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BIO-ECOLOGICAL CHARACTERISTICS OF THE CEREAL CYST NEMATODE *HETERODERA AVENAE* IN SPAIN

by
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Summary. The life cycles of *Heterodera avenae* populations from three cereal growing areas in Spain with mediterranean continental climate, showed similar biological characteristics to those from other mediterranean countries. Juvenile emergence starts in the autumn. Second stage juveniles undergo a diapause of four months, followed by a period, probably of quiescence in which hatching is possible if moisture is suitable. An increase of emergence was observed at the beginning of spring, and was more evident for populations from areas with the most extreme climatic characteristics. This can be considered as an adaptation of the nematode to climatic conditions that allow it to develop in an area in which spring sowing is a frequent cultural practice.

Distribution of *Heterodera avenae* on cereal crops throughout the world (Meagher, 1977; Ritter, 1982) has been possible because of its biological adaptation to different environmental conditions. In the Northern European countries with cold winters and temperate summers, second stage juveniles are dormant during the winter and emerge in the spring (Andersen, 1961; Kerry and Hague, 1974;), while in countries with a mediterranean climate (hot, dry summers and cool winters) dormancy occurs in summer and juveniles emerge in the autumn (Mezzetti, 1953; Meagher, 1970; Kyrou, 1976).

Rivoal (1978, 1979, 1982, 1983, 1986) has demonstrated the existence of two French races which differ in their biological behaviour (ecotypes). The northern race (Fr4) has a life cycle similar to that from Northern European countries, and the southern race (Fr1) has a mediterranean life cycle. The different cycles are maintained even if populations are transferred to other regions with different climates.

This paper extends our previous work on the life cycle of *H. avenae* (Valdeolivas and Romero, 1986) and attemps to explain some aspects of inherent and environmental factors on its biology.

Materials and methods

Populations of *H. avenae* Woll. were selected from three representative cereal growing areas in the provinces of Teruel, Sevilla and Toledo (Fig. 1) whose climatic characteristics are shown in Table I. Populations 1 and 3 were substituted by 2 and 4 after one and two years respectively. According to Font Tullot (1983) all the sampling sites are in a sub-arid mediterranean continental climate; 1 and 2 are in the area with the most extreme climatic characteristics, 3 and 4 can be considered to be in a subcontinental climate and 5 represents an intermediate climatic situation.

The experiments were done at 'La Higueruela' Experimental Farm in 1983-84, and in the garden of the Instituto Español de Entomologia in Madrid in 1984-85 and 1985-86. Every year, four blocks of 7x7 uralite cylinders (20 cm long x 6 cm diameter) open at both ends were embedded in steamed sterilised soil in 50 cm deep plastic lined holes (Fig. 2). Three blocks were filled with infested soil from the three regions and the other one with uninfested soil (control). The experiments were situated in an

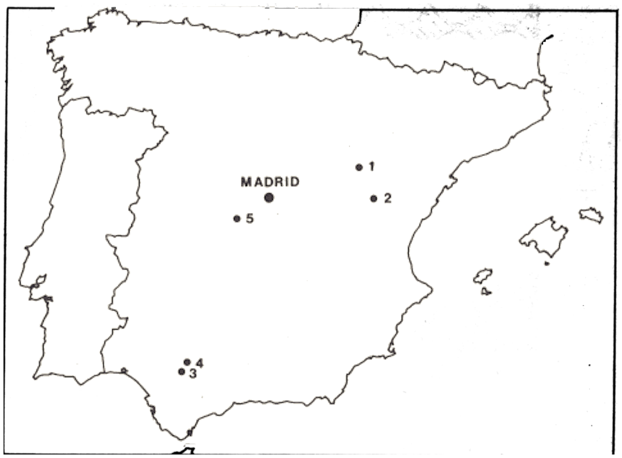

Fig. 1 - Location of sampling sites in the study of life cycles of *Heterodera avenae* in Spain.

area where *H. avenae* did not occur, as determined by previous investigations. A single seed of wheat cv. Anza susceptible to *H. avenae* was sown in each cylinder. Every 15 days throughout the growing cycle (November to July) two cylinders were taken from each block, nematodes were extracted from the total soil content and counted, and roots examined.

To study the life cycle in natural conditions, field experiments were also carried out at 'La Higueruela' in plots naturally infested by *H. avenae*. Two soil samples were taken every 15 days in 1984-85 to establish the characteristics of the cycle. In the following years, soil samples were taken whenever unusual weather conditions occurred e. g., early rainfall or abnormal temperature for the season, or when conditions were altered artificially by irrigation of the land before sowing. Such observations helped to explain some aspects of the biology of the nematode as discussed later.

Cysts were extracted using a Fenwick apparatus; males and juveniles (J2) were extracted by centrifugation (Nombela and Bello, 1983); roots were stained with lactophenol-cotton blue and examined with a stereomicroscope. Mean temperatures were calculated from records taken every 6 h at a depth of 15 cm.

Results

Fig. 3 summarises the results relating to the life cycle, and Fig. 4 represents the juvenile emergence for the different populations over the three years.

TABLE I - *Climatic characteristics of the studied areas.*

Population	Year	Province	Temperature and rainfall			
			Dec-Jan		Jul-Aug	
			°C	l/m²	°C	l/m²
1 Bello	1983-84	Teruel*	2.6	23.1	19.8	28.2
2 Concud	1984-86	Teruel*	3.8	23.3	20.8	33.2
3 Alcalá de Guadaira	1983-85	Sevilla*	10.3	77.2	26.9	2.9
4 Carmona	1985-86	Sevilla*	8.7	80.5	26.8	3.0
5 la Higueruela	1983-86	Toledo**	6.4	52.5	23.8	9.7

* Atlas Agroclimático Nacional de España, Ministerio de Agricultura, Madrid, 1986.
** Climatic data from La Higueruela, 1975-84.

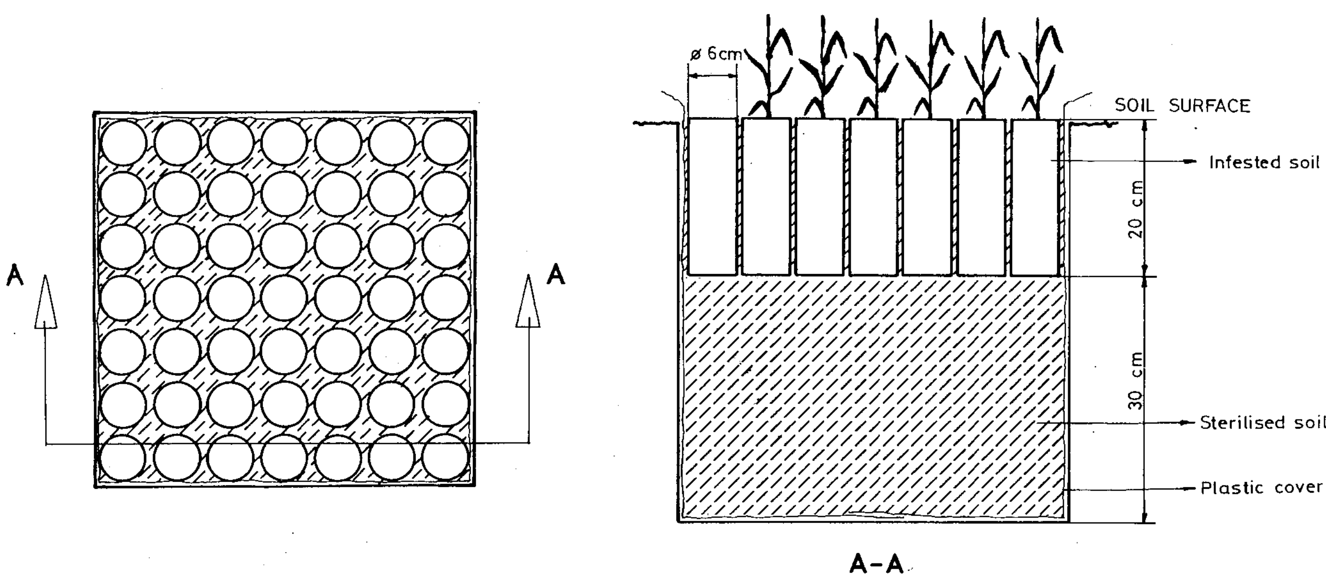

Fig. 2 - Study of development of cycles of *Heterodera avenae* in Spain: scheme of cultural experiments (1 block for each population and 1 block for control).

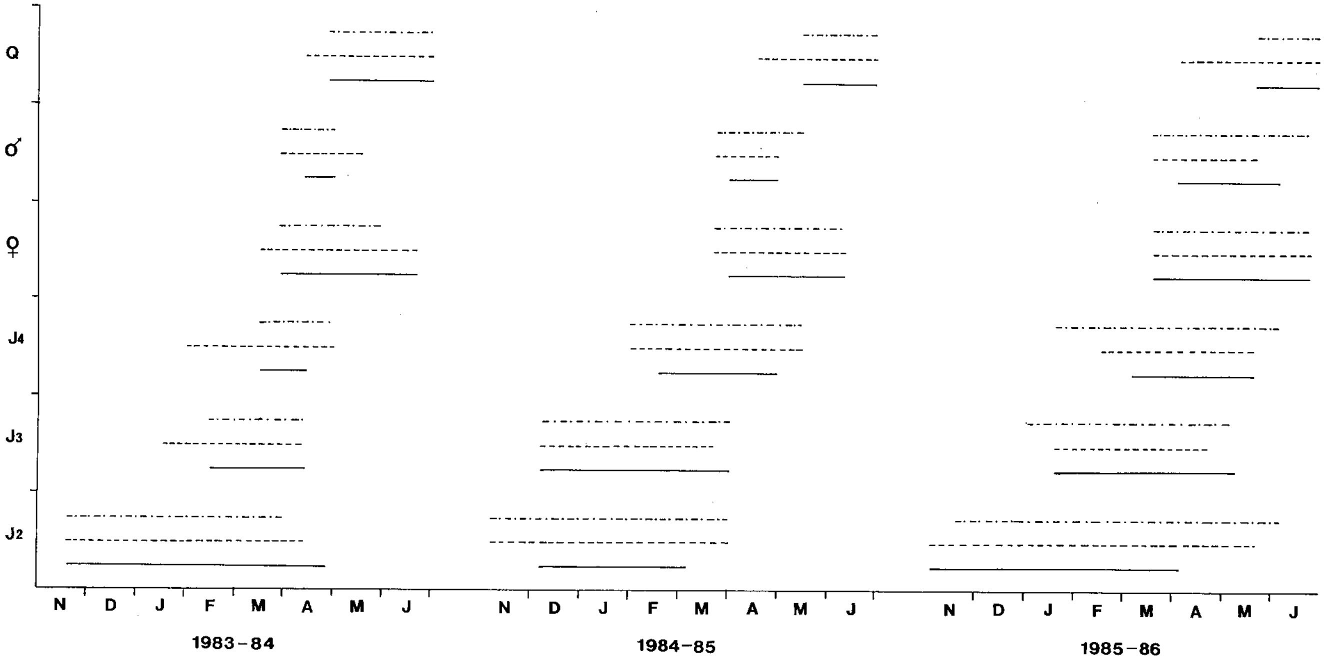

Fig. 3 - Life cycle of the three populations along the three years. Toledo (————), Sevilla (– – – – –) and Teruel (·–·–·–·–·).

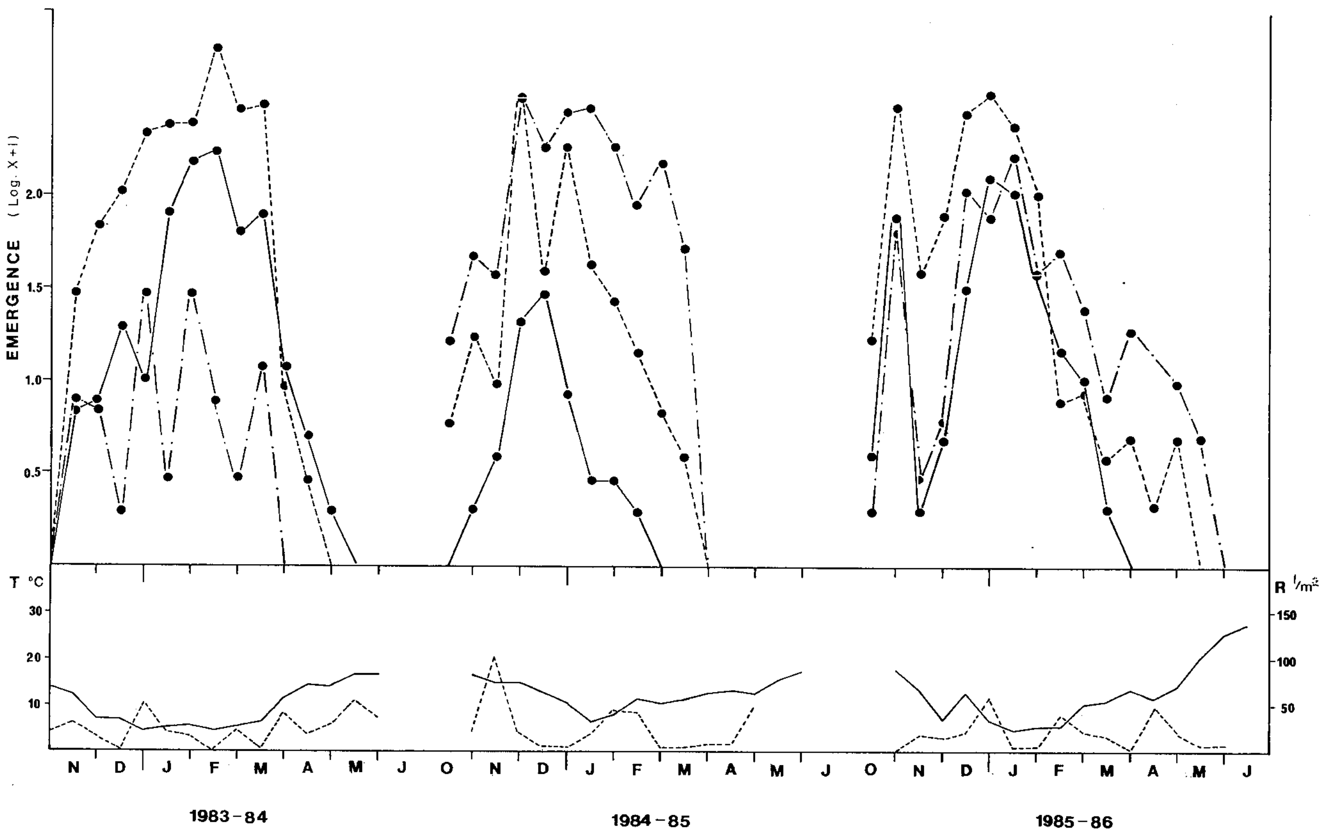

Fig. 4 - Hatching cycles of *H. avenae* along the three years. Emergence (N° J2/100 cc) for Toledo (————), Sevilla (– – – – –) and Teruel (·–·–·–·–·) population. Mean temperatures (15 cm depth) °C (————) and rainfall l/m² (– – – – –).

Second stage juveniles first emerged in late October or early November in all populations, coinciding with temperatures of about 15°C, the start of autumn rains and sowing time of the wheat crop (Fig. 4). The emergence of J2s increased to maximum number in January or February, afterwards decreasing, though a new increase, particularly evident for the population from Teruel was observed at the middle of March or beginning of April. After this time, numbers of J2s decreased abruptly and disappeared; however, some specimens from Sevilla and Teruel populations were exceptionally observed in May in 1986.

Two weeks after the beginning of emergence, J2s were observed inside the roots, and penetration continued until the middle of March or even the middle of April depending on the weather occurring during the year. J2s observed in May in 1986 did not penetrate the roots.

In field experiments in 1986-87, J2s were present in the roots of the wheat seedlings on 9 October. The crop had been sown on 15 September in land that had previously been irrigated when the temperature was 20-27 (23.8°C); J2s were not found in the soil samples taken on 21 July, 11 September or 1 October 1987. The rainfall on these occasions was 30.4, O and 10.3 l/m^2 respectively and the average temperatures 28, 25.6 and 21.5°C respectively.

The time when J3s and J4s were present in the roots varied among years, but females always appeared mid March-early April in all populations and were present until the middle or end of May. Cysts were first observed in the populations from Sevilla from the beginning to mid April, but in the other populations they did not appear until the end of April or mid May.

The life cycle ascertained in the field experiments did not differ from that observed for the population mantained in the uralite cylinders.

Discussion

Each of the populations studied showed a biological behaviour similar to that from the other countries with mediterranean type climate. Second stage juveniles were dormant inside the cysts from June to the end of October or early November. Hatching began earlier than in other European populations from France (Rivoal, 1978), Italy (Mezzetti, 1953) and Greece (Kyrou, 1976). Cysts from Teruel and Toledo populations were observed at the same time as in these countries, but occurred much earlier in the Sevilla population.

Spanish populations behaved similarly to populations from the South of Italy (Greco, 1981). They do not require cold stimulus to initiate hatching of eggs in the new cysts, unlike those from the South of France (Rivoal, 1983) which need a temperature of 5-10°C to emerge. This is why the J2s emerged earlier in the Spanish populations compared with French population Fr1.

The increase of emergence near the middle of March, especially in the population from Teruel, coincided with a rise of temperature (Valdeolivas and Romero, 1986) and was probably due to cold winter temperatures in this region inducing a second diapause for part of the juvenile population. Results for 1986 are insufficient to support this hypothesis, but even if emergence is simply delayed, this late emergence means an adaptation of the nematode to climatic conditions and allows it to develop in one area in which spring sowing is a frequent cultural practice.

The earlier appearance of cysts in the population from Sevilla compared with the other populations may also be due to an adaptation of the nematode to the growing season of the plant in its original area, which is at least one month shorter than in the province of Toledo and even more than in Teruel.

Second stage juveniles of Spanish populations undergo a period of seasonal diapause provoked by inherent factors, from June to the end of September in which they do not emerge even if environmental conditions are apparently favourable, which agrees with the results of Rivoal (1983) for mediterranean race of *H. avenae* Fr1. This is followed by a period (until the end of October), that should probably be considered as a quiescence when J2s emerge if there is sufficient moisture even at high temperatures, which agrees with the observations of Greco (1989) and Meagher (1970).

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