Suitability of Prunus Selections as Hosts for the Ring Nematode (Criconemella xenoplax)

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Abstract. Prunus accessions were screened in a greenhouse for suitability as hosts for Criconemella xenoplax (Raski Luc and Raski). All 410 accessions examined were suitable hosts for the nematode. Included in this study were 266 Prunus persica L. Batsch cultivars and cultivars representing 25 other Prunus species: P. americana Marsh., P. andersonii A. Gray, P. angustifolia Marsh., P. argentea (Lam.) Rehd., P. armeniaca L., P. besseyi L. H. Bailey, P. cerasifera Ehrh., P. cistena N.E. Hansen, P. davidiana (Carriere) Franch., P. domestica L., P. dulcis (Mill.) D. Webb, P. emarginata (Dougl. ex Hook.) Walp., P. hortulana L. H. Bailey, P. insititia L., P. kansuensis Rehd., P. maritima Marsh., P. munsoniana W. Wright & Hedr., P. pumila L., P. salicina Lindl., P. simonii Carriere, P. spinosa L., P. tenella Batsch, P. texana D. Dietr., P. tomentosa Thunb., and P. webbii (Spach) Vierh. Also, another 66 interspecific hybrids were tested. Although a few accessions seemed to exhibit an unstable form of resistance, it seems unlikely that Prunus selections that exhibit useful resistance to population increase by C. xenoplax will be found.

Peach trees often die prematurely when grown in sandy soils in the southeastern United States (Dozier et al., 1984). The ring nematode, Criconemella xenoplax [Mesocriconema xenoplax (Raski) Loof and DeGrisse], seems to be a major contributor to this problem (Nyczepir et al., 1983), and controlling nematodes improves tree survival (Chandler, 1969; Ritchie, 1984; Zehr and Golden, 1986; Zehret al., 1976, 1982). Therefore, selecting rootstocks that are unsuitable hosts for the ring nematode was proposed as a way to increase longevity of peach trees on infested sites.

Criconemella xenoplax reproduces on many Prunus spp. besides P. persica, including P. dulcis (Seshadri, 1964), P. armeniaca (Lownesby, 1964), P. avium (L.) L. (Lownesby, 1964), P. cerasifera (Mojtahedi and Lownesby, 1975), P. domestica (Goodey and Franklin, 1956), P. mahaleb L. (Lownesby, 1964), and P. moserii (P. cerasifera var. atropurpurea) (Mojtahedi and Lownesby, 1975). Six interspecific hybrids from various Prunus spp. have supported ring nematode reproduction (Mojtahedi and Lownesby, 1975). To our knowledge, few Prunus selections have been examined for host suitability to C. xenoplax.

Our objective was to discover Prunus selections that supported little or no population increase by C. xenoplax in greenhouse trials. Methods have been developed to identify individual Prunus seedlings that inhibit nematode reproduction, and a wide variety of accessions has been examined. Part of this study has been summarized (Cain et al., 1988; Westcott and Zehr, 1991).

Materials and Methods

Seeds and cuttings were collected from accessions grown in a Prunus germplasm collection at Clemson Univ., S.C., and from the Sandhills Research and Education Center, Elgin, S.C. Seeds were stratified for 12 to 15 weeks and planted after the radicle emerged. Cuttings from field-grown trees were treated with indole-3-butyric acid (2 mg·g⁻¹) and rooted under mist in a peat-lite mixture containing 0.42 g·liter⁻¹ each of N, P, and K as mixed salts from a commercial slow-release fertilizer. Cuttings from seedlings grown in the greenhouse were rooted in a similar manner but without auxin. All soil used in greenhouse tests was steamed at 60 to 70°C for 30 min.

Tasks in 1985–86. Six 2-week-old seedlings from each accession were transplanted to plastic pots containing 2.5 liters of Lakeland sand (89% sand, 6% silt, 5% clay). Soil containing ~500 adults and juveniles of C. xenoplax was added to each pot 7 weeks after transplanting. Plants were fertilized at 2-week intervals (Eayre et al., 1987). After an additional 10, 14, and 24 weeks for three experiments, respectively, nematodes were extracted from 20% of a 500-cm² sample of soil from each pot by elutriation for 4.25 min at a flow rate of ~60 ml·s⁻¹ (Byrd et al., 1976) followed by centrifugal flotation (Jenkins, 1964). Seven accessions were common to all three experiments.

Values for final population density of nematodes per plant without correcting for extraction efficiency (Cf) were transformed to the natural logarithm of C, + 1. The portion of total variance attributable to differences among accessions was determined by estimating the variance component associated with accessions. Results for each experiment were evaluated by normal order statistics to detect those accessions of interest for further study. The observed SD (O) from the population mean was estimated as

\[ O = (L_x – M)/E \]

where Lₓ is the average for each accession of the transformed values, M is the average value within each experiment, and E is the SE attached to Lₓ.

After ordering from smallest to largest, these SDs were compared with their expected values, \( \xi(X_i) \) estimated according to Harter (1961):

\[ \xi(X_i) – \Phi^{-1}[\xi – \alpha/(n – 2\alpha + 1)] \]

where \( \Phi^{-1} \) is the Probit transformation and \( X_i \) is the iᵗʰ largest after ordering a sample size of n; \( \alpha \) was taken to be 0.4 for sample sizes included in this study.

Tasks in 1987–90. Seedlings and cuttings were screened for host
suitability according to the methods of Westcott and Zehr (1991). Results from these greenhouse tests are reported in terms of $\beta$, an estimate of degree-days required for the nematode population to double. Under the average conditions in our experiments, the estimated $\beta$ for a suitable host is 139 degree-days (Westcott and Burrows, 1991). An increase in $\beta$ indicates a decrease in the suitability of a given host. Under this evaluation system, plants that initially seem to inhibit nematode population increase are tested additional times, and rooted cuttings from the plant may be tested to support or refute the presumed resistance to the nematode. Data were not transformed before analysis. Results for all experiments were compiled, and the variance component associated with accessions was determined. The results were evaluated by normal-order statistics as described above, except that accessions were ordered from largest to smallest to maintain the same functional order relative to host suitability.

A score was determined for each accession to reflect its relative host suitability based on all observations available. To combine information from all experimental systems, a percentile ranking for each accession in each experiment conducted in 1985–86 and in the combined results of all experiments conducted in 1987–90 was calculated. This resulted in four groups of ranked accessions. Where an accession was included in more than one group, a weighted average of the percentile ranking was determined. The number of observations was used as the weighting factor. This provided a single score of relative host suitability for each accession. Three selection levels were established. Those of most interest had a score $\leq 11\%$ with 10 or more observations. Selections of possible interest were those with low scores ($\leq 15\%$), but very few observations ($\leq 10$). All other selections were considered to be highly suitable hosts for the nematode.

**Results**

More than 4270 seedlings representing 410 accessions were screened. Most were highly suitable hosts for *C. xenoplax*, but a few that seemed to be relatively poor hosts may be of further interest. Some of these poor hosts were identified by few observations and must be evaluated more extensively to be confident of their placement.

*Tests in 1985–86.* The average nematode population densities per 100 cm$^3$ soil for the three experiments were 52 after 10 weeks, 114 after 14 weeks, and 161 after 24 weeks. The relationship between logarithm-transformed averages and incubation periods indicates that nematode population increase slowed between 14 and 24 weeks of incubation (Fig. 1). The percentage variance component associated with differences among accessions was 11\% after 10 weeks, 19\% after 14 weeks, and 15\% after 24 weeks. In all three experiments there seemed to be a strong effect associated with differences among accessions (Fig. 2).

In the experiment incubated for 10 weeks, 15 accessions seemed able to inhibit nematode population increase (Fig. 2A). Twelve
were selected from the experiment incubated for 14 weeks (Fig. 2B) and 26 were selected from the experiment incubated for 24 weeks (Fig. 2C). Of these accessions, Montclar and Siberian C were included in all three experiments but were not among those with a low nematode population density in any experiment. Selection of some accessions was based on only one or two observations. Since many of these were examined further in subsequent tests, final ranking was determined after including all subsequent observations.

Tests in 1987–90. The least squares mean for rating nematode host suitability (Westcott and Zehr, 1991) was 199 degree-days for doubling an increment of the nematode population. The reaction of accessions based on β did not seem to be normally distributed (Fig. 3). Forty-two accessions seemed to inhibit nematode population increase (Fig. 3), but some of these had been examined in previous experiments and were highly suitable hosts. Conversely, many identified as potentially unsuitable hosts in the previous experiments were highly suitable nematode hosts.

Based on a relative host suitability score, 23 accessions seemed to support slower nematode population increase than other accessions tested (Table 1). Although these are scored as the least suitable hosts, they can support substantial nematode populations. No accessions were highly resistant as hosts. Another 22 accessions were scored as poor hosts after limited testing (Table 2), but these require more extensive testing to fully characterize their suitability as hosts. All others tested were considered highly suitable hosts for *C. xenoplax*.

Of those considered highly suitable, 192 accessions have been examined fewer than 10 times. This list includes members of 15 species and various interspecific hybrids. These are separated from other highly suitable hosts that were more thoroughly tested because of the tentative nature of their classification with the highly suitable hosts. Included in this group were Hangchow; *P. angustifolia*; *P. angustifolia* hybrid ‘Blue Goose’; *P. emarginata*; *P. maritima* IR 427-2; *P. pumila* IR 333-2; *P. tenella*; *P. armeniaca* HW 408; *P. besseyi* 2-1; six accessions of *P. cerasifer*—Myrobalan B IR 871-2, Ohio 2 IR 421-3, Wa 106 IR 769-2, Wa 1210 IR 373-1, and Wa 734 IR 369-1—and one unnamed accession; five accessions of *P. dulcis*—Amara, F1(R.486 x dehiscens)2, Mission, Ruby, and Titan IR 934-1; three accessions of *P. domestica*. From the data available, the number of observations (N), host suitability score, doubling constant (b), and its SE are shown.

### Table 1. *Prunus* accessions scored as most limiting of *Criconemella xenoplax* population increase. The number of observations (N), host suitability score, doubling constant (b), and its SE are shown.

| Accession | Type | N | Score | b | SE |
|-----------|------|---|-------|---|----|
| Bounty (Assiniboine op) | P | 18 | 5 | 272 | 25 |
| Chui Lum Tso | P | 27 | 6 | 339 | 22 |
| Damas GF 1869 [M x O] | I | 14 | 4 | 364 | 35 |
| Freestone Goose | U | 69 | 9 | 224 | 13 |
| Giallo Di Padova PI 65797 | P | 11 | 11 | 245 | 32 |
| Hann | D | 19 | 8 | 249 | 24 |
| Hui Hun Tao | P | 33 | 9 | 231 | 18 |
| J.L. Budd | A | 44 | 2 | 282 | 16 |
| Kahinta IR 552-2 [probably S x E] | I | 41 | 3 | 292 | 17 |
| Manor IR 929-1 (Sapa op) | I | 41 | 7 | 237 | 16 |
| *P. argentea* | P | 12 | 11 | 243 | 30 |
| *P. besseyi* | P | 98 | 1 | 281 | 11 |
| *P. davidiana* x almond F5 22-11 | I | 11 | 11 | 243 | 32 |
| *P. kansuensis* (Ark) | P | 86 | 2 | 254 | 11 |
| *P. pumila* ‘Mando’ | P | 53 | 1 | 301 | 15 |
| Redcoat [‘Burbank’ x E ‘Wolf’] | I | 83 | 0 | 308 | 12 |
| Rubira | P | 85 | 1 | 285 | 11 |
| Rutgers Redleaf | P | 74 | 9 | 243 | 14 |
| Sapa IR 868-1 [B x S] | I | 30 | 4 | 270 | 19 |
| St. Anthony IR 870-1 | I | 13 | 11 | 244 | 29 |
| Tennessee Natural IR 281-1-9 | P | 71 | 9 | 269 | 13 |
| Tos China #1 PI 77876 | P | 63 | 9 | 220 | 14 |
| Wayland | I | 10 | 9 | 258 | 33 |

op = Open pollinated.

A = *Prunus armeniaca*; B = *P. besseyi*; D = *P. dulcis*; E = *P. americana*; I = interspecific hybrid; M = *P. domestica*; O = *P. spinosa*; P = *P. persica*; S = *P. salicina*; U = *P. mansoniana*. Also indicated in brackets for interspecific hybrids.

### Table 2. *Prunus* accessions scored as most limiting of *Criconemella xenoplax* population increase, but for which few observations were made. The number of observations (N), host suitability score, doubling constant (b), and its SE are shown.

| Accession | Type | N | Score | b | SE |
|-----------|------|---|-------|---|----|
| C12-21 6(50) (probably exotic type) | P | 9 | 8 | 278 | 35 |
| C4-14-88 | P | 8 | 6 | 299 | 37 |
| Fairtime | P | 8 | 13 | 234 | 37 |
| Fayette | P | 2 | 12 | ND | ND |
| Goldrush | D | 6 | 2 | ND | ND |
| Irani Olji | A | 4 | 4 | 415 | 53 |
| Ku Chang Hung #14 Q375-15 | P | 9 | 8 | 316 | 37 |
| NJ 682227062 | P | 5 | 11 | ND | ND |
| Outer space | P | 8 | 15 | 227 | 37 |
| P 52-103 | P | 4 | 13 | ND | ND |
| *P. andersonii* | A | 4 | 5 | ND | ND |
| *P. maritima* | P | 1 | 13 | ND | ND |
| *P. simonii* | P | 5 | 14 | ND | ND |
| *P. texana* op | I | 6 | 12 | 233 | 53 |
| Redhaven | P | 6 | 7 | ND | ND |
| Reliance | P | 3 | 7 | ND | ND |
| Satsuma | S | 1 | 14 | 296 | 105 |
| SC 8110-2-139 | P | 4 | 7 | 323 | 53 |
| Ta Tao #3 PI 101665 | P | 9 | 6 | 384 | 43 |
| Tennessee Natural IR 281-1-1 | P | 4 | 14 | 245 | 53 |
| Tennessee Natural IR 281-1-17 | P | 6 | 5 | ND | ND |
| Vision | M | 4 | 8 | ND | ND |

op = Open pollinated.

A = *Prunus armeniaca*; D = *P. dulcis*; I = interspecific hybrid; M = *P. domestica*; P = *P. persica*; S = *P. salicina*.

ND = not determined.
hortulana—IR 753-1, P 4-13—and one unnamed accession; two accessions of *P. insititia*—Methley, and St. Julian 53-7; *P. domestica* Mt. Royal; three accessions of *P. salicina*—Frontier, Late Santa Rosa, and PI 494754; and *P. tomentosa* Orient. There were 26 interspecific hybrids: #6 R 8.5; (S x R.185;6); Alf 43-21 (plumcot); Ark 7993; BY 68-071; BY 68-389; BY 68-87; BY 7401-5; BY 8-3908; Deep Purple IR 867-1; Dura IR 789-2; F. (P. fenzliana x P. burcharia)x; Goff IR 972-1; Isthara; Kag; Mansan IR 740-1; Monitor IR 574-3; NCA 10254; Opata IR 554-3; P. besseyi x peach; peach x *P. cerasifera* var divaricata (ot); R9.5; S 2729; Sapa Q 84-10-A-01A; Superior IR 544-2; and Wessex Q22-109B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B. There were eight nectarines: 14DR51; 14DR52; 14DR56; 14DR57; Brandy Morton; Darwin IR 131430; NH 62 N; and 09B.
Prunus selections that are unsuitable as hosts for the ring nematode may not exist, since this nematode has a very broad host range including species in diverse plant families (Raski and Radewald, 1958; Ruehle, 1966, 1971; Sher, 1959; Zehr et al., 1986, 1990). The fact that no Prunus spp. have been reported resistant to C. xenoplax (Goodey and Franklin, 1956; Lownsbery, 1964; Mojtahedi and Lownsbery, 1975; Seshadri, 1964) and that we found only moderate resistance among a few accessions lends substantial support to this hypothesis. Taken together, the evidence suggests that further attempts to find natural resistance to C. xenoplax may not be warranted.

An appropriate incubation period for experiments designed similar to those conducted in 1985–86 can be recommended. The variance component was highest and nematode population increase remained rapid after a 14-week incubation. This suggests that a 14-week incubation may provide the greatest separation of accessions based on nematode population densities and the best information about host suitability for experiments of this design. This is similar to the incubation period suggested by the greenhouse growth model for this nematode (Westcott and Burrows, 1990).

With respect to those tests conducted in 1987–90, a highly suitable host would have a β of 139 degree-days (Westcott and Zehr, 1991). It seems that β is too sensitive in the range of low host suitability (Fig. 3) and the population is not normally distributed. This arises from the nature of this measure of nematode population increase (Westcott and Burrows, 1990). As population increase nears 0 for an incubation period, β rapidly increases. It remains to be determined what values of β would characterize effective resistance in the field.

The utility of any selection as a rootstock for peach to suppress C. xenoplax must be assessed in field tests to verify that C. xenoplax does not increase to damaging levels under normal orchard conditions, or that the selection is not severely injured due to extreme sensitivity to the nematode. As an alternative to resistance, field tolerance to C. xenoplax may be a mechanism involved in reducing early tree death (Reighard et al., 1989; Westcott and Zehr, 1991). Eliminating the ring nematode as a problem using an unsuitable host as a rootstock may improve longevity of peaches on nematode-infested sites. However, C. xenoplax has a broad host range, and even those selections that seem to limit nematode population increase probably will not reduce population densities in the field sufficiently. If resistance is eventually found, improved understanding of this phenomenon may be used to develop new ways to limit nematode damage to peach trees in the orchard.

**Literature Cited**

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