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Cereal Cyst Nematodes: An unnoticed threat to global cereal production

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Global distribution and crop loss

Nematodes are among the earliest recognized parasites of wheat that occur worldwide in nearly all environments. A loss of 10% of world crop production has been estimated as a result of plant nematode damage (Whitehead 1998). The cereal cyst nematodes (CCNs) are the most important group of plant parasitic nematodes attacking temperate cereals, including wheat and barley (Sikora 1988). CCNs are a group of several closely related species which have been documented as causing economic yield loss in rainfed wheat production systems in several parts of the world including North Africa, West Asia, China, India, Australia, the United States of America and countries in Europe (Nicol and Rivoal 2008). The species most reported are *Heterodera avenae*, *H. filipjevi* and *H. latipons* (Rivoal and Cook 1993) and each species consists of different pathotypes. At least 12 pathotypes have been described for *H. avenae*. Their worldwide distribution, predominance in areas where cereal is grown, and their devastating yield loss rank them as major pests affecting the world's food supply. Their effects on plant growth and yield are commonly underestimated by farmers, agronomists, and pest management advisors because of difficulties in detection (Bridge *et al.* 2002).

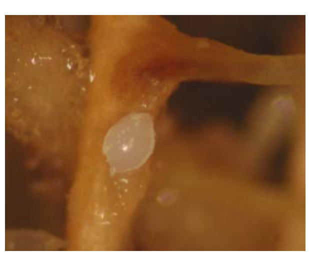
Winter wheat affected by *H. avenae* combined with lower soil fertility on a hilltop near Palouse, Washington, USA. – R. Smiley

Irrigated winter wheat infested with *Heterodera avenae* with tolerant (left) and intolerant (right) cultivars growing in adjacent farmer's fields in Xuchang, Henan, China. – I. Riley

Biology and damage symptoms

CCNs are sedentary and monocyclic nematodes. The life cycle consits of the egg, four juvenile stages and the adult stage. CCNs are characterized by the development of white females swelling to form resistant cysts which may remain dormant in the soil for several years. The larvae of the nematodes emerge from eggs as second stage juveniles, and migrates into the soil where they penetrate root tips.

The symptoms of nematode attack are more visible in seedlings than in the older plants. The symptoms appear early in the season as pale green patches, with the lower leaves of the plant becoming yellow, and the plants generally have few tillers. Infected plants grow poorly and in uneven patches. Symptoms can easily be confused with those from other problems such as nitrogen deficiency and poor soil. Infected root systems show increased root production, and have a `bushy-knotted´ appearance. This highly-branched root system is a characteristic enabling CCNs to be diagnosed in wheat and barley. As the life cycle of CCNs progresses, several white females in the form of cysts are usually visible at each knot.

A  B  C 

A) White female of *Heterodera filipjevi* on wheat root system. – H. Saglam. **B**) "Knotting" of wheat roots. **C)** Stunted wheat plant with knotted roots heavily infested with *Heterodera avenae* (right) compared with uninfested plant (left). – H. Li

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Management

Many examples around the world have shown that the population of CCNs can be reduced effectively through an integrated approach.

Cultural practices

Cultural practices are the most efficient methods of reducing CCNs. Crop rotation with non-cereals or grass-free rotation is very successful in reducing the population below the damaging threshold level. Organic amendments, such as manure, organic matter, and compost may also compensate for the reducing effect of CCNs on wheat yield. Under fallow, non-host, or resistant cultivars, populations of *H. avenae* can decline by 70-80% annually through spontaneous hatching which results in the death of juveniles (Singh *et al*. 2009).

Chemical control

In the past, low rates of nematicides applied to both soil and seeds have provided effective and economical control of CCNs, in Australia, India, and Israel (Rivoal and Nicol 2009). The use of chemicals becomes economic when other methods of control are too costly, difficult to apply, or when a method such as rotation is inadequate (Hague and Gowen 1987). Today however, no chemical is considered adequate because of costs, environmental hazards, and high health risks for farmers.

Biological control

It has been shown that fungal pathogens of nematodes such as *Catenaria auxiliaries, Pochonia chlamydosporia* and *Nematophthora gynophila* could infect and kill the eggs and females of CCNs (Mitchinson *et al.* 2009, Kerry *et al.* 1977). However, these fungi have not yet been exploited as biological control agents at a commercial scale.

Host plant resistance

Using resistant crop cultivars is considered the most effective and economical method for managing nematodes in both high and low value cropping systems. The effectivness of resistance to CCN depends on the effectiveness and durability of the sources of resistance and on ther correct identification of the nematode species and/or pathotype/s (Nicol and Rivoal 2008). CIMMYT-Turkey, in collaboration with partners in Turkey, are screening up to 3000 germplasm against *Hetetodera filipjevi* and *H. avenae* under controlled conditions. Then, the best resistant germplasm will be tested in the open field under high and low nematode pressure to evaluate their tolerance as well. In Turkey, 2 resistant varieties (Sonnmez and Katea) are grown in areas where *H. filipjevi* is predominant. The next step it to identify of molecular markers for resistance to CCNs through association mapping. This approach will require to assemble a set of germplasm (about 300 entries) with variable levels of resistance to CCN.

Further reading

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