CEREAL CYST NEMATODES:
STATUS, RESEARCH AND OUTLOOK

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Abstract: The first meeting of the International Cereal Cyst Nematode Initiative, held in October 2009 in Turkey, involved over 60 scientists from wheat-growing regions in Asia, Australia, Europe, north Africa and North America. Cereal cyst nematodes (CCN) are damaging root parasites of barley, oat, wheat and related plants; the most important species being *Heterodera avenae*, *H. filipjevi* and *H. latipons*. Forty three papers in this volume cover: the history and status of CCN both globally and regionally; research on CCN morphological, genetic and ecology diversity; development and deployment of host resistance as the principal means of control, including advancements provided by molecular technology; and investigations into other types of control and opportunities for integrated management. The papers provide valuable insight into the impact of CCN and endeavours to provide sustainable management options for farmers. CCN's impact ranges from severe in resource-limited cropping systems with high pathotype diversity through to the now easily managed situation in Australia, with one pathotype and many resistant cultivars released. In many countries, unacceptable economic losses continue and international collaboration is needed to ensure that appropriate genetic resources and technology are developed, disseminated and applied where the need is greatest.

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Cover illustration: Irrigated winter wheat infested with *Heterodera avenae* with an intolerant cultivar (front), showing patches of stunted plants, and intolerant cultivar (back) growing in adjacent farmer's fields in Xuchang, Henan, China. Photograph: Ian T. Riley.

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OCCURRENCE AND DISTRIBUTION OF CYST NEMATODES INFECTING CEREALS IN SICILY, ITALY*

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SUMMARY

During 2008 and 2009, a survey on specific composition, frequency and geographical distribution of cyst nematodes living on cereals was conducted in Sicily, Italy. *Heterodera latipons* and *Heterodera hordecalis* appeared to be the most common species in durum wheat (*Triticum durum*) and barley (*Hordeum vulgare*) samples. Less widespread was *Heterodera avenae*, which occurred in a few fields of durum wheat. Laboratory investigations on soil samples and roots revealed the presence of all developmental stages for each species detected, with a marked preponderance of adult females and cysts. Symptoms and damage accompanying infestations by the above cyst nematode species were homogeneous in all fields and crops investigated: infected plants were stunted, small and scrubby and possessed chlorotic leaves and small roots.

INTRODUCTION

Cyst nematodes attack many species of cereals, frequently causing serious yield losses in major food crops. In particular, nematodes in the *avenae* group of the genus *Heterodera* occur in all main areas of cereal production in the Mediterranean Basin and cause substantial economic losses. They are major pests of cereals throughout the world as well (Handoo 2002). The taxonomy and diagnostic morphological characteristics of the group have been developed by numerous scholars: cysts are lemon-shaped and their colour is dark-brown to black and vulval cones are characterised by fenestration.

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Following infections by nematodes of the *avenae* group, plants are stunted, small and scrubby and possessed small roots and chlorotic leaves. In view of the economic significance of cereal crops (mainly wheat, oats, barley and forage grasses) in Sicily, a growing importance must be accorded to cyst nematodes in this area. In this light, the main target of this study was to investigate the occurrence and distribution of cyst nematodes infecting cereals in Sicily.

METHODS

The survey was carried out over two years (2008-2009) in the main cereal growing areas of Sicily. Samples were taken especially where plants showed chlorotic and yellowing leaves, poor growth and reduced production, and therefore were suspected to be attacked by nematodes of this group. Each sampled area was 1 ha in size, and each sample was a composite of 30 subsamples collected with a small spade in the plant rhizosphere, and at a depth of 5-20 cm after removing the top 5 cm soil. The entire sample was thoroughly mixed and 2 kg of sample kept in a plastic bag and taken to the laboratory. Samples were stored at 6C until they were processed. Both durum wheat (*Triticum durum*) and barley (*Hordeum vulgare*) crops were samples by the same method. Roots were carefully washed free of adhering soil and a portion was observed under a stereomicroscope (25x magnification) to ascertain the presence of nematodes; females were subsequently dissected. Soil samples were then thoroughly mixed, air dried and processed with a Fenwick can to extract cysts. Emerging second-stage juveniles were killed by gentle heat, fixed in triethanolamine-formalin (TAF) solution and mounted in anhydrous glycerol on permanent slides. Cone mounts of cysts, previously cleaned, were also prepared and mounted in Canadian balsam.

The identification process was based on cyst morphology, namely on posterior regions (cone mounts), and on morphology of 30 second-stage juveniles, namely body length, the length of the region around the tail and the shape and length of the stylet. These morphometric measurements were compared with those of other populations of various species of the *avenae* group and other cyst forming nematodes collected on Poaceae deposited in the USDA Nematode Collection at Beltsville, Maryland.

RESULTS

Specimens of the *avenae* group were abundant in both soil and root samples of the aforementioned crop plants. Morphological examination of cyst vulval cones and second-stage juveniles revealed the presence of three species: *H. latipons*, *H. hordecalis* and *Heterodera avenae.*

Adult females of *H. latipons*, discovered for the first time in Italy (Veneto) in 1975 (Tacconi 1976), are lemon-shaped; some individuals are smaller or larger compared to the typical shape. Females show a distinct neck and a prominent vulval cone. The cuticle is characterised by a thin sub-crystalline layer; females are pearl white in colour and later turn gradually to dark brown cysts. Vulval cones (Figure 1c) are characterised by a short vulval slit (6-9 µm), two different translucent areas called fenestrae, a strong underbridge with a pronounced thickening in the middle and a bifurcation at both ends and sometimes a few bullae, as reported by Tacconi (1976)

on other Italian populations of *H. latipons*. The second-stage juveniles are vermiform with a rounded and conical tail (tail length 48-57 µm). The stylet is well developed (stylet length 23-25 µm) with basal rounded knobs which display a typical anchor shape (Figure 1a). All other morphological details agree with the typical characters of *H. latipons* (Franklin 1969) as described by Handoo (2002).

H. hordecalis (Figure 2) morphological characteristics (Andersson 1974) are quite similar to those of *H. latipons*. Nevertheless, they display fine distinctive features: the most important distinguishing character between *H. latipons* and *H. hordecalis* is

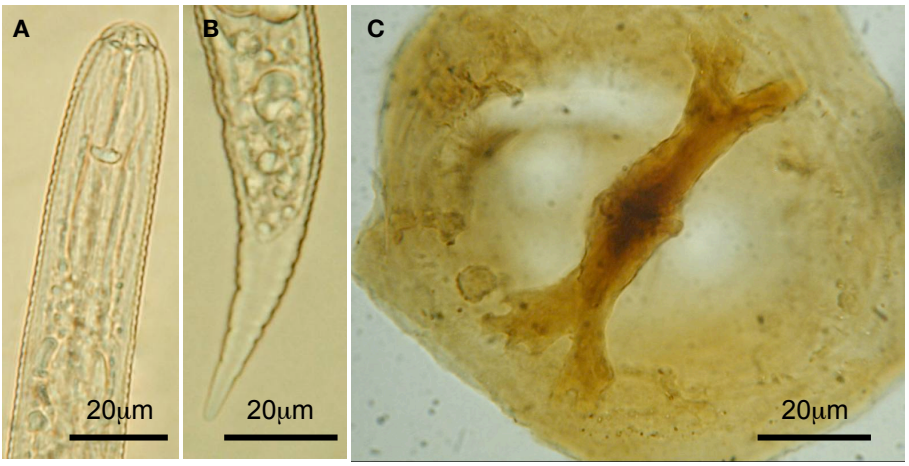

Figure 1. Photomicrograph of *Heterodera latipons*. A, head and B, tail of second-stage juveniles, C, cyst vulval cone pattern with underbridge and bullae.

the vulval slit (Figure 2c), which in *H. hordecalis* is bigger than in *H. latipons*. In *H. hordecalis*, the vulval slit is about 17-25 µm; moreover *H. hordecalis* differs from the above described *H. latipons* because its underbridge is less sclerotised than in *H. latipons*. The mentioned distinctive morphological details agree with the typical characters of *H. hordecalis* (Andersson 1974).

H. avenae cysts were dark brown to black, ambifenestrate, bullae and underbridge prominent with a shorter vulval slit 9-10 µm long; the second-stage juveniles had a body length of 530-553 µm, stylet measured 24-26 µm, stylet knobs were shallowly concave anteriorly, tail measured 50-56 µm and hyaline tail terminus was 30-36 µm long. All these and other morphological and morphometric details for *H. avenae* were consistent with those given by Handoo (2002).

DISCUSSION

Because symptoms and damage caused by the above-mentioned nematodes are not specific only to nematodes, nematode diagnosis based on symptomatology is difficult. The stunting and yellowing may have often misled farmers to erroneously attribute the symptoms to other causes, such as drought, iron or other nutrient deficiencies, chlorosis or other plant pathogens. This may be why the species in this study have remained undetected for several years in Sicily.

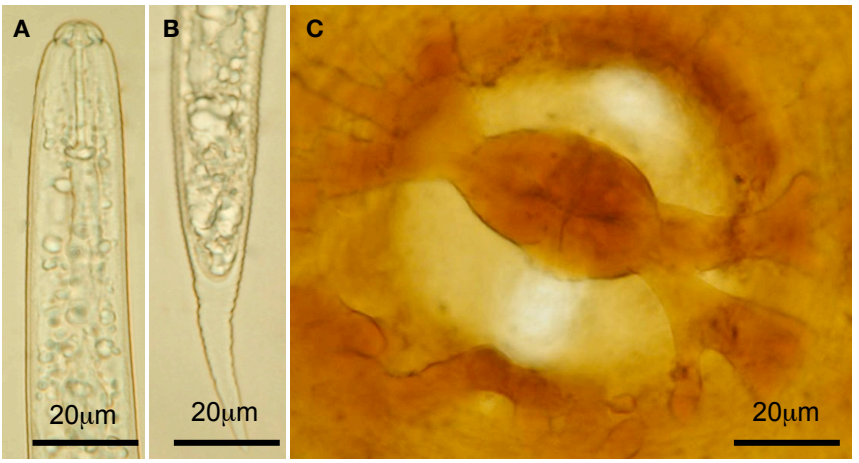

Figure 2. Photomicrograph of *Heterodera hordecalis*. A, B, head and tail of second-stage juveniles; C, cyst vulval cone pattern with underbridge and bullae.

Heterodera spp. do not cause definite symptoms on cereals when present at low population densities in the soil. Only when *Heterodera* populations increase above a crop's tolerance limit (Potter and Olthof 1993) do symptoms of nematode infection become sufficiently obvious to concern farmers and plant pathologists about the consequent damage and economic losses *Heterodera avenae* and *H. latipons* produce only one generation per host plant growing season; within 4 months at 6C but only 40 d at 18C (Mor *et al.* 1992). Nematodes of the *avenae* group have been studied in Italy (Inserra *et al.* 1978, Greco and Brandonisio 1987) to provide biological information and to suggest control strategies. As to *H. avenae* on wheat, Greco and Brandonisio (1987) concluded that soil containing over 35% clay and other environmental conditions in southern Italy are responsible for maintaining the nematode populations at very low levels and therefore for the apparent absence of damage. We observed that major crop damage was strictly related to the peculiar environmental conditions of Sicily and to soil with very low clay content and high sand content. This combination of environmental conditions and heterogeneity in soil composition over different areas accounts for the variation in nematode-inflicted crop damage between different fields of cereals.

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