Asian pears in California

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California now has only a few hundred acres of Asian pears in commercial orchards. Demand for these crisp, juicy pears has increased in recent years, and planting the best commercial varieties should result in further increases.

Asian pears are also called Oriental, Chinese, Japanese, Nihon Nashi, sand, Shalea, apple, and salad pears. Fresh-fruit market reports usually use the misleading term "apple pears." Although most Japanese pear varieties are roundish, their texture and flavor are entirely different from those of apples. Also, the main Chinese pear varieties are pyriform (the classical pear shape). Asian pears remain firm, and are crisp and juicy when eating-ripe; Bartlett and other *Pyrus communis* Linnaeus varieties become soft and melting when ripe.

In China and Japan, Asian pears are usually eaten as fresh fruit between meals. These crisp, succulent pears are also delicious with vegetables or with other fruits in salads. Growers in California's Loomis and Newcastle areas have capitalized on this by marketing the fruits as "salad pears." Demand for Asian pears has increased in recent years, and growers receive relatively high prices for them. Replacing the old, poor-quality seedling trees and varieties with the best commercial varieties should result in further increases in demand.

During the California gold rush, Chinese miners brought in and planted Chinese pear seeds along streams of the Sierra Nevada. Later Chinese and Japanese immigrants brought more seeds, and evidently scion wood, from cultivated varieties in China and Japan. These pears have been maintained, for the most part, in the yards of city residents and by farmers of Asian descent. There have also been a few small commercial plantings in California since early in this century.

The cultivated varieties of Chinese and Japanese pears were developed from *Pyrus ussuriensis* Maximowicz, *P. serotina* Rehder [*P. pyrifolia* (Burman) Nakai], and possibly other native species, according to Akio Kikuchi, a Japanese authority.

The Chojuro variety, a russet-

skinned pear that originated in Japan in about 1895, seems to be the most widely grown Asian pear in California and probably was one of the first true Japanese varieties brought into the state. Another variety, Okusankichi, has been grown in the Loomis—Newcastle district of Placer County for many years, where it is known as the "late Japanese pear" or "October Japanese pear." In Tulare County, it is called "Nihon Nashi" (Japanese pear).

In the 1950s, the U. S. Plant Introduction Station at Glenn Dale, Maryland, provided the authors with scion wood from a number of Asian pear varieties received from Japan, China, and Korea. These varieties have been maintained and propagated under continuing study in the University of California Department of Pomology orchards at Davis.

Japanese horticulturists classify their pear varieties according to skin color and russeting. Green-skinned varieties usually are free of russeting, and some turn yellow upon ripening. Russet-skinned varieties have brown, yellowish-brown, or greenish-brown skin. Included in our study are the Japanese green-skinned varieties Kikusui, Nijisseiki (Twentieth Century), and Shinseiki, and russet-skinned varieties Chojuro and Okusankichi (Bansankichi). In addition, we have maintained two Chinese varieties, Tsu Li (Tzu Li) and Ya Li (Yarr Li). These have yellowish-green skin, but their pyriform shape distinguishes them from the roundish Japanese varieties. Although Tsu Li and Ya Li originated in China, they are also cultivated in Japan.

Japan had 46,930 acres of Asian pears in 1974. Chojuro and Nijisseiki (Twentieth Century) comprise approximately 39 and 35 percent, respectively, of the acreage. At present California has only a few hundred acres of Asian pears in commercial orchards. Tulare County, with approximately 225 acres, is the leading producer of these pears. There are small acreages in Fresno, Placer, Sacramento, San Bernardino, Solano, and Yolo counties. In general, California growers use the same cultural practices for Japanese and Chinese pear trees as for *P. communis* varieties.

Rootstocks

In Japan, Asian pear varieties are generally propagated on *P. serotina* (*P. pyrifolia*) seedlings. Tsu Li and Ya Li are commonly propagated in China on *P. betulaefolia* Bunge seedlings. In California, most Asian pears have been propagated on *P. communis* seedlings, mainly Bartlett and Winter Nelis. Such trees have been fairly satisfactory in most areas of the state but tend to lose vigor with maturity. When planted as one-year-old nursery trees, most varieties produce some fruits in their fourth year in the orchard.

Periodically during 1961 through 1969 at Davis, Asian varieties were top-grafted on young *P. communis* seedlings (Bartlett and Winter Nelis), and on *P. betulaefolia* seedlings. The resulting trees with *P. betulaefolia* roots are much larger and more vigorous than comparable trees with Bartlett and Winter Nelis seedling roots. Trees with *P. betulaefolia* roots came into bearing about one year later than those on *P. communis* roots, but once they started fruiting they had more and larger fruits.

Pollination

Although the Japanese pear varieties are partly self-fruitful, cross-pollination is generally required to ensure commercial crops.

Chojuro, Twentieth Century, Kikusui, Shinseiki, and Okusankichi have overlapping bloom periods and produce adequate amounts of viable pollen. Hence, with the possible exception of Twentieth Century and Kikusui, combinations of these varieties, interplanted in an orchard, should serve as satisfactory pollenizers for each other.

In tests at Davis, Kikusui flowers gave good fruit-set (20 percent) when cross-pollinated with Twentieth Century pollen, but Twentieth Century flowers gave comparatively low fruit-set (3 percent) when cross-pollinated with Kikusui pollen. To be sure of effective cross-pollination, the orchardist who wants to grow Twentieth Century and Kikusui should plant at least one other variety, such as Chojuro or Shinseiki, as a pollenizer. Bartlett also overlaps the Japanese varieties in bloom period and is an effective pollenizer for each of them.

The Chinese varieties Ya Li and Tsu Li are self-incompatible and thus need cross-pollination for satisfactory crops. Since they are intercompatible and bloom at approximately the same time, they should serve as good pollenizers for each other.

Ya Li and Tsu Li are also intercompatible with several of the Japanese varieties, but they usually reach full bloom before or at about the time the Japanese varieties start to bloom. Evidently the bloom periods of the two types overlap enough for cross-pollination, however, because the Chinese varieties usually set good crops when interplanted with Shinseiki, Chojuro, and Twentieth Century.

Enough pollenizer trees and bees should be provided to ensure adequate fruit-set when adverse weather conditions occur during the bloom and fruit-setting period. We recommend planting every fourth row to a pollenizer variety. However, if the number of pollenizers is to be kept to a minimum, one tree to eight, planted as every third tree in every third row, is suggested. During the blossoming period, the grower should provide at least one strong colony of honey bees for each acre of trees to be cross-pollinated. Excessive fruit-set may be expected in years when weather conditions are ideal for flower development, bee activity, pollen tube growth, and fertilization. Fruit thinning will then be required for satisfactory fruit size.

Training and pruning

To yield good-sized fruits, Asian pear trees generally require somewhat more severe pruning than do Bartlett and other *P. communis* varieties, but otherwise, the Asian varieties may be satisfactorily trained and pruned by the same methods. Growth conditions and the characteristics of the different varieties help determine the type and degree of pruning in a given situation.

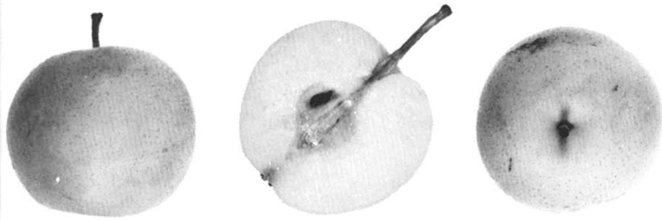
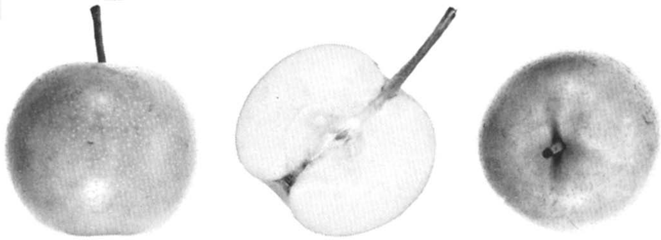
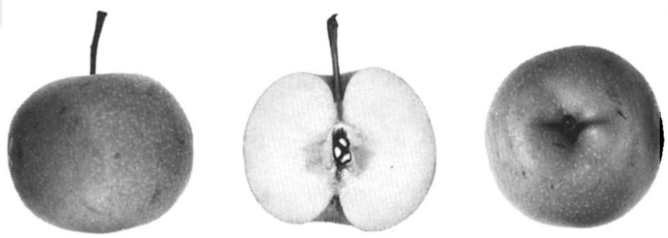
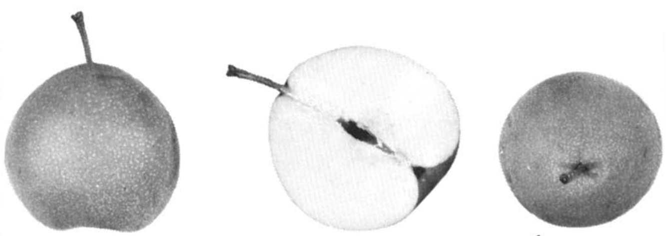
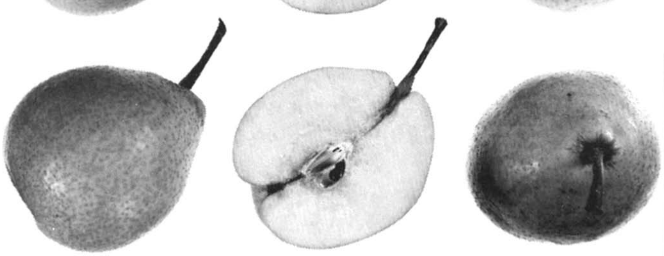
We have not tried to develop the Asian pear varieties in hedgerows. However, in some young Asian pear orchards in Tulare County, trees are planted 7 feet apart in rows 14 feet apart. Since the Japanese train their pear trees on horizontal trellises 5 to 6 feet high under the severe and stylistic "Tanazukuri" training system, we feel that the Asian varieties could be grown in hedgerows as successfully as *P. communis* varieties.

Storage

Like peaches and apples, Asian pears attain their best eating quality when ripened on the tree. European pears are usually harvested when they are firm or hard ripe, held in cold storage for various periods, then allowed to soften to eating ripeness at nearly room temperature.

Text continued on page 12.

VARIETY CHARACTERISTICS:
(averages for three to five years at Davis, California)

Variety		Tree	Dates	Season—if held at 32° F(0° C)
SHINSEIKI Early-maturing. Origin: Japan (1945); seedling of Nijisseiki x Chojuro.		Medium size and vigor, spreading, medium dense, productive.	First bloom: 3/18 Full bloom: 3/23 Harvest: 7/25 to 8/15	Harvest through January.
KIKUSUI Mid-season variety. Origin: Japan (1927); seedling of Taihaku x Nijisseiki.		Medium size and vigor, spreading, slightly drooping, dense, very productive.	First bloom: 3/21 Full bloom: 3/27 Harvest: 8/10 to 8/19	Harvest through January.
NIJISSEIKI (TWENTIETH CENTURY) Mid-season variety. Origin: Japan (1898); chance seedling.		Medium size and vigor, medium upright-spreading, dense, productive.	First bloom: 3/18 Full bloom: 3/25 Harvest: 8/10 to 8/20	Harvest through December.
CHOJURO Mid-season, russet-skinned. Origin: Japan (1895); chance seedling.		Medium size, vigorous, spreading, slightly drooping, dense, very productive.	First bloom: 3/17 Full bloom: 3/24 Harvest: 8/9 to 8/19	Harvest through January.
OKUSANKICHI (BANSANKICHI) Large, late-season, russet-skinned. Origin: Japan (an old variety); open-pollinated seedling of Wasesankichi.		Fairly large, very vigorous, upright, spreading, dense, productive.	First bloom: 3/21 Full bloom: 3/27 Harvest: 9/20 to 10/15	Harvest through February.
YA LI Late-season variety. Origin: China; old variety.		Large, vigorous, upright, somewhat spreading, dense, productive.	First bloom: 3/10 Full bloom: 3/17 Harvest: 9/8 to 9/23	Harvest through December.
TSU LI Late-season variety. Origin: China; old, renowned variety.		Large, vigorous, upright, dense, moderately productive.	First bloom: 3/10 Full bloom: 3/18 Harvest: 9/10 to 9/23	Harvest through January.

Terms: **Acute**–sharply pointed but not drawn out. **Cavity**–depression in which stem is set and joined to fruit axis. **Elliptical**–in the form of a flattened circle. **Globular**–nearly rounded or spherical. **Lenticel**–a pore surrounded by cork.

Fruit characteristics at harvest:

Size	Shape	Stem	Skin	Flesh	Quality
Lgth: 57 mm Diam: 67 mm Wgt: 153 g	Uniform, globular to oblate in longitudinal section, circular in transverse section.	Length 19 mm; relatively straight; light green; pubescent with raised, tan to brown, oval or oblong lenticels.	Yellow; taste bland; medium tough and thick; surface fairly smooth, semiglossy; lenticels light brown, conspicuous, small to medium, slightly raised, hexagonal or roundish.	White; sweet, mild; soluble solids 12.7%; aroma faint; texture firm, crisp, juicy; more pulpy and coarse with more stone cells than Twentieth Century.	Good to excellent.
Lgth: 58 mm Diam: 73 mm Wgt: 185 g	Uniform, oblate and lopsided in longitudinal section, angular in transverse section.	Length 31 mm; slightly curved; broader at cavity; light green; slightly pubescent with raised, light-tan, elliptical lenticels.	Yellowish green, usually faintly mottled with green; slightly bitter; relatively tough and thick; surface dull, smooth except for lenticels; lenticels conspicuous, medium sized, slightly raised, hexagonal or roundish, tan.	White; sweet, mild, trace of tartness; soluble solids 14.4%; faint aroma peculiar to variety; texture firm, tender, crisp, juicy; somewhat more pulpy and coarse with more stone cells than Twentieth Century.	Good to very good.
Lgth: 55 mm Diam: 66 mm Wgt: 146 g	Fairly uniform; round to oblate, often lopsided, in longitudinal section; circular in transverse section.	Length 25 mm; slightly curved; light green; pubescent with raised, tan, oval lenticels.	Greenish yellow, mottled with green; taste bland; relatively thin and tender; surface smooth, dull to semiglossy; lenticels inconspicuous, small to medium size, slightly raised, round or hexagonal, light tan.	White; sweet, mild, refreshing, slight tartness; core slightly acidic; soluble solids 12.3%; aroma slight; texture firm, tender, crisp, very juicy, somewhat coarse and pulpy (compared with Bartlett fruits), with a few stone cells.	Good to excellent.
Lgth: 54 mm Diam: 66 mm Wgt: 150 g	Oblate and lopsided in longitudinal section, circular or slightly angular in transverse section.	Length 28 mm; slightly curved; brown with greenish tint on exposed side, green on shaded side; lenticels very small, raised, light tan, elliptical.	Greenish brown to brown; taste faintly astringent; relatively tough, medium thick; surface completely russeted, usually dull; lenticels conspicuous, medium size, slightly raised, roundish or hexagonal, light tan.	White; mildly sweet, somewhat bland, core somewhat sour; soluble solids 13.4%; distinctive, characteristic aroma; texture firm, crisp, somewhat coarse and pulpy, some stone cells; less tender and juicy than the green-skin types.	Good.
Lgth: 86 mm Diam: 93 mm Wgt: 390 g	Turbinate or globular in longitudinal section, circular to somewhat angular in transverse section.	Length 35 mm; relatively straight; green; lenticels raised, tan, circular to elliptical.	Greenish tan to tan; taste somewhat bitter; tough, relatively thick; surface russeted, dull; lenticels conspicuous, large, raised, round or hexagonal, light tan.	Dull white; slightly tart, refreshing; soluble solids 12.0%; aroma faint or lacking; texture firm, crisp, juicy, relatively few stone cells; more coarse and pulpy than Twentieth Century.	Poor to fair.
Lgth: 82 mm Diam: 70 mm Wgt: 198 g	Fairly uniform; turbinate to globular-acute-pyriform in longitudinal section, often lopsided, neck obscure in some specimens; circular in transverse section.	Length 47 mm; curved; broader at cavity; fleshy, often lipped; light brown, some with greenish tint; lenticels small, elliptical, slightly raised, sparsely scattered, tan.	Light greenish-yellow; taste bland; moderately tough, medium thick; surface smooth, dull to semiglossy, slightly waxy; lenticels conspicuous, small to medium, slightly raised, numerous, pentagonal or hexagonal, tan; usually free of russet.	White; mildly sweet, trace of tartness; soluble solids 11.7%; fragrant aroma; texture tender, crisp, juicy, slightly pulpy and coarse, relatively few stone cells.	Good to excellent.
Lgth: 88 mm Diam: 75 mm Wgt: 242 g	Variable; ovate-pyriform in longitudinal section, neck obscure in some specimens; circular to angular in transverse section.	Length 40 mm; broadened near cavity, may be lipped; slightly curved, often obliquely set; brown or brown with a greenish tint; lenticels raised, medium-sized, elliptical, tan.	Light green to yellowish green; taste slightly bitter; relatively tough and thick; surface semiglossy, but lenticels make it look rough and dull; lenticels numerous, small to very large, raised, roundish or polygonal, tan.	White with faint tint of yellow; sweet, trace of tartness, refreshingly mild; soluble solids 13.1%; aroma distinct and characteristic of the variety; texture firm, tender, crisp, juicy, somewhat coarse and pulpy.	Good.

Oblate–flattened at the poles; axis is shorter than diameter. **Ovate**–shaped like longitudinal section of hen's egg, the broader end basal. **Pubescent**–covered with fine, short, soft hairs. **Pyriform**–the classical pear shape. **Turbinate**–shaped like a top or inverted cone.

東洋梨

Asian pears . . .

Asian pears have a relatively long shelf life, maintaining their harvest quality for 10 to 14 days at room temperature. If held in cold storage at about 32° F (0° C) after summer or early fall harvest, most varieties keep until the Christmas season; a few varieties, such as Chojuro, Okusankichi, and Shinseiki, maintain acceptable quality until February.

Disease and insect susceptibility

Asian pear varieties are susceptible to infection by fireblight (*Erwinia amylovora* [Burr.] Winslow et al.). Although most varieties are not damaged as severely as Bartlett and other susceptible *P. communis* varieties, bactericidal treatment is required during the bloom period to control the disease.

The codling moth (*Carpocapsa pomonella* Linnaeus) is the principal insect pest of Asian as well as of *P. communis* pears. This insect is a constant threat from petal fall until harvest, and a regular seasonal spray program is necessary.

The pear psylla (*Psylla pyricola* Foerster) is another serious pest of pear trees. Although the Asian varieties are subject to attack, in our experience, they are much less attractive to the psylla and suffer much less damage than do *P. communis* varieties.

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Measuring nitrogen loss

Denitrification is the biological reduction of nitrate and nitrite to volatile gases, usually nitrous oxide or molecular nitrogen, or both. Denitrification is accomplished by bacteria capable of using nitrate in place of oxygen. Under aerobic conditions the bacteria oxidize carbohydrates to carbon dioxide and water. In the absence of oxygen these bacteria oxidize carbohydrates in nitrate respiration, yielding carbon dioxide, water, and the volatile gases, nitrous oxide and molecular nitrogen.

The amount of denitrification is generally the unknown in attempts to evaluate the fate of nitrogen fertilizers or wastes applied to soils. Denitrification is usually calculated by difference from measurements of the other components of the nitrogen cycle, such as fertilizer addition, plant uptake, leaching, and residual soil nitrogen. The reliability of such denitrification values is at best no better than the reliability of the other measurements, with all errors accumulating in the difference value. It is not always easy to accurately measure leaching, plant uptake, and residual soil nitrogen, especially in the field. In addition, determinating denitrification by difference generally does not allow evaluation of rates or the dynamic nature of the denitrification process. There is also considerable concern about possible nitrous oxide reaction with the ozone layer of the stratosphere. Thus, the amount of nitrous oxide gas resulting from denitrification is also an important environmental consideration.

Field methods for measuring denitrification other than by difference have required placing a sealed compartment over the soil surface and either trapping or sampling the gases evolved. This method measures nitrous oxide evolution reasonably well. However, it is difficult to determine how much nitrogen gas has evolved, because small increases above the ambient atmospheric concentration of 78 percent nitrogen cannot be measured.

Research was conducted to measure both nitrous oxide and nitrogen gas evolved from denitrification of fertilizer applied to a field soil under controlled conditions conducive to denitrification. In an open system, such as a field, some means must be used to distinguish fertilizer-derived nitrogen gas from the nitrogen gas of the soil atmosphere. High enrichments of the stable isotope, nitrogen-15, were used to learn if the nitrogen gas component of the volatile denitrification products could be measured effectively in a field soil from the isotopic composition of the gas.

Measurement techniques

The field plot (4.6 x 6.1 meters), on Yolo loam soil at Davis, California, was cropped with perennial ryegrass for more than a year before the experiment. The plot was kept constantly wet near saturation by rainfall or by a sprinkler system. The soil-water suction in the top 10 centimeters (cm) of soil was maintained at approximately 0.2 centibar. In the center of the plot were placed tensiometers, soil solution samplers, neutron

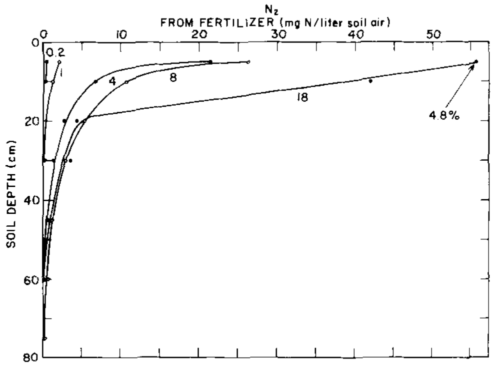

Fig. 1. Nitrogen gas concentration profiles derived from the fertilizer at five sampling times (0.2, 1, 4, 8, and 18 days) after application of potassium nitrate. Each data point is the average from two gas samplers with the open and closed circles used to distinguish different days.

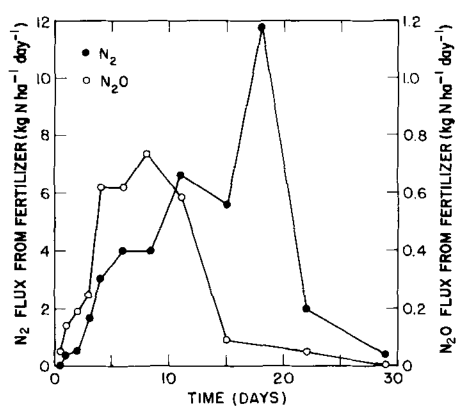

Fig. 2. Nitrous oxide (N_2O) and nitrogen (N_2) gas diffusing from the soil surface as a function of time after applying nitrate fertilizer. Note that the scale for N_2O is ten times smaller than for N_2. Each data point is the average gas diffusion (flux) determined from two gas samplers.