Nematol. medit. (2000), 28: 73-76

Istituto Sperimentale per la Zoologia Agraria, Mi.P.A.F.-50125 Firenze, Italy

BASAL THRESHOLD TEMPERATURE AND LIFE CYCLE OF *GLOBODERA TABACUM* ON EGGPLANT IN RELATION TO ACCUMULATED DAY DEGREES

by

LAURA AMBROGIONI, TIZIANA IRDANI and S. CAROPPO

Summary. The basal threshold temperature for development of *Globodera tabacum* was estimated to be 11 °C. Population dynamics was compared under constant and fluctuating temperatures in growth chambers and in the field experiments respectively, in relation to accumulated degree-days (DD). Completion of the first generation required 70, 34 and 30 days (630, 510 and 570 DD) at 20, 26 and 30 °C respectively; 31 days (476 DD) at field soil temperatures ranging from 23.3 to 29.7. In the field (Campania) four consecutive generations occurred on eggplant requiring 476, 458, 377 and 423 respectively DD. The completion of the fifth generation was arrested by plant removal.

Optimal temperature for development and reproduction of *Globodera tabacum* in Italy resulted to be 26 °C, while at 32 °C invasion of eggplant roots is inhibited (Ambrogioni *et al.*, 1995). In growth chambers, at 20, 26 and 30 °C, one generation on eggplant, from inoculation to newly hatched juveniles, was completed in 72, 36 and 32 days respectively.

In field at Camposano (Naples) the nematode completed almost five generations on eggplant during a growing season (29 May - 23 October) with daily minimum and maximum soil temperatures ranging from 19,9 to 28,5 °C and 21,7 to 30,6 °C respectively (Ambrogioni and D'Errico, 1998).

Experiments were undertaken in growth chambers and in the field to calculate the basal threshold temperature for development of *G. tabacum* and to compare the temperature requirement for its development in Day-Degrees under constant and fluctuating soil temperatures, namely in climatic chamber and field experiments.

Materials and methods

A population of *G. tabacum* (Lownsbery *et* Lownsbery) Skarbilovich, collected at Camposano was reared on eggplant, *Solanum melongena* L., cv Violetta Lunga in a glasshouse, thirty plastic pots containing 200 cc of a steam sterilized sandy soil were each sown with one pregerminated seed of eggplant. When the seedlings were about 10 cm high, six pots were transferred to each of five growth chambers (8, 10, 12, 14 and 16 °C) with 16 hours light/day. About 1000 freshly hatched second stage juveniles, collected from cysts incubated for four days in tap water at 26 °C, were inoculated into the rhizosphere of the plants. After 23 days the roots were lifted, washed and nematodes were

extracted by Coolen's (1979) method. They were then divided into different developmental stages as JJ2, swallen JJ2, moulting JJ2 and JJ3. Based on an estimated basal temperature of 11 °C, the Day Degrees (DD) required for each developmental stage were calculated at constant and fluctuating temperatures using biological data obtained previously (Ambrogioni *et al.*, 1995; Ambrogioni and D'Errico, 1998).

The observations, either in growth chambers or under field conditions, were started when root penetration occurred and proceded until juveniles hatched from newly formed cysts, appeared.

Results

At 8 °C only one or two JJ2 specimens per plant root were found 23 days after inoculation (Table I). The number of individuals collected from the roots increased at 10 °C (from a minimum of 7 to a maximum of 19 per plant); no further development of these juveniles occurred. Swallen and moulting JJ2 and JJ3 were found at higher temperatures, however their number differed with the different conditions.

At 12 °C most of the specimens were found as JJ2 (80%), very few as swallen JJ2 (17%) and a few in moulting JJ2 and JJ3 (1.5% for each stage). At 14 °C the largest nematode population inside the roots was represented by swallen and moulting JJ2 (37.5%), at 16 °C by JJ3 (36.8%). The greatest population density in the roots was observed at 16 °C with a minimum of 11 to a maximum of 35 individuals per plant.

The penetration of the eggplant roots by *G. tabacum* juveniles, without any further development, recorded at 8 and 10 °C and the presence of few swallen and moulting JJ2 and JJ3 at 12 °C could mean that some development may occur at 11 °C. Thus it is assumed that 11 °C may be considered as the basal temperature for development of this cyst nematode.

The cumulative days and the accumulated DD above 11 °C, necessary for completion of different life stages and several generations in growth chambers and in the field, are reported in Table II. At 20 and 26 °C third stage juveniles were observed when 90 DD were accumulated; the fourth stage males and females and the adults required the same DD, viz. 126 and 198 at 20 °C, 150 and 210 at 26 °C respectively; at 30 °C males required for their development 76 DD less than females. The lowest number of DD from adult female to cyst were recorded at 26 °C (60 vs 108 and 76 employed at 20 and 30 °C respectively); still at this temperature fewer DD were sufficient to complete the first generation than at the other two temperatures (510 vs 630 and 570 DD). At 30 °C the second generation required for its completion 52 DD less than at 26 °C (608 vs 660 DD).

TABLE I - *Effect of different temperatures on the development of* Globodera tabacum *in eggplant roots (23 days after inoculation).*

Temperature °C	Mean number of developmental stages/plant			
	J2	Enlarged J2	Moulting J2	J3
8	1.1	–	–	–
10	13.1	–	–	–
12	13.2	2.8	0.2	0.2
14	1.3	2.7	2.7	0.5
16	7.5	5.5	2.8	9.2

Under open air conditions (with soil temperatures ranging from 23.3 to 29.7) a greater number of DD was required from root invasion by JJ2 to appearance of JJ3. The fourth stage male and the adults were simultaneously found after 266 DD, the cysts after 376.

During the first generation, the juveniles hatched very quickly from newly formed cysts requiring 100 DD for this stage. The first, the second and the fourth generations, being completed on July 3, July 31 and September 18, required 476, 458 and 423 DD at average soil temperatures of 26.3, 27.4 and 26.1 °C respectively; the third generation, completed on August 21, at 29 °C mean soil temperature, accu-

TABLE II - *Cumulative days and accumulated degree - days required by* G. tabacum *to complete various developmental stages after root invasion.*

Developmental stage	Cumulative days*				Accumulated degree - days above 11 °C			
	20 °C	26 °C	30 °C	Field	20 °C	26 °C	30 °C	Field
J3	10	6	6	10	90	90	114	153
J4♀	14	10	10	10	126	150	190	153
J4♂	14	10	6	17	126	150	114	266
♀♀	22	14	14	17	198	210	266	266
♂♂	22	14	10	17	198	210	190	266
Cysts	34	18	18	24	306	270	342	376
J2 2nd gen.	70	34	30	31	630	510	570	476
J2 3rd gen.		78	62	59		1170	1178	934
J2 4th gen.				80				1311
J2 5th gen.				108				1734

* Data from Ambrogioni *et al.*, 1995; Ambrogioni and D'Errico, 1998.

mulated only 377 DD. The fifth generation, begun on 18 September, but was interrupted by plant pull out on 28 October, with mean soil temperature of 22.3 °C. So the 416 DD accumulated, resulted insufficient for its completion.

Discussion

The estimated basal temperature of 11 °C for *G. tabacum* reflects the thermal environment to which the nematode is adapted; tropical species usually have higher basal temperature values than temperate ones (Trudgill, 1995). This cyst nematode appears to be better adapted to survival in areas where temperatures, during the summer, are frequently above 30 °C, as it occurs in Southern Italy. The basal temperature determined for *G. tabacum*, in this research, confirms its adaptation to warm areas.

G. tabacum has the same basal temperature threshold of *Heterodera cajani* (Singh and Sharma, 1994) which is higher than that of other cyst nematodes. In fact it has been found to be 5.6 for *Heterodera glycines* (Alston and Schmitt, 1988), 5 for *Heterodera cruciferae* (Kosky and Evans, 1986), 10 for *Heterodera carotae* and *Heterodera ciceri* (Greco and Brandonisio, 1985; Kaloshian *et al.*, 1986), 6.3 for *Heterodera schachtii* (Griffin, 1988), 7 for *H. latipons* (Philis, 1999), 5.9-6.3 for *Globodera rostochiensis* and 3.9-6.8 for *Globodera pallida* (Mugniéry, 1977; Langeslag *et al.*, 1982).

The completion of various stages of *G. tabacum* generally required more DD at constant temperatures of 26 and 30 °C than at 20 °C, according to data obtained for *H. cajani* and *H. glycines* (Alston and Schmitt, 1988; Singh and Sharma, 1994).

Under field conditions the estimate of time needed to reach a given developmental stage has been less accurate than that obtained at constant temperatures because the roots were sampled at weekly intervals instead of once every four days. However, at fluctuating temperatures more DD are generally required to complete various life stages than at controlled ones, while less DD are necessary for completion of the generations. The hatching of second generation juveniles from cysts was more rapid under natural than under constant temperature conditions. In fact only 100 DD are required,

compared with 324, 240 and 228 DD determined at controlled temperatures of 20, 26 and 30 °C, respectively. Therefore, it might be assumed that in spite of temperature changes, under natural soil conditions other biochemical factors occur that make the environment more suitable to juveniles emergence from cysts than at constant temperature in a steam sterilized soil.

In field the third generation, begun in early August, was the shortest generation and required 99, 81 and 46 DD less than the first, the second and the fourth respectively.

Literature cited

ALSTON D. G. and SCHMITT D. P., 1988. Development of *Heterodera glycines* life stages as influenced by temperature. *J. Nematol., 20*: 366-372.

AMBROGIONI L., CAROPPO S. and CONIGLIO D., 1995. Effetti della temperatura sullo sviluppo di *Globodera tabacum* su melanzana. *Atti V Congresso Società Italiana di Nematologia*, Martina Franca, 19-21 ottobre 1995, *Nematol. medit. (suppl.), 23*: 61-66.

AMBROGIONI L. and D'ERRICO F. P., 1998. Studies on the biology of *Globodera tabacum* in Southern Italy. *Nematol. medit., 26*: 117-121.

COOLEN W. A., 1979. Methods for the extraction of *Meloidogyne* spp. and other nematodes from roots and soil, pp. 317-329. *In*: *Root-knot Nematodes* (Meloidogyne *species*) *Systematics, Biology and Control*, (F. Lamberti and C.E. Taylor Eds.); Academic Press, London and New York.

GRECO N. and BRANDONISIO A., 1986. The biology of *Heterodera carotae*. *Nematologica, 32*: 447-460.

GRIFFIN G. D., 1988. Factors affecting the biology and pathogenicity of *Heterodera schachtii* on sugarbeet. *J. Nematol., 20*: 396-404.

KALOSHIAN I., GRECO N., SAAD A. T. and VOVLAS N., 1986. Life cycle of *Heterodera ciceri* on chickpea. *Nematol. medit., 14*: 135-145.

KOSHY P. K. and EVANS K., 1986. Hatching from cysts and egg sacs of *Heterodera cruciferae* and effects of temperature on hatching and development on oilseed rape. *Ann. appl. Biol., 109*: 163-171.

LANGESLAG M., MUGNIÉRY D. and FAYET G., 1982. Développement embryonnaire de *Globodera rostochiensis* et *G. pallida* en fonction de la température en conditions contrôlées et naturelles. *Rev. Nématol., 5*: 103-109.

MUGNIÉRY D., 1978. Vitesse de developpement, en fonction de la température de *Globodera rostochiensis* et *G. pallida* (Nematoda: Heteroderidae). *Rev. Nématol., 1*: 3-12.

PHILIS J., 1999. The life cycle of the Mediterranean cereal cyst nematode *Heterodera latipons* in Cyprus. *Nematol. medit., 27*: 43-46.

SINGH M. and SHARMA S. B., 1994. Temperature effects on development and reproduction of *Heterodera cajani* on pigeonpea. *J. Nematol., 26*: 241-248.

TRUDGILL D. L., 1995. An assessment of the relevance of thermal time relationships to nematology. *Fundam. appl. Nematol., 18*: 407-417.

Accepted for publication on 26 January 2000.