fruit was the result of either *xxyyzz* or *Xxyyzz* (or *xxYyzz* or *xxyyZz*) genotypes. However, he was unable to present precise genotypes for the varieties studied and did not determine the phenotypic consequence of more than 2 dominant alleles or of homozygous dominant loci.

Support for the present hypothesis can be found in the literature. Black-fruited seedlings were not found by Snyder and Harmon (4) in the selfed progeny of 3 red-fruited varieties and the ratio of white- to red-fruited seedlings approached 1:3, suggesting that the 3 red-fruited varieties studied, 'Castiza', 'Chasselas Rose de Falleaux', and 'Emperor', have the genotype *bbRr*. In the selfed and crossed progenies of white- and red-fruited varieties Wagner (6) did not obtain black-fruited seedlings. He obtained a 1:1 ratio of white- to red-fruited seedlings when crossing 'Muscat Rose' × 'Muscat Ottonel', indicating that 'Muscat Rose' has the genotype *bbRr*. A white- to red-fruited seedling ratio of 1:3 obtained by Wagner (6) when he crossed 'Chasselas Rose' × 'Muscat Rose' suggests that 'Chasselas Rose' also has the genotype *bbRr*. Snyder and Harmon (4) selfed 3 black-fruited varieties, 'Mission', 'Mondeuse', and 'Zinfandel', and obtained only white- and black-fruited seedlings in a ratio approaching 1:3, suggesting that these varieties have the genotype *Bbrr*.

Certain genotypes, *bbRR*, *BbRr*, and *BB – –*, were conspicuously absent from the parents studied as all red-fruited parents had the genotype *bbRr* and all black-fruited varieties had the genotypes *Bbrr* or *BbRR*. An explanation for these findings is lacking but perhaps with a wider survey of varieties the remaining genotypes will be found. For example, the *V. vinifera* variety 'Petit Syrah', selfed by Snyder and Harmon (4), produced only black-fruited seedlings, indicating that it is probably homozygous dominant for the black gene.

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# Selection of Intercompatible Almond and Root-Knot Nematode Resistant Peach Rootstocks as Parents for Production of Hybrid Rootstock Seed[1]


Robert W. Jones[2]



*Abstract.* Suitable parents for the production of $F_1$ hybrid seed between almond and root-knot nematode resistant peach were selected. Three of 13 almond selections were found which, when pollinated by 'Nemaguard' pollen, produced good sets of seed. When germinated, their seedlings showed good root-knot nematode resistance, hybrid vigor, and exceptional compatibility with almond tops.

The self-incompatibility of almond was used to permit natural pollination between selection CP5-33 and a selected seedling of 'Nemaguard', 3–28. The $F_1$ hybrids proved to be very compatible as rootstocks with almond and peach tops and imparted increased vigor to them.

Both 'Nemaguard' and a selected seedlings of 'Nemaguard' served as good pollen parents. 'Okinawa' peach, another rootknot nematode resistant peach type rootstock, was a less satisfactory pollen parent.


## Introduction

PEACH-almond hybrids have been recognized for a long time as superior rootstocks for stone fruits because of their vigor (2, 3, 11). Advantages of their use have been summarized by Kester and Hansen (7). They have usually been vegetatively propagated, and extensive studies on their propagation have been made by these and other workers (2, 5, 6, 8, 9). Vegetative propagation of rootstocks is expensive and in the past has been responsible for the spread of viruses (1, 4).


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[2]Research Horticulturist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Fresno, California.


[3]Bright, Arthur. 1968 personal communication.

Kester and Hansen (7) state: "Theoretically, self-incompatibility of the almond should make it possible to isolate peach and almond trees and harvest $F_1$ hybrid seeds. We have not done this, but our results indicate that interfertility between peach and almond may be low except when environmental conditions during bloom are particularly favorable." In the present study, the emphasis is on the selection of commercially usable almond and peach parents for $F_1$ hybrid seed production, with the use of almonds as the female parent because of their self-incompatibility. One California nurseryman has recently produced $F_1$ hybrids of almond × Nemaguard peach commercially.[3]

It has been observed that some almond seedlings and clones hybridize more readily with certain peaches than others. The selection of mutually compatible almond and rootstock peach parents which produce seedlings with hybrid vigor, minimal root-knot nematode galling and uniform growth has been the objective of this work.

## Materials and Methods

Pollen from the 'Nemaguard peach, from a selected seedling of 'Nemaguard' and from 'Okinawa' peach was used in controlled crosses on almond selections blooming simultaneously with 'Okinawa' or with 'Nemaguard'. This was done by hand pollinating almond flowers without emasculation under cheesecloth tree covers. Also, hybridization was accomplished by placing peach pollen parent bouquets in selected blooming almond trees for insect cross pollination. Few almond trees were in flower with the early flowering 'Okinawa' or with the late flowering 'Nemaguard' to provide natural pollination. Also, the almond parent trees were somewhat isolated, so that their pollination with other almonds was largely avoided. These procedures produced the desired $F_1$ hybrid seed. Since almonds are self-incompatible, there was almost no chance of selfing.

The peach rootstocks mentioned in this manuscript are not solely *Prunus persica* L. but are the result of chance hybridization and selection, and involve other related species.

Almond selections CP4-37, CP5-33,

CP5-47 and CP5-50 originated in a joint University of California, Davis – U. S. Department of Agriculture almond breeding program.

Hybrids in seedling progenies made by insect pollinations were identified by distinct leaf and stem characters which were intermediate between almond and peach. Almond seedlings were rogued from the populations.

Resistance to root-knot nematodes was determined by planting seeds in heavily infested soil in the greenhouse. The same soil source was used each year and was obtained from rootknot nematode infested grapes. After 3 months the roots were examined and rated for galls on a graduated 0–5 scale. Zero represented no galling. Further evaluation was made by planting hybrid seedlings in orchards in places where almonds or peaches had been growing poorly even on resistant rootstocks. Trunk circumference measurements were made on these replants.

One lot of $F_1$ hybrid seedlings was planted in a fertile soil where a peach orchard had been recently removed. They were alternated with 'Nemaguard' rootstock in 2 rows, 20 trees long. These 20 pairs of rootstock trees were fall budded in 1965 to one of 3 almond selections or the almond variety 'Nonpareil'. Each pair was therefore replicated 5 times. The buds were forced the next spring. Tree growth was compared by taking trunk circumference measurements after 3 seasons' growth.

*Table 1.* Growth and nematode gall rating of $F_1$ hybrid almond × rootstock peach seedlings as compared to almond and rootstock peach seedlings.

| Parentage | No. of seedlings | Average seedling height (inches) | Average nematode galling (0–5)[a] |
|---|---|---|---|
| *1959 season* | | | |
| CP4-37 × 'Nemaguard' | 5 | 12.0 | 4.0 |
| CP5-33 × 'Nemaguard' | 11 | 11.7 | 1.1 |
| CP5-46 × 'Nemaguard' | 17 | 13.9 | 1.8 |
| CP5-47 × 'Nemaguard' | 44 | 9.6 | 2.4 |
| CP5-50 × 'Nemaguard' | 9 | 10.9 | 0.5 |
| 73-2 × 'Okinawa'..... | 3 | 5.0 | 3.3 |
| 'Texas' O.P........... | 7 | 4.5 | 3.5 |
| *1960 season* | | | |
| CP5-33 × 'Nemaguard' | 14 | 16.8 | 2.2 |
| CP5-46 × 'Nemaguard' | 21 | 18.5 | 2.1 |
| CP5-47 × 'Nemaguard' | 9 | 21.8 | 2.4 |
| CP5-50 × 'Nemaguard' | 16 | 16.1 | 1.1 |
| 'Nonpareil' O.P........ | 13 | 14.0 | 4.0 |
| P.I. #87459 almond O.P................ | 10 | 12.7 | 3.9 |
| 'Fraser' almond O.P.... | 29 | 13.3 | 3.1 |
| *1961 season* | | | |
| CP5-33 × 'Nemaguard' | 10 | | 1.0 |
| 13.5-123 × 'Nemaguard' | 25 | | 2.8 |
| 15-11 × 'Nemaguard'.. | 4 | | 1.5 |
| 15.5-36 × 'Nemaguard' | 4 | | 0.0 |
| 16-69 × 'Nemaguard'.. | 4 | | 1.8 |
| 19.5-36 × 'Nemaguard' | 25 | | 1.7 |
| 19.5-85 × 'Nemaguard' | 8 | | 1.5 |
| 20-12 × 'Nemaguard'.. | 4 | | .8 |
| 20.5-84 × 'Nemaguard' | 16 | | .7 |
| $F_2$ S-37 rootstock peach.............. | 201 | | .05 |

[a]0 = no galls, 5 = severe galling.

## Results

In exploratory tests, 2 almond selections, CP5-50 and CP5-46, were pollinated with 'Nemaguard' pollen in 1957. Sufficient hybrids were produced and identified by seedling characters to indicate that commercial production of hybrid seed would be feasible.

In 1959, 1960 and 1961 additional almond selections were pollinated by 'Nemaguard' pollen. Also, several hundred flowers of almond selection 73-2 were hand pollinated by 'Okinawa' pollen. Results of nematode tests shown in Table 1 indicate that hybrid seedlings from CP5-33, CP5-46, and CP5-50 had fewer galls and were more vigorous than seedlings of CP5-47 or CP4-37. Moreover, these selections formed hybrid seed readily with 'Nemaguard' pollen, and progenies from these parents were large enough to allow conclusions to be drawn. Data for other parents are indicative only. Galling was less (0.2–4) on $F_1$ hybrids than on almond (3.1–4.0), but greater than the .05 rating on S-37 rootstock peach. However, vigor of the $F_1$ hybrids was superior to both almond and rootstock peach. Variations in amount of galling on the seedlings between seasons may have been due to seasonal variations in growth conditions. Galling for 1961 was less than during the previous 2 years. The 15.5–36 seedlings were the only progeny showing no galling, but the small sample size may or may not have been responsible for the absence of galls.

In 1963 'Nemaguard' seedling 3-28, which is immune to the root-knot nematodes, *Meloidogyne incognita*, and resistant to *M. javanica* as determined by test at the University of California, Davis, was used as a pollen parent. Bouquets of 3-28 were placed in almond selection CP5-33, and a crop of nuts resulted. When planted the following spring, 98 of 171 or 57.3% of the seedlings proved to be $F_1$ hybrids.

Seedlings from 1963 seed of CP5-33 × 'Nemaguard' seedling 3-28 were planted in sandy loam soil. After one year's growth, they were dug, and 52 of the 98 were evaluated for root type. Ten of these showed the spreading root type like peach, 9 showed the deep rooting character of almond, and 33 showed an intermediate type of root growth (Fig. 1). Neither parental type appeared to be dominant.

Where pairs of almond trees with hybrid roots and those on 'Nemaguard' were compared, the average trunk circumference measurement 5 to 7 cm above the soil level in the spring of 1968 was 41.5 cm for trees on hybrid rootstock, whereas that for trees on 'Nemaguard' was 26.2 cm. This 60% increase in size of trees due to rootstock was highly significant. Analysis of variance gave F values of 36.49 for treatment, over 10 times the amount necessary for significance at the 1% level (3.39). The F value for rootstock effect (248.46) was over 30 times as great as necessary for significance at the 1% level (7.68).

Some of the 1963 hybrids of CP5-33 × 'Nemaguard' seedling 3-28 were planted in February 1965 in areas in a sandy peach orchard where peach trees on 'Nemaguard' root were stunted in growth. When circumference measurements were taken 3 years after planting and 2 years after grafting to peach, trees on hybrid root had an average of 28.7 cm compared with only 21.1 cm for the 8-year-old trees on 'Nemaguard'. In another area on the same soil type, hybrid rooted trees measured 18.7 cm in circumference,

*Fig. 1.* $F_1$ almond × 'Nemaguard' seedling hybrids showing spreading, intermediate, and deep growing types of roots.

whereas 'Nemaguard' rooted trees 1 year older measured 15.8 cm.

'Okinawa' was tried as a pollen parent on the almond P.I. #87459 in 1963 spring, but only a few hybrid seedlings were obtained. Three of these were planted out in a poor sandy soil where they have grown well.

'Texas' ('Mission') almond and 2 seedlings of 'Texas' in 2 seasons' trials have set little or no fruit when pollinated by 'Nemaguard' pollen.

### Discussion

The heterozygosity in almond resulted in variability in the $F_1$ progenies in both vigor and nematode resistance, depending upon the almond parent. However, by eliminating the weaker seedlings among the progenies of selected parents, very vigorous and fairly uniform rootstocks were achieved.

Replants in these growth comparisons were grown as seedlings for at least 2 seasons. On the other hand, had these trees been June budded as nursery seedlings, the degree of superiority in vigor over 'Nemaguard' root might have been much less. Moreover, these almond × peach hybrids grow better than peach roots on sites where peaches have been removed (10).

'Okinawa' has been less successful as a parent in hybridizing with almond than 'Nemaguard' and seedlings of 'Nemaguard'. This may be due to the failure by chance to match or mate those almond clones which are compatible with 'Okinawa' or the greater incompatibility of genes between almond and 'Okinawa'. Viability of 'Okinawa' pollen was not considered because 'Okinawa' trees have set adequate crops and 'Okinawa' pollen has appeared normal.

Some almond clones have not set seed when pollinated by 'Nemaguard' pollen. The 'Texas' variety and its seedlings have been among this group. The late flowering 'Nonpareil' as well as its seedlings 15.5-36 and 20.5-84 have functioned well as female, almond parents. So have CP5-33, CP5-46, and CP5-50, which have come from the hybridization of 2 obscure varieties, 'Reams' and 'McLish'.

$F_1$ hybrid almond × peach rootstocks offer several advantages. They grow better in alkaline soils than does 'Nemaguard'.[4] Also, peaches and almonds June budded on them develop into larger nursery trees.[4] They appear to have excellent compatibility with commercial varieties of peaches and almonds.[4] The compatibility factor may eventually be more important in the productive life of the tree than the vigor characteristic. However, the vigor has demonstrated its usefulness in replant situations where other nematode resistant rootstocks have been unsuccessful.

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# Degree of Resistance Among Pear Species to the Woolly Pear Aphid, *Eriosoma pyricola*[1]


M. N. Westwood,[2] and P. H. Westigard,[3]
*Oregon State University, Corvallis*



*Abstract.* Roots of most of the primitive *Pyrus* species were infested with pear root aphid *Eriosoma pyricola* Bak. and David., and increase or decrease in number noted 30 days later. Although seedling populations varied somewhat, *P. amygdaliformis, P. elaeagrifolia, P. syriaca, P. betulaefolia, P. calleryana, P. koehnei, P. ussuriensis,* and *P. nivalis* can be considered resistant. *P. communis, P. cordata, P. gharbiana, P. pashia, P. Fauriei,* and *P. pyrifolia* were either susceptible or very variable in resistance. Only *P. bucharica, P. dimorphophylla,* and *P. mamorensis* had no resistant seedlings in the lots tested. Interspecific hybrid populations were predictable though variable in resistance.


### Introduction

THE woolly pear aphid *Eriosoma pyricola,* Baker and Davidson, is a pest on young pear trees in Oregon. It infests the roots and devitalizes trees both in the nursery and during the first few seasons in the orchard. Nursery trees are seldom killed but may be stunted and thus unmarketable. However, if orchard trees become dry in late summer, aphid infestations can result in death of young trees on susceptible rootstocks.

Reimer (3) in Southern Oregon found that the most serious weaknesses of *Pyrus communis* rootstock were its susceptibility to fire blight and to pear root aphid. He grew thousands of nursery trees on different roots and compared the extent of natural infestations as the trees were dug. He listed *P. communis* as susceptible, *P. pyrifolia (serotina)* as moderately resistant and *P. calleryana, P. ussuriensis,* and *P. betulaefolia* as resistant. In their pear rootstock research nursery at Corvallis, Westwood and Bjornstad (6) recently cataloged natural aphid infestations at digging time. Their findings were similar to Reimer's but some forms of wild *P. communis,* considered susceptible by Reimer (3), showed resistance, while some species thought to be resistant (whose pollen parent was uncertain) were susceptible. A recent study of materials from arboretums (5) indicates that a large percentage of the pear species retained in collections are misnamed, mislabelled or are hybrids resulting from open pollination by an unknown male parent. In conjunction with an ex-


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[2]Department of Horticulture.
[3]Department of Entomology.