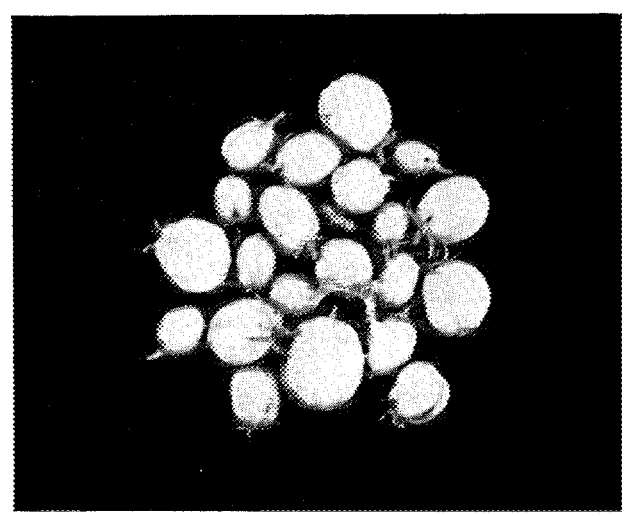

Fig. 5. — Total fruit production of the susceptible tomato variety Roma 60 days after transplanting into a field heavily infested with *Meloidogyne* spp.

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