COMPARATIVE FIELD REACTION OF SUGARBEET AND SEVERAL CRUCIFEROUS CROPS TO *NACOBBUS ABERRANS*†

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ABSTRACT

Gray, F. A., D. W. Koch, and J. M. Krall. 1997. Comparative Field Reaction of Sugarbeet and Several Cruciferous Crops to *Nacobbus aberrans.* Nematropica 27:221-227.

Varieties of oil seed rape (*Brassica napus* L. and *B. campestris* L.), forage Brassicas (kale, *B. oleracea* L.; turnip, *B. rapa* L.; rape, *B. napus* L.; and a turnip × Chinese cabbage hybrid, *B. rapa* L. × *B. pekinensis* L.) and sugarbeet cyst nematode-resistant trap crops (radish, *Raphanus sativus* L., and mustard, *Sinapis alba* L.), all in the Brassicaceae (Cruciferae) family and sugarbeet (*Beta vulgaris* L.) in the Chenopodiaceae family, were evaluated for root galling in naturally infested field plots after 5 wk in 1992 and after 14 wk in 1993 for comparative reaction to the false root-knot nematode (*Nacobbus aberrans* Thorne and Allen), a root parasite of sugarbeet in eastern Wyoming. *Nacobbus aberrans* did not induce galls on any cruciferous crop. Incidence of sugarbeet with root galls was 41% in 1992 and 82% in 1993, while severity was 1.1 galls/root and 3.3 galls/root, respectively. Increased incidence of galling in 1993 appeared to be due to a longer period of evaluation with optimum soil temperature [3291 and 2423 growing degree days (GDD) base 5°C at 2.5 and 10.2 cm soil depth in 1993 compared to only 1102 and 870 GDDs in 1992]. Additional symptomatic hosts of *N. aberrans* included several weeds growing in the test site; common lambsquarters (*Chenopodium album* L.), kochia (*Kochia scoparia* L.), and Russian thistle (*Salsola iberica*, Sennen and Pau), all in the Chenopodiaceae family, common purslane (*Portulaca oleracea* L.), in the Portulacaceae family, and puncturevine (*Tribulus terrestris* L.), in the Zygophyllaceae family. Common purslane represents a new weed host of *N. aberrans* in North America. Lambsquarters was used as a bioassay for *N. aberrans* during both years to verify presence of *N. aberrans* in plots of entries with asymptomatic roots. Incidence of lambsquarters with galls was 36% in 1992 and 60% in 1993 while severity was 0.8 and 2.0 galls/root, respectively.

Key words: *Beta vulgaris*, common purslane, false root-knot nematode, *Nacobbus aberrans*, nematode-resistant trap crops, *Portulaca oleracea*, sugarbeet, weed hosts.

RESUMEN

Gray, F. A., D. W. Koch y J. M. Krall. 1997. Comparación de la reacción en el campo de la remolacha azucarera y de varios cultivos crucíferos a *Nacobbus aberrans.* Nematropica 27:221-227.

Variedades de nabo aceitero(*Brassica napus* L. y *B. campestris* L.) *Brassicas* forrajeras (berza, *B. oleracea* L.; nabo, *B. rapa* L.; bledo, *B. napus* L.; y un híbrido de nabo y col china, *B. rapa* L. × *B. perkinensis* L.) y cultivos trampa de remolacha azucarera resistentes al nematodo del quiste de la remolacha (*Heterodera Schachtii*) (rábano, *Raphanus sativus* L. y mostaza, *Sinapis alba* L.), todos dentro de la familia Brassicaceae (Crucífera) y la remolacha azucarera (*Beta vulgaris* L.) de la familia Chenopodiaceae, fueron evaluadas en relación al agallamiento de la raíz, en parcelas de campos naturalmente infestados, despues de 5 semanas en 1992 y luego de 14 semanas en 1993, para comparar la reacción frente al nematodo falso agallador de la raíz (*Nacobbus aberrans* Thorne and Allen), parasitador de la raíz en

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la remolacha azucarera, en el este de Wyoming. *Nacobbus aberrans* no indujo agallamiento en ninguno de los cultivos crucíferos. La incidencia de remolacha azucarera con agallas en la raíz fue de 41% en 1992, y de 82% en 1993, mientras la severidad fue de 1.1 y 3.3 agallas/raíz, respectivamente. El incremento en la incidencia de agallamiento en 1993 parece ser debido a un periodo evaluativo más largo, con temperatura óptima del suelo (3291 y 2423 días grado de crecimiento (GDC) en base a 5°C a 2.5 y 10.2 cm de profundidad del suelo en 1993, comparado con solo 1102 y 870 GDCs en 1992). Hospedantes sintomáticos adicionales de *N. aberrans*, lo fueron varias malezas creciendo en el sitio del ensayo; quenopodio común (*Chenopodium album* L.), kochia (*Kochia scoparia* L.), y el cardo ruso (*Salsola iberica*, Sennen and Pau), todos dentro de la familia Chenopodiaceae, la verdolaga común (*Portulaca oleracea* L.) de la familia Portulacaceae, y tribulo (*Tribulus terrestris* L.) de la familia Zygophyllaceae. La verdolaga común representa una nueva maleza hospedante de *N. aberrans* en Norte America. El quenopodio fue usado como bioreconocimiento para *N. aberrans* durante ambos años, para verificar la presencia del mismo en parcelas con registros de raíces sin síntomas. La incidencia de quenopodio con agallas fue de 36% en 1992 y 60% en 1993 mientras que la severidad fue de 0.8 y 2.0 agallas/raíz, respectivamente.

Palabras claves: *Beta vulgaris*, cultivos trampa resistentes a nematodos, malezas hospedantes, *Nacobbus aberrans*, nematodo falso agallador de la raíz, *Portulaca oleracea*, remolacha azucarera, verdolaga común.

INTRODUCTION

Nacobbus spp. appears to be native to the western part of North and South America where it parasitizes and causes galls on roots of a number of native and agricultural plants (Sher, 1944). Because these nematodes induce galls on the roots of their host plants, as do root-knot nematodes, *Meloidogyne* spp., they are familiarly known as "false root-knot" nematodes (Clark, 1997). *Nacobbus aberrans* Thorne and Allen, was first reported in the U.S.A. on sugarbeet (*Beta vulgaris* L.) in 1935 (Thorne, 1935). Its life cycle is completed in 48 days at 25°C and in 75 days at 20°C (Inserra *et al.*, 1983). Less than 1% egg hatch was measured at 5°C. Symptoms consist of galls on storage and fibrous roots resulting in the initiation of small rootlets (Jatala, 1991). Galls vary in size depending on the plant species. On sugarbeet, individual galls may exceed 10 mm in diameter and multiple galls may occur in a chain on the same root (Thorne and Schuster, 1956).

A survey of sugarbeet fields in 1953-1954 showed widespread occurrence of the nematode in western Nebraska, eastern Wyoming and northeastern Colorado, particularly in fields with sandy soils (Thorne and Schuster, 1956). The authors collected and examined plants from fields and experimental plots and plants were evaluated in the greenhouse. Soil density of *N. aberrans* was not given. Although they indicated that the degree of root distortion and galling varied greatly among plants, gall indices were not given. The authors indicated that the presence of females producing viable eggs was the criterion by which plant species were determined to be susceptible. All Chenopodiaceae, Cruciferae, Cataceae and Zygophylloaceae species observed or tested were reported to be susceptible, whereas those of the Gramineae, Liliaceae, Malvaceae, Iridaceae, Amaranthaceae and Convolvulaceae were reported non-susceptible. Species of the Leguminosae were reported to be non-susceptible with the exception of *Pisum sativum* L., on which small galls were produced. Some species of the Cucurbitaceae, Umbelliferae, Compositae and Solanceae were reported to be resistant while others were susceptible. The authors indicated that sugarbeet was the most economically important known host. *Nacobbus aberrans* has also been reported in Utah, Kansas, Montana and South Dakota (Inserra *et al.*, 1996; Thorne, 1935).

The sugarbeet race of *N. aberrans* (Inserra *et al.*, 1996) is still an important root parasite of sugarbeet in Wyoming (Steele, 1991). It can be managed through long-term (4-6 year) rotations of non-host crops and good weed control. Corn and small grains are recommended rotation crops. Therefore, knowledge of the reaction of cruciferous crops to this nematode is important if they are to be grown in rotation with sugarbeets. Canola (*Brassica napus* L. and *B. campestris* L.) is a type of rape grown for seed oil in Wyoming. Several other species of the genus Brassica, including kale (*B. oleracea* L.), turnip (*B. rapa* L.), rape (*B. napus* L.) and a turnip × Chinese cabbage hybrid (*B. rapa* × *B. pekinensis* L.) are grown as forage crops for late fall-early winter grazing. More recently, radish (*Raphanus sativus* L.) and mustard (*Sinapis alba* L.), developed in Germany and used throughout Europe as nematode-resistant trap crops to reduce soil populations of the sugarbeet cyst nematode (*Heterodera schachtii* Schmidt) (Cooke, 1991), are being evaluated for possible use in Wyoming (Koch and Gray, 1997). Each of these specialty crops (oil seed rape, forage brassicas and nematode-resistant trap crops), all in the Brassicaceae (Cruciferae) family, are either presently grown or are being considered by growers in the sugarbeet producing areas of Wyoming. The object of our study was to evaluate the comparative reaction of these aforementioned specialty crops and sugarbeet, as well as local weeds, in a field having a natural infestation of *N. aberrans.*

MATERIALS AND METHODS

The test site was located at the University of Wyoming, Research and Extension Center at Torrington in southeastern Wyoming. The soil was a Bayard sandy loam containing 70% sand, 14% silt, 16% clay, and 1.5% organic matter with a pH 7.4, on which sugarbeet had been grown the previous five years. The test was conducted at the same location in 1992 and in 1993. Each year, the entire test site area was double disked and seeded to sugarbeet (cv. Monohikari) which was allowed to grow several weeks prior to establishing plots, in hopes of increasing soil inoculum density of *N. aberrans.* Sugarbeet was seeded on 14 April and plowed-down on 15 June (9 weeks) in 1992. There were 1441 and 1001 growing degree days GDD base 5°C at 2.5 and 10.2 cm soil depth during this period. Sugarbeet was seeded on 20 April and plowed-down on 25 May (5 weeks) in 1993 (622 and 364 GDD base 5°C at 2.5 and 10.2 cm soil depth). After plow-down, the entire test site area was disked in both directions and leveled for a seed bed. Plots were established on 16 June, 1992 and 26 May, 1993. Prior to establishing test plots in 1992 and 1993, 91 kg of nitrogen (urea) and 18 kg of phosphorus (P_2O_5) fertilizer per hectare were applied and the plot area was double disked. To suppress weed populations, in the early sugarbeet plantings a tank mix of ethofumesate and diethatyl ethyl was applied preplant the day prior to establishment of sugarbeet, and a mixture of phenmedipham and desmedipham was applied postplant each year.

Plots, 1.8 m × 24.4 m and 3.05 m × 24.4 m, respectively, were planted at a seeding rate of approximately 2.24 kg/ha for specialty crops and 85,000 seeds/ha for sugarbeet. Row spacing for specialty crops was 15.3 cm, and for sugarbeet was 76.2 cm. In order to evaluate weeds as possible hosts of

Table 1. Specialty crops in the family Brassicaceae and sugarbeet (family Chenopodiaceae) evaluated for field reaction to *Nacobbus aberrans.*

Cool Season Forage Brassicas	
	Kale (*B. oleracea*) cv. Premier
	Rape (*B. napus*) cv. Dwarf Essex
	Turnip (*B. rapa*) cv. Green Globe
	Turnip × Chinese cabbage hybrid (*B. rapa* × *B. pekinensis*) cv. Tyfon
Seed Oil Rapes	
	Canola (*B. napus*) cvs. Global, Westar
	Canola (*B. campestris*) cv. Colt
Nematode-Resistant Trap Crops	
	Radish (*Raphanus sativus*) cvs. Adagio,[1] Nemex, Pegletta
	Mustard (*Sinapis alba*) cv. Maxi
Sugarbeet	
	(*Beta vulgaris*) cv. Monohikari

[1]Adagio was tested in 1993 only.

N. aberrans, post emergence herbicides were not applied on experimental plots. The experimental design was a randomized complete block with three replicates. Entries were randomized each year. Information on the 12 crop entries is given in Table 1. Eleven entries were evaluated in 1992 (Adagio was not available in 1992) and 12 entries were evaluated in 1993.

1992 Test. On 21 July 1992, 5 wk after planting, 50 random plants were dug from each entry, washed free of soil and observed for root galling. Incidence of root galling and number of galls/root were determined. Weeds of several plant families were dug from plots and observed for root galling. Galled specimens of each weed species and of sugarbeet were mailed to M. Golden, USDA-ARS Nematologist, Beltsville, MD, and E. D. Kerr, University of Nebraska Plant Pathologist/Nematologist, Scottsbluff, NE for positive identification of the causal nematode. Since many of the lambsquarters plants were galled, and since galling of crop entries was observed only in the sugarbeet plots, five random lambsquarters plants were dug from each plot (55 plants/replicate), and rated for galling to bioassay for the presence of *N. aberrans.* Incidence and severity of root galling for lambsquarters were determined in all plots except sugarbeet.

Monthly irrigation and rainfall totals for May through August were; 51, 104, 218 and 80 mm, respectively (four month total = 453 mm).

1993 Test. On 11 September, after 15 wk, 25 random plants were dug from each entry. Plant roots of each entry were washed free of soil and examined for galling. Both incidence and severity of root galling were determined. Also, five lambsquarters plants were removed from each plot (65 plants/replicate) of the specialty crops and incidence and severity of galling determined.

Monthly irrigation and rainfall totals for May through August were: 128, 144, 121 and 111 mm, respectively (four month total = 503 mm).

Data were analyzed using the MSTAT microcomputer statistical program (Freed *et al.,* 1988). ANOVA's were calculated and means separated using the RANGE (Duncan's Multiple Range Test).

RESULTS AND DISCUSSION

None of the cruciferous crops showed any symptoms of root galling by *N. aberrans* during either test year, while sugarbeet plants were galled both years. Roots of all cruciferous plants were exceptionally white and healthy in appearance. Some of the sugarbeet roots were infected by *Rhizoctonia solani* Kühn and showed signs of root and crown rot (Schneider and

Table 2. Incidence and severity of the false root-knot nematode injury to roots of sugar beet and lambsquarters plants in a naturally infested field in Wyoming.

	Incidence (% plants galled)		Severity (galls/root)		
Crop/Weed	1992	1993	1992	1993	Crop Average
Sugarbeet	41 aB[z]	82 aA	1.1 aA	3.3 aA	2.2 a
Lambsquarters	36 aB	60 bA	0.8 aA	2.0 aA	1.4 b
Year Average			1.0 B	2.7 A	

[y]Plants were evaluated after 5 weeks in 1992 and after 14 weeks in 1993.
[z]Values are means of three replicates. Means not followed by the same letter (lowercase letters for columns, and uppercase letters for rows) differ (P ≤ 0.05) according to Duncan's multiple range test.

Whitney, 1991). Nematodes in root galls of sugarbeet and weeds removed from plots in 1992 were positively identified as *N. abberans.* Weeds included kochia (*Kochia scoparia* L.), common lambsquarters (*Chenopodium album* L.), Russian thistle (*Salsola iberica*, Sennen and Pau), all in the Chenpodiaceae family, common purslane (*Portulaca oleracea* L.), in the Portulacaceae family and puncturevine (*Tribulus terrestris* L.), in the Zygophyllaceae family (Whitson, *et al.*, 1992).

There was a significant ($P = 0.05$) crop (sugarbeet, lambsquarters) × year interaction for incidence of galling. Percent root galling in sugarbeet and lambsquarters were statistically similar in 1992 (41% and 36%, respectively) while incidence of galling of sugarbeet roots was significantly higher than lambsquarters in 1993 (82% and 60%, respectively) (Table 2). Galling was present on lambsquarters plants in all but three plots in 1992 and in all plots in 1993. Range of galled plants per plot were, 0-5 in 1992, and 1-5 in 1993.

Crop × year interaction for galling severity was not significant. However, when means were bulked over years, sugarbeet had significantly more galls/root (2.2) compared to lambsquarters (1.4). Also, when means were bulked over crops, plant roots had more galls/root in 1993 (2.7) compared to 1992 (1.0) (Table 2).

Higher incidence and severity of root galling in 1993 was most likely due to the longer period of favorable environmental conditions for *N. aberrans* between establishment and evaluation; 5 weeks in 1992 and 15 weeks in 1993. There were 3291 and 2423 GDD base 5°C at 2.5 and 10.2 cm soil depth from planting to harvest in 1993 compared to 1102 and 870 GDD in 1992.

Root galls of common lambsquarters, kochia, common purslane, Russian thistle, puncturevine and sugarbeet, were all positively identified as being parasitized by females of *N. aberrans.* All of these weed hosts were introduced into the U.S., and have become naturalized (Anonymous, 1970). All, with the exception of common purslane, are widespread in the western U.S., extending southward to the Mexican border and most likely occur in Mexico as well.

Although authors of a previous study (Thorne and Schuster, 1956) indicated that the presence of females of *N. aberrans* producing viable eggs was the criterion by which plant species were determined to be susceptible, they also indicated that the degree of root distortion and galling varied greatly among the infected plants. However, they did not indicate that reproduction occurred on symptomless plants. Although a positive association between the amount of root galling and the amount of egg reproduction by *N. abberans* on susceptible tomato roots has been reported (Veremis *et al.*, 1997), additional testing will be required to verify that a similar association exists in these crops.

Our results agree with the previous report of several annual weed hosts of *N. aberrans* in eastern Wyoming (Thorne and Schuster, 1956). Our findings, in part, disagree with the previous report of kale, turnip, mustard and radish susceptibility to *N. aberrans* (Thorne and Schuster, 1956). Explanation for differences in results may relate to cultivar reaction, nematode races (Boluarte and Jatala, 1992), or to different inoculum densities. Cultivars of kale, turnip, mustard and radish used in our study were different from those previously tested, which could give different reactions. A study with several species of the root-knot nematode (*Meloidogyne* spp.) showed that some cultivars of cauliflower in the Cruciferae family were susceptible, while others were resistant (McSorley and Fredrick, 1995). Also, the cultivars of radish and mustard in our study were selected for resistance to the sugarbeet cyst nematode which may explain their resistant reaction to *N. aberrans.* Healthy appearing, symptomless roots were not examined for gravid females in our field study. Therefore, if reproduction occurred in symptomless cruciferous plants, this could also explain differences in crop variety reaction.

The fourteen plant species evaluated in our study represented three taxonomic Orders with different degrees of host reaction to *N. aberrans.* Sugarbeet, kochia and common lambsquarters (Chenopodiaceae family), which appeared to be the most susceptible plant species in our study, and common purslane (in the Portulacaceae family), which appeared to be least susceptible, are all in the order Caryophyllales. Puncturevine (in the Zygophyllaceae family), which appeared to be less susceptible than hosts in the order Caryophyllales, is in the order Sapindales, while the cruciferous crops (family Cruciferae), which were all asymptomatic, are in the order Capparales (Cronquist, 1988).

The lack of root galling in any of the cruciferous crops suggests that *N. aberrans* may not increase on their roots. The occurrence of reproduction without galling in cruciferous plants has not been reported. However, additional studies are currently underway to determine if female maturity and egg production can occur on these asymptomatic crop roots. The high incidence of root galling by *N. aberrans* in lambsquarters and other weed hosts indicates their importance as alternate hosts and the need for their control during sugarbeet rotations. In our study, lambsquarters provided a good indicator plant for the bioassay of *N. aberrans* in asymptomatic crops. Other weed hosts, especially kochia, may also serve as good indicator plants for *N. abberans.*

In this paper, the authors present new information on host root tissue reaction of twelve cruciferous crop cultivars to the false rootknot nematode and field evaluation methods for measuring crop reaction to *N. aberrans.* This is the first report of common purslane as a host of *N. aberrans* in North America.

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