Peach Rootstocks for the United States: Are Foreign Rootstocks the Answer?

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SUMMARY. New foreign rootstocks for peaches [*Prunus persica* (L.) Batsch] are now being introduced into the United States through commercial nurseries for future sales to stone fruit growers. Almost all of these rootstocks are complex *Prunus* L. hybrids that are propagated vegetatively. Past experience with foreign *Prunus* rootstocks has shown that extensive testing is critical to avoid potential problems in commercial situations due to nonadaptation of some rootstocks to North American climatic and edaphic conditions. In addition, putative resistance of introduced rootstocks to common soil diseases and other pathogens has not always carried over to orchard sites in the United States. To ensure widespread horticultural testing of new rootstocks, the NC-140 regional research group continues to serve as an unbiased tester in many different geographic and production areas of the United States and Canada.

Economic viability of a fruit production enterprise is linked directly to orchard productivity and management efficiency. To increase productivity and efficiency requires tree survival, managed vigor, and increased marketable yields over the expected life span of the orchard. The growers' choice of rootstock is often as important if not more so than the scion variety whenever peaches are grown on soils having high bulk density, parasitic nematodes, root rot fungal pathogens, or other edaphic or replant problems. If one or more of these conditions are present, peach tree survival and growth can be improved significantly by selecting the appropriate rootstock for each soil or site situation. A longtime limitation to peach production has been the absence of rootstocks that moderate vigor or are tolerant to undesirable soil properties, site characteristics, and soilborne pathogens. As good orchard sites become scarce and chemical control practices become cost-prohibitive or unavailable, new rootstocks need to be found to solve soil and site problems which were corrected previously by orchard relocation or chemical fumigation.

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Many new rootstocks for peach have been released in the past 20 years in Europe (Loreti, 1994; Loreti, 1997) and now are becoming available for testing in the United States (Table 1). This paper discusses some of these new rootstock releases and their potential for solving some of the specific soil and site problems that U.S. peach growers currently are experiencing.

Biotic and abiotic soil factors affecting peach rootstocks

PARASITIC NEMATODES. Many nematode species successfully parasitize peach roots and frequently reduce peach tree growth and survival. Four types of nematodes are recognized as injurious to peach trees in North America (Nyczepir and Becker, 1998). They are the ring [*Criconemella xenoplax* (Raski) Luc & Raski], root-knot [*Meloidogyne incognita* (Kofoid & White) Chitwood, *M. javanica* (Treub) Chitwood, *M. arenaria* (Neal) Chitwood, and *M. hapla* Chitwood], lesion [*Pratylenchus vulnus* Allen & Jensen and *P. penetrans* (Cobb) Chitwood & Oteifa] and dagger (*Xiphenema americanum* Cobb) nematodes. Rootstocks often are categorized as immune, resistant, tolerant or susceptible to nematodes. For a specific nematode species, rootstocks labeled as immune or resistant are poor or nonhosts for nematode survival and reproduction and are not impacted by nematode feeding. Tolerant rootstocks are fair to good hosts for a specific nematode, but nematode reproduction and feeding does not significantly alter the rootstock's ability to supply the scion's mineral, hormonal and water requirements to survive, grow and bear fruit. Rootstocks susceptible to a specific nematode are good hosts for nematode reproduction and are impacted negatively by nematode feeding in areas such as tree survival, growth and fruiting.

Ring nematode has been linked directly to the onset of peach tree short life (PTSL) syndrome in the Southeast (Nyczepir et al., 1983; Zehr et al., 1976). Many new foreign rootstocks have not been tested for reaction to ring nematode. However, older (1980s) rootstock introductions (Grasselly, 1987; Renaud et al., 1988) such as the French peach seedling rootstocks Montclar, Rubira, GF 305, and Higama, and the plum hybrids 'Ishtara' and 'Myran', were good hosts for ring nematode (Westcott et al., 1994) and were susceptible to PTSL (G.L. Reighard, unpublished data). No foreign rootstock survived better in field tests in South Carolina and Georgia than the regionally developed BY520-9 (now Guardian) (Okie et al., 1994; Reighard et al., 1997).

Root-knot nematodes cause serious growth reduction in peach trees grown in warmer regions. There are at least four species of root-knot nematode (*Meloidogyne arenaria, M. incognita, M. javanica, M. hapla*) as well as a number of races within each species that feed on peach. *M. incognita* and *M. javanica* are the most common on peach in the United States. Many peach rootstocks were introduced for root-knot nematode resistance in the United States in the 20th century (Day, 1953). These included Shalil, Yunnan, Okinawa, and Higama. All of these rootstocks either were not resistant to *M. javanica* or had other problems and eventually were replaced by domestically developed rootstocks such as Nemaguard, Nemared, Flordaguard, and Guardian.

Recent introductions still not evaluated in the United States for root-knot resistance include the Italian rootstocks 'Barrier 1' [*P. persica* x *P. davidiana* (Carr.) Franch.], 'Penta' and 'Tetra' (*P. domestica* L.), the Spanish rootstocks 'Adesoto 101'(*P. insititia* L.) and 'Adarcias','G x N 8', 'G x N 15' and 'G x N 22' (all *P. dulcis* (Mill.) D.A. Webb x *P. persica*), the French rootstocks 'Myran', a cross of 'Belsiana' (*P. cerasifera* Ehrh. x *P. salicina* Lindl.) and 'Yunnan' peach, and 'Ishtara', a cross of 'Belsiana' and a *P. persica* x *P. cerasifera* hybrid. Many of the above introductions have been evaulated for root-knot resistance in Europe and some of the resistant ones reported are 'Barrier 1', 'Tetra', 'Adesoto 101', 'G x N 15', 'G x N 22' and 'Myran' (Esmenjaud et al., 1997; Fernandez et al., 1994; A. Nicotra, personal communication).

Lesion (*Pratylenchus vulnus* and *P. penetrans*) and dagger (*Xiphenema americanum*) nematodes are two other root parasites that create problems in the northern and mid-Atlantic U.S. peach production areas. Lesion nematodes can significantly reduce tree growth and fruit production if not controlled. *P. vulnus* is a problem in the southern United States and California, while *P. penetrans* occurs in northern areas. Rootstocks tolerant to *P. vulnus* in Europe (Alcaniz et al., 1996) have been introduced. Rubira, GF 305, 'Penta', 'Tetra', 'Torinel '(*P. domestica*) and P.S.B2 (*P. persica* from Italy) are listed as having tolerance. However, testing of GF 305 by McFadden-Smith et al. (1998) showed that this rootstock was quite susceptible to *P. penetrans* and that the Canadian peach seedling rootstocks Chui Lum Tao and H7338013 were more tolerant in greenhouse studies. Bailey and Guardian were less susceptible than many of the European rootstocks tested. Multiple nematode species and races appear to be a significant obstacle to finding a broadly adapted, nematode resistant rootstock from outside North America.

The dagger nematode can be a severe problem in the mid-Atlantic states. The major damage to peach trees from dagger nematode feeding is that it serves as the vector for tomato ringspot virus (TomRSV) that causes stem pitting. Since many weed species such as dandelions (*Taraxacum officinale* Weber) are hosts for this virus, dagger nematode resistance in rootstocks is the only way to prevent infection. Dagger nematode species are also vectors for nepoviruses in other regions of the world. Peach seedling rootstocks are not resistant to dagger nematodes, and therefore, new nonpeach rootstocks need to be evaluated as to their susceptibility to the nematode or the virus. Some cherry plum *P. cerasifera* genotypes appear to be less sensitive to tomato ringspot virus (Hoy and Mircetich, 1984; Halbrendt et al., 1994). Thus, rootstocks such as the clonal rootstocks 'Mr.S. 2 / 5' and 'Mr.S. 2 / 8' (both *P. cerasifera*) from Italy (Loreti, 1994), 'VVA-1' (*P. cerasifera* x *P. tomentosa* Thunb.) and 'VSV-1' [*P. incana* (Pall.) Batsch x *P. cerasifera*] from Russia and 'Adara' (*P. cerasifera*) from Spain, may offer some tolerance. However, none of them have been yet tested in the United States for TomRSV resistance.

SOIL TEXTURE, PH AND FUNGAL PATHOGENS. Peach rootstocks generally are not adapted to poorly drained, heavy clay soils or to calcareous soils where pH is above 7.5. Poorly drained soils result in peach tree decline or death. Weak, unproductive, chlorotic peach trees are typical when grown on peach roots in high pH soils. Alkaline soils in North America where new peach rootstocks can be useful include the stone fruit production areas in Texas, Colorado, and a few other locations in the western states.

A number of new hybrid rootstocks introduced from Europe were developed for calcareous soils. These include the French rootstocks 'Jaspi' [(*P. domestica* x *P. salicina*) x *P. spinosa* L.], 'Julior' (*P. insititia* x *P. domestica*), 'Torinel', 'Paramount' [formerly 'GF 677', a natural peach–almond (*P. dulcis*) hybrid], and 'Cadaman' (*P. persica* x *P. davidiana*); the Italian rootstocks 'Barrier 1', 'Mr.S. 2 / 5', 'Mr.S. 2 / 8' and 'Sirio' (*P. persica* x *P. dulcis* formerly 'I.S. 5 / 22' of the Pisa series); and the Spanish rootstocks 'Adesoto 101', 'Montizo' (*P. insititia*), 'Adara', 'Adarcias' (Moreno et al., 1995a, 1995b) and 'G x N 8', 'G x N 15' and 'G x N 22' (Felipe et al., 1997) from the GN series. Of these new rootstocks only 'Paramount' and 'Jaspi' have been tested in the United States. 'Paramount' does reasonably well on alkaline soils but it is very vigorous and has not been as yield efficient as peach rootstocks (Perry et al., 2000). 'Jaspi' has been very susceptible to bacterial canker when tested on an acid soil in

Table 1. Imported rootstocks for peach currently or soon to be tested in the United States and their reported horticultural characteristics, nematode resistance, and edaphic adaptability.

Rootstock cultivar[z]	Origin (country)[y]	Species code[x]	Test status[w]	Vigor rating[v]	Cold tolerance[u]	Nematode resistance: Mi[t]	Mj[s]	Ppv[r]	Xa[q]	Tolerance to heavy wet soils[p]	Alkaline soil tolerance
Chui Lum Tao	China	1	1	3	Yes	3	3	2	3	2	No
GF 305	France	1	1	2	No	3	3	2	3	2	No
Higama	France	1	1	1	No	1	1	2	3	2	No
H7338013	Canada	1	2	2	Yes	3	3	3	3	2	No
H7338019	Canada	1	2	2	Yes	3	3	3	3	2	No
Montclar	France	1	1	2	No	3	3	?	3	2	Some
P.S.A5	Italy	1	3	3	No	?	?	?	3	3	No
P.S.B2	Italy	1	3	3	No	?	?	2	3	2	No
Rubira	France	1	1	3	No	3	3	2	3	2	No
Tzim Pee Tao	China	1	1	3	Yes	3	3	2	3	2	No
Adarcias	Spain	2	3	3	No	?	?	?	?	3	Yes
G x N 8	Spain	2	3	1	No	1	1	?	?	3	Yes
G x N 15	Spain	2	3	1	No	1	1	?	?	3	Yes
G x N 22	Spain	2	3	1	No	1	1	2	?	3	Yes
Paramount	France	2	1	1	No	3	3	3	?	3	Yes
Sirio	Italy	2	3	4	No	?	3	?	?	3	Yes
Penta	Italy	3	3	1	No	2	2	2	?	1	Yes
Tetra	Italy	3	3	3	No	1	2	2	?	1	Yes
Torinel	France	3	3	3	No	1	1	2	?	1	Yes
Adara	Spain	4	3	3	No	?	1	?	?	1	Yes
Mr.S. 2 / 5	Italy	4	3	3	No	?	?	?	?	1	Yes
Mr.S. 2 / 8	Italy	4	3	3	No	?	?	?	?	1	Yes
Kuban86	Russia	5	3	2	Yes	?	?	?	?	1	Unknown
VVA-1	Russia	6	3	4	Yes	?	?	?	?	1	Unknown
VSV-1	Russia	7	3	3	Yes	?	?	?	?	1	Unknown
Adesoto 101	Spain	8	3	3	No	1	1	3	?	1	Yes
Montizo	Spain	8	3	3	No	1	1	3	?	1	Yes
Julior	France	9	3	2	No	1	1	3	?	1	No
Pumiselect	Germany	10	2	3	Yes	?	?	?	?	3	No
Barrier 1	Italy	11	3	1	No	1	2	2	?	1	Yes
Cadaman	France	11	3	2	No	1	1	3	?	2	Yes
Ishtara	France	12	1	4	No	1	1	3	?	2	No
Myran	France	12	1	1	No	1	1	?	?	1	No
Jaspi	France	13	2	3	No	?	?	?	?	1	Yes

[z]Additional testing of compatibility with U.S. peach cultivars may be needed for Adara, Ishtara, Jaspi, Pumiselect, Torinel, VVA-1, and VSV-1. Excessive suckering may occur with Adesoto 101.

[y]Country of origin and / or initial testing.

[x]Species type: 1=*Prunus persica* , 2= *P. dulcis* x *P. persica*, 3= *P. domestica*, 4= *P. cerasifera*, 5= *P. cerasifera* x *P. persica*, 6= *P. cerasifera* x *P. tomentosa*, 7= *P. incana* x *P. cerasifera*, 8= *P. insititia*, 9= *P. insititia* x *P. domestica*, 10= *P. pumila*, 11= *P. persica* x *P. davidiana*, 12=(*P. cerasifera* x *P. salicina*) x *P. persica*, 13= (*P. domestica* x *P. salicina*) x *P. spinosa*.

[w]1 = has had limited field testing, 2 = currently in field tests, 3 = will be in field tests soon.

[v]1 = vigor similar to 'GF 677' or Nemaguard, 2 = vigor similar to Lovell, 3 = vigor slightly less than Lovell, and 4 = vigor at least 30 percent less than Lovell.

[u]Rootstock is considered to have better tolerance to cold winter temperatures than Lovell.

[t]Resistance to root-knot nematode (*Meloidogyne incognita*). 1 = immune or resistant, 2 = moderately resistant or some tolerance, 3 = susceptible and ? = unknown.

[s]Resistance to root-knot nematode (*Meloidogyne javanica*). 1 = immune or resistant, 2 = moderately resistant or some tolerance, 3=susceptible and ? = unknown.

[r]Resistance to lesion nematode (*Pratylenchus penetrans* or *P. vulnus*). 1=immune or resistant, 2=moderately resistant or some tolerance, 3=susceptible and ?= unknown.

[q]Resistance to dagger nematode (*Xiphenema americanum*). 1 = immune or resistant, 2 = moderately resistant or some tolerance, 3 = likely susceptible and ? = unknown. No resistance has yet been observed in peach.

[p]Tolerance of heavy textured soils when waterlogged. 1 = good, 2 = fair, and 3 = poor.

the southeastern United States (personal observation).

On heavy or poorly drained soils, peach rootstocks are often at risk of becoming infected with fungi (*Phytophthora* de Bary) that cause crown rot. Similarly, all peach rootstocks are susceptible to the oak root rot fungus (*Armillaria mellea* (Vahl: Fr.) P. Kumm. and *A. tabescens* (Scop.) Emel) where it is present, regardless of soil texture or drainage. Both organisms are difficult to control or eradicate; therefore, genetic resistance to them is highly desirable in rootstocks.

Many European rootstocks recently introduced to the United States are listed as tolerant of waterlogging. Rootstocks labeled as tolerant to waterlogged soils include 'Jaspi', 'Julior', 'Torinel', 'Penta', 'Tetra', 'Mr.S. 2 / 5', 'Barrier 1', 'Adesoto 101', 'Adara', 'Montizo', and the Russian rootstocks 'VVA-1' and 'VSV-1'. The season of waterlogging usually is not specified in release notices, and thus it is not known whether these rootstocks are tolerant of dormant or growing season wet soil conditions. Many of these rootstocks were developed in Mediteranean climates that receive their rainfall in the winter. In North America, waterlogging can occur during the growing season. Thus, testing of these rootstocks in different climatic regions is important before release to commercial fruit growers.

Most of the new hybrid plum European rootstocks are listed by the breeders as tolerant of replant sites and soil diseases. However, specific soil diseases usually are not identified. 'Ishtara' and 'Myran' were reported by Renaud et al. (1988) to be resistant or tolerant to oak root rot (*A. mellea*) in France. Observations in the southeastern United States by T.G. Beckman (unpublished data) show that these rootstocks are susceptible to *A. tabescens* and may not be resistant to the endemic fungal soil pathogens. These preliminary observations further warrant widespread field testing of the European disease tolerant rootstocks. These rootstocks remain untested under North American climatic conditions, but many will be included in the 2001 NC-140 regional peach rootstock test where a few of the 24 test locations will be orchard sites having a past history of peach tree short life or *Armillaria* (Fr.:Fr.) Staude.

WINTER TEMPERATURES. Winter cold hardiness of peach root systems varies considerably among rootstock cultivars. The absence of snow cover or some orchard floor management practices can increase the susceptibility of peach rootstocks to cold injury. Rootstocks that are inherently cold hardy or deacclimate at a slower rate after warm temperatures are necessary to grow peaches in cold regions. The majority of cold tolerant peach rootstocks have come from the Canadian breeding program (Layne, 1987). Releases of the cold hardy peach seedling rootstocks Siberian C, Harrow Blood, Tzim Pee Tao, and Chui Lum Tao either have not conveyed outstanding cold hardiness to peach scion cultivars or have had some other deficiency such as susceptibility to ring, rootknot and lesion nematodes or *Armillaria* and *Phytophthora* root rots. New cold hardy and perennial canker (*Cytospora cincta* Sacc.) resistant selections from the former Harrow breeding program currently are being tested in a NC-140 peach rootstock test in 20 states and provinces and may be available in the future. Some of these Harrow selections like H7338013, H7338019 (*P. persica*), Tzim Pee Tao and Chui Lum Tao delay scion bloom by 1 to 2 d in South Carolina (G. Reighard, unpublished data). Introduction of three Russian rootstocks, 'Kuban86' (*P. cerasifera* x *P. persica*), 'VVA-1', and 'VSV-1' may offer more cold hardiness than the Canadian peach rootstocks since they were developed from *Prunus* species from colder regions that are marginal for peach production due to very cold winters and spring freezes.

Peach scion and rootstock interactions

VIGOR CONTROL. Peach seedling rootstocks including brachtytic dwarfs rarely reduce scion vigor more than 10% to 15%. Size control of peaches through rootstocks of other *Prunus* species has not been achieved satisfactorily due to incompatibility or poor tree vigor. Without graft compatible and size controlling rootstocks such as in apple, increases in peach orchard productivity via intensive training systems may be difficult to achieve. New dwarfing rootstocks for peach must reduce vigor, be graft compatible, and give good fruit production without reduction of fruit size and quality.

European rootstocks listed as mildly dwarfing (approximate percent of peach standard) include 'Ishtara' (70%), 'Julior' (70%), Rubira (90%), 'Tetra' (90%), 'Mr.S. 2 / 5' (90%), Italian peach seedlings P.S. A5 (80%) and P.S. B2 (90%), 'Adesoto 101' (80%), 'Adarcias' (70%) and 'Adara' (80%). Semidwarfing rootstocks are 'Pumiselect' (60%), a *Prunus pumila* L. selection developed in Germany (Jacob, 1992), 'Sirio' (60%) (Loreti and Massai, 1998), and 'VVA-1' (40%) (Devyatov, 1996). The degree of dwarfing of these rootstocks will vary with the climate, soil type and site history. Without extensive geographic testing, it is uncertain if these rootstocks will perform adequately as size controlling rootstocks in many peach production areas. In addition, California breeders have developed size controlling rootstocks for peach (DeJong et al., 1994) that are now in advanced testing in California and thus far have reportedly maintained yield efficiency and fruit size despite significant tree dwarfing.

Commercial outlook

New and better peach rootstocks are on the horizon, but the time from initial testing to commercial production of a selection often takes many years. New rootstocks from the France, Italy, Spain and other breeding programs that now are becoming available are complex species hybrids that must be propagated vegetatively. Micropropagation from tissue culture explants commonly is employed in these countries to mass produce these unique hybrid rootstocks. Due to strong grower interest this technology now has been incorporated by a few fruit tree nurseries in the U.S. and has expedited virus testing procedures at NRSP5, Prosser, Wash., and the U.S. Department of Agriculture Animal and Plant Health Inspection Service in Glenn Dale, Md. Other factors still complicating the commercial release of these new rootstocks into the U.S. are patent laws and licensing agreements that must be negotiated between government agencies, nurseries, and grower groups. Despite these problems, some new rootstocks are being tested through regional and national trials such as the NC-140 regional project that evaluates new rootstocks for stone and pome fruits across the U.S. and Canada. This, in conjunction with new screening methods and extensive cooperation among researchers, is decreasing the time to evaluate promising rootstock selections so that new releases for fruit growers can occur more frequently than they have in the past.

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