the other hand, the area method was applied to the average juvenile and the average female of *H. sacchari*. The area values were of 237.6 × 10^3 µm³ for the female and of 8.9 × 10^3 µm² for the juvenile and the ratio equaled 26.7, which was very close to the value of 32 observed by Bird (1959).

Results were different on the two varieties. On " IR 1529 ", the development was more rapid than on " Morobérékan " and the maximum value of COD was higher. This effect of host varieties on the feeding of the parasite has been observed in *Heterodera avenae* by Cook (1977).

Between 4 and 5 weeks, the COD decreased on " IR 1529 ". This was related with the presence of some eggs in the nutritive solution of the jars. Thus, eggs formed by this species may be partly layed freely in soil. This decrease of COD could be also related with chemical changes occuring when females become cysts, especially the tanning of the cuticle, which involves a large oxygen uptake in *Globodera rostochiensis* (Hominick, 1983).

There was not enough material produced to evaluate the egg content of females at each time. This was done only at 5 weeks for " IR 1529 ". Five batches of 30 females were recovered and kept for 4 weeks in a 0.3 M NaCl solution, which inhibits hatching but allows the development (Dropkin, Martin & Johnson, 1958). The cysts were crushed and the juveniles hatched with potassium permanganate (Reversat, 1981*b*). The individual cyst content had an average of 327 juveniles (standard deviation : 41). In the COD value of the female, the part due to the eggs was 13.8 µl (327 × 0.042), which represents 26 % of the total value.

References

Andrássy, I. (1956). Die Rauminhalts- und Gewichtbestimmung der Fadenwürmer (Nematoden). *Act. Zool. Acad. Scient. Hungar.*, 2 : 1-15.

Bird, A. F. (1959). Development of the root-knot nematode *Meloidogyne javanica* (Treub) and *Meloidogyne hapla* Chitwood in the tomato. *Nematologica*, 4 : 31-42.

Bird, A. F. (1971). *The structure of nematodes.* New York, Academic Press, 318 p.

Cook, R. (1977). The relationship between feeding and fecundity of females of *Heterodera avenae*. *Nematologica*, 23 : 403-410.

Dropkin, V. H., Martin, G. C. & Johnson, R. W. (1958). Effect of osmotic concentration on hatching of some plant parasitic nematodes. *Nematologica*, 3 : 115-126.

Hoagland, D. R. & Arnon, D. I. (1950). The water culture method for growing plants without soil. *Circ. Calif. agric. Exp. Stat.*, No. 347.

Hominick, W. M. (1983). Oxygen uptake during tanning of *Globodera rostochiensis*. *Revue Nématol.*, 6 : 199-206.

Krusberg, L. R., Hussey, R. S. & Fletcher, C. L. (1973). Lipid and fatty acid composition of females and eggs of *Meloidogyne incognita* and *M. arenaria*. *Comp. Biochem. Physiol.*, 45 B : 335-341.

Luc, M. & Merny, G. (1963). *Heterodera sacchari* n. sp. (Nematoda : Tylenchoidea) parasite de la canne à sucre au Congo-Brazzaville. *Nematologica*, 9 : 31-37.

Ohba, K. & Ishibashi, N. (1981). Effect of procaine on the development, longevity and fecundity of *Caenorhabditis elegans*. *Nematologica*, 27 : 275-284.

Reversat, G. (1976). Étude de la composition biochimique globale des juvéniles des nématodes *Meloidogyne javanica* et *Heterodera oryzae*. *Cah. ORSTOM, sér. Biol.*, 11 : 225-234.

Reversat, G. (1980). More about the drop by drop distribution of a nematode suspension. *Revue Nématol.*, 3 : 146-150.

Reversat, G. (1981*a*). Age related changes in the chemical oxygen demand of second stage juveniles of *Meloidogyne javanica* and *Heterodera oryzae*. *Nematologica*, 27 : 220-227.

Reversat, G. (1981*b*). Potassium permanganate as a hatching agent for *Heterodera sacchari*. *Revue Nématol.*, 4 : 174-176.

Accepté pour publication le 23 juillet 1986.

HOST RANGE OF *ANGUINA AMSINCKIAE* WITHIN THE GENUS *AMSINCKIA*

Dan J. Pantone*

Anguina amsinckiae (Steiner & Scott, 1934) Thorne, 1961 is a potential agent for biological weed control and is known to have three hosts under natural conditions : *Amsinckia intermedia* Fischer & Meyer, *A. lycopsoides* Lehmann, and *A. gloriosa* Suksdorf (Pantone, Griesbach & Maggenti, 1986). The genus *Amsinckia* has four sections (Ray & Chisaki, 1957*a,b,c*), and all known hosts are either in the Muricatae or the Tessellatae

* *Graduate Group in Ecology and Department of Plant Pathology, University of California, Davis, Ca 95616, USA.*

Table 1
Locations of seed sources of *Amsinckia* spp. used in host range tests.

Amsinckia species	Location
A. menziesii (489*) (Muricatae**)	Monterey County, 6.4 km west of Highway 101 on Highway G18
A. intermedia (385) (Muricatae)	Santa Clara County, 3.2 km south of Morgan Hill on Monterey Road at Crowner Avenue
A. lycopsoides (425) (Muricatae)	San Benito County, intersection of Highway 25 and Live Oak Road
A. lunaris (325) (Disjunctae)	Contra Costa County, 4.6 km east of San Pablo Dam Road on Bear Creek Road
A. spectabilis (485) (Microcarpae)	San Luis Obispo County, 3.1 km north of Santa Maria River on Highway 101
A. tessellata (605) (Tessellatae)	Kern County, 1.6 km east of Interstate Highway 5 on Highway 138
A. gloriosa (563) (Tessellatae)	San Luis Obispo County, 4.8 km east of Simmler on Highway 58
A. douglasiana (575) (Tessellatae)	Santa Barbara County, 1.6 km west of Little Pine Mountain, San Rafael Mountains
A. vernicosa (566) (Tessellatae)	San Luis Obispo County, 4.8 km east of Simmler on Highway 58

* Assession number. Voucher specimens deposited in the University of California, Davis, Department of Botany Herbarium (DAV).

** Section within the genus *Amsinckia*.

(Tab. 1). It is probable that additional species of *Amsinckia* within the Muricatae or Tessellatae are hosts of the nematode. In the present study, nine of the ten California species of *Amsinckia*, as interpreted by Munz (1959), were evaluated as potential hosts of the nematode. *A. grandiflora* Kleeberger was not used because it is a protected endangered species (Anon., 1982) and, therefore, collecting seeds from the last known population was not feasible. No evaluation of host range for *Anguina amsinckiae* had been performed under controlled conditions previous to this study.

Seeds from *Amsinckia* spp. were placed in Petri dishes on two pieces of dampened filter paper and allowed to imbibe water overnight (approximately 17 hours). Scarification of seeds was achieved by cutting through the seed coat of the imbibed seeds with a fine jeweler's forceps on the side opposite the hilum, and planted into sandy loam soil (61 % sand, 20 % clay, and 19 % silt) approximately 1 cm deep. Seedlings were thinned to four plants per 15 cm clay pot. Eight replicate pots were used for each *Amsinckia* species, and the pots were arranged in a randomized complete block design. Plants were watered as needed with Hoagland's solution at one-half strength by subirrigation. All plants were grown within a growth chamber maintained at 15° with a light intensity of 200 $uE.m^{-2}.S^{-1}$. The photoperiod was eight hours per day for the first 60 days of the experiment, when the photoperiod was increased to twelve hours for the remainder of the experiment to induce flowering. Nine species of *Amsinckia* (Tab. 1) were used in the study, and three of the species (*A. intermedia, A. lycopsoides, and A. gloriosa*) were grown from seed obtained from *Anguina amsinckiae* galled plants. All nematodes used in the experiments were obtained from galls collected from a single population of *Amsinckia intermedia* (Tab. 1). Forty days after planting, all pots were inoculated at the soil surface near the base of the plants with 10 000 second-stage juveniles obtained from previously dried galls that had been soaked in water for one hour to revive the anhydrobiotic nematodes. After inoculation, all pots were covered with polyethelene plastic bags to maintain the humidity at approximately 95 percent, and a small hole (approximately 1 cm^2) was cut at the base and top of the plastic bag for ventilation. Plants were harvested after 120 days and evaluated for the presence of nematode galls.

Nematode galls with reproducing adults formed on *A. intermedia* and *A. menziesii*, which represented the first time that artificially inoculated plants were induced to form galls. Previously, *A. menziesii* was not known as a host of the nematode. No galls with reproducing nematodes were found on any other species, including *A. lycopsoides* or *A. gloriosa*, both of which were grown from seed obtained from nematode-galled plants. However, *A. spectabilis* Fischer & Meyer formed one gall approximately 1.5 mm in diameter; only juvenile nematodes were found inside, and the inner gall surface was necrotic, indicating a hypersensitive response of the plant to the nematode. In addition to flower galls, two leaf galls were found on *A. intermedia*.

A. menziesii hybridizes with *A. intermedia* (Ray & Chisaki, 1957*c*) and, therefore, it should not be surprising that a nematode population from *A. intermedia* can also reproduce on *A. menziesii*. However, *A. intermedia* can also hybridize with *A. lycopsoides* (Ray & Chisaki, 1957*c*), but no nematode galls formed on *A. lycopsoides*, a known host of *Anguina amsinckiae*. This failure to stimulate *Amsinckia lycopsoides* and *A. gloriosa* to form galls could indicate that the environment provided was not favorable for the nematode to attack these two hosts. More likely, there may be different races of the nematode, and the race used in this study may not have been

virulent on *A. lycopsoides* or *A. gloriosa*. The latter hypothesis agrees with the field observations of Pantone, Griesbach and Maggenti (1986) who reported that known hosts of the nematode were unaffected at several sites of nematosis where only one species was galled.

A. spectabilis, which is in the section Microcarpae, is not as close taxonomically to *A. intermedia* as is *A. menziesii*, the later two species both being in the section Muricatae (Ray & Chisaki, 1957*a*). The hypersensitive reaction within the gall that formed on *A. spectabilis* could have been a defense mechanism that prevented the nematode from reproducing.

Nagamine and Maggenti (1980) are the only other researchers who have reported *Anguina amsinckiae* forming leaf galls. They hypothesized that only under very moist environmental conditions will leaf galls form. Other studies failed to find evidence of nematode galls on any tissues other than floral tissues (Steiner & Scott, 1934; Godfrey, 1940; Pantone & Womersley, 1986). It is probable that the high relative humidity in this experiment provided the conditions necessary for leaf galls to form.

References

Anon. (1982). Plants of California declared to be endangered or rare. *State Calif. Fish & Game Commission, Calif. Administr. Code*, 14 : Section 670.2.

Godfrey, G. H. (1940). Ecological specialization in the stem- and bulb-infesting nematode, *Ditylenchus dipsaci* var. *amsinckiae*. *Phytopathology*, 38 : 41-53.

Munz, P. A. (1959). *A California Flora*. Berkeley, Univ. Calif. Press, 1681 p.

Nagamine, C., & Maggenti, A. R. (1980). Blinding of shoots and a leaf gall in *Amsinckia intermedia* induced by *Anguina amsinckiae* (Steiner and Scott, 1934) (Nemata, Tylenchidae), with a note on the absence of a rachis in *A. amsinckiae*. *J. Nematol.*, 12 : 129-132.

Pantone, D. J., Griesbach, J. A. & Maggenti, A. R. (1986). Morphometric analysis of *Anguina amsinckiae* from three host species, *J. Nematol.* (in Press).

Pantone, D. J. & Womersley, C. (1986). The distribution of flower galls caused by *Anguina amsinckiae* on the weed, common fiddleneck, *Amsinckia intermedia*. *Revue Nématol.*, 9 : 185-189.

Ray, P. M. & Chisaki, H. F. (1957*a*). Studies on *Amsinckia*. I. A synopsis of the genus with a study of heterostyly in it. *Am. J. Bot.*, 44 : 529-536.

Ray, P. M. & Chisaki, H. F. (1957*b*). Studies on *Amsinckia*. II. Relationships among the primitive species. *Am. J. Bot.*, 44 : 537-544.

Ray, P. M. & Chisaki, H. F. (1957*c*). Studies on *Amsinckia*. III. Aneuploid diversification in the Muricatae. *Am. J. Bot.*, 44 : 545-554.

Steiner, G. & Scott, C. E. (1934). A nematosis of *Amsinckia* caused by a new variety of *Anguillulina dipsaci*. *J. agric. Res.*, 49 : 1087-1092.

Accepté pour publication le 13 août 1986.

ASSESSING RESISTANCE OF CITRUS ROOTSTOCKS TO *TYLENCHULUS SEMIPENETRANS* WITH ROOTED LEAVES (1)

Yaakov Gottlieb*, Eli Cohn* and Pinchas Spiegel-Roy**

A major problem in citrus rootstock breeding programs is the extended period needed to obtain seedlings adequate for the evaluation of desired characters — among these, resistance to the citrus nematode, *Tylenchulus semipenetrans* Cobb, 1913. It has been suggested (Ford, 1957) that rooted leaves might be useful for this purpose, and techniques for rooting citrus leaf cuttings have been known for many years (Halma, 1931; Salomon & Mendel, 1965). However, Inserra and O'Bannon (1975) have shown that the burrowing nematode, *Radopholus similis*, reproduced equally well after 30 days on callus and roots produced from leaves originating from citrus varieties resistant and susceptible to the nematode. The aim of the present investigation, therefore, was twofold : *(i)* to assess the rooting potential of leaves from different citrus rootstocks, susceptible and resistant to the citrus nematode; and *(ii)* to determine whether the resistance or susceptibility exhibited in natural roots of the parent plant is retained in roots produced by their leaves.

(1) *Contribution from the Agricultural Research Organization (ARO), The Volcani Center, Bet Dagan, Israel. No. 1771-E, 1986 series.*

* *Dept. of Nematology and* ** *Dept. of Fruit-Tree Breeding, Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel.*