Two-year-old French seedling inarches approach-grafted to a three-year-old declining Bartlett pear tree. Three inarches per tree maintained the same trunk size as that of unaffected trees. Declining trees not inarched were approximately 1½ inches smaller in circumference.

Two-year-old Winter Nelis inarches which were bark-grafted above the union of the 30-year-old Bartlett scion on an Oriental pear root. Inarches placed low and close to the tree are least vulnerable to damage by cultivation equipment and do not grow as many sucker shoots.

New Pear Roots for Old...

Inarching Decline-Imm Into Susceptible Pear

AN AGRICULTURAL EXTENSION project was initiated in the spring of 1962 to determine whether pear trees susceptible to decline could be saved by adding a new nonsusceptible root system around the base of the trees. Although the cause of pear decline was not yet known, it was an established fact that pear trees on Oriental pear and Old French (churn bottom) rootstocks were most susceptible to the disease. Rootstocks produced from Old Home cuttings or Domestic French seedlings grown from a seed source known to be free of Oriental pear pollination were for the most part immune to decline.

It had been observed that inarched declining pear trees in Washington had increased vigor. In California, trees inarched with French seedlings for the correction of black end, generally showed less pear decline. Rootstock substitution by inarching has been used in the past to restore vigor to walnuts affected by black line, nematodes, crown rot, mechanical injury and crown gall.

Trees in these tests were inarched in orchards where the rate of decline appeared slow enough to permit adequate growth of the inarches before the trees collapsed. Orchards showing a generally rapid downward trend in vigor were not considered desirable for inarching. It was more difficult to establish a graft union between inarched seedlings and trees in the advanced stages of decline.

Stocks used for inarches over a two-year period included 1,900 Winter Nelis and Bartlett seedlings, 800 Old Home and 100 Bartlett callused cuttings. Eighteen- to 24-inch Bartlett and Old Home (callused) cuttings were produced, according to procedures outlined in the article, "Pear Decline Research," *California Agriculture*, October, 1962. They were stored at 32°F in moist peat until used. Callused cuttings developed more roots and less rot when the bottom of each cutting was planted no more than 8 to 10 inches deep. They were very susceptible to cortical rot by *Phytophthora cactorum*. Cuttings were inarched at the time of planting at the rate of one-per-4 inches of tree circumference. Sixty per cent of the Old Home callused cuttings which were bark grafted in late May and early June developed graft unions and roots. Only 12% of all Old Home cuttings grafted earlier initiated roots and developed into vigorous inarches. These were ½ inch in diameter when planted and ranged from ¾ to 1½ inches after two years. It appeared that warm soil was necessary for the development of good roots.

Seedlings

Seedlings were either planted in the winter and inarched in the spring, or stored at 32°F until planted and inarched at the same time. Five ⅜-inch seedlings were inarched per tree the first year, but the number was increased to eight or ten ⅝-inch seedlings in the second and third years. This resulted in one inarch to about 5 inches of tree circumference. Seedlings were planted at the same depth at which they had been growing in the nursery. They should be close to the tree and grafted as low as possible above the original Bartlett-to-Oriental root bud union.

Approximately 400 mature Bartlett pear trees, inarched during the last three years, were growing on *Pyrus serotina*, *P. ussuriensis*, and Old French rootstocks; however, a few badly debilitated Bartlett trees on domestic French rootstocks were also inarched.

Experimental grafts made from February through June the first year resulted in the abandonment of two types of chisel

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une Seedlings Trees

Old Home inarches grafted into a Bartlett pear tree approximately 30 years ago. Note the size of the inarches on either side of the Bartlett trunk.

grafts made in the winter months in favor of the bark and approach grafts made after the bloom period when the bark was easily separated from the wood at the cambium.

Grafts

The bark grafts were made by cutting a "U"-shaped flap in the bark above the bud union, after the rough outer bark had been scraped away. This resulted in a flap of bark hinged on the top about 1 inch long and as wide as the inarch stock. The top of the planted inarch was cut to a wedge shape about 1 inch long, so that the inner cut surface was parallel to the tree surface and pushed up tightly under the bark flap in the tree. A size 18 × 1-inch flathead nail was driven through the bark flap to hold the cambium of the seedling or cutting against the tree cambium. Hot grafting wax and asphaltum grafting compounds were used satisfactorily if the grafts were checked and rewaxed when necessary in four to seven days. Hot wax did not crack as badly as the asphaltum grafting compounds. Good healthy unions were obtained with 93.3% of the seedlings bark-grafted in April, May and June.

Approach grafts were made by removing a vertical strip of bark from the tree above the bud union, about 6 inches long and as wide as the seedling. A 6-inch strip of bark and wood was removed from one side of the seedling so that the cambiums of the seedling and tree would contact when nailed to the slot in the tree. Size number 18 × 1-inch nails were satisfactory for most seedlings. A limited number of approach grafts had slightly better "take," but the extra time required tends to favor the bark graft.

Ratings

There was no difference in the growth of terminal shoots or decline ratings between inarched trees and similar check trees not inarched after one or two years. The diameter of the seedlings varied from ½ inch to 1½ inches, two years after inarching. Shoots from the inarches were allowed to grow during the first season to increase the size of the inarch. They were pruned off thereafter to allow growth through the graft union rather than up the shoot. Trees successfully inarched will be checked in the future for growth response.

Timing

Since optimum timing and good graft techniques had been found, inarching studies in the 1964 season were confined to a 40-year-old, Oriental-rooted Bartlett orchard in Lake County. Twenty-five large trees were inarched with eight ⅝-inch Winter Nelis seedlings; 15 were inarched with four similar seedlings, and alternate check trees were left untreated.

It was thought that a great deal could be learned from the commercial inarching practiced by growers over the years. One-half of a 10-acre Oriental rooted orchard in Mendocino County was inarched with French seedlings in 1935. The intended purpose of the work was to correct a condition on the fruit known as "black end." The total orchard was rated for decline in the fall of 1962 and 1963. Yields from both sides of the orchard were projected according to the amount of decline determined by individual tree ratings. These numerical ratings were: (1) trees with normal shoot growth, (2) terminal shoot growth somewhat limited, (3) very limited terminal shoot growth, (4) no terminal shoot growth, (5) no terminal shoot growth, very sparse foliage, trees nearly dead.

Grading

It was assumed that trees grading 1 and 2 would produce 15 tons per acre, and trees grading No. 3 would produce 7.5 tons per acre. Trees with more advanced decline and stumps or recent replants would yield no crop. Table 1 shows the rate of decline of inarched and non-inarched sections of the orchard. Possible yields, as influenced by decline, are based on 15 tons per acre for healthy trees.

If an average price of $75 per ton is received for pears, an increased production of .4 ton per acre is required to pay for the cost of inarching if the orchard is to remain in production for 20 years. The

TABLE 1. Severity of pear decline and estimated yield of 10 acres of Bartlett pears on susceptible Oriental rootstock. One half of the block was inarched in 1935 with Domestic French seedlings.

Pear decline grades	1962				1963			
	Inarched		Not inarched		Inarched		Not inarched	
	%	Tons per acre*	%	Tons per Acre*	%	Tons per Acre*	%	Tons per Acre*
1 and 2	92	13.8	86	12.9	95.8	14.4	91.8	13.8
3	5	.4	7	.5	2.2	.2	3.7	.3
4, 5 and collapsed	3	...	7	...	2.0	...	4.5	...
Total	100	14.2	100	13.4	100	14.6	100	14.1

* Based on a normal yield of 15 tons per acre for pear decline grades 1 and 2, 7.5 tons per acre for grade 3 and nothing for grades 4, 5, collapsed trees and stumps.

TABLE 2. Inarched declining pear trees had trunks as large as normal trees with no decline symptoms; however, declining trees not inarched were significantly reduced in trunk size.

Fall leaf color	Number of trees	Trunk circumference (inches)
Normal	467	13.07
Red (trees inarched)*	225	13.04
Red (trees not inarched)*	121	11.52
Difference required for significance	5%	.33
	1%	.44

* Representative bark samples from these trees had phloem necrosis at the bud union.

expected yield increase due to the 28-year-old inarches was .8 ton in 1962, more than adequate to cover the costs of inarching. Due to less severe decline ratings in 1963, the expected yield increase due to inarching was .5 ton per acre. This orchard has a low incidence of decline; however, if the rate of decline increases it would be expected that the inarched trees would be less severely affected, and the cost of inarching could be paid for over a shorter period of years.

Trunk growth

Trunk circumference measurements of 811 five-year-old pear trees in Sutter County showed that declining trees responded to inarched domestic French seedlings. Three-year-old pear trees with pear decline symptoms the previous spring (including red leaves and plugged conductive tissue at the bud union, on microscopic examination), were inarched with three domestic French seedlings per tree in the spring of 1962.

In the fall of 1963, randomly scattered inarched trees with decline symptoms had trunk circumference measurements nearly identical to the trees with no decline. Randomly scattered trees showing decline symptoms in the fall of 1962 without inarching, averaged approximately 1.5 inches smaller in trunk circumference than either the normal or inarched declining trees (see table 2). It appears that the inarches not only saved the young trees, but sustained normal trunk growth.

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Stubby root nematode infestation was major factor in stunted growth of immature onions to left with leaves less than 5 inches in length, as compared with leaves over 10 inches long on onions from nematode-free soil seen to right in photo above.

Nematocides Increase Onion Yields

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THESE TESTS BEGAN in August 1961 with a field of severely stunted onions found near Hesperia, San Bernardino County. In approximately 20% of this field, the onions were immature and leaves were less than 5 inches in length. Healthy leaves were 10 inches or more in length, as shown in the photo.

Close-up of roots of these onions shows severe stunting, swollen tips with numerous branches, and a yellowish brown discoloration. Soil in the root zone of the stunted onions contained 2,000 or more stubby root nematodes per pint. Soil in the root zone of healthy plants contained an average of 44 stubby root nematodes per pint.

Greenhouse test

Soil samples from the highly infested areas were taken into the greenhouse for pathogenicity tests. The soil was screened and half of it was exposed to the sun in a 1-inch layer for two days. The other half was stored in a large container to prevent drying and heating. After "treatment," both soils were placed in 6-inch pots and seeded to Yellow Globe onions.

At the time of potting, the soils were sampled for nematodes. Soil exposed to the sun contained no nematodes, while the nontreated soil had approximately 190 stubby root nematodes per pint. No other plant parasitic nematodes were present in these samples.

After a 90-day growing period in the greenhouse, the onions from both treatments were harvested and weighed. The soil containing no nematodes produced onions twice the dry weight of those grown in the nematode-infested soil. Roots of onions from nematode-infested soil were severely stunted, as shown in close-up of roots. The treated soil contained no nematodes at the end of 90 days. The nontreated soil had approximately the same number of nematodes as when the onions were first seeded.

1962 field trials

In March 1962, a fumigation trial for nematode control in onions was established in cooperation with August Reallon, an onion grower near Adelanto, in the Mojave River basin. This plot was established in a field previously cropped to alfalfa for 20 years. A nematode survey showed that both the stubby root and root knot nematode were present. Experimental design consisted of 12 paired plots, each 12×100 ft in size. Telone at the rate of 20 gallons per acre, was injected at a depth of 8 inches on 12-inch centers for comparison with untreated check plots. The soil was cultipacked immediately after applying the nematocide. Considerable plant residue in the soil made fumigation difficult in this test and may have impaired the efficiency of the Telone. Sweet Spanish onions were seeded in these plots March 15, 1962.