Distribution, Relation to Weeds, and Histology of Sugar Beet Root Galls Caused by Nacobbus Batatiformis Thorne and Schuster[1]

M. L. Schuster and Gerald Thorne[2]

Galled roots from sugar beets and other economic crop plants collected in western Nebraska in 1949 contained nematodes which differed from the commonly recognized root knot nematodes (*Meloidogyne* spp.) of economic plants. Thorne and Schuster (2)[3] identified and named the nematode *Nacobbus batatiformis* Thorne and Schuster, 1956. The present paper includes investigations concerning the distribution, mode of dissemination, relation of weeds, and the histology of the galled roots of sugar beet caused by the newly described nematode.

Distribution in Western Nebraska

The pattern of distribution of the new nematode in the western Nebraska panhandle became apparent as a result of a survey in 1953 and 1954, in Scotts Bluff, Sioux, and Morrill counties. Included in this survey were 125 sugar beet fields selected at random: 71 in 1953 and 54 in 1954. *Nacobbus batatiformis* was found in 32 percent of the fields. This new nematode appeared in combination with *Heterodera schachtii* Schmidt in one percent of the fields. *Meloidogyne hapla* Chitwood appeared in 16 percent of the samples, in 12 percent in combination with the new nematode. Although several species of *Meloidogyne* are described, it was deduced from previous studies that the northern root knot nematode, *M. hapla,* was present in western Nebraska.

Sampling in August or September insured the presence of mature nematodes in infected roots, which aided in genus determination. Representative root samples stained in hot lactophenol acid fuchsin mixture aided in locating the nematodes to be identified.

The survey shows *N. batatiformis* to be present north of the North Platte River but not south of it where the soil of examined fields is primarily silt loam. The soil class north of the river is sandy loam or very fine sandy loam. The distribution pattern of the new species may be coincidental to soil class. Neverthless, this conforms to findings that *Meloidogyne* is more common on coarse-textured than on fine-textured soils. It might be stated that although *M. hapla* was found in 16 fields it is not of much economic importance on sugar beets; on occasions it disqualifies seed potatoes for certification by its presence in the tubers. *Nacobbus batatiformis,* on the other hand, is important economically on sugar beets causing reduced stands and lower plant vigor.

Relation of Native Plants to New Nematode

The fact that *N. batatiformis,* which produces such very obvious symptoms on sugar beets and other plants, was not found elsewhere indicated

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[2] Associate Plant Pathologist, Department of Plant Pathology, Nebraska Agricultural Experiment Station, Lincoln, Nebraska, and Senior Nematologist, Section of Nematology, Agricultural Research Service, United States Department of Agriculture, Salt Lake City, Utah.

[3] Numbers in parentheses refer to literature cited.

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that it might be native to western Nebraska. Native weeds on virgin or uncultivated land were checked for galls and for the associated nematodes. Three species of cacti infected with *N. batatiformis* were located on cattle ranges or uncultivated areas near Henry and Mitchell, and along a main irrigation canal north of Mitchell in an area which abuts a cattle range. These infected cacti were *Opuntia tortispina* Nutt., *O. fragilis* (Nutt.) Haw. and *Coryphantha vivipara Nutt.*[4] (Figure 1).

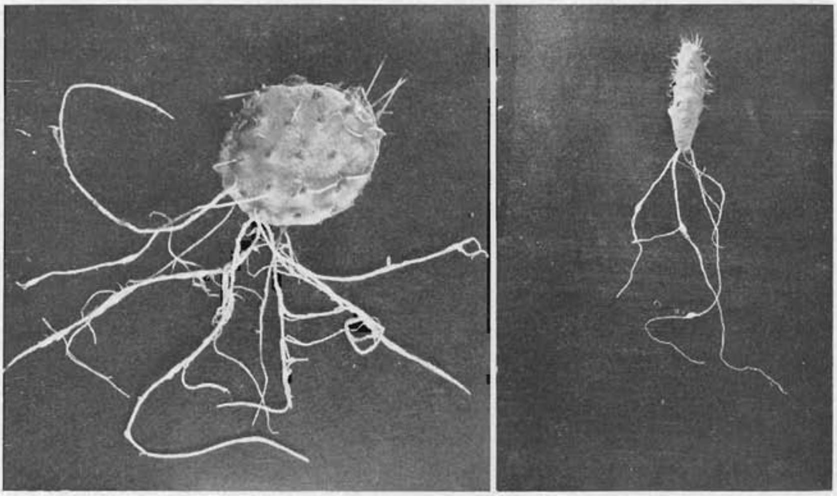

Figure 1.—Cacti native to western Nebraska with root galls caused by *Nacobbus batatiformis*. Left, *Opuntia tortispina*. Right, *Opuntia fragilis*.

Experiments in 1954 and 1955 with the new species of nematode emphasized the similarity of isolates from sugar beets and cacti. Cross inoculation tests with the isolates indicated that the nematodes on cacti and sugar beets were similar since reciprocal infection resulted. The progeny from sugar beets were from a single egg sac; the isolates from the cacti consisted of a population transfer. Each inoculation consisted of four replications. The morphology and mode of reproduction of the isolates from sugar beets and cacti were similar. On the basis of this information it is assumed that *N. batatiformis* is indigenous to western Nebraska. Another important point in justifying this assumption is that the organism is capable of reproducing in naturally infected cacti, as well as in artificially infected plants.

Relation of Weeds to Control by Crop Rotation

An explanation for occasional ineffective control by rotation with nonsusceptible crops included the possible dissemination of nematodes in irrigation water and the importance of weeds as harborers of the pathogens. Weeds investigated from this standpoint were *Kochia scoparia* (L.) Schrader and *Chenopodium album* L. in roots of which *N. batatiformis* causes pronounced galling and completes its life cycle.

[4] Dr. J. F. Davidson, Curator of Botanical Herbarium-Museum, University of Nebraska, stated that cacti deposited in the herbarium include these three species.

Kochia scoparia appears most important from the standpoint of harboring the nematode in and along irrigation ditches in western Nebraska. This weed commonly grows in an area north of Mitchell where the root knot disease is most important. These infected plants were found the entire distance from a main canal (Interstate) and the Dry Spottedtail Creek to the ditches which supply water to individual farms. The area most intensively studied included parts of sections 16, 17, 20, and 21 of T-23-N and R-56-W. This information is circumstantial evidence that *N. batatiformis* is spread by irrigation water.

Attempts to determine spread of root knot nematodes by isolation from irrigation water proved incomplete. It was found that many nematodes could be obtained by screening water from an irrigation ditch in and along which were present infected *Kochia*. In two separate tests in 1955, 1073 and 298 nematodes were isolated from irrigation water conducted through a one-inch siphon tube and were deposited on a 300 mesh soil screen in one hour. Although only two nematodes among those isolated appeared to be larvae of *Nacobbus batatiformis,* this test emphasizes the importance of water in the movement of these organisms. The finding of greater populations of the root-knot nematode may involve proper timing and sampling.

Ineffective control, even when proper crop rotation is practiced, could conceivably be caused by the persistence of the weeds, *Kochia scoparia* and *Chenopodium album* in the cultivated fields, acting as hosts. Host range studies have shown that the main crop plants, except sugar beets grown under irrigation, were not susceptible to *N. batatiformis* (2). This non-susceptible group included potatoes, beans, corn, barley, oats, alfalfa, and sweet clover. Two fields near Mitchell proved suitable areas for investigation. One field in alfalfa for the past five years contained scattered infected *Kochia scoparia* and *Chenopodium album.* Another field in barley-alfala, which was in sugar beets the previous year, contained many severely infected *Kochia scoparia* plants. Thus it appears that weeds in fields of non-susceptible crops and in irrigation ditches serve as harborers of the organism and under these circumstances nullify the purpose of crop rotation from the standpoint of root knot control.

Pathological Histology

After penetration of the root, the larvae of *N. batatiiformis* usually orient themselves near the vascular tissue. The first visible disease symptoms are a necrosis of cell walls and increased cell division in the vicinity of the nematode. These effects are apparent when the larvae assume a spiral or "C" form commonly found in the early stages of infection.

Gall formation is the result of increase in cell size and numbers. Comparison of histological symptoms of advanced stages of gall development caused by *N. batatiformis* with those caused by *Meloidogyne* spp. indicated differences and similarities. *Meloidogyne* usually produces in each gall several, usually three to six, giant cells, that remain as distinct units (1). Comparable to these giant cells in galls produced by *N. batatiformis* is a more extensive area near the *N. batatiformis* oral region which usually assumes a spindle or egg shape with the female's head imbedded in one end (Figure 2). The "spindle" may be distorted in shape depending on the assymetry of the root; it is localized in a definite area delimited possibly by the endodermis (Figure 3). The long axis of the "spindle" is most commonly parallel to the main axis of the root.

The "spindle" appears to function as a unit. The individual cells may lose their identity in advanced stages and the entire area may be of an amorphous tissue type with cell walls that do not take on the characteristic

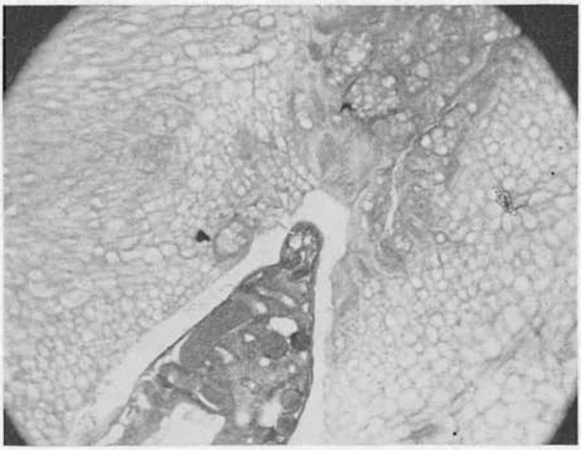

Figure 2.—Longitudinal section of a portion of sugar beet root infected with *N. batatiformis* showing anterior portion of female and effect on root. Observe presence of numerous globules (probably fat or oil in nature) in cells near head of nematode and the apparent dissolution of cell walls in this area. Photomicrograph. About 144X.

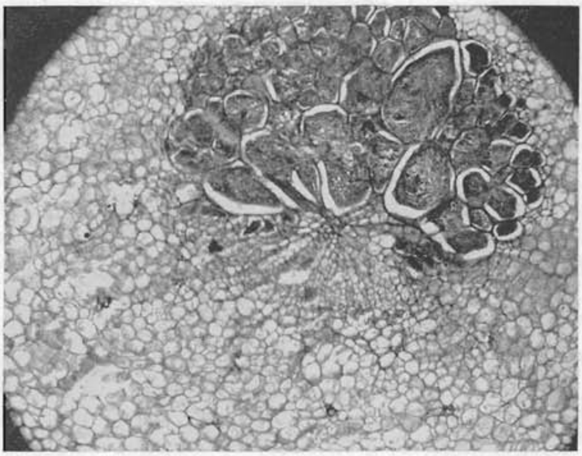

Figure 3.—Transection of a portion of sugar beet root infected with *N. batatiformis*. Observe the extensive area that stains differently because of the presence of the nematode (which is not evident in this photograph) and is limited to the stelar area of the note; note hypertrophied cells. Photomicrograph. About 144X.

stain of normal walls. Cell walls commonly collapse, and enlarged cells result from "coalescence" of adjacent cells; cell enlargement also results from accentuated cell growth (Figure 3). Nuclei occasionally divide without concomitant cell division and multinucleate cells result.

In some histological sections of certain galls, walls of the "spindle" cells appear thickened with deeply staining areas occurring in the "corners" of the cells. These effects may be due to a breakdown of cell walls. Since all the cells of the spindle possess thickened walls these results could not be due to transformation of undifferentiated xylem elements.

Unstained, the "spindle" area appears grayish or granular and can be readily differentiated from the remainder of the root tissues. In stained sections the "spindle" area appears distinct because of differences in staining reaction when a combination fast green-safranin or fast green-acid fuchsin stain or fast green alone is employed. In stained sections, the cells contain either a fibrillar or globular materials. It is assumed that these cytoplasmic materials give the unstained tissue the granular appearance.

The effect on the root is similar to that of *Meloidogyne* spp. in that infection seems to cause a movement of nutritive material into a region about the nematode's oral region as evidenced by the rich granular cytoplasmic contents in the "spindle" area. This localization of materials and their removal from the plant's use undoubtedly affects the metabolism and growth of the plant.

Infection outside the vascular cylinder results in galls, or "warts," on the surface of older tap roots, arising almost entirely from cortical tissue. A structure similar to the vascular spindle is formed, but it is not sharply delimited and is more irregular in shape. It is near the proximal region of the nematode, however, and takes the same stain as the vascular spindle. Cell wall thickenings have not been observed in these instances, however.

Summary

Nacobbus batatiformis was found in 32 percent of sugar beet fields examined in western Nebraska.

Native cacti appear to be important hosts and therefore sources of the new nematode; it is therefore assumed that *N. batatiformis* is indigenous to the state.

Weeds play an important role in the harboring of the nematode in fields and irrigation ditch banks. Circumstantial evidence indicates that irrigation water is a vehicle for transport of root knot nematodes.

Histological studies of *N. batatiformis*-produced galls indicate differences from and similarities with those caused by *Meloidogyne* spp.

References

(1) Christie, J. R. 1936. The development of root-knot nematode galls. Phytopathology 26:1-22.

(2) Thorne, Gerald and M. L. Schuster. 1956. *Nacobbus batatiformis* n. sp. (Nematoda: Tylenchidae), producing galls on the roots of sugar beets and other plants. Proc. Helminth. Soc. Wash. 23(2):/128:134.