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STUDIES ON THE BIOLOGY OF *GLOBODERA TABACUM* IN SOUTHERN ITALY

by
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Summary. In the Mediterranean climate experienced at Camposano, near Naples, *Globodera tabacum* completed almost five generations on egg-plant during the period 29 May - 23 October, 1996. A reproduction rate (ratio between initial and final densities of eggs and juveniles in cysts in the soil) of 96.1 was recorded in September during the fourth generation. However, at the end of the investigation the equilibrium density was 1.4 eggs and 1.9 encysted juveniles per cc of soil.

The tobacco cyst nematode *Globodera tabacum* (Lownsberry *et* Lownsberry) Skarbilovich is an important parasite of tobacco in northeastern USA. Its host range also includes some cultivars of tomato, egg-plant, sweet pepper, and several solanaceous weeds (Lownsberry and Lownsberry, 1954; Barker and Lucas, 1984; Baldwin and Mundo-Ocampo, 1991).

Also, *G. tabacum* has been reported on tobacco in Bulgaria (Katalan-Gateva and Baicheva, 1976), on egg-plant in Argentina (Chaves, 1987) and recently in Southern Italy, in the province of Naples, on egg-plant (Ambrogioni and D'Errico, 1995).

Information on the biology of this cyst nematode is limited. Barker and Lucas (1984) report that *G. tabacum* usually may have four to five generations on a single tobacco crop under field conditions in USA with the life cycle completed in about 20 days. In Connecticut two generations were completed per growing season on shade tobacco and 5-6 weeks were necessary for development from a second stage juvenile to a female (La Mondia, 1990; 1995).

Under controlled conditions at 20, 26 and 30 °C *G. tabacum* required 72, 36 and 32 days respectively to complete a generation on egg-plant seedlings; during a period of three months a generation only occurred at 20 °C, two with the beginning of the third at 26 °C and almost three generations at 30 °C (Ambrogioni *et al.*, 1995).

Knowledge of the biology of *G. tabacum* under Italian field conditions is lacking; therefore investigations were undertaken in 1996 in an egg-plant field near Naples to gather information on its life cycle and population dynamics in soil and in roots of solanaceous plants.

Materials and methods

The observations were carried out at Camposano (Province of Naples) on a sandy loam naturally infested with *G. tabacum* on which egg-plant, potato and tomato had been cropped for several years.

Egg-plant (*Solanum melongena* L. cv. Violetta Napoletana) seedlings were transplanted in a plot comprising four rows with 25 plants in each on 29 May, 1996. The plot was irrigated and fertilized as required. Roots were sampled four and seven days after transplanting and then at weekly intervals until 28 October, 1996. On each sampling date four plants were lifted at random and a 3 g sample of roots taken from each was washed and fixed. Soil samples were also collected every seven days during the growing season.

Nematodes were extracted from each root sample and life stages were determined. Second stage juveniles and free males were extracted from two subsamples of 100 cc of soil and processed by Baermann funnel. Cysts were processed by Fenwick can from 300 cc of air dried soil and crushed to estimate the number of eggs and juveniles in them. Soil temperature was recorded hourly at 15 cm of depth throughout the experiment.

Results

Second stage juveniles had penetrated the roots of egg-plant four days after transplanting and after one week 30% of juveniles were already swollen. Third stage juveniles and preadult females were observed two weeks after transplanting, while preadult males, adult white females, with non embryonated eggs, and adult males within the last cuticle, were present three weeks later (Table I).

At four weeks some light brown cysts were already formed and the males had migrated into the soil (Table II). The density of juveniles in the soil was highest at one week after transplanting then, decreased moderately to increase again at the beginning of July, a week after the new cysts were formed. This first generation, calculated from juvenile penetration of the roots to the hatching of juveniles from the new cysts, was completed in 31 days at a soil mean temperature of 26.5 °C (23.3-29.7 °C).

The peaks of juvenile abundance in the soil (Table II) indicate that in 1996 at Camposano, *G. tabacum* completed almost five generations during the growing season of egg-plant (from 29 May until 23 October).

The time required for each generation from invasion of roots to the hatching of the new juveniles varied depending upon the season of the year. The first, second and fourth generations were completed in 28-31 days, at an average soil temperature of 26.3 °C (23.3-29.7 °C), 27.4 °C (25.1-30.2 °C) or 26.1 °C (21.8-30.1 °C), respectively. The third generation, at soil mean temperature of 29.0 °C (26.9-30.8 °C), was the shortest at about 21 days, whereas the fifth one, perhaps not completed by plant harvest, was

TABLE I - *Number of different stages of* Globodera tabacum *recovered from egg-plant roots.*

Developmental stages/g root	Sampling date (1996)																					
	3/6	5/6	12/6	19/6	26/6	3/7	10/7	17/7	24/7	31/7	7/8	14/8	21/8	28/8	4/9	11/9	18/9	25/9	2/10	9/10	16/10	23/10
JJ2	5	12.5	90.0	35.6	11.9	26.3	25.7	9.0	42.0	82.4	53.3	80.3	70.8	59.7	34.6	29.7	31.9	47.3	66.6	32.5	26.9	12.1
JJ3			4.3	6.7	8.1	21.3	26.2	16.5	7.5	10.3	143.5	25.3	110.8	32.1	13.1	10.8	1.9	16.7	31.8	38.2	50.0	25.3
JJ4 ♀			1.4	21.1	26.9	17.5	15.7	12.5	2.0	0.6	89.8	2.9	82.1	9.7	30.0	24.6	7.7	8.2	10.9	15.7	7.1	5.1
JJ4 ♂				45.6	11.3	18.8	4.8	15.5	3.5	0.6	112.6	14.2	21.3	15.5	0	2.1	0	5.1	7.6	13.8	10.5	6.3
♀♀				2.2	6.9	8.8	10.5	12.5	5.0	0.6	59.3	1.1	48.2	12.8	14.1	84.6	8.4	10.0	12.0	25.0	12.6	10.5
♂♂				2.2	18.1	32.5	7.1	7.5	4.0	0	65.6	7.1	17.9	10.7	3.1	3.3	0	4.0	2.4	15.5	2.4	1.0
cysts					2.5	0	0.5	1.5	1.5	0	1.4	0.3	0.5	1.4	3.6	18.5	1.6	5.7	8.1	10.1	2.6	6.7
Total number	5	12.5	95.7	113.4	85.7	125.2	90.5	75.0	65.5	94.5	525.5	131.2	351.6	141.9	98.5	173.6	51.5	97.0	139.4	150.8	112.1	67.0

TABLE II - *Soil population densities of* G. tabacum *in a field of egg-plants.*

	Sampling date (1996)																					
	29/5	5/6	12/6	19/6	26/6	3/7	10/7	17/7	24/7	31/7	7/8	14/8	21/8	28/8	4/9	11/9	18/9	25/9	2/10	9/10	16/10	23/10
JJ2 / 100 cc soil	0	43.0	41.0	37.0	15.0	30.0	20.0	10.0	20.0	70.0	260.0	250.0	1030.0	580.0	380.0	330.0	1060.0	710.0	680.0	210.0	60.0	20.0
♂♂ / 100cc soil	0	0	0	0	5.0	25.0	20.0	10.0	0	0	10.0	30.0	10.0	30.0	140.0	0	0	0	20.0	10.0	0	0
cysts / 100 cc soil	12.3	6.3	5.0	6.0	10.0	10.3	9.3	14.3	15.0	15.3	13.7	22.7	58.3	46.7	34.0	145.0	88.0	101.0	165.3	110.0	75.0	8.7
JJ2 / cyst	15.5	7.7	17.9	12.7	10.5	7.9	4.8	35.8	12.0	75.1	51.1	42.7	58.5	57.2	45.0	125.9	35.9	94.7	97.9	124.6	151.4	15.8
JJ2 cysts / cc soil	1.9	0.5	0.9	0.8	1.0	0.8	0.4	5.1	1.8	11.5	7.0	9.7	34.1	26.7	15.3	182.6	31.6	95.6	161.9	137.1	113.6	1.4

the longest (over 35 days), with soil mean temperature of 22.3 °C (19.9-25.2 °C).

During the growing season of egg-plant there was almost continuous root penetration by juveniles, which were always present, either inside the roots or free in the soil. There was a maximum number of 90/g root and 1060/100 cc at two and sixteen weeks, respectively, after transplanting.

The third stage juveniles, the fourth stage males and adult males reached their peak numbers of 143.5, 112.6 and 65.6/g root, respectively, at the same time, i.e. ten weeks after transplanting. Adult males peaked in the soil (140/100 cc), 14 weeks after transplanting. Fourth stage females and adult females reached a maximum of 89.8 and 84.6/g root at 10 and 15 weeks, respectively, after transplanting.

The number of the cysts in the roots did not change substantially, rising only to 18.5/g root during the fourth generation at 15 weeks after transplanting; on the contrary cyst densities in the soil were variable, ranging from 5 to a peak of 165.3/100 cc soil, almost at the end of the growing season of egg-plant, i.e. at 18 weeks from transplanting. The maximum egg and encysted juvenile densities were of 151.4/cyst and 182.6/cc soil at 20 and 15 weeks, respectively.

Overlapping life stages were observed during the field experiment.

Total numbers of nematodes in the roots reached a maximum of 525.5/g root in early August at the beginning of the third generation and declined to a minimum of 51.5/g root by mid September at the end of the fourth generation.

Discussion and conclusion

Information on *G. tabacum* reared on egg-plant seedlings has already been obtained in growth chambers at 20, 26 and 30 °C (Ambrogioni *et al.*, 1995), but this is the first study to determine the life cycle of the tobacco cyst nematode under field conditions.

At Camposano (NA) the juveniles hatched promptly from the cysts present in the soil when egg-plant seedlings were planted. Juveniles were recovered from the roots within four days and after a week several juveniles present in the roots were swollen. This is in agreement with laboratory investigations which showed that the juveniles hatched very quickly from cysts immersed in tap water and incubated at 20, 26 and 30 °C in growth chambers (Ambrogioni, unpublished) and invaded the roots of the solanaceous plants within 48 hours of inoculation.

The five generations of *G. tabacum*, that occurred during a single cropping season of egg-plant at Camposano are similar to those reported in USA on a single tobacco crop (Barker and Lucas, 1984), but differ from only two generations per growing season of tobacco reported by La Mondia (1990; 1995). This difference probably reflects different environmental conditions and management practices. Soil temperature, considered to be the dominant factor determining the activity and therefore the rate of development of the females of sedentary root endoparasitic nematodes (Jones, 1975), affected the span of the generation time of the tobacco cyst nematode in the field. Our observations suggest that the fluctuating temperatures in the field result in a shorter generation time than that in growth chamber at an equivalent constant temperature (Ambrogioni *et al.*, 1995). For example, in the field the first was completed in 28 days at an average temperature of 26.3 °C and the third generation in 21 days at an average temperature of 29.0 °C which is five and eleven days fewer than at comparable constant temperatures (31 vs 36 days; 21 vs 32 days). These findings are similar to those reported for *Heterodera cajani* Koshy on pigeonpea (Singh and Sharma, 1994).

The total number of different developmental stages recovered from the egg-plant roots reached the maximum in August during the third generation at ten weeks from transplanting, then the number declined when the roots of egg-plant were particularly put under stress conditions for the highest density of juveniles in the soil. When the plants were cut back at the end of August, the growth of newly formed roots was sufficient to allow population levels to be maintained at an almost constant density until harvest of the crop.

Field experiments revealed a reproduction rate (based on the ratio between the maximum number of eggs and encysted juveniles/cc of soil and the initial density of eggs and encysted juveniles) of 96.1 during the fourth generation in September. At the end of the field experiment the population level of *G. tabacum* in the soil was almost the same as at transplanting (1.4 eggs and encysted juveniles per cc of soil vs 1.9), thus reaching the equilibrium density. The egg-plants, because of the attack of the cyst nematode, showed considerable growth reduction, greatly suppressed root system, and consequently heavy yield losses.

In conclusion *G. tabacum* can be considered a serious pest of egg-plant in southern Italy where, when supported by Mediterranean climates, may complete five generations per growing season and, therefore, be particularly destructive.

Globodera tabacum was probably introduced into Italy in contaminated seed of tobacco from the Eastern States of North America (Ambrogioni and D'Errico, 1995), and so far has been reported only in an isolated locus in Campania.

Our investigations have shown that in the Mediterranean climate of southern Italy five generations of *G. tabacum* may be completed during the growing season of a suitable host plant, such as egg-plant, and it may thus become a particularly destructive pest. Further studies should be undertaken to ascertain the occurrence and distribution of *G. tabacum* in Italy and appropriate methods for its control should be considered in advance of the discovery of any outbreaks.

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