

The Potato Pathotype of the False-Root Knot Nematode, *Nacobbus aberrans*

Working Group of the SON Exotic Nematode Plant Pest List

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The false root-knot nematode, *Nacobbus aberrans*, is a species complex with many pathotypes having different host preference. This species is native in the United States, where it is a damaging pest of sugarbeet. Native hosts parasitized by *N. aberrans* in the United States have favored the specialization of *N. aberrans* populations to infect sugarbeet. These populations are named the sugarbeet pathotype of *N. aberrans*. According to Thorne and Schuster (1956), the sugarbeet pathotype of *N. aberrans* (= *N. batatiformis*) is an indigenous species in the Great Basin and Great Plains where it infects a native shrub, *Atriplex confertifolia*, a member of the same family as the sugarbeet (Chenopodiaceae). It is reasonable to assume that the nematode became adapted to infect the more succulent host sugarbeet when this industrial crop was introduced into the United States from Europe.

The false root-knot nematode is also present in Mexico and the Andean regions of South America. In these regions the native nematode populations became specialized to infect native solanaceous plants and especially the native potatoes in the Andean regions. The broad geographical distribution of the nematode along the Pacific coast of Americas has favored the selection of other pathotypes in these regions. The potato pathotype of the false root-knot nematode is among the most economically important nematode pests of potatoes in Latin America.

So far, there is no evidence that the potato pathotype of *N. aberrans* occurs in the United States.

During the initial compilation of the SON list of the exotic nematode pests of agricultural and environmental significance to the United States, the Working Group placed *N. aberrans* on Table 2 with the plant-parasitic nematodes of limited distribution in the United States.

During the past year, the Working Group has reconsidered this decision. An in depth review of the literature published on *N. aberrans* was conducted. The results of this study indicate that it is more appropriate to take the false root-knot nematode off of Table

2 and to list it instead on Table 1 (with plant-parasitic nematodes not present in the United States) under the name of the potato pathotype of *N. aberrans*, because this pathotype is not present in the United States. As a consequence, *N. aberrans* (potato pathotype) is listed now on Table 1. A high (H) priority rating for a complete risk assessment to be conducted by APHIS is assigned to this pathotype of the nematode. The criteria adopted for the high (H) rating status were the great economic importance of this nematode for the potato industry worldwide, the exceptional adaptation of all life-stages of this pathotype to be transported and disseminated with plant tissue such as roots and tubers.

The legality concerning the implementation of a quarantine action against a nematode pathotype (race) was taken into appropriate consideration by the Working Group. There was no evidence that the International Plant Protection Convention rules opposed the implementation of quarantine measures against pathotypes or races or strains of an organism. The Working Group also observed that EPPO imposes quarantine restrictions against the potato cyst (*Globodera pallida* and *G. rostochiensis*) and the stem nematodes (*Ditylenchus dipsaci*) in spite of the fact these three nematode pests are widespread in Europe (A2 list) (Annexes to EC Plant Health Directive 2000/29EC). EPPO justifies the adoption of these preventative measures by the fact that they are meant to protect the European potato and vegetable industries from the introduction and spread of pathotypes of these three nematode pests.

A complete report on *N. aberrans* follows.

REPORT ON THE FALSE ROOT-KNOT NEMATODE, *NACOBBUS ABERRANS*

Distribution and economic importance of the false root-knot nematode:

The false root-knot nematode occurs in temperate and tropical latitudes of North and South America. The results of host and field studies conducted in North and South America indicate that *N. aberrans* populations can be separated into pathotypes. The populations of each pathotype have distinct host preferences. Recent studies on the characterization of DNA of several populations of *N. aberrans* indicate that these

pathotypes consist of different species (Manzanilla-López *et al.*, 2004). These findings suggest that separation of the *Nacobbus* pathotypes by DNA analysis is feasible. **The yield losses reported on staple and industrial crops parasitized by *N. aberrans* average 65% for potato in the Andean regions of Latin America and 55% for tomato in Mexico** (Canto-Sáenz *et al.*, 1996; Franco *et al.*, 1992, 1993; Manzanilla-López *et al.*, 2002; Ortuño *et al.*, 1994; Otazú *et al.*, 1985). The only Latin American countries where there are no reports of this pest are those of Central America, Brazil, Colombia, Guyana, Paraguay, Uruguay and Venezuela.

In the United States, *N. aberrans* is an economic pest of sugarbeet. The distribution of the false root-knot nematode includes Arkansas, Colorado, Kansas, Montana, Nebraska, South Dakota, Utah and Wyoming (Manzanilla-López *et al.*, 2002; Gray *et al.*, 1997). According to Thorne and Schuster (1956), the sugarbeet pathotype of *N. aberrans* (= *N. batatiformis*) is an indigenous species in the Great Basin and Great Plains where it infects a native shrub, *Atriplex confertifolia*, a member of the same family as the sugarbeet (Chenopodiaceae). It is reasonable to assume that the nematode became adapted to infect the more succulent host sugarbeet, which is an industrial crop introduced into the United States from Europe. The spread of the nematode was facilitated by the movement of contaminated agricultural machinery, harvesting combines and the use of soil amendments consisting of nematode-infected sugarbeet residues from the sugar processing plants. In the last two decades, the sugarbeet growing areas have decreased drastically for economic and market reasons. Today, Nebraska and Wyoming are the states most affected by the damage of this nematode which causes sugarbeet crop

losses of 10-20%. *Nacobbus aberrans* does not occur in the southwestern and eastern United States.

Host preference of *N. aberrans* populations in the United States and in Latin

America:

In the United States, the false root-knot nematode is an economically important pest of sugarbeet in Nebraska and Wyoming. In spite of the fact that the populations of *N. aberrans* in the United States are able to infect many selected species of Cactaceae, Chenopodiaceae, Compositae, Cruciferae, Cucurbitaceae, Leguminosae, Solanaceae, Umbelliferae and Zygophylliaceae (Thorne and Schuster, 1956; Inserra *et al.*, 1985; Gray *et al.*, 1997), **they are not able to infect potato (*Solanum tuberosum*)** (Inserra *et al.*, 1985; Manzanilla-López *et al.*, 2002). The populations with the host preferences of the U.S. populations are called the sugarbeet pathotype of the false root-knot nematode. So far, the sugarbeet pathotype, which also occurs in Latin America (Argentina and Ecuador), has not been found in potato growing regions of the United States.

Another pathotype of the nematode which is specialized to infect potato occurs in Mexico and in the Andean regions of Argentina, Bolivia, Chile and Peru. This pathotype infects many other cultivated plants including sugarbeet, beet, carrot and turnip and is called the potato race of the false root-knot nematode (Manzanilla- López *et al.*, 2002). This pathotype causes serious economic losses to the potato industry of Latin America (Franco, 1994; Manzanilla-López *et al.*, 2002). This pathotype has not been reported in the United States.

A third pathotype, which is specialized to infect bean, occurs in Mexico and is called the bean race of the false root-knot nematode. However, this nematode does not infect either potato or sugarbeet (Manzanilla-López *et al.*, 2002).

Additional reported hosts of *N. aberrans*, including the potato pathotype, are Austrian winter pea (*Pisum sativum* var. *arvense*), black mustard (*Brassica nigra*), broccoli, Brussel sprouts, cabbage and collard (*Brassica oleracea*), carrot (*Daucus carota*), cucumber (*Cucumis sativus*), eggplant (*Solanum melongena*), fat hen (*Chenopodium album*), grain amaranth (*Amaranthus* sp.), kohlrabi (*Brassica oleracea*), lettuce (*Lactuca sativa*), mashua (*Tropaeolum tuberosum*), ornamental gourd (*Cucurbita pepo*), pepper (*Capsicum annuum* and *C. baccatum*), potato (*Solanum tuberosum*), pumpkin (*Cucurbita maxima*), spinach (*Spinacia oleracea*), sugarbeet (*Beta vulgaris*), sweet potato (*Ipomea batata*), tobacco (*Nicotiana tabacum*), tomato (*Lycopersicon esculentum*), and ulluco (*Ullucus tuberosum*). Weed hosts include chickweed (*Stellaria media*), corn spurry (*Spergula arvensis*), fireweed (*Datura ferox*), ground cherry (*Physalis* sp.), London rocket (*Sysimbrium irio*), kochia (*Kochia scoparia*), lambsquarter (*Chenopodium album*), nightshade (*Solanum nigrum*), oregano (*Origanum vulgare*), purslane (*Portulaca oleracea*), and quinoa (*Chenopodium quinoa*) (Brodie, et al., 1993; CAB International, 2001; Canto- Sáenz, 1992; Manzanilla-López *et al.*, 2002). **The broad host range of the potato pathotype of the false root-knot nematode would facilitate the establishment of this pest on alternative hosts other than potato if the nematode were introduced into the United States.**

Nematode biology and dissemination:

All the pathotypes of the false root-knot nematode have both endoparasitic migratory and sedentary feeding habits. The juveniles and immature adults have endoparasitic migratory habits like those of lesion nematodes. They invade the feeder root tissues or tubers where they feed, migrate and develop, causing lesions, necrosis and cavities (Figs. 1, 2). Juveniles (3rd and 4th stages) are able to undergo dormancy and to survive adverse environmental conditions inside dry roots or tubers. The vermiform females abandon the necrotic tissues and reinvade suitable healthy roots where they become sedentary and establish permanent feeding sites, producing root galls and egg masses (Fig. 1). **These peculiar parasitic habits allow the nematode to be transported long distances inside the infected roots and tubers as eggs, juveniles and adults thus making *N. aberrans* one of the most targeted organisms by international quarantine legislation** (Lehman, 2004).

Nematode detection:

Roots and tubers infected by *N. aberrans* usually escape the visual inspection conducted at ports of entry. Large root swellings as those shown in Figure 1 can be detected by inspectors with nematological training; however tubers and feeder roots inhabited by the vermiform and motile stages of the nematode (Fig. 2) escape any visual inspection.

International quarantine measures against *N. aberrans*:

Nacobbus aberrans is restricted by many countries because of the severe yield losses it causes in many crops, and especially potato. The state of California includes *N. aberrans* on the list of organisms that require state-enforced action involving eradication,

quarantine regulation, containment, rejection or other holding action (A list). **Countries that restrict *N. aberrans* include Argentina, Brazil, Bulgaria, Colombia, the European Union, Iceland, Indonesia, Japan, Morocco, Norway, Paraguay, Republic of Korea, Thailand, Tunisia, the United States (California), Uruguay and the Former Republic of Yugoslavia** (Export Certification Project-Excerpt, 2004; Lehman, 2004; Manzanilla- López *et al.*, 2002). The European and Mediterranean Plant Protection Organization (EPPO) includes *N. aberrans* on the A1 list of “harmful organisms whose introduction into, and spread within, all member states shall be banned” (Annexes to EC Plant Health Directive 2000/29/EC).

Direct and indirect consequences of the introduction of the potato race of *N. aberrans* into the United States:

The direct economic impact of this potato nematode pest on the potato industry in the United States can be easily deduced from field studies conducted in Latin America (Brodie *et al.*, 1993; Franco, 1994; Manzanilla-López *et al.*, 2002). **Potato crop losses of 65% that are reported in the Andean regions of South America could occur in the cool potato growing areas of the Pacific Northwest and other northern states. The indirect economic and regulatory impact to the U. S. potato industry and other U. S. agricultural interests such as the ornamental industry should not be underestimated.** These industries would be seriously affected by quarantine restrictions against *N. aberrans* imposed by more than 15 countries against plant shipments originating from U.S. areas that would be infested by this nematode pest of potatoes.

The introduction and establishment of the potato pathotype of *N. aberrans* would have indirect negative repercussion on the USDA-APHIS golden nematode quarantine program. The USDA-APHIS has been conducting this program for more than 50 years, devoting considerable resources, to containing the golden nematode in New York, the only known state in the United States where the golden nematode is present, and to preventing its spread to other states. The success of this quarantine program in protecting the potato industry from cyst nematode pests will be indirectly diminished by an accidental introduction and establishment of the potato pathotype of *N. aberrans* from Latin America, since this nematode has destructive effects and ability to spread equivalent to those of the golden nematode.

In conclusion, the Working Group points out that there are enough reasons for considering the potato pathotype of *N. aberrans* a quarantinable exotic nematode pest posing a high risk for the agriculture of the United States.

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Fig.1. A beet seedling infected by the false root-knot nematode *Nacobbus aberrans*. Note the root galls induced by the nematode.



Fig. 2. A tip of a beet feeder root colonized by vermiform life-stages of *Nacobbus aberrans*. Note nematodes artificially stained in red along the center cylinder of the root.