OBSERVATIONS ON EMERGENCE, SURVIVAL AND ROOT INVASION OF SECOND-STAGE LARVAE OF THE CEREAL CYST-NEMATODE, HETERODERA AVENAE

BY

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Eggs in cysts hatch in a seasonal cycle with inactive periods in winter and summer when few second-stage larvae can be recovered from soil. The cessation of hatch in May occurs before soil temperatures reach the optimum and when moisture tensions are not limiting. Most second-stage larvae can remain free in the soil over winter but their survival is reduced to 1-2 months in spring when soil temperatures increase.

The hatch of eggs is affected by the cereal species and cultivar grown and there is evidence that root exudates stimulate hatch at temperatures prevailing in the soil in spring. The cereal species and cultivar grown also influenced the number of nematodes successfully invading roots.

Eggs of the cereal cyst-nematode, Heterodera avenae Woll., hatch in a seasonal cycle which includes an inactive period in winter (Hesling, 1958; Duggan, 1961; Meagher, 1970; Banyer & Fisher, 1971a). In Europe and N. America rapid escape of larvae from cysts has been associated with previous exposure to low temperatures (Cotten, 1962) and Fushtey & Johnson (1966) considered 8 weeks at 7° were necessary to stimulate hatching. Banyer & Fisher (1971b) thought that dormancy could be induced by an increase in temperature and was most rapidly broken by low temperatures but the latter were not essential for hatching to occur.

In Britain, the emergence of second-stage larvae begins in the autumn (Kerry & Hague, 1974) and the crop may be damaged (Vernon, 1962). The amount of emergence is unknown but Kerry (1975) found that, in soils sampled in the spring, second-stage larvae were few, but whether they had survived overwinter was not investigated. Some larvae of H. schachtii survive, free in soil, up to a year (Golden & Schafer, 1960) but Den Ouden (1960) reported a 50% loss of H. rostochiensis larvae in soil after 7 weeks. Soil temperature and rainfall affect the activity of nematodes (Jones, 1975) and influence the survival of Heterodera larvae in the absence of a host.

Root exudates increase the hatch of eggs of H. avenae in vitro at temperatures of 10° and 15° (Williams & Beane, 1971). Graham & Stone (1975) observed differences in the invasion of oats, wheat and barley but it was unclear whether this arose from the hatch of eggs or the movement of larvae towards the roots. This paper describes pot experiments on the emergence and overwinter survival of second-stage larvae, from a population of pathotype 1 of the cereal cyst-nematode, and their invasion of the roots of oats, wheat and barley.
MATERIAL AND METHODS

Heavily infested soil was collected from the field in August, screened through a coarse sieve (0.6 mm apertures) and stored in plastic bags out-of-doors.

**Emergence of second-stage larvae in soil.** Forty-eight pots were each filled with 50 g of infested soil diluted with 400 g sterilised loam and plunged in sand out-of-doors. Four pots were removed at 28-day intervals from September until mid-July and the second-stage larvae and eggs in the soil extracted by the tray method (Whitehead & Hemming, 1965) and the Fenwick can respectively.

**Survival of second-stage larvae in soil.** Newly formed cysts with subcrystalline layers still adhering were selected from a bulk of soil extracted in a fluidising column (Trudgill, Evans & Faulkner, 1972). Short lengths (1 cm) of plastic tubing (diam. 1 cm) each with one end covered by bolting silk were made. In each tube thirty five cysts were placed on the silk and the tube filled with coarse sand. The tubes (two per pot) with cysts were buried in pots each containing 450 g sterilised loam and plunged in sand out-of-doors in September. Six pots were removed at 28-day intervals until January and the second-stage larvae in the soil and the unhatched eggs remaining in cysts in the tubes counted. In January the tubes were removed and thereafter the numbers of larvae in the soil were counted at fortnightly intervals until May. Three pots were planted with three germinated seedlings of oats cv. Mostyn and three pots with barley cv. Julia on two occasions on 25 March and 6 May and the plants removed after 21 days and the number of larvae in their root systems estimated.

**Egg hatch and larval invasion in autumn and spring-sown cereals in pots plunged out-of-doors.** Infested soil (50 g) was mixed with 400 g sterilised loam, as in the experiment above and sown on 16 October and 18 March to give three seedlings/pot of three cultivars, of autumn and spring oats, wheat, and barley (48 pots in all). In late April and May, when larval emergence had ceased, the numbers of nematodes in the roots and eggs remaining in the soil were counted.

**Invasion of autumn and spring sown cereals in pots in the glasshouse.** Seedlings (10 days old) of the cereal cultivars used above were inoculated with 1,000, 5,000 and 10,000 second-stage larvae (<1 week old) in pots containing 200 g sterilised loam. Each variety was replicated three times at each inoculum level and sampled after 21 days when larval invasion was estimated (54 pots in all).

RESULTS

Twenty-six percent of eggs hatched in the autumn during September, October and early November, and hatch was most rapid in September at the beginning of the period when soil temperatures were highest (Fig. 1). Hatching ceased in December, January and February when the soil temperature fluctuated narrowly