

*Asian Pear
Varieties
in California*



Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

Sale Publication 4068

Printed May 1977

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in California

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THIS PUBLICATION provides technical and practical information about Asian pear varieties in California for pear growers, horticulturists, plant science students, and research scientists. Horticultural descriptions and photographs of ten Japanese and two Chinese pear varieties offer a ready means of tree and fruit identification. Information on origin, source, bloom dates, pollination status, harvest dates, fruit quality, storage, and season are included for each variety. General information concerning history, rootstocks, pollination requirements, training and pruning, disease and insect susceptibility, and fruit storage are also presented.

The authors hope the publication will stimulate interest in and further research with these delicious and versatile fruits.

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ACKNOWLEDGMENTS

Thanks are gratefully expressed to Dr. James J. Dunning for a critical reading of the manuscript. Appreciation is also due to Ruth B. Griggs for her assistance with the horticultural descriptions, to Don A. Edwards for the photographic work, to Ayako Maeda for her arrangement of the material in the cover photograph, to Dr. Kay Ryugo and Dr. Henry Schneider for obtaining background information from Japanese scientists regarding Asian pears, and to James A. Beutel, John J. Smith, and Steven G. Sibbett for information regarding Asian pear orchards in California.

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Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. James B. Kendrick, Jr., Director, Cooperative Extension, University of California.

7½M-6/77-VL/SL

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Chojuro pear tree with fruit.

Asian Pear Varieties in California

ORIGIN AND HISTORY

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 Kikuchi (1948). Hu (1937) included the Chinese varieties Tsu Li and Ya Li under the binomial *P. bretschneideri* Rehder. Catlin and Olsson (1966) reported the Japanese pears Kikusui, Nijisseiki, Seigyoku, Shinseiki, Chojuro, Doitsu, Imamura Aki, and Ishiiwase were varieties of *P. serotina*, and were unable to chromatographically distinguish Tsu Li and Ya Li from the Japanese varieties.

Asian pears remain firm, and are crisp and juicy when eating-ripe, whereas Bartlett and other *Pyrus communis* Linnaeus varieties become soft and melting when ripe. Asian pears are also called Oriental, Chinese, Japanese, Nihon nashi, sand, apple, and salad pears. In fresh-fruit market reports they are usually called "apple pears", an unfortunate and misleading term. Although most Japanese pear varieties are roundish, their texture and flavor are entirely different from those of apples: the main Chinese pear varieties are pyriform. Sometimes the market reports refer to Asian pears as "apple (Shalea) pears". The name Shalea probably is derived from the word "sha li", which means "sand pear" in Chinese. Sha Li is also the name of one of the three main groups of pears grown in China, as well as the name of an old variety within the group (Hu, 1937).

Chinese miners brought in and planted seeds of Chinese pears along streams of the Sierra Nevada during the California gold rush (Day, 1947). Later Chinese and Japanese immigrants brought more seeds and evidently some scion wood from cultivated varieties in China and Japan. These pears have been maintained for the most part in the yards of city residents, as well as by farmers of Asian descent. There have also been a few small commercial plantings in California since near the beginning of the century. One such planting was developed about 1921 by Dr. Wong Him, a San Francisco physician, near the town of Agnew in the Santa Clara Valley. It consisted of approximately 15 acres of Sha Lea pear trees which produced roundish, russet-skinned fruits. The orchard was purchased in 1934 by Mr. Williams B. Weston, who marketed the pears in San Francisco, Los Angeles, and Honolulu for many years before the orchard was lost to urbanization in 1970.¹ Other early plantings of Asian pears were developed in the Sacramento River delta area, in the Sierra foothills around the towns of Loomis, Penryn, and Newcastle, and possibly in other areas of the state.

California nurseries may have been responsible for bringing some varieties of Asian pears into the state. Mr. Charles Choichi Nitta, an orchardist in the Loomis area, recalls that a nursery in the Newcastle area was the source of his first Nijisseiki (Twentieth Century) pear trees, which he obtained about 1927.

The Chojuro variety, a brown, russet-skinned pear which originated in Japan about 1895, seems to be the most widely grown Asian pear in California, and probably was one of the

¹ This information provided by William B. Weston, Jr., Santa Clara.

first true Japanese varieties brought into the state. During the 1950's, the U.S. Plant Introduction Station at Glenn Dale, Maryland, provided the authors with scion wood from a number of varieties of Asian pears. Various institutions in Japan, China, and Korea had supplied the wood to the Plant Introduction Station. These varieties have been maintained and propagated under continuing study in the University of California Department of Pomology orchards. In recent years, scion wood from the best of these varieties has been available to growers and nurserymen.

Japanese horticulturists classify their pear varieties according to skin color and russeting. The green-skinned varieties usually are free of russeting, and some turn yellow upon ripening. The russet-skinned varieties have brown, yellowish-brown, or greenish-brown skin. The green-skinned varieties maintained in the Pomology orchards and included in this study are Kikusui, Nijisseiki (Twentieth Century), Seigyoku, and Shinseiki. The russet-skinned varieties are Chojuro, Doitsu, Imamura Aki, Ishiiwase, Kumoi, and Okusankichi (Bansankichi). All of these Japanese varieties are roundish in shape. 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 Japanese varieties. Although Tsu Li and Ya Li originated in China, they are also cultivated in Japan.

To determine which types of Asian pears are preferred by consumers, several varieties from the University collection were placed in an oriental food store in Sacramento during August and September of 2 years. Patrons tasted and evaluated the fruits. The results indicated that most customers preferred the green-skinned varieties over the russet-skinned.

Interest in Asian pears has increased in recent years. Pear growers have noted the fresh-fruit market reports indicating higher prices paid

for Asian pears than paid for Bartletts. The increased demand is probably due to the increased number of immigrants from Asian countries, as well as to the increased availability of these fruits. Most people like Asian pears once they have tried them. These crisp, succulent fruits are compatible with vegetables as well as with other fruits, and are delicious in either fruit or vegetable salads. Growers in the Loomis and Newcastle areas capitalized on this, and increased their sales by marketing the Asian pears under the name "salad pears". In China and Japan, Asian pears are usually consumed between meals as fresh fruit. Evidently the use of these pears in salads, and the term salad pear, are American. Replacing the old poor quality seedling trees and varieties with the best commercial varieties, such as Twentieth Century, Kikusui, Shinseiki, Seigyoku, and Ya Li, should result in further increased demand.

At present there are only a few hundred acres of Asian pears in commercial orchards in the state. Tulare County, with approximately 225 acres planted mainly to Twentieth Century, is the leading producer of these pears. There are small acreages in Fresno, Placer, Sacramento, San Bernardino, Solano, and Yolo counties. Undoubtedly, there are also some yard and home orchard trees scattered throughout the state. In contrast, in 1974 there were 42,080 acres of European pears in California, with the Bartlett variety making up 95.7 percent of the acreage (California Crop and Livestock Reporting Service, 1975). In Japan, there were 46,930 acres of Asian pears and 2,470 acres of European pears in 1974 (Ministry of Agriculture and Forestry, Japan, 1975). According to Chino (1968), Chojuro and Nijisseiki (Twentieth Century) comprise 39.0 percent and 35.4 percent, respectively, of the Asian pear acreage in Japan. Average yields for Japanese and European pears in Japan for the period 1969-74 were, respectively, 11.1 and 6.2 tons per acre (Ministry of Agriculture and Forestry, Japan, 1975). For the same 6-year period in California, Bartlett pears had an

average annual yield of 8.3 tons per acre (California Crop and Livestock Reporting Service, 1971-75). Comparable data for Asian pears in California are not available.

In general, Japanese and Chinese pear trees are grown in California under the same cultural practices as those used for *P. communis* varieties.

ROOTSTOCKS

In Japan, Asian pear varieties are generally propagated on *P. serotina* (*P. pyrifolia*) seedlings. Tanaka (1933) studied several different Asian pear species as rootstocks for the Chojuro pear in Japan. Trees with *P. serotina*, *P. betulaeifolia*, or *P. bretschneideri* seedling roots made better growth, and had higher percentages of survival, than did trees with *P. calleryana* roots. He concluded that Chojuro trees with native *P. serotina* seedling rootstocks were equal or superior to trees with any of the other rootstocks studied. In China, Tsu Li and Ya Li are commonly propagated on *P. betulaeifolia* Bunge seedlings (Hu, 1937). 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 1-year-old nursery trees, most varieties produce some fruits in their 4th year in the orchard. Production in Tsu Li, however, is usually delayed until the 5th year.

Experience with other rootstocks has been more limited. During 1955 through 1959, a number of Asian varieties were topgrafted on young Old Home trees with Angers quince rootstocks. In the Pomology orchards these grafts usually produced fruits in their second or third growing season. As these trees matured, most of them lacked vigor, tended to set too many fruits, and required heavy thinning for satisfactory fruit size. When the trees were pulled in 1964 to accommodate campus expansion, it was noted that the more

vigorous ones had developed large roots above the Old Home / quince graft union. The vigorous trees, therefore were being supported by an Old Home root system as well as by the original quince rootstock, whereas the weak trees were supported by quince roots only.

Periodically during 1961 through 1969, the 12 Asian varieties were topgrafted on young *P. communis* seedlings (Bartlett and Winter Nelis), and on *P. betulaeifolia* seedlings, in the Department of Pomology orchards. The resulting trees with *P. betulaeifolia* roots are much larger and more vigorous than comparable trees with Bartlett or Winter Nelis seedling roots. Trees with *P. betulaeifolia* roots came into bearing about 1 year later than those on *P. communis* roots, but once they started fruiting they had more and larger fruits.

In October, 1972, Farm Advisor John J. Smith reported that young Twentieth Century, Chojuro, and Kikusui trees with *P. calleryana* or *P. betulaeifolia* seedling rootstocks were approximately twice the size of comparable trees with *P. communis* seedling (Bartlett and Winter Nelis) rootstocks. The trees were planted in replicated plots in four commercial orchards in Placer County in 1967 and 1968. Trees with *P. calleryana* or *P. betulaeifolia* seedling roots maintained vigor as they came into production, whereas those with Bartlett or Winter Nelis seedling roots set heavy crops which evidently retarded framework growth.

We examined the Placer County rootstock plots August 11, 1976 and found the trees with *P. betulaeifolia* or *P. calleryana* seedling rootstocks to be larger and more vigorous than comparable trees with *P. communis* seedling rootstocks, but the differences were not as great as they had been in 1972. Trees with *P. betulaeifolia* or *P. calleryana* rootstocks were about equal except that trees with *P. betulaeifolia* rootstocks were apparently more tolerant to wet soils in poorly drained areas.

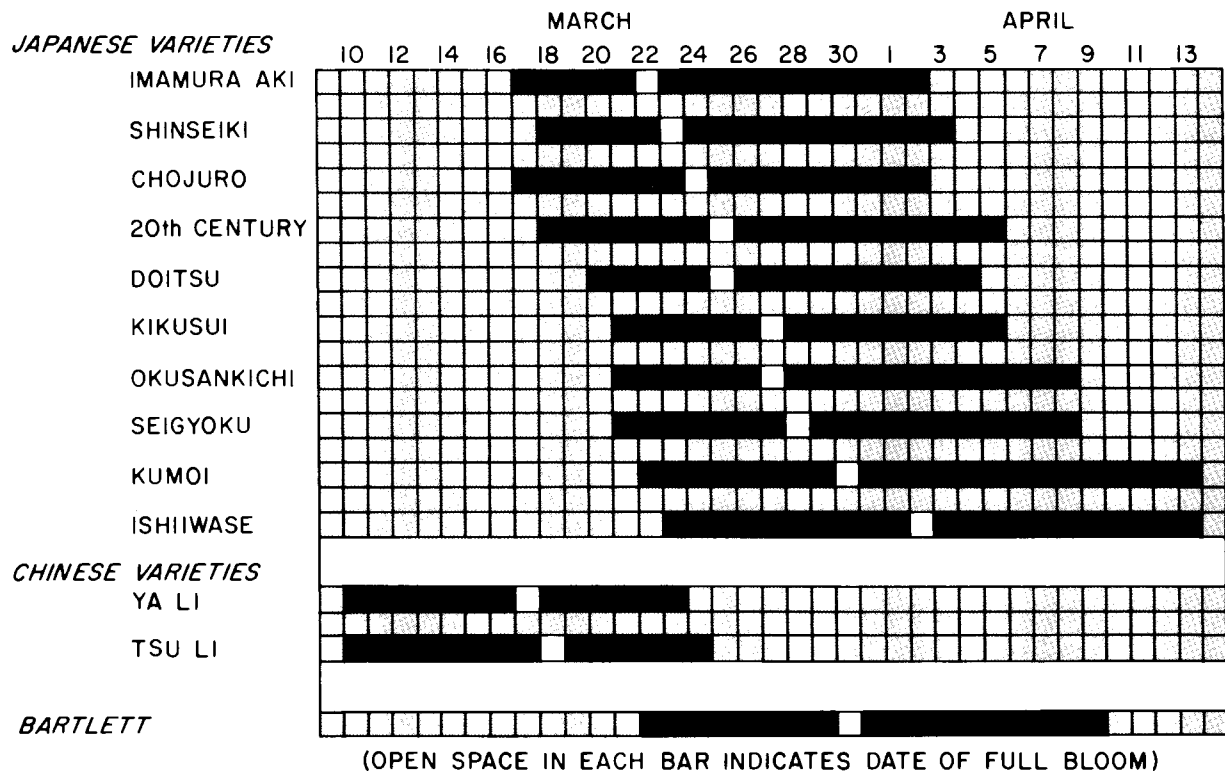
POLLINATION REQUIREMENTS

Cross-pollination is generally required to ensure commercial crops of Asian pears. In Japan, the two most widely planted varieties, Chojuro and Twentieth Century, are generally considered self-incompatible (Asami and Hayami, 1934). But Dr. Shunzo Watanabe, Faculty of Agriculture, Yamagata University, Tsuruoka, Japan, informed us of a recent study in which self-pollinated Chojuro flowers in seven different prefectures gave fruit-sets ranging from 0 to 11.2 percent, with an average of 1.6 percent. Self-pollinated Twentieth Century flowers in five prefectures gave fruit-sets ranging from 0 to 16.3 percent, with an average of 5.8 percent (correspondence of March 1, 1973). Under California conditions,

these varieties will set a few seeded fruits after self-pollination, and are therefore considered partly self-compatible. However, the percentages of flowers setting fruits after self-pollination are very low in comparison with the percentages obtained from cross-pollination.

In addition to Chojuro and Twentieth Century, we consider Kikusui and Shinseiki to be the most promising Japanese pears for California. These latter varieties have higher percentages of fruit-set after self-pollination than do Chojuro or Twentieth Century, and also produce some parthenocarpic fruits. Consequently, Kikusui and Shinseiki may range from partly to nearly commercially self-fruitful under the most favorable conditions.

AVERAGE DATES OF FIRST, LAST, AND FULL BLOOM OF ASIAN PEAR VARIETIES, AND OF BARTLETT PEAR, AT DAVIS, CALIFORNIA



Average dates of first, last, and full bloom of Asian pear varieties and Bartlett pear, Davis.

Table 1

PERCENT FRUIT-SET FROM SELF- AND CROSS-POLLINATION OF ASIAN VARIETIES

Variety pollinated	PERCENT FRUIT-SET FROM ASIAN VARIETIES ¹												
	Pollen variety												
	Imamura Aki	Shinseiki	Chojuro	20th Century	Doitsu	Kikusui	Okusankichi	Seigyoku	Kumoi	Ishiiwase	Ya Li	Tsu Li	Bartlett
Imamura Aki	0	13	17	25	11	21	—	10	0	0	19	6	19
Shinseiki	9	11	42	40	29	39	30	12	0	8	38	39	36
Chojuro	7	20	5	20	50	20	—	5	0	—	47	25	17
Nijisseiki (20th Century)	36	47	54	0	7	3	10	8	0	4	56	57	57
Doitsu	26	45	14	22	0	22	—	22	—	—	4	38	25
Kikusui	—	53	65	20	43	6	3	41	2	21	35	41	45
Okusankichi	—	22	14	31	—	28	3	—	—	—	—	—	16
Seigyoku	—	0	16	24	38	32	8	0	0	—	26	50	46
Kumoi	—	40	33	42	27	69	—	57	3	—	32	49	8
Ishiiwase	6	43	16	25	14	41	—	27	0	0	—	23	32
Ya Li	12	24	25	60	—	34	—	9	—	—	1	16	24
Tsu Li	0	8	9	4	—	2	—	—	—	—	31	2	6

¹ Values are percentages of emasculated flowers that set fruits following self- or cross-pollination. Pollination tests were made during the period 1965 through 1976.

Chojuro, Twentieth Century, Kikusui, and Shinseiki 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. Dr. Shunzo Watanabe informed us of a study in Japan that indicated that Kikusui and Twentieth Century are inter-incompatible (correspondence of March 1, 1973). In California, Kikusui flowers gave good fruit-set (20 percent) when cross-pollinated with Twentieth Century pollen, whereas 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. The bloom period of Bartlett also overlaps the bloom periods of these oriental varieties, and is an effective pollenizer for each of them. Honeybees or other pollinating insects are necessary to effect natural cross-pollination between varieties interplanted in an orchard.

The Chinese varieties Ya Li and Tsu Li are self-incompatible, and need cross-pollination for satisfactory crops. Since they are inter-compatible and bloom at approximately the same time, they should serve as good pollenizers for each other. Ya Li and Tsu Li are also inter-compatible with several of the Japanese varieties, but they usually reach full bloom before or about the time the Japanese varieties start to bloom. Evidently there is adequate overlap in the bloom periods of the two types for cross-pollination, however, as the Chinese varieties usually set good crops when interplanted with Japanese trees.

Enough pollenizer trees and bees should be provided to ensure adequate fruit-set for both Japanese and Chinese varieties in years when adverse weather conditions prevail during part

of the bloom and fruit-setting period. Based on our past experience with self-unfruitful European pear varieties (Griggs, 1953), we recommend that every fourth row be planted 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. This places a pollenizer next to every tree of the main variety in the orchard. During the blossoming period, the grower should provide at least one strong colony of honeybees for each acre of trees to be cross-pollinated. It is not necessary to distribute the hives singly throughout the orchard. They may be dispersed in groups of 8 to 10 without significant loss of pollinating potential. During years when weather conditions are ideal for flower development, bee activity, pollen tube growth, and fertilization, excessive fruit-set may be expected. Under these conditions, thinning will be required for satisfactory fruit size.

Evidently none of the Asian pear varieties in our collection produces enough parthenocarpic fruits for a commercial crop. The low percentages of seedless fruits set from flowers emasculated and bagged to prevent self-pollination as well as cross-pollination, indicate that parthenocarpy is not an important factor in the production of these pears.

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. Otherwise the Asian varieties may be satisfactorily trained and pruned by the standard methods for *P. communis* varieties. Growth conditions, and the various characteristics of different varieties, help determine the type and degree of pruning in a given situation. Part of the following is based on discussions by Davis and Tufts (1941) and Tufts and Harris (1955).

Pruning young trees

The pruning of young trees should be a training process to develop sturdy trees capable of producing large crops of good quality fruits. At planting, the nursery tree should be cut back to 24 to 30 inches (61.0 to 76.2 cm) from the ground to balance the loss of roots removed in digging at the nursery, and also to form a relatively low head. A coat of white-wash or white water-based paint will prevent sunburn on the trunk of the newly planted tree.

In the dormant period after the first growing season, the tree should be thinned to three primary scaffold branches; and these should be headed to a length of 24 to 30 inches (61.0 to 76.2 cm) to force secondary branches. Ideally, the primary scaffolds should be 6 to 12 inches (15.2 to 30.5 cm) apart, with the lowest at least 12 inches (30.5 cm) above the ground. The three primary scaffolds should be properly balanced around the trunk, forming angles of about 120 degrees each when viewed from above. This will give balance and symmetry to the tree.

Where fireblight (*Erwinia amylovora* [Burr.] Winslow *et al.*) is a severe problem, some growers allow four or five primary scaffolds to develop, since fireblight infection may necessitate removal of some branches.

Usually each of the three branches forming the original framework gives rise to several shoots. At the second dormant pruning, retain one or two of these on each primary scaffold for a total of four to six secondary framework branches. Other vigorous growth should be removed. Each secondary scaffold should be headed to a length of 24 to 30 inches (61.0 to 76.2 cm) to force the third set of framework branches. If two shoots forming a fork are headed evenly, they tend to develop equally with a crotch that is usually mechanically weak. But if the shoot that best continues the

general direction of the framework is pruned less severely, it will grow strong. The second and shorter shoot will then develop into a minor branch, forming a strong crotch. Three branches should never be allowed to arise from one point.

At the third dormant pruning, 8 to 12 tertiary framework branches are selected and headed at the point where the next whorl of branches is desired. The other shoots are thinned out, and those remaining are left unheaded.

In later dormant prunings, the fourth and fifth tiers of framework branches may be selected and headed where branching is desired, until the framework is complete. Other branches are moderately thinned.

Lightly pruned, nonbearing trees have stockier and stronger trunks and branches than do more severely pruned ones. The lighter the pruning, the greater the development. To check any branch or part, cut it heavily. To encourage any part, prune it lightly, or not at all. Lightly pruned trees bear sooner than heavily pruned ones.

Pruning bearing trees

Young Asian pear trees, similarly to *P. communis* trees, produce a good portion of their fruits at or near the tips of 1-year-old shoots; but as the trees mature, most of the fruits are borne terminally on spurs. The productive life of an individual spur is about 8 to 10 years. Therefore, only about 10 to 12 percent of the spurs need to be replaced each year. In addition to thinning the branches, spurs should also be thinned. Longer, many-branched spurs should be renewed by removing older parts to stimulate new growth.

The bearing tree is pruned to maintain a balance between production of marketable fruits and vegetative growth. Pruning should consist primarily of removing weak wood and

water sprouts, maintaining the desired height, and keeping the top of the tree sufficiently open to admit light and permit adequate spray coverage. As the tree reaches the desired height, the top branches should be cut back to laterals. In later years, shoots arising near each of these pruning cuts should be thinned to one or two.

Removal of branches to admit sunlight into all parts of the tree is essential for new spur development and regular bearing of existing spurs. This is particularly important in maintaining the lower branches of older trees. These branches should not be cut back to laterals, as this may progressively shorten and eventually eliminate them. The terminal shoots on these lower branches should be tipped to remove the terminal fruit buds and stimulate growth, so the branch will maintain its position and not be shaded out.

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 (1.5 to 1.8 m) high under the severe and stylistic Tanazukuri training system (Kubo, 1962), we feel that the Asian varieties could be grown in hedgerows as successfully as the *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 near room temperature. Asian pears have a relatively long

shelf life, and will maintain their harvest quality for 10 to 14 days at room temperature. If held in cold storage at about 32° F (0° C), most varieties will keep until the Christmas season; and a few varieties, such as Chojuro, Okusankichi, and Shinseiki, will maintain acceptable quality until February.

DISEASE AND INSECT SUSCEPTIBILITY

Asian pear varieties are susceptible to fire-blight (*Erwinia amylovora*) infection. Although most varieties are not damaged as severely as Bartlett and other susceptible varieties of *P. communis*, bactericidal treatment is necessary during the bloom period to control the disease.

In Japan, black rot disease, caused by the fungus *Physalospora piricola* Nose, may cause serious damage to pear trees by attacking fruits, leaves, and branches. Standard varieties such as Chojuro and Twentieth Century apparently are susceptible to the disease. Doitsu, Ishiiwase, Kikusui, and Shinseiki are reportedly highly resistant to black rot (Plant Inventory No. 163, 1964). According to Kubo (1962), Kumoi also is highly resistant.

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 must be directed against it.

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

Japanese Pears:

Varieties producing fruits with green or yellowish-green skin relatively free of russet

KIKUSUI

ORIGIN. Seedling of Taihaku x Nijisseiki (Twentieth Century), originated by Dr. Akio Kikuchi, Tokyo Horticultural School, Tamagawa District, Tokyo, Japan. Cross made in 1915, introduced in 1927 (Kubo, 1962).

SOURCE. U.S. Department of Agriculture from the Faculty of Agriculture, Toyko University, Hongo, Tokyo, Japan; received March 10, 1955 and numbered P. I. 224086 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1957.

Horticultural Description

TREE. Medium size and vigor, spreading, slightly drooping, dense, very productive. **Trunk:** medium diameter; bark medium rough with dark, greenish-brown under-color overlaid with thin, scaling, grayish-white cork tissue. **Branch:** medium diameter; bark medium rough with dark brown under-color overspread with scattered areas of scaling, grayish-white cork tissue; lenticels conspicuous, large, elliptical or oblate, light brown. **Branchlet:** medium diameter; internode length 1.81¹ inches (45.9 mm); bark smooth, greenish brown; lenticels numerous, elliptical, raised, medium-sized, tan; pubescence on new growth, sloughing off with age. **Leaf bud:** alternate phyllotaxis; free; conical; length 0.29 inch (7.3 mm); width 0.20 inch (5.2 mm); scales dark brown, covered with grayish-white scarfskin, tan pubescence protruding from scale margins. **Flower bud:** length 0.40 inch (10.2 mm); width 0.20 inch (5.0 mm); conical; plump; scales dark brown with a covering of grayish-white scarfskin, pubescence from ventral surfaces

¹ All measurements in this study except ranges are averages.



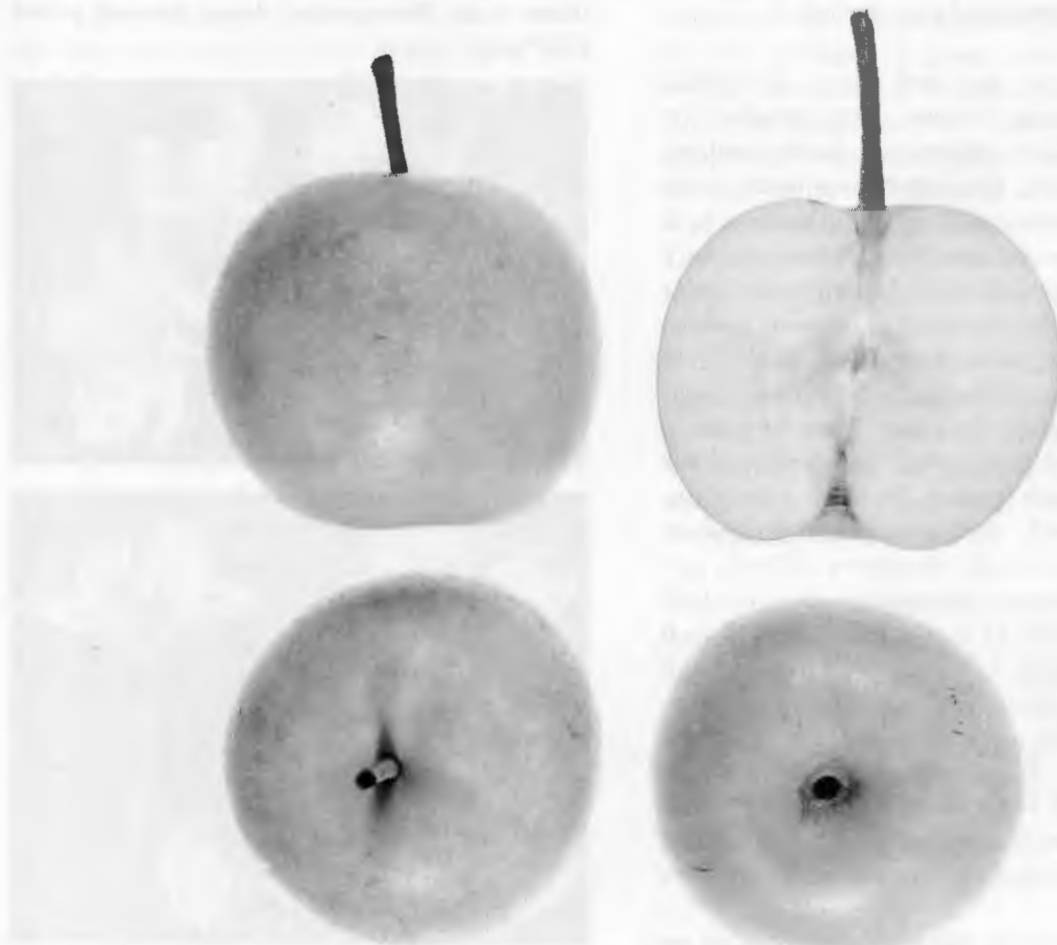
Kikusui. Left to right: first three are old spurs bearing flower buds; fourth from left: 2-year-old wood terminated by three young spurs; extreme right: 1-year-old shoot bearing one terminal and two lateral flower buds. Photographed during dormant period (February).



Kikusui flower cluster, and flowers and petals.



Kikusui leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Kikusui fruits, mature (eating-ripe).

protrudes along margins. Buds borne terminally on 0.50- to 1.00-inch (12.7- to 25.4-mm) spurs arising from 2- or 3-year-old wood, old spur systems, and 1-year-old shoots; a few are borne laterally on 1-year-old shoots. Lenticels on the spurs are small, round, unevenly scattered, raised, tan, and many have median longitudinal fissures.

LEAF (from current season's shoots). **Blade:** length 4.88 inches (124.0 mm); width 2.94 inches (74.8 mm); most folded upward slightly from ventral midrib; ovate; apex acuminate, sometimes acute; base rounded; thick; stiff; leathery; ventral (upper) surface of young leaves green with a cast of red; mature leaves with dark green ventral and light green dorsal surfaces; both surfaces of young leaves pubescent; old leaves glabrous or subglabrous; midrib light green, pubescent on upper and lower surfaces of young leaves, subglabrous in old leaves, ventral surface with many small, black trichomes and some larger green ones with brown tips; veins pinnately netted, upper surface pubescent, lower surface glabrous; margins with sharply setose serration, teeth length 0.06 to 0.08 inch (1.5 to 2.0 mm), sinuses wide, shallow, angular or somewhat rounded at bases. **Petiole:** length 1.54 inches (39.0 mm), mid-diameter 0.07 inch (1.9 mm), light green, pubescent, channeled. One to three spiny, needle-like stipules may occur on ventral side of petiole near base of blade.

INFLORESCENCE. Corymb, with an average of eight flowers.

FLOWER. Width 1.46 inches (37.1 mm). **Pedicel:** length 0.47 inch (11.9 mm), mid-diameter 0.04 to 0.06 inch (1.0 to 1.5 mm), light green, pubescent. **Floral tube** (surrounding ovary): light green, subglabrous, or glabrous. **Sepals:** acuminate; length 0.17 inch (4.4 mm); basal width 0.14 inch (3.6 mm); slightly reflexed downward to slightly erect; light green; ventral surface pubescent, dorsal surface glabrous; margins appear serrated due to small, brown glandular trichomes. **Petals:** white; length 0.54 inch (13.8 mm);

width 0.42 inch (10.6 mm); oval or oblong; concave; margins variable, most undulate, some entire, few clefted. Most Kikusui flowers have five petals, but specimens with eight or ten petals are common. **Stamens:** 28 to 36 per flower, length sufficient to extend anthers to level of stigmas, filaments white, anthers purplish red (Plate 6 F 4, Maerz and Paul, 1950). **Pistil:** with five or six glabrous, light green styles separated to ovary; ovary usually with five carpels.

FRUIT. **Size:** fairly uniform, length 2.30 inches (58.4 mm), diameter 2.89 inches (73.4 mm), weight 185.4 grams. **Shape:** uniform, oblate and lopsided in longitudinal section, angular in transverse section. (Kikusui fruits are more oblate in longitudinal section and more angular in transverse section than Twentieth Century fruits which they closely resemble.) **Stem (pedicel):** length 1.24 inches (31.4 mm); mid-diameter 0.09 inch (2.4 mm); slightly curved; broader at cavity; light green (Plate 14 L 1, "Palmleaf", Maerz and Paul, 1950); slightly pubescent with raised, light tan, elliptical lenticels. **Cavity:** acute; shallow to medium depth; medium breadth; sides slightly angular; surface smooth except for numerous, small, inconspicuous lenticels. **Basin:** angular; deep and broad; sides sloping; surface smooth; lenticels small, nearly obscure. (Kikusui fruits have deeper basins than Twentieth Century fruits.) In most specimens a rough, russeted ring of tan or brown scar tissue present where sepals were attached; exposed surface of the calyx tube also russeted. **Calyx:** usually deciduous, but remnants persist in some specimens; persistent lobes narrow, open, separated at base, usually erect. **Skin** (ripe fruits): predominantly yellowish green (Plate 13 L 1, Maerz and Paul, 1950), usually faintly mottled with green; a few faint green streaks extend from the cavity to near the basin; slightly bitter, detracts somewhat from general flesh flavor; relatively tough and thick; adhesion to flesh tight; surface dull, smooth except for lenticels; lenticels conspicuous, medium-sized, slightly raised, numerous, hexagonal or roundish, tan (Plate 12 I 6, "Powdered gold", Maerz and Paul, 1950), some with a glob of pinkish-tan

Table 2.

SELF-FRUITFULNESS OF ASIAN PEAR VARIETIES, DAVIS, CALIFORNIA, 1976

Variety	Treatment						
	Emasculated, then bagged ¹	Emasculated, self-pollinated, then bagged ²		Bagged only ³		Open-pollinated ⁴	
	<i>Percent fruit-set</i>	<i>Percent fruit-set</i>	<i>Average number seeds per fruit⁵</i>	<i>Percent fruit-set</i>	<i>Average number seeds per fruit⁵</i>	<i>Percent fruit-set</i>	<i>Average number seeds per fruit⁵</i>
Imamura Aki	0.0	0.0	—	0.0	—	4.8	8.2
Shinseiki	0.0	14.1	2.6	4.4	4.0	14.7	7.4
Chojuro	0.0	4.6	4.0	0.0	—	12.7	6.3
Nijisseiki (20th Century)	0.0	0.0	—	0.0	—	7.1	6.5
Doitsu	0.0	0.0	—	0.0	—	14.6	6.7
Kikusui	0.0	0.0	—	5.4	3.4	14.6	4.7
Okusankichi	0.0	0.0	—	1.3	3.0	12.3	3.8
Seigyoku	0.0	0.0	—	0.0	—	29.0	7.2
Kumoi	0.0	2.9	1.5	0.0	—	21.0	8.0
Ishiiwase	0.0	0.0	—	0.0	—	15.5	6.8
Ya Li	0.0	0.0	—	0.4	2.0	24.9	6.8
Tsu Li	0.0	6.2	2.0	0.0	—	21.8	3.7

¹ Any fruits developing from emasculated, bagged flowers would have been the result of parthenocarpy.

² Fruits developing from emasculated, self-pollinated, bagged flowers could be the result of either parthenocarpy or self-compatibility.

³ Fruits developing from bagged, but not emasculated, flowers could be the result of either parthenocarpy or self-compatibility.

⁴ Fruits developing from open-pollinated flowers could be the result of parthenocarpy, self-compatibility, or cross-pollination.

⁵ No seedless (parthenocarpic) fruits developed under this treatment.

cork at their centers. **Calyx tube** (cavity beneath the calyx lobes as seen in longitudinal midsection): funnel shaped, long, medium wide; remnants of styles extend nearly to base of scar where stamens were attached. **Stamens**: generally deciduous, marginal when present. **Core line**: distinct; clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often hexagonal, in transverse midsection; outlined by concentration of stone cells. **Core**: length 1.18 inches (30.0 mm), width 1.24 inches (31.5 mm), distant from stem, medium in relation to fruit size. **Carpels**: five in number, obovate, usually abaxile and closed. **Axial sac**: medium width. **Seeds**: length 0.29 inch (7.3 mm), width 0.19 inch (4.8 mm), plump on one side and flat on the other, apex acute, seed coat dark brown with nearly black margins, average number 4.8. **Flesh**: white (Plate 10 B 1, "Oyster white", Maerz and Paul, 1950); sweet, mild, with a trace of tartness; soluble solids 14.4 percent; aroma faint, but peculiar to this variety; texture firm, tender, crisp, juicy. (Kikusui fruits are somewhat more pulpy and coarse and have more stone cells than do Twentieth Century fruits.) **Quality**: good to very good.

HARVEST. August 10 to 19 at Davis. Pick when eating ripe, usually when skin turns yellowish green. Kikusui fruits should be harvested with care because the stem is relatively easy to separate from the base of the ovary. Stemless fruits have reduced storage and shelf life.

SEASON. From harvest through January if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Kikusui is partly self-fruitful under favorable California conditions, but fruit-sets of this variety will generally be greatly increased with cross-pollination. The self-fruitfulness in this variety is apparently due to a degree of self-compatibility and to the production of parthenocarpic fruits (without fertilization and seed development). The amount of fruits produced as a result of self-compatibility or parthenocarpy varies from year to year, depending upon weather conditions during the bloom and fruit-setting periods as well as on the vigor of the tree.

In 1965, 1966, 1967, 1973, and 1976, Kikusui flowers bagged to prevent cross-pollination set a few fruits, some of which contained fertile seeds. Kikusui flowers emasculated but not pollinated set a few parthenocarpic fruits in 1965 and 1966, but failed to set any fruits in 1967 and 1976. During the same years, Kikusui flowers gave heavy fruit-sets when emasculated and cross-pollinated with Chojuro, Shinseiki, Bartlett, Doitsu, Seigyoku, Tsu Li, or Ya Li pollen, and good fruit-sets when cross-pollinated with Ishiiwase or Twentieth Century pollen. With the exception of Ya Li and Tsu Li, which bloom relatively early, the bloom period of each of these varieties has sufficient overlap with that of Kikusui for good cross-pollination.

Kikusui produces viable pollen, and tests at Davis indicated that its pollen gives good fruit-sets on Imamura Aki, Shinseiki, Chojuro, Doitsu, Seigyoku, Okusankichi, Kumoi, Ishiiwase, and Ya Li.

NIJISSEIKI (TWENTIETH CENTURY)

SYNONYMS. None. Nijisseiki is the Japanese term for twentieth century. In China, the Twentieth Century pear is known as "Er Shih Shih Chi" (Hu, 1937).

ORIGIN. Chance seedling found in Mr. Kakunosuke Matsudo's garden in Matsudo City, Chiba Prefecture, Japan. Introduced in 1898 (Kubo, 1962).

SOURCES. Mr Alfred Nitta, Loomis, California, gave us scions in 1958. Mr. Nitta's father, Mr. Charles C. Nitta, obtained the variety from a California nursery about 1927.

U.S. Department of Agriculture from the Ministry of Agriculture and Forestry, Tokyo, Japan, received March 15, 1955 and numbered P. I. 224196 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1969.

Horticultural Description

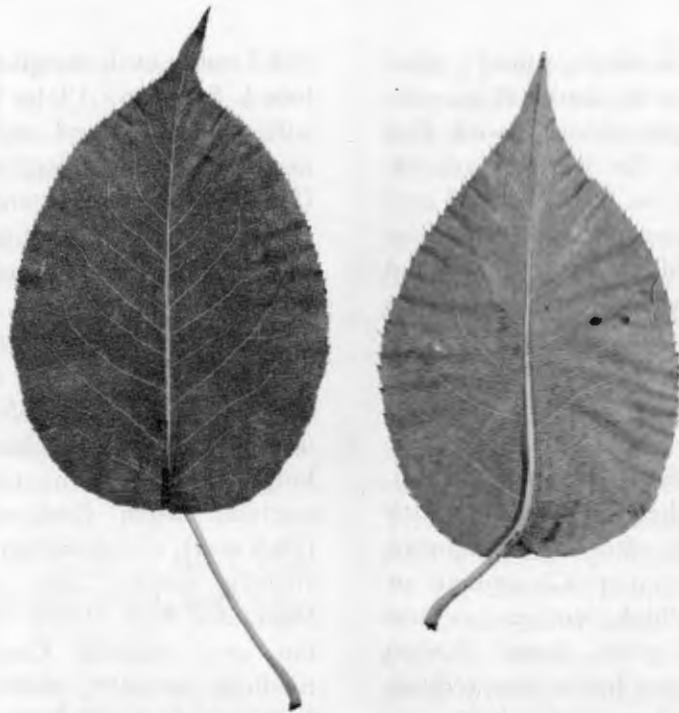
TREE. Medium size and vigor, medium upright-spreading, dense, productive. **Trunk:** medium diameter; bark slightly shaggy or rough with dark greenish-brown under-color overlaid with thin, scaling, grayish-white cork tissue. **Branch:** medium diameter; bark smooth with dark brown under-color and a sparse covering of grayish-white, scaling cork tissue; lenticels conspicuous, raised, large, oblate, tan. **Branchlet:** medium to thick diameter; internode length 1.65 inches (42.0 mm); bark smooth, greenish-brown to greenish-yellowish brown; lenticels oval or elliptical, medium-sized, conspicuous, tan; pubescence on new growth, sloughing off with age. **Leaf bud:** alternate phyllotaxis; free; conical; length 0.28 inch (7.2 mm); width 0.19 inch (4.8 mm); scales dark brown, covered with fine, grayish pubescence and fringed with fine, tan hairs protruding from the margins. **Flower bud:** length 0.39 inch (9.9 mm); width



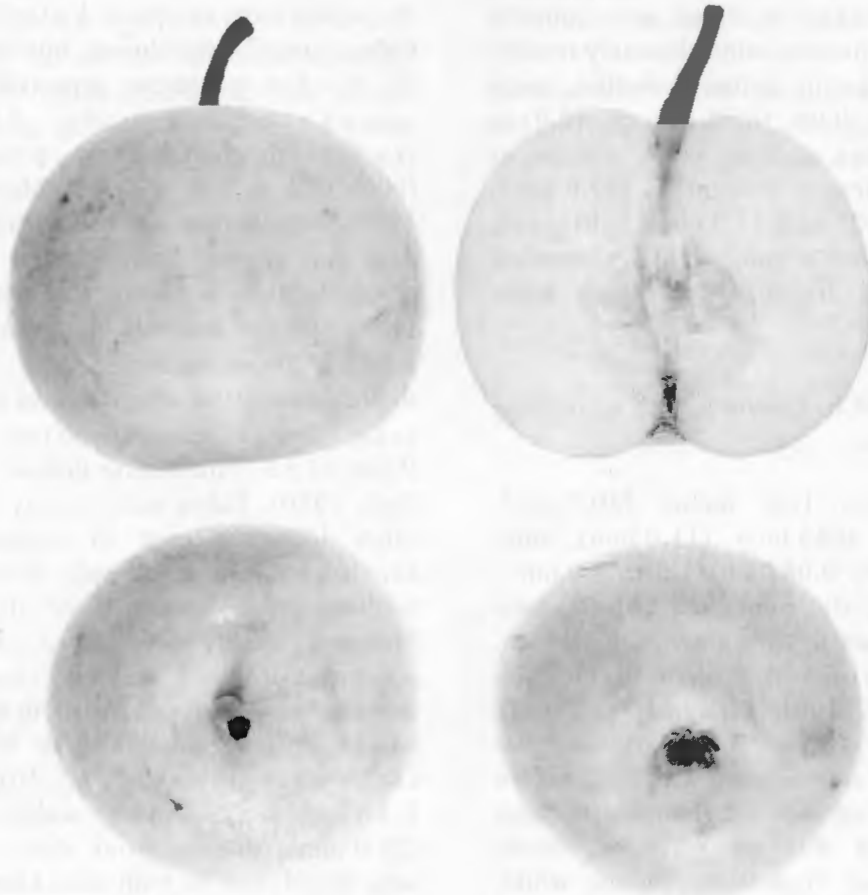
Twentieth Century. Left: old spurs bearing flower and vegetative buds; center: 2-year-old wood with two young spurs bearing flower buds, and 1-year-old wood with a lateral flower bud; right: 1-year-old shoot bearing a terminal flower bud and two lateral vegetative buds. Photographed during dormant period.



Twentieth Century flower cluster, and flowers and petals.



Twentieth Century leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Twentieth Century fruits, mature (eating-ripe).

0.20 inch (5.1 mm); conical; plump; apex tufted; scales brown with scattered grayish-white scarfskin, margins fringed with fine hairs protruding from the ventral surfaces. Buds borne terminally on 0.37- to 1.00-inch (9.4- to 25.4-mm) spurs arising from 2- or 3-year-old wood, old spur systems, and 1-year-old shoots; a few are borne laterally on 1-year-old shoots. The characteristic lenticels scattered on the spurs are small, round, raised, and tan.

LEAF (from current season's shoots). **Blade:** length 4.37 inches (111.1 mm), width 2.50 inches (63.5 mm); often folded upward from central midrib; oval; apex acuminate or acute; base rounded; thick; leathery; ventral (upper) surface dark green, dorsal (lower) surface light green; young leaves have reddish cast and are finely pubescent on both surfaces; old leaves subglabrous or glabrous on both surfaces; midrib light green and pubescent, ventral surface speckled with minute, dark brown trichomes; veins pinnately netted; margins with sharply setose serration, teeth length variable 0.08 to 0.12 inch (2.0 to 3.0 mm), sinuses shallow, wide, angular at bases. **Petiole:** length 1.46 inches (37.0 mm), mid-diameter 0.07 inch (1.9 mm), light green, pubescent on ventral side, slightly channeled near base of blade, stipules on some specimens.

INFLORESCENCE. Corymb, with an average of seven flowers.

FLOWER. Width 1.22 inches (30.9 mm). **Pedicel:** length 0.43 inch (11.0 mm), mid-diameter 0.04 to 0.08 inch (1.0 to 2.0 mm), light green, lightly pubescent. **Floral tube** (surrounding ovary): light green, subglabrous. **Sepals:** acuminate; length 0.16 inch (4.0 mm), basal width 0.13 inch (3.2 mm); often reflexed; pale green, nearly white at margins; ventral side covered with light brown pubescence, dorsal side subglabrous; margins slightly serrated due to scattered, small, brown glandular trichomes. **Petals:** white, length 0.59 inch (15.0 mm), width 0.46 inch

(11.7 mm), oval, margins undulate or slightly lobed. **Stamens:** 19 to 28 per flower, length sufficient to extend anthers to level of stigmas, filaments white, anthers purplish red (Plate 6 G 4, Maerz and Paul, 1950). **Pistil:** five glabrous, light green styles separated to the ovary; ovary usually with five carpels.

FRUIT. **Size:** fairly uniform, length 2.17 inches (55.2 mm), diameter 2.60 inches (66.0 mm), weight 146.5 grams. **Shape:** fairly uniform; round to oblate, often lopsided in longitudinal section; circular in transverse section. **Stem (pedicel):** length 0.97 inch (24.6 mm); mid-diameter 0.10 inch (2.6 mm); slightly curved; light green (Plate 13 H 1, Maerz and Paul, 1950); pubescent with raised, tan, oval lenticels. **Cavity:** acute, uniform, medium breadth, shallow, surface smooth except for small lenticels. **Basin:** circular; broad; shallow; sides sloping; surface smooth except for some russet and scar tissue where the sepals were attached; lenticels small, oval. **Calyx:** usually deciduous, but remnants persist in a few specimens; persistent lobes erect, separated at base. **Skin** (ripe fruits): predominantly greenish yellow (Plate 12 L 1, "Oil yellow", Maerz and Paul, 1950), blotched or mottled with green; bland, does not detract from general flesh flavor; relatively thin and tender; adhesion to flesh tight; surface smooth, dull to semiglossy; lenticels inconspicuous, small to medium, slightly raised, numerous, round or hexagonal, scaly under magnification, light tan (Plate 11 J 5, "Buttercup yellow", Maerz and Paul, 1950). **Calyx tube** (cavity beneath the calyx lobes as seen in longitudinal mid-section): funnel shaped, relatively long, medium wide, remnants of styles present. **Stamens:** usually deciduous, marginal when present. **Core line:** distinct, clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often pentagonal or hexagonal, in transverse midsection. **Core:** length 1.16 inches (29.5 mm), width 1.14 inches (29.0 mm), distant from stem, medium to large in relation to fruit size. **Carpels:** five in number, obovate with basal end acute, usually

abaxile and closed. Axial sac: medium width. Seeds: length 0.33 inch (8.3 mm), width 0.19 inch (4.9 mm), plump, apex acute, seed coat dark brown (Plate 8 L 9, "Domingo brown", Maerz and Paul, 1950), average number 5.5. Flesh: white (Plate 10 B 1, "Oyster white", Maerz and Paul, 1950); sweet, mild, refreshing, slightly tart; core slightly sour; soluble solids 12.3 percent; aroma slight; texture firm, tender, crisp, very juicy, somewhat coarse and pulpy (in relation to Bartlett fruits), with a few stone cells. Quality: good to excellent.

HARVEST. August 10 to 20 at Davis. Pick when eating ripe, usually when skin turns greenish yellow.

SEASON. From harvest through December if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Twentieth Century is slightly self-fruitful under favorable California conditions, but should not be planted without provision for cross-pollination. The self-fruitfulness in this

variety is apparently due to a degree of self-compatibility, which varies from year to year according to weather conditions during the bloom period.

In 1965 tests at Davis, Twentieth Century flowers, bagged to prevent cross-pollination, set a few seeded fruits; but similar bagged controls failed to set any fruits in 1966, 1971, 1973, and 1976. Also, Twentieth Century flowers, emasculated and hand self-pollinated, failed to set any fruits in 1971 and 1976. In contrast, heavy fruit-sets were obtained when Twentieth Century flowers were hand cross-pollinated with pollen from Bartlett, Tsu Li, Ya Li, Chojuro, Shinseiki, or Imamura Aki. Of these pollenizers, the bloom periods of Chojuro, Shinseiki, and Imamura Aki have good overlap with the Twentieth Century bloom. The bloom period of Bartlett has a fairly good overlap with that of Twentieth Century, but the Chinese pears, Ya Li and Tsu Li, bloom too early for a good overlap.

Twentieth Century produces viable pollen, and in tests at Davis it gave good fruit-sets on most of the other Asian pear varieties.

SEIGYOKU

ORIGIN. Seedling of Nijisseiki (Twentieth Century) x Chojuro, originated by Mr. Takuzo Kawashima in Minami-Tama, Tokyo, Japan. Cross made in 1922, introduced in 1952 (Kubo, 1962).

SOURCE. U.S. Department of Agriculture from the National Agricultural Research Institute, Hiratsuka, Kanagawa Prefecture, Japan, received September 19, 1955 and numbered P. I. 228017 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1959.

Horticultural Description

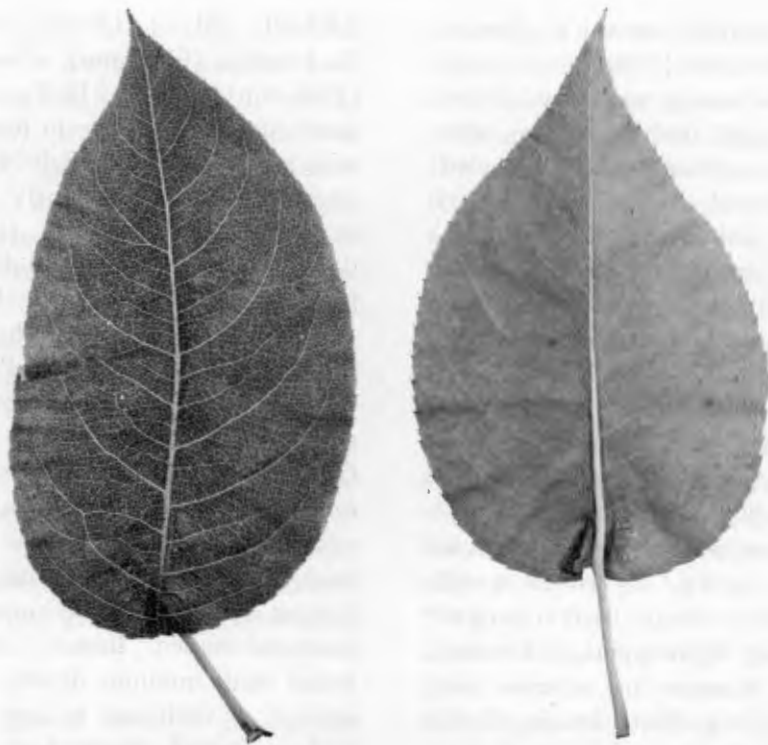
TREE. Small to medium size, medium vigor, open, spreading, somewhat drooping, very productive. **Trunk:** small to medium diameter; bark shaggy with brown under-color overlaid with scaling, grayish-white cork tissue. **Branch:** medium diameter; bark medium rough with dark, greenish-brown under-color covered with shedding, grayish-white cork tissue; lenticels conspicuous, raised, medium-sized, round to oval, tan. **Branchlet:** medium diameter; internode length 1.92 inches (48.7 mm); bark smooth, brown with faint greenish tinge; lenticels small, conspicuous, oval, tan; new growth pubescent. **Leaf bud:** alternate phyllotaxis; free; conical; length 0.20 inch (5.1 mm); width 0.15 inch (3.7 mm); scales brown with scattered covering of whitish-gray scarfskin, tan hairs protruding from margins. **Flower bud:** length 0.45 inch (11.4 mm); width 0.21 inch (5.3 mm); conical; plump; scales dark brown with scattered grayish-white scarfskin, margins fringed with tan pubescence from the ventral surfaces. Buds borne terminally on 0.50- to 1.00-inch (12.7- to 25.4-mm) spurs arising from 3- or 4-year-old wood, old spur systems, and 1-year-old shoots; a very few are borne laterally on 1-year-old shoots. Lenticels on the spurs are variable in size, roundish, raised, tan.



Seigyoku. Left to right: first three are old spurs bearing flower buds; extreme right: two old spurs and a 1-year-old shoot bearing two flower buds. Photographed during dormant period (February).



Seigyoku flower cluster, and flowers and petals.



Seigyoku leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Seigyoku fruits, mature (eating-ripe).

LEAF (from current season's shoots). **Blade:** length 4.50 inches (114.3 mm); width 2.88 inches (73.2 mm); majority folded upward from ventral midrib; ovate; apex usually acuminate, some acute; base rounded; thick; leathery; ventral (upper) surface dark green and slightly pubescent; dorsal (lower) surface light green and glabrous; young leaves light green on both surfaces and pubescent; midrib light green, ventral surface pubescent and speckled with minute, dark brown trichomes, dorsal surface pubescent in young leaves, subglabrous in older ones; veins pinnately netted; margins with sharply setose serration, teeth length 0.03 to 0.04 inch (0.8 to 1.0 mm), sinuses very wide and shallow, nearly flat at bases. **Petiole:** length 1.28 inches (32.6 mm), mid-diameter 0.07 inch (1.9 mm), light green, pubescent, channel shallow. Absence of stipules may serve as an identifying characteristic of this variety.

INFLORESCENCE. Corymb, with an average of five flowers.

FLOWER. Width 1.17 inches (29.8 mm). **Pedicel:** length 0.81 inch (20.7 mm), mid-diameter 0.04 to 0.06 inch (1.0 to 1.5 mm), light green, lightly pubescent. **Floral tube** (surrounding ovary): light green, very lightly pubescent. **Sepals:** acuminate; length 0.15 inch (3.9 mm); basal width 0.13 inch (3.2 mm); often reflexed downward, some horizontal; light green; ventral side matted with light brown pubescence, dorsal side coarse with a few scattered, white hairs; margins appear serrated due to presence of small, brown, glandular trichomes. **Petals:** white; length 0.48 inch (12.1 mm); width 0.43 inch (11.0 mm) roundish to oval; concave; margins undulate, entire, or lobed, a few clefted. **Stamens:** 18 to 36 per flower, length sufficient to extend anthers to level of stigmas, filaments white, anthers purplish red (Plate 4 F 3, Maerz and Paul, 1950). **Pistil:** five or six glabrous, light green styles separated to ovary, one style often considerably shorter than others; ovary usually with five carpels.

FRUIT. **Size:** fairly uniform, length 2.43 inches (61.7 mm), diameter 2.97 inches (75.5 mm), weight 213.2 grams. **Shape:** relatively uniform; oblate in longitudinal section with some specimens slightly lopsided; usually circular, but some slightly angular in transverse section. **Stem (pedicel):** length 0.87 inch (23.8 mm); mid-diameter 0.10 inch (2.5 mm); slightly curved; broadened at the cavity; slightly fleshy; light green (Plate 13 K 2, Maerz and Paul, 1950); glabrous with raised, small, oval, elliptical, or diamond-shaped, light tan lenticels. **Cavity:** usually obtuse, sometimes acute; medium depth and breadth; sides smooth or with two or three shallow furrows; surface smooth, glossy, free of russet; lenticels small, grayish brown, inconspicuous, angular, often diamond-shaped. **Basin:** circular or angular; broad with medium depth; sides sloping and smooth or with two to four shallow furrows; surface smooth, glossy, free of russet; lenticels very small and obscure. In most specimens there is a ring of tan scar tissue where sepals were attached; exposed surface of the calyx tube also russeted. **Calyx:** usually deciduous. **Skin** (ripe fruits): light greenish yellow (Plate 12 L 1, "Oil yellow", Maerz and Paul, 1950) or light yellow (Plate 9 K 3, "Empire yellow", Maerz and Paul, 1950); nearly tasteless; medium tough and thick; adhesion to flesh tight; surface very smooth, semiglossy, usually free of russet; lenticels small, numerous, relatively inconspicuous, angular, often pentagonal or hexagonal, scaly under magnification, tan or light brown (Plate 11 J 5, "Buttercup", Maerz and Paul, 1950). The attractive skin with its inconspicuous lenticels is a distinguishing characteristic of this variety. **Calyx tube** (cavity beneath the calyx lobes as seen in longitudinal mid-section): funnel or slightly urn shaped, long, medium width, remnants of the styles present. **Stamens:** deciduous. **Core line:** distinct; clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often hexagonal, in transverse midsection. **Core:** length 1.16 inches (29.4 mm), width 1.08 inches (27.5 mm), position median or slightly distant from stem, medium in relation to fruit size.

Carpels: five in number, obovate, abaxile, usually closed. **Axial sac:** narrow. **Seeds:** length 0.31 inch (8.0 mm), width 0.17 inch (4.3 mm), plump on one side and flat on the other, apex usually acute, seed coat dark brown with the flat side often lighter than the plump side, average number 4.6. **Flesh:** white (Plate 10 B 1, "Oyster white", Maerz and Paul, 1950); sweet, mild, slightly tart; soluble solids 12.6 percent; aroma faint and similar to that of the Chojuro variety; texture firm, tender, crisp, juicy, somewhat coarse and pulpy, with relatively light concentration of stone cells at the core line. **Quality:** good to very good.

HARVEST. August 1 through 15 at Davis. Pick when eating ripe, usually when skin turns greenish yellow.

SEASON. From harvest through January if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Seigyoku is self-incompatible, or nearly so, but is slightly self-fruitful due to the production of parthenocarpic fruits under favorable weather conditions. At Davis, Seigyoku flowers bagged

to prevent cross-pollination, failed to set fruits in 1965, 1966, 1967, and 1976. Seigyoku flowers, emasculated and self-pollinated by hand, failed to set fruits in 1965, 1971, and 1976. However, Seigyoku flowers emasculated but not pollinated (emasculated controls), set a few parthenocarpic fruits in 1965, 1966, and 1971, but failed to set any fruits in 1967 and 1976. Seigyoku should be interplanted with other varieties to provide cross-pollination.

Heavy fruit-sets were obtained when Seigyoku flowers were emasculated and cross-pollinated with pollen from Tsu Li, Bartlett, Doitsu, and Kikusui, and good fruit-sets were obtained with pollen of Ya Li, Twentieth Century, and Chojuro. The bloom periods of Bartlett, Doitsu, Kikusui, and Twentieth Century have good overlap with that of Seigyoku and the bloom period of Chojuro has a fairly good overlap. Tsu Li and Ya Li bloom too early to be dependable pollenizers for Seigyoku.

Seigyoku produces viable pollen. In tests at Davis it gave good fruit-sets on Doitsu, Kikusui, Kumoi, and Ishiiwase, and fairly good sets on Shinseiki and Imamura Aki.

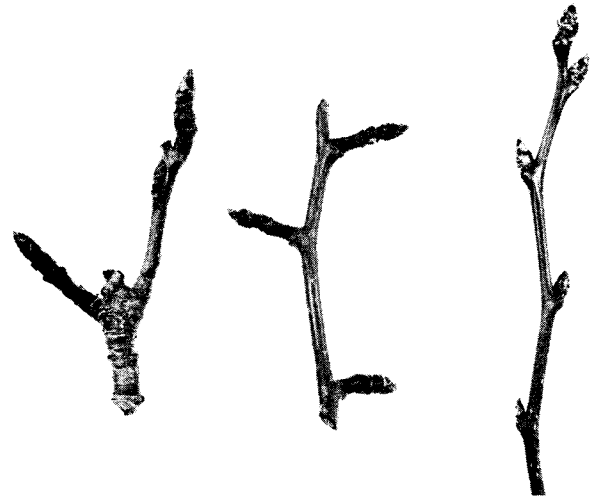
SHINSEIKI

ORIGIN. Seedling of Nijisseiki (Twentieth Century) x Chojuro, originated by Mr. Teiji Ishikawa, Department of Horticulture, Okayama Agricultural Experiment Station, Okayama Prefecture, Japan, introduced in 1945 (Kubo, 1962).

SOURCE. U.S. Department of Agriculture from the Faculty of Agriculture, Tokyo University, Hongo, Tokyo, Japan; received March 10, 1955 and numbered P. I. 224087 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1957.

Horticultural Description

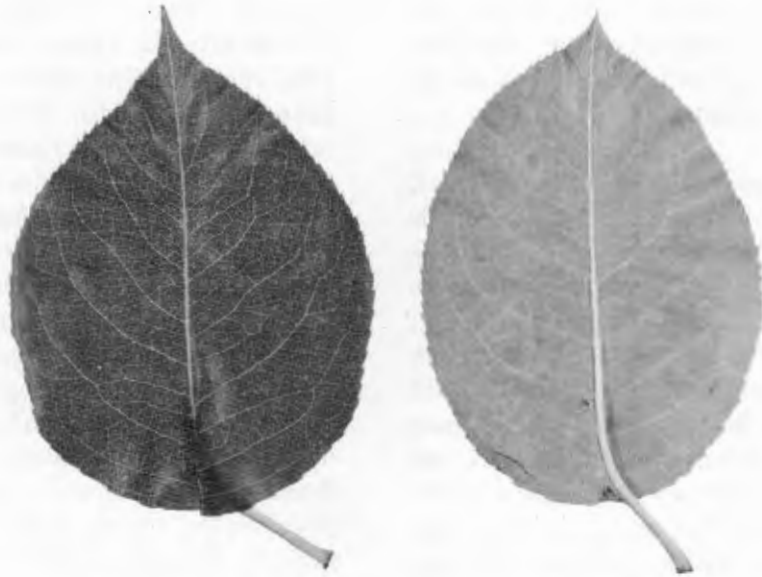
TREE. Medium size and vigor, spreading, medium dense, productive. **Trunk:** medium diameter; bark slightly rough with dark brown under-color overlaid with scaling, grayish-white cork tissue. **Branch:** medium diameter; bark smooth with brown under-color over-spread with scattered areas of shedding, grayish-white cork tissue; lenticels conspicuous, raised, medium to large, round or oval, tan or grayish white. **Branchlet:** medium diameter; internode length 1.46 inches (37.0 mm); bark smooth, greenish brown to brown with sparse covering of grayish-white scarfskin; lenticels elliptical, smooth, conspicuous, small to medium size, tan or ash gray; whitish pubescence on tips of new growth, sloughing off with age. **Leaf bud:** alternate phyllotaxis, nearly free or free, conical, length 0.25 inch (6.4 mm), width 0.18 inch (4.7 mm); scales brown, covered with whitish-gray scarfskin with fine, tan pubescence protruding from the margins. **Flower bud:** length 0.40 inch (10.2 mm), width 0.23 inch (5.8 mm), conical, plump; scales dark brown with scattered covering of grayish-white scarfskin, margins fringed with tan hairs protruding from the ventral surfaces. Buds borne terminally on 0.75- to 1.00-inch (19.0- to 25.4-mm) spurs arising from 2- or 3-year-old wood, old spur systems, and



Shinseiki. Left: old spurs bearing flower buds; center: 2-year-old wood with young spurs bearing flower buds; right: 1-year-old shoot bearing terminal and lateral flower buds and one vegetative bud. Photographed during dormant period (February).



Shinseiki flower cluster, and flowers and petals.



Shinseiki leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Shinseiki fruits, mature (eating-ripe).

1-year-old shoots; a few are borne laterally on 1-year-old shoots. Lenticels on the spurs are small, elliptical to round, raised, tan, many with longitudinal fissures.

LEAF (from current season's shoots). **Blade:** length 4.2 inches (106.7 mm), width 3.0 inches (76.2 mm); majority folded upward from ventral midrib, some flat; ovate; apex usually acuminate, sometimes acute; base rounded; medium thick; stiff; leathery; ventral (upper) surface dark green, dorsal (lower) surface light green, subglabrous; young leaves light green on both surfaces and pubescent; midrib light green and pubescent, ventral surface speckled with minute, dark brown trichomes; veins pinnately netted; margins with sharply setose serration, teeth length 0.06 to 0.08 inch (1.5 to 2.0 mm), sinuses wide, more angular than rounded at bases. **Petiole:** length 1.38 inches (35.0 mm), mid-diameter 0.07 inch (1.9 mm), light green, pubescent, channel shallow and well defined.

INFLORESCENCE. Corymb, with an average of seven flowers.

FLOWER. Width 1.28 inches (32.4 mm). **Pedicel:** length 0.64 inch (16.3 mm), mid-diameter 0.04 to 0.06 inch (1.0 to 1.5 mm), light green, pubescent. **Floral tube** (surrounding ovary): light green, glabrous. **Sepals:** acuminate, length 0.16 inch (4.0 mm), basal width 0.13 inch (3.3 mm); horizontal to erect; light green; ventral surface with light brown hairs, dorsal surface glabrous but coarse; margins appear serrated due to small, brown glandular trichomes. **Petals:** white; length 0.50 inch (12.7 mm); width 0.36 inch (9.1 mm); oval to oblong; margins variable, most slightly wavy, some clefted, some entire. **Stamens:** 20 to 22 per flower, length sufficient to extend anthers to level of stigmas, filaments white, anthers light purplish red (Plate 6 F 4, "Crushed berry", Maerz and Paul, 1950). **Pistil:** with five glabrous, light green styles separated to the ovary; one style may be considerably shorter than others; ovary usually with five carpels.

FRUIT. Size: fairly uniform, length 2.26 inches (57.4 mm), diameter 2.63 inches (66.7 mm), weight 153.2 grams. **Shape:** uniform, globular to oblate in longitudinal section, circular in transverse section. **Stem (pedicel):** length 0.76 inch (19.3 mm); mid-diameter 0.10 inch (2.6 mm); relatively straight; light green (Plate 12 J 1, Maerz and Paul, 1950); pubescent with raised, tan to brown, oval or oblong lenticels. **Cavity:** acute, uniform, medium depth and breadth, sides usually smooth or with one or two shallow furrows, surface smooth and free of russet, lenticels small and inconspicuous. **Basin:** circular, medium depth and breadth, sides sloping and smooth or with one to three shallow furrows, surface may be partially russeted, lenticels small and inconspicuous. In most specimens a russeted ring of brown scar tissue present where sepals were attached; exposed surface of calyx tube also russeted. **Calyx:** usually deciduous, but remnants persist in some specimens; persistent lobes open, separated at base, usually erect. **Skin** (ripe fruits): predominantly yellow (Plate 10 J 3, "Amber yellow", Maerz and Paul, 1950); taste bland, does not detract from general flesh flavor; medium tough and thick; adhesion to flesh tight; surface fairly smooth, semiglossy; lenticels conspicuous, small to medium, slightly raised, numerous, hexagonal or roundish, scaly under magnification, light brown (Plate 11 J 5, "Buttercup", Maerz and Paul, 1950). **Calyx tube** (cavity beneath the calyx lobes as seen in longitudinal mid-section): funnel shaped, long, wide, remnants of styles present. **Stamens:** generally deciduous, marginal when present. **Core line:** distinct; clasping (clasps calyx tube) as seen in longitudinal midsection; angular, pentagonal or hexagonal, in transverse midsection. **Core:** length 1.09 inches (27.6 mm), width 1.10 inches (27.9 mm), distant from stem, medium in relation to fruit size. **Carpels:** five in number, obovate, usually axile and closed. **Axial sac:** medium width when present. **Seeds:** length 0.31 inch (7.8 mm), width 0.20 inch (5.1 mm), plump on one side and flat on the other, apex acute, seed coat light

brown with dark brown or black margins, average number 5.6. Flesh: white (Plate 10 B 1, "Oyster white", Maerz and Paul, 1950); sweet, mild; soluble solids 12.7 percent; aroma faint; texture firm, tender, crisp, juicy. (Shinseiki fruits are more pulpy and coarse and have more stone cells than Twentieth Century fruits.) **Quality:** good to excellent.

HARVEST. July 25 to August 15 at Davis. Pick when eating ripe, usually when skin is greenish yellow.

SEASON. From harvest through January if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Shinseiki is partly self-fruitful under California conditions, but should not be planted without some provision for cross-pollination. The self-fruitfulness is mainly due to a degree of self-compatibility, which apparently varies from year to year according to temperature during bloom period. Shinseiki flowers bagged to prevent cross-pollination gave fruit-sets comparable to those of bagged and cross-pollinated flowers at Davis in 1965 and 1973, but in 1966 the bagged controls set no fruits. In 1976, bagged Shinseiki flowers set at the rate of 4.4 percent. Shinseiki flowers emasculated and self-pollinated by hand in 1971 and 1976, set at the rate of 11.0 and 14.1 percent,

respectively; comparable flowers cross-pollinated with Chojuro, Twentieth Century, or Kikusui pollen gave, respectively, 42, 40, and 39 percent. Most fruits that developed from the self-pollinated or cross-pollinated flowers contained viable seeds. The few seedless fruits from these flowers indicate that a portion of the self-fruitfulness of Shinseiki may be due to parthenocarpy.

At Davis, the bloom periods of Imamura Aki, Chojuro, and Twentieth Century most nearly coincide with that of Shinseiki. However, there is sufficient overlap for cross-pollination in the bloom periods of Shinseiki and Bartlett, as well as in the bloom periods of Shinseiki and all other Japanese pear varieties included in this study.

Because of results of hand pollinations and coincidence of bloom periods, Chojuro, Twentieth Century, and Kikusui are considered the best pollenizers for Shinseiki; however, Doitsu, Okusankichi, Seigyoku, and Bartlett are also satisfactory pollenizers. Both Ya Li and Tsu Li gave good fruit-sets on Shinseiki, but these varieties bloom too early at Davis to be good pollenizers.

Shinseiki produces viable pollen, and in tests at Davis it gave good fruit-sets on Twentieth Century, Doitsu, Kikusui, Kumoi, Ishiiwase, and Ya Li, and fair fruit-sets on Imamura Aki, Chojuro, and Okusankichi.

Japanese Pears:

Varieties producing fruits with greenish-brown, yellowish-brown, or brown russet skin

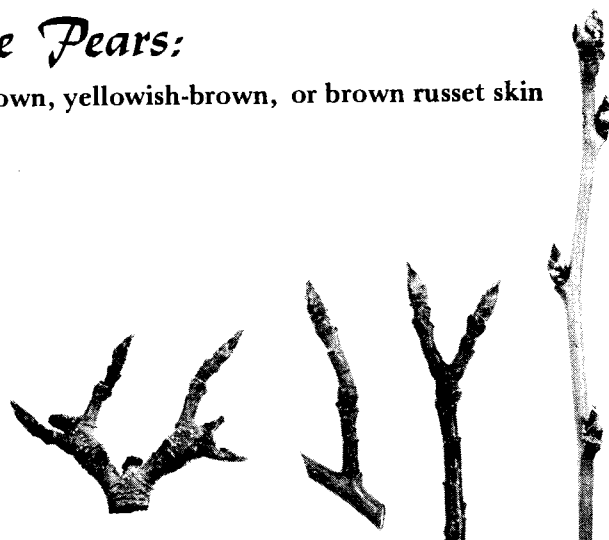
CHOJURO

ORIGIN. Chance seedling found in the orchard of Mr. Chojuro Toma in Kitsuju County, Kanagawa Prefecture, Japan, in 1895 or 1896 (Kubo, 1962). The orchard is now a part of Kawasaki City.

SOURCE. U.S. Department of Agriculture from the Agricultural Experiment Station, Tachikawa, Tokyo, Japan, received February 15, 1930 and numbered P. I. 97347 (USDA Plant Inventory No. 110, 1933). We obtained scions from the USDA in 1955.

Horticultural Description

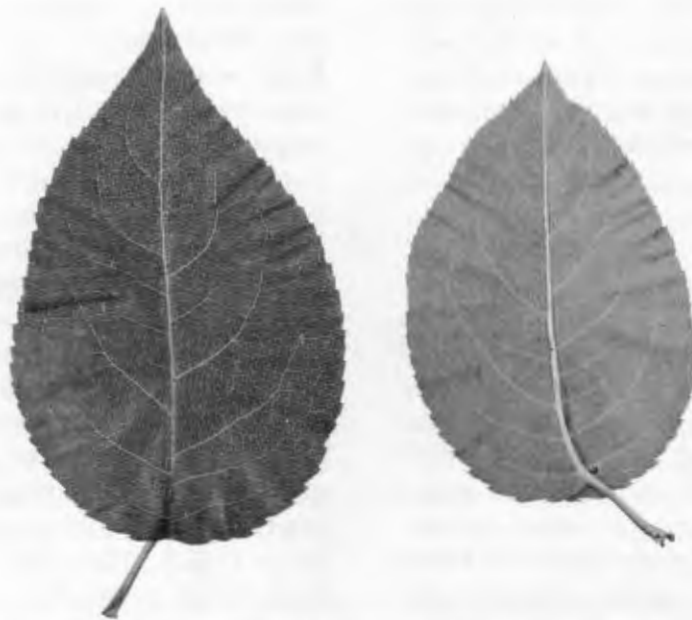
TREE. Medium size, vigorous, spreading, slightly drooping, dense, very productive. **Trunk:** medium diameter; bark rough with greenish-brown under-color covered with thin, grayish-white cork tissue. **Branch:** medium diameter; bark smooth with greenish-brown under-color overlaid with thin covering of grayish-white cork tissue; lenticels conspicuous, raised, small, round to oblate, tan. **Branchlet:** medium diameter; internode length 1.83 inches (46.6 mm); bark smooth, brown with greenish tinge; lenticels oval or elliptical, conspicuous, raised, small, tan; new growth is pubescent. **Leaf bud:** alternate phyllotaxis; free; conical; plump; length 0.26 inch (6.7 mm), width 0.16 inch (4.1 mm); scales dark brown, covered with whitish-gray scarfskin, fine, tan hairs protruding from scale margins. **Flower bud:** length 0.48 inch (12.2 mm), width 0.18 inch (4.6 mm); conical; plump; scales brown with partial covering of grayish-white scarfskin, tan pubescence from ventral sides protrudes along margins; tufted at apex. Buds



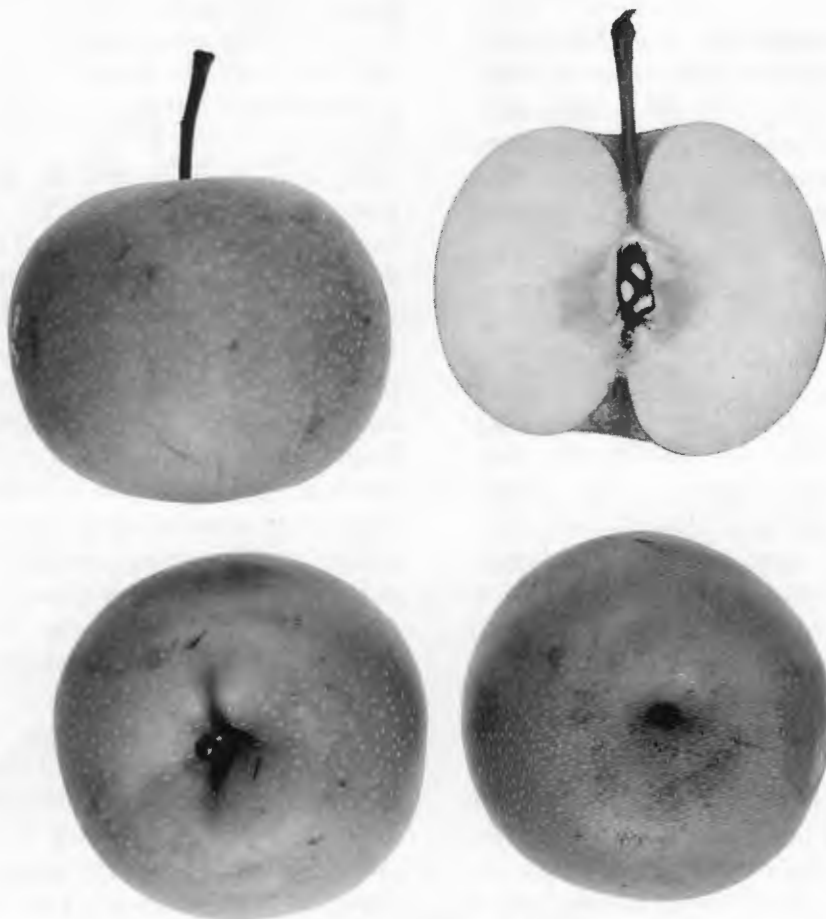
Chojuro. Left to right: first three are old spurs bearing flower buds; extreme right: 1-year-old shoot bearing terminal and lateral flower buds. Photographed during dormant period (February).



Chojuro flower cluster, and flowers and petals.



Chojuro leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Chojuro fruits, mature (eating-ripe).

borne terminally on 0.50- to 1.75-inch (12.7- to 44.4-mm) spurs arising from 2- or 3-year-old wood, old spurs, and on 1-year-old shoots; buds also borne laterally near tips of vigorous 1-year-old shoots. Lenticels on the spurs are small to medium size, roundish, raised, tan, many with median longitudinal fissures.

LEAF (from current season's shoots). **Blade:** length 4.07 inches (103.3 mm); width 2.94 inches (74.8 mm); most folded upward from ventral midrib; ovate; apex usually acuminate, sometimes acute; base rounded; thick; leathery; ventral (upper) surface dark green, dorsal (lower) surface light green; young leaves pubescent on upper surface, slightly pubescent on lower surface, old leaves glabrous; midrib light green, pubescent on upper and lower surfaces of young leaves, nearly glabrous in old leaves, ventral surface speckled with minute black trichomes; veins pinnately netted; margins with sharply setose serration, teeth length 0.04 to 0.08 inch (1.0 to 2.0 mm), sinuses wide and angular at bases. **Petiole:** length 1.01 inches (25.8 mm), mid-diameter 0.07 inch (1.8 mm), light green, pubescent on young leaves, channeled, some specimens with one or two small stipules near base of blade.

INFLORESCENCE. Corymb, with an average of six flowers.

FLOWER. Width 1.08 inches (27.4 mm). **Pedicel:** length 0.83 inch (21.0 mm), mid-diameter 0.04 inch (1.0 mm), light green, subglabrous to glabrous. **Floral tube** (surrounding ovary): light green, subglabrous. **Sepals:** acuminate; length 0.17 inch (4.3 mm); basal width 0.13 inch (3.3 mm); horizontal or slightly upright; light green; ventral surface pubescent, dorsal surface glabrous; margins appear serrated due to small, brown glandular trichomes. **Petals:** white; length 0.50 inch (12.7 mm); width 0.44 inch (11.3 mm); roundish; concave; margins may be entire, undulate, lobed, or clefted. **Stamens:** 18 to 26 per flower, length sufficient to extend most anthers slightly

above stigmas, filaments white, anthers purplish red (Plate 5 G 5, Maerz and Paul, 1950). **Pistil:** with five glabrous, light green styles separated to the ovary; ovary usually with five carpels.

FRUIT. **Size:** variable, length 2.14 inches (54.5 mm), diameter 2.61 inches (66.4 mm), weight 149.6 grams. **Shape:** oblate and lopsided in longitudinal section, circular or slightly angular in transverse section. **Stem** (pedicel): length 1.09 inches (27.7 mm); mid-diameter 0.10 inch (2.5 mm); slightly curved; does not broaden at the cavity; brown with greenish tint (Plate 14 L 8, "Syrup", Maerz and Paul, 1950) on exposed side, green (Plate 14 L 3, "Romantic green", Maerz and Paul, 1950) on the shaded side; lenticels very small, raised, light tan, elliptical. **Cavity:** deep; acuminate; medium breadth; sides with three or four wide, shallow furrows, giving it an angular shape; surface uniformly russeted with small, narrow, angular, scaly, light tan lenticels. **Basin:** circular; deep with medium width; smooth, sloping sides; surface uniformly russeted; lenticels small, narrow, light tan, more numerous than in cavity. **Calyx:** deciduous. **Skin** (ripe fruits): ranges from greenish brown (Plate 13 L 6, Maerz and Paul, 1950) to brown (Plate 13 L 9, "Chipmunk", Maerz and Paul, 1950); ground color is light green to greenish yellow, but this is completely overlaid with a very thin layer of russet; faintly astringent, may slightly detract from general flesh flavor; relatively tough, medium thick; adhesion to flesh tight; surface completely russeted, feels smooth, but is scaly under magnification, usually dull, but exposed side may be semiglossy; lenticels conspicuous, medium-sized, slightly raised, numerous, roundish or hexagonal, scaly, light tan (Plate 11 J 5, "Buttercup", Maerz and Paul, 1950). **Calyx tube** (cavity beneath the calyx lobes as seen in longitudinal mid-section): urn shaped, medium length and width, remnants of styles present in most specimens. **Stamens:** usually deciduous, marginal when present. **Core line:** distinct, outlined by heavy concentration of stone

cells; clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often pentagonal in transverse midsection. Core: length 0.93 inch (23.6 mm), width 1.01 inches (25.7 mm), position median, medium in relation to fruit size. Carpels: five in number, obovate, usually abaxile, open in some specimens, closed in others. Axial sac: medium to wide. Seeds: length 0.37 inch (9.4 mm); width 0.22 inch (5.6 mm); plump on one side, flattened on the other; apex usually acute, but acuminate in some specimens, may be curved; seed coat dark brown to nearly black, some specimens with light, cream-colored spots; coating may be slightly gelatinous; average number 5.4. Flesh: white (Plate 10 B 1, Maerz and Paul, 1950); mildly sweet, somewhat bland, core somewhat sour; soluble solids 13.4 percent; aroma distinctive and characteristic of this variety; texture firm, crisp, somewhat coarse and pulpy, some stone cells; less tender and juicy than the green-skin type of Asian pear. **Quality:** good.

HARVEST. August 9 through 19 at Davis. Pick when eating ripe, usually when some yellow shows through the russeted skin.

SEASON. From harvest through January if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Chojuro is partly self-fruitful under favorable California conditions, but should not be planted without provision for cross-pollination. The self-fruitfulness is evidently due to a slight degree of self-compatibility, and a slight

tendency to develop parthenocarpic fruits. In tests at Davis, Chojuro flowers bagged to prevent cross-pollination set a few fruits in 1965, but similar bagged controls failed to set any fruits in 1966, 1973, and 1976. In 1971 and 1976, emasculated and hand self-pollinated Chojuro flowers set a few fruits, but similar self-pollinated flowers set no fruits in 1973. Most pears that developed from the self-pollinated flowers contained seeds. Those fruits evidently resulted from self-compatibility, whereas the seedless ones evidently resulted from the stimulation of self-pollination (stimulative parthenocarpy). Chojuro flowers emasculated but not pollinated (emasculated controls), failed to set fruits in 1965, 1966, and 1976, indicating that vegetative parthenocarpy (fruit development without fertilization or the stimulation of pollination) is not an important factor in the productiveness of this variety.

Heavy fruit-sets were obtained when Chojuro flowers were cross-pollinated with pollen from Doitsu, Ya Li, or Tsu Li; good sets were obtained with pollen of Kikusui, Shinseiki, Twentieth Century, and Bartlett. Of these pollenizers, the bloom periods of Shinseiki, Twentieth Century, Doitsu, and Kikusui have good overlap with the Chojuro bloom. The bloom period of Bartlett has a fairly good overlap with that of Chojuro, but the Chinese pears, Ya Li and Tsu Li, bloom too early for a good overlap.

Chojuro produces viable pollen, and in tests at Davis it gave good fruit-sets on most of the other Asian pear varieties.

DOITSU

ORIGIN. Kikuchi (1948) reported that Doitsu originated in the Kanagawa Prefecture, Japan, but gave no date. Doitsu was a chance seedling which originated in the Kawasaki City area, Kanagawa Prefecture or in the Niigata Prefecture, Japan, according to Dr. Minoru Kajiura, Director, Horticultural Research Station, Hiratsuka, Kanagawa, Japan (personal correspondence of May 6, 1965).

SOURCE. U.S. Department of Agriculture from the National Agricultural Research Institute, Hiratsuka, Kanagawa, Japan, received September 19, 1955 and numbered P. I. 228012 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1958.

Horticultural Description

TREE. Small to medium size with medium to low vigor, open, spreading, drooping, moderately productive. **Trunk:** small to medium diameter; bark fairly smooth with greenish-brown under-color overlaid with scaling, grayish-white cork tissue. **Branch:** medium diameter; bark relatively smooth with greenish-brown under-color overspread with scaling, grayish-white cork tissue; lenticels conspicuous, raised, medium-sized, round to oblate, tan. **Branchlet:** slender; internode length 1.80 inches (45.7 mm); bark smooth, greenish brown with sparse covering of grayish-white scarfskin; lenticels scattered, raised, round to oblate, medium-sized, tan. **Leaf bud:** alternate phyllotaxis; free; conical; length 0.18 inch (4.5 mm); width 0.13 inch (3.2 mm); scales brown with partial covering of whitish-gray scarfskin, tan hairs protrude from scale margins. **Flower bud:** length 0.34 inch (8.6 mm); width 0.17 inch (4.4 mm); conical; scales dark brown with scattered covering of grayish-white scarfskin, tan hairs from ventral sides protrude along scale margins. Buds borne terminally on 0.25- to 0.37-inch (6.4- to 9.5-mm) spurs arising



Doitsu. Left to right: first three are spurs bearing flower buds; extreme right: 1-year-old shoot bearing a terminal flower bud, a lateral leaf bud, and two lateral flower buds. Photographed during dormant season (February).



Doitsu flower cluster, and flowers and petals.



Doitsu leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Doitsu fruits, mature (eating-ripe).

from 2- or 3-year-old wood, old spur systems, and 1-year-old shoots; a few are borne laterally on 1-year-old shoots. Lenticels on the spurs are small to medium-sized, roundish, raised, rough, and tan.

LEAF (from current season's shoots). **Blade:** length 4.32 inches (109.7 mm), width 2.70 inches (68.5 mm); some folded upward from ventral midrib; ovate; apex acuminate; base rounded; medium thick, stiff, leathery; ventral (upper) surface dark green, slightly pubescent, dorsal (lower) surface light green and glabrous; midrib light green, may have reddish cast in new foliage, ventral surface pubescent with very few minute, brown trichomes, dorsal surface slightly pubescent or glabrous; veins pinnately netted; margins with sharply setose serration, teeth length 0.08 to 0.12 inch (2.0 to 3.0 mm), sinuses medium width, fairly deep, angular at bases. **Petiole:** length 2.17 inches (55.1 mm); mid-diameter 0.06 inch (1.4 mm); light green; channel narrow, fairly deep with fine, protruding, nearly white hairs. Many specimens have two narrow, green stipules, about 0.12 inch (3.0 mm) long, arising from the ventral side of the petiole at the base of the blade.

INFLORESCENCE. Corymb, with an average of eight flowers.

FLOWER. Width 1.11 inches (28.3 mm). **Pedicel:** length 0.52 inch (13.3 mm), mid-diameter 0.04 to 0.06 inch (1.0 to 1.5 mm), light green. **Floral tube** (surrounding ovary): light yellowish green, glabrous or subglabrous. **Sepals:** acute to acuminate; length 0.12 inch (3.1 mm); basal width 0.09 inch (2.3 mm); majority reflexed downward; light green; ventral surface heavily pubescent, dorsal surface glabrous; small, brown, glandular trichomes make margins appear serrated. **Petals:** white; length 0.45 inch (11.5 mm); width 0.37 inch (9.4 mm); oval to roundish; many concave; margins variable, many undulate, some lobed,

some clefted. **Stamens:** 15 to 21 per flower, length sufficient to extend a portion of anthers to level of stigmas, filaments white, anthers purplish red (Plate 6 F 4, "Crushed berry", Maerz and Paul, 1950). **Pistil:** with five glabrous, light green styles of various lengths and separated to the ovary; ovary usually with five carpels.

FRUIT. Size: fairly uniform, length 2.14 inches (54.3 mm), diameter 2.71 inches (68.8 mm), weight 151.6 grams. **Shape:** variable; oblate, with some specimens lopsided, in longitudinal section; circular or angular in transverse section. **Stem** (pedicel): length 1.16 inches (29.4 mm); mid-diameter 0.11 inch (2.7 mm); slightly curved to nearly straight; broadened slightly at cavity; yellowish green (Plate 13 L 2, Maerz and Paul, 1950) with small, raised, light tan, mostly elliptical lenticels. **Cavity:** acuminate; deep and broad; sides relatively smooth, some specimens with two or three shallow furrows, giving an undulating appearance; surface russeted but smooth, with light tan lenticels which are smaller than on the rest of the skin surface. **Basin:** circular; deep and broad; sides smooth and acutely sloping; surface russeted, smooth; lenticels smaller, more numerous, and less conspicuous than in cavity. **Calyx:** deciduous. **Skin** (ripe fruits): predominantly light brown (Plate 12 I 7, "Desert", Maerz and Paul, 1950), faint greenish tinge on some specimens; slightly bitter; coarse, tough; medium thick; adhesion to flesh tight; surface over-spread with russet smooth to touch, but rough and scaly under magnification; dull; surface often marred with dark brown or nearly black blemish marks; lenticels conspicuous, medium to large, numerous, angular, somewhat scaly, light tan (Plate 10 H 4, "Sunlight", Maerz and Paul, 1950). (The lenticels of Doitsu are larger and their margins less clearly outlined than those of Kumoi, characteristics which help distinguish these similar varieties.) **Calyx tube** (cavity beneath the calyx lobes as seen in

longitudinal midsection): funnel shaped, long and narrow, remnants of styles present. **Stamens:** deciduous. **Core line:** distinct; clasping (clasps calyx tube) as seen in longitudinal midsection; usually angular, often pentagonal, some circular, in transverse midsection. **Core:** length 0.90 inch (22.9 mm), width 0.95 inch (24.2 mm), position median, medium in relation to fruit size. **Carpels:** five in number, obovate, abaxile and closed. **Axial sac:** narrow. **Seeds:** length 0.28 inch (7.2 mm); width 0.18 inch (4.6 mm); plump on one side and nearly flat on the other, marginal groove on the flat side; apex usually acute, some nearly acuminate; seed coat dark brown to almost black; average number 5.8. **Flesh:** white (Plate 9 B 1, Maerz and Paul, 1950); sweet, mild; soluble solids 13.1 percent; aroma faint; texture firm, crispy, juicy, pulpy, coarse and slightly granular, with stone cells clustered near the core line. **Quality:** fair.

HARVEST. August 10 through 25 at Davis. Pick when eating ripe, usually when skin turns light yellowish tan or brown.

SEASON. From harvest through January if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Doitsu is self-incompatible and requires cross-pollination for commercial crops. Doitsu flowers bagged to prevent cross-pollination, failed to set any fruits at Davis in 1965, 1966, 1973, and 1976. Flowers emasculated but not pollinated also failed to set fruits in these years, indicating a low potential for parthenocarpic fruit production. Good fruit-sets were obtained when Doitsu flowers were emasculated and cross-pollinated with pollen from Shinseiki, Tsu Li, Imamura Aki, Bartlett, Twentieth Century, Kikusui, Seigyoku, and Chojuro. With the exception of Tsu Li, which blooms relatively early, the bloom period of each of the varieties studied has sufficient overlap with that of Doitsu for good cross-pollination.

Doitsu produces viable pollen which, in tests at Davis, gave good fruit-sets on Chojuro, Kikusui, Seigyoku, Shinseiki, and Kumoi, and fair sets on Ishiiwase and Imamura Aki.

IMAMURA AKI

ORIGIN. Kubo (1962) reported that this variety originated near Takaoka, Kochi Prefecture, Japan. Dr. Minoru Kajiura, Director, Horticultural Research Station, Hiratsuka, Kanagawa, Japan, concurred, and added that Imamura Aki was a chance seedling. Although the date of origin is unknown, he stated that large, old trees of this variety are scattered in the Niyodo River basin (personal correspondence of May 6, 1965).

SOURCE. U.S. Department of Agriculture from Kiho, Korea. The scions came from the Narusada Fruit Farm near Fusan, Korea; received December 7, 1929 and numbered P. I. 83814 (USDA Plant Inventory No. 102, 1931). We obtained scions from the USDA in 1955.

Horticultural Description

TREE. Medium size and vigor, open, spreading, moderately productive. **Trunk:** medium diameter; bark rough and shaggy, with brown under-color overlaid with scaling, grayish-white cork tissue. **Branch:** diameter medium; bark smooth with brown under-color covered with thin layer of shedding, grayish-white cork tissue; lenticels conspicuous, raised, medium to large, rough, oblate, tan. **Branchlet:** medium diameter; internode length 1.68 inches (42.6 mm); bark smooth, dark, greenish brown; lenticels numerous, round to oval, raised, medium-sized, tan. **Leaf bud:** alternate phyllotaxis; free; conical; length 0.29 inch (7.4 mm); width 0.20 inch (5.1 mm); scales brown, covered with thin layer of grayish-white scarfskin, tan pubescence protruding from margins. **Flower bud:** length 0.54 inch (13.7 mm); width 0.21 inch (5.3 mm); pointed; scales dark brown with scattered, grayish-white covering of scarfskin; margins fringed with fine, tan pubescence protruding from the ventral surfaces. Buds borne terminally on 0.25- to 0.75-inch (6.4- to 19.1-mm) spurs arising



Imamura Aki. Left: old spurs bearing flower buds; second from left: 2-year-old wood with a small vegetative bud and four young spurs bearing flower buds; third from left: 2-year-old wood with three young spurs bearing flower buds, and a 1-year-old shoot bearing three flower buds; extreme right: 1-year-old shoot bearing terminal flower bud and three lateral buds. Photographed during dormant period (February).



Imamura Aki flower cluster, and flowers and petals.



Doitsu leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Doitsu fruits, mature (eating-ripe).

from 3- to 4-year-old wood, old spur systems, and 1-year-old shoots; a few are borne laterally on 1-year-old shoots. Lenticels on the spurs are small, round, raised, tan, and many have median longitudinal fissures.

LEAF (from current season's shoots). **Blade:** length 4.40 inches (112.9 mm); width 3.06 inches (77.8 mm); majority folded upward from ventral midrib; broadly ovate; apex acuminate; base obtuse; thick, leathery; young leaves light green with reddish cast on both surfaces and pubescent; in old leaves, ventral surface dark green and subglabrous, dorsal surface light green and glabrous; midrib ventral surface pubescent, light green with reddish cast in some specimens, speckled with minute, black trichomes; dorsal surface pale green and subglabrous or glabrous; veins pinnately netted; margins with sharply setose serration, teeth length 0.04 to 0.08 inch (1.0 to 2.0 mm), sinuses deeply lobed, rounded at bases. **Petiole:** length 0.96 inch (24.6 mm), mid-diameter 0.07 inch (1.8 mm), light green, some specimens with reddish cast on ventral side, pubescent in young leaves, subglabrous in older leaves, channel narrow and deep. The short petiole is a distinguishing characteristic of this variety.

INFLORESCENCE. Corymb, with an average of 6.9 flowers.

FLOWER. Width 1.50 inches (38.0 mm). **Pedice:** length 0.79 inch (19.8 mm), mid-diameter 0.04 to 0.06 inch (1.0 to 1.5 mm), light green, lightly pubescent. **Floral tube** (surrounding ovary): light green, glabrous or subglabrous. **Sepals:** acuminate; length 0.19 inch (4.8 mm); width at base 0.14 inch (3.6 mm); horizontal to reflexed downward; light yellowish green; ventral side with light brown hairs, dorsal side glabrous; margins appear serrated due to small, brown glandular trichomes. **Petals:** white; length 0.48 inch (12.2 mm); width 0.41 inch (10.3 mm); oval to round; concave; some margins undulate, some clefted, some entire. **Stamens:** 20 to 28 per flower, length places anthers slightly

below level of stigmas, filaments white, anthers purplish red (Plate 6 F 5, Maerz and Paul, 1950). **Pistil:** with five glabrous, light green styles separated to the ovary; ovary usually with five carpels.

FRUIT. **Size:** variable, length 2.66 inches (67.6 mm), diameter 3.19 inches (81.0 mm), weight 259.5 grams. **Shape:** variable; in longitudinal section usually oblate, but may be globular or ovate; usually angular in transverse section, but may be nearly round. **Stem** (pedicel): length 1.16 inches (29.5 mm), mid-diameter 0.11 inch (2.8 mm), slightly curved, usually brown (Plate 13 G 9, "Sayal brown", Maerz and Paul, 1950), some specimens greenish brown (Plate 14 L 5, Maerz and Paul, 1950) on shaded side. Lenticels on stem small, raised, round, elliptical or diamond-shaped, light tan. **Cavity:** acute to nearly acuminate, medium depth and narrow to medium breadth, sides may be smooth or have 3 to 5 shallow furrows, surface russeted and rough, lenticels smaller than on major portion of skin surface. **Basin:** angular; deep and broad; sides abrupt to sloping, with 4 or 5 shallow furrows; surface uniformly russeted; lenticels smaller, more numerous, and less conspicuous than on rest of surface. **Calyx:** may be deciduous or persistent; persistent lobes partly open, separated at base, and usually upright. **Skin** (ripe fruits): predominantly light brown (Plate 13 I 8, "Aztec", Maerz and Paul, 1950); ground color light yellowish green, completely overlaid with a very thin layer of russet which appears rough and scaly under magnification; bland to slightly bitter; coarse and tough; medium thick; adhesion to flesh tight; surface russeted, dull; lenticels conspicuous, large, slightly raised, numerous, angular, often pentagonal or hexagonal, scaly, tan (Plate 11 I 5, "Chamois", Maerz and Paul, 1950). **Calyx tube** (cavity beneath the calyx lobes as seen in longitudinal mid-section): funnel shaped, long with medium width, remnants of styles present. **Stamens:** often deciduous, marginal when

present. **Core line:** distinct, outlined with stone cells; clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often pentagonal, in transverse midsection. **Core:** length 1.19 inches (30.3 mm), width 1.26 inches (31.9 mm), median position, medium in relation to fruit size. **Carpels:** five in number, obovate, wide, abaxile and closed. **Axial sac:** wide. **Seeds:** length 0.33 inch (8.4 mm), width 0.22 inch (5.7 mm), plump on one side and flattened on the other, apex acute, seed coat dark brown to nearly black, average number 7.2. **Flesh:** white (Plate 10 B 1, "Oyster white", Maerz and Paul, 1950); mildly sweet with a trace of tartness, slightly astringent; soluble solids 12.8 percent; aroma lacking; texture firm, crisp, juicy, slightly pulpy, relatively coarse and granular, with stone cells concentrated near core line. **Quality:** fair.

HARVEST. September 18 to October 2 at Davis. Pick when eating ripe.

SEASON. From harvest through December if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Imamura Aki trees are self-incompatible, or nearly so, and require cross-pollination to set commercial crops. At Davis, in 1966, flowering Imamura Aki branches bagged to prevent cross-pollination, set only one seedless fruit, and similar branches bagged in 1973 and 1976 set no fruits. In the same years, good fruit-sets were obtained when Imamura Aki flowers were cross-pollinated with Twentieth Century, Kikusui, Ya Li, Bartlett or Chojuro pollen; fair sets were obtained when they were cross-pollinated with Shinseiki, Doitsu, or Seigyoku pollen. Of these pollenizers, the bloom periods of Shinseiki, Chojuro, Twentieth Century, and Doitsu have good overlap with that of Imamura Aki. Ya Li blooms too early, and Bartlett somewhat late, to serve as good pollenizers for Imamura Aki, although there is enough overlap in the bloom periods of these varieties for adequate cross-pollination in many years.

Imamura Aki produces viable pollen. In tests at Davis it gave good fruit-sets on Twentieth Century and Doitsu, and fair sets on Ya Li, Shinseiki, and Ishiiwase.

ISHIIWASE

ORIGIN. Seedling of Nijisseiki (Twentieth Century) x Doitsu, originated by Mr. Kenkichi Ishii in Ichikawa City, Chiba Prefecture, Japan. Cross made in 1916, selected in 1921 (Kubo, 1962). Dr. Minoru Kajiura, Director, Horticultural Research Station, Hiratsuka, Kanagawa Prefecture, Japan, added that Ishiiwase was introduced by the Chiba Agricultural Experiment Station, but did not give the date (personal correspondence of May 6, 1965).

SOURCE. U.S. Department of Agriculture from the Faculty of Agriculture, Tokyo University, Hongo, Tokyo, Japan; received March 10, 1955 and numbered P. I. 224085 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1957.

Horticultural Description

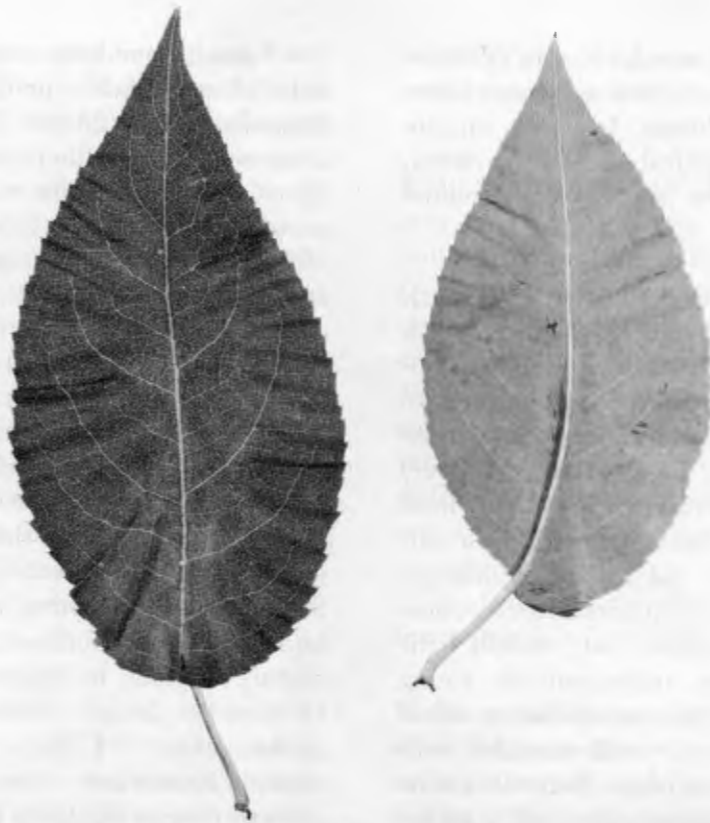
TREE. Large, vigorous, upright, somewhat spreading, dense, medium productive. **Trunk:** medium diameter, bark relatively smooth with greenish-brown under-color overlaid with scaling, grayish-white cork tissue. **Branch:** medium to broad diameter; bark medium rough with dark brown under-color overlaid with shedding, grayish-white cork tissue; lenticels conspicuous, raised, large, round, tan. **Branchlet:** medium diameter; internode length 1.51 inches (38.5 mm); bark smooth, greenish brown; lenticels scattered, elliptical, raised, medium-sized, tan. **Leaf bud:** alternate phyllotaxis, free, conical, length 0.28 inch (7.1 mm), width 0.17 inch (4.4 mm); scales brown with scattered areas of whitish-gray scarfskin, tan pubescence from ventral surfaces protrudes along margins. **Flower bud:** length 0.46 inch (11.8 mm), width 0.21 inch (5.3 mm), free, conical; scales dark brown and partially covered with grayish-white scarfskin, margins fringed with tan pubescence protruding from ventral surfaces. Buds borne terminally on 0.75- to 1.00-inch (19.0- to 25.4-mm) spurs arising



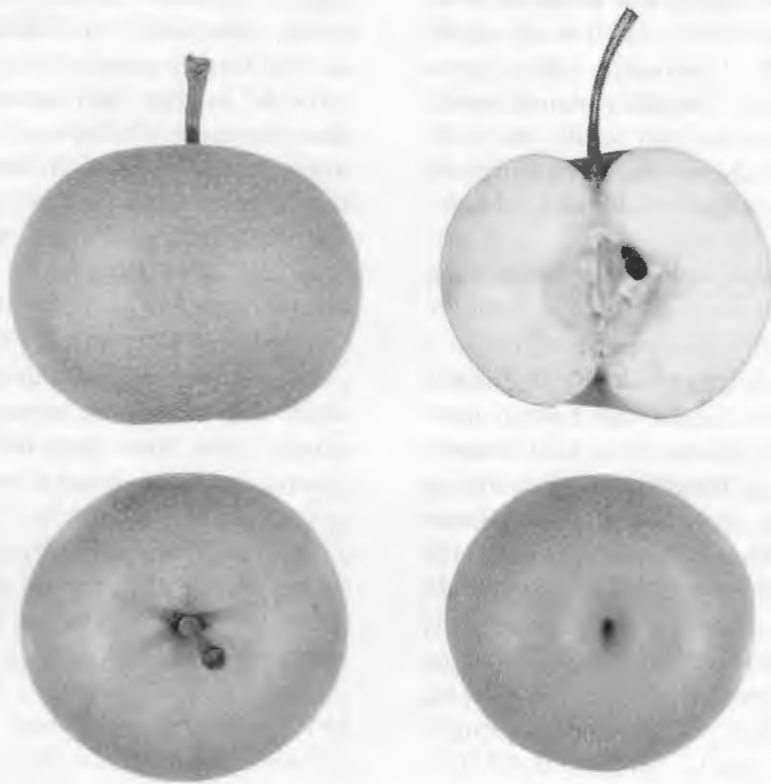
Ishiiwase. Left: old spurs bearing flower buds; center: 2- and 3-year-old wood bearing young spurs terminated with flower buds; right: 1-year-old shoot bearing flower buds. Photographed during dormant period.



Ishiiwase flower cluster, and flowers and petals.



Ishiiwase leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Ishiiwase fruits, mature (eating-ripe).

from 2- or 3-year-old wood, old spur systems, and 1-year-old shoots; a few are borne laterally on 1-year-old shoots. Lenticels on the spurs are small, elliptical to round, raised, tan, and many have median longitudinal fissures.

LEAF (from current season's shoots). **Blade:** length 5.0 inches (127.0 mm), width 2.5 inches (63.5 mm); majority folded upward from ventral midrib; ovate to lanceolate; apex acuminate or acute; base rounded; medium thick, leathery, pliant; ventral (upper) surface dark green, dorsal (lower) surface light green; young leaves light green on both surfaces and pubescent; old leaves subglabrous on ventral and glabrous on dorsal surface; new foliage has faint reddish cast; midrib light green, both surfaces pubescent in young leaves, dorsal surface becomes glabrous as leaf ages; ventral surface of midrib speckled with minute, dark brown to black trichomes; veins pinnately netted; margins with sharply setose serration, teeth length 0.03 to 0.07 inch (0.8 to 1.8 mm), widely spaced, sinuses wide and shallow, angular or nearly flat at bases. **Petiole:** length 1.41 inches (35.7 mm), mid-diameter 0.07 inch (1.8 mm), light green, pubescent, channel of medium depth; some specimens have one or two small, 0.10- to 0.18-inch (3.0- to 4.5-mm), spine-like stipules on the ventral side near the base of the blade.

INFLORESCENCE. Corymb, with an average of 6.3 flowers.

FLOWER. Width 0.98 inch (24.8 mm). **Pedicel:** length 1.15 inches (29.3 mm), mid-diameter 0.04 to 0.06 inch (1.0 to 1.5 mm), light green, glabrous. **Floral tube** (surrounding ovary): light green, glabrous. **Sepals:** acuminate; length 0.16 inch (4.1 mm), basal width 0.12 inch (3.1 mm); reflexed downward; pale green; ventral side matted with light tan hairs, dorsal side glabrous and rough; margins appear sparsely serrated due to small, tan, glandular trichomes. **Petals:** white; length 0.39 inch (9.8 mm), width 0.42 inch

(10.7 mm); roundish; concave; margins variable, often undulate or clefted, some entire. **Stamens:** 19 to 28 per flower, length sufficient to extend anthers to approximate level of stigmas, filaments white, anthers light purplish red (Plate 5 G 3, Maerz and Paul, 1950). **Pistil:** with five glabrous, light green styles separated to the ovary; one or two styles may be considerably shorter than others; ovary usually with five carpels.

FRUIT. Size: somewhat variable, length 2.44 inches (62.1 mm), diameter 2.93 inches (74.5 mm), weight 200.1 grams. (Fruits of Ishiiwase are larger on the average than those of Chojuro, which they resemble.) **Shape:** fairly uniform, oblate and slightly lopsided in longitudinal section, circular or slightly angular in transverse section. **Stem (pedicel):** length 1.40 inches (35.3 mm), mid-diameter 0.11 inch (2.8 mm); slightly curved; broadened somewhat at the cavity; greenish brown (Plate 14 L 5, Maerz and Paul, 1950); lenticels are small, roundish or elliptical, raised and light tan. **Cavity:** acute, angular, medium depth, breadth medium to broad, sides with 3 to 5 shallow furrows, surface uniformly russeted but smooth to touch, lenticels smaller and more elongated than those on most of skin surface. **Basin:** usually angular, medium depth, breadth medium to broad, sides sloping with 3 to 5 shallow furrows in most specimens, surface uniformly russeted but smooth to touch, lenticels smaller and less conspicuous than those on remainder of skin surface. In most specimens a ring of brown scar tissue present where sepals were attached; exposed surface of the calyx tube also russeted. **Calyx:** usually deciduous, but remnants persistent in some specimens; persistent lobes open, separated at base, and usually erect. **Skin** (ripe fruits): ranges from greenish brown (Plate 14 L 6, "Citrine", Maerz and Paul, 1950) for shaded fruits to yellowish brown (Plate 13 K 7, "Isabella", Maerz and Paul, 1950) for exposed ones; ground color is greenish yellow, but completely overlaid with

a very thin layer of russet; taste bland, does not detract from general flesh flavor; coarse and tough, medium thick to thick; adhesion to flesh tight; surface dull, fairly smooth despite russeting; lenticels conspicuous, small to medium, very slightly raised, numerous, pentagonal or hexagonal, scaly under magnification, light tan (Plate 11 H 5, Maerz and Paul, 1950). (Lenticels on Ishiiwase fruits are smaller and more numerous than those on Chojuro fruits. Under magnification, russet on Ishiiwase fruits appears less scaly than that on Chojuro fruits.) **Calyx tube** (cavity beneath the calyx lobes as seen in longitudinal mid-section): urn shaped, short, narrow; remnants of styles present. **Stamens**: usually deciduous, marginal when present. **Core line**: distinct, clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often pentagonal or hexagonal, in transverse mid-section. **Core**: length 1.25 inches (31.8 mm), width 1.24 inches (31.5 mm), position somewhat closer to calyx end than to stem end of fruit, medium in relation to fruit size. **Carpels**: five in number, obovate, abaxile, closed. **Axial sac**: wide. **Seeds**: length 0.33 inch (8.5 mm), width 0.20 inch (5.0 mm); somewhat plump on one side and flat on the other; indented margin around the edge of flat side; apex usually acute, some obtuse; seed coat dark brown or nearly black; average number 5.4. **Flesh**: white with a faint yellow cast (Plate 9 B 1, Maerz and Paul, 1950); sweet, bland, core is sour; soluble solids 12.7 percent; aroma very faint or lacking; texture firm, relatively tough, crisp, juicy, somewhat coarse and pulpy, relatively few stone cells. (Ishiiwase fruits have a much lighter concentration of stone cells at the core line than do Chojuro fruits.) **Quality**: fair to good.

HARVEST. August 6 through 15 at Davis. Pick when eating ripe, usually when some yellow shows through the russeted skin.

SEASON. From harvest through December if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Ishiiwase may set a few fruits as a result of self-pollination and vegetative parthenocarpy, but cross-pollination is required for commercial crops. Ishiiwase flowers, bagged to prevent cross-pollination, set a few fruits at Davis in 1965, but similar bagged controls failed to set any fruits in 1966, 1967, and 1976. Also, Ishiiwase flowers, emasculated and self-pollinated by hand, failed to set fruits in 1971 and 1976. Ishiiwase flowers, emasculated but not pollinated, set no fruits in 1965 and 1976, but similar emasculated controls set a few seedless fruits in 1966.

Good or satisfactory fruit-sets were obtained when Ishiiwase flowers were emasculated and cross-pollinated with pollen from Shinseiki, Kikusui, Bartlett, Seigyoku, Twentieth Century, Tsu Li, and Chojuro. The bloom periods of Bartlett, Seigyoku, Kikusui, and Twentieth Century have good overlap with that of Ishiiwase, but Tsu Li blooms too early to serve as a satisfactory pollenizer. Although Shinseiki and Chojuro bloom earlier than Ishiiwase, there is enough overlap in the bloom periods of these varieties for adequate cross-pollination in most years.

Ishiiwase is a relatively poor pollenizer for other pear varieties because its flowers produce only meager amounts of pollen. It is difficult to obtain enough Ishiiwase pollen for testing germinability *in vitro*, or for cross-compatibility tests with other varieties. A few pollen grains germinated on an aqueous sugar-agar medium, but relatively low and inconsistent fruit-sets resulted when Ishiiwase pollen was applied to the emasculated flowers of other varieties.

KUMOI

ORIGIN. Seedling of Ishiiwase x Yakumo, originated at the Horticultural Experiment Station in Okitsu City, Shizuoka Prefecture, Japan. Cross made in 1939, introduced in 1955 (Kubo, 1962).

SOURCE. U.S. Department of Agriculture from the National Agricultural Research Institute, Hiratsuka, Kanagawa Prefecture, Japan; received September 19, 1955 and numbered P. I. 228015 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1959.

Horticultural Description

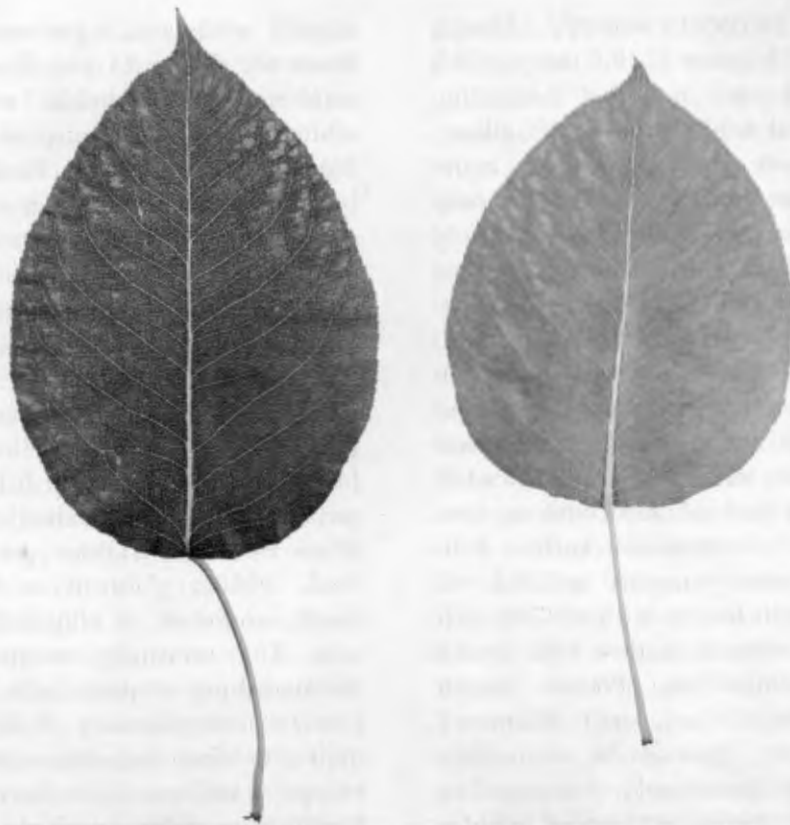
TREE. Medium size and vigor, upright, dense, moderately productive. **Trunk:** medium diameter; bark relatively smooth with dark greenish-brown under-color overlaid with scaling, grayish-white cork tissue. **Branch:** medium diameter; bark smooth with dark brown under-color overspread with thin, shedding cork tissue; lenticels conspicuous, raised, large, oblate to round, tan. **Branchlet:** medium diameter; internode length 1.81 inches (45.9 mm); bark smooth, greenish brown; lenticels numerous, elliptical, raised, medium-sized, tan; pubescence on new growth, sloughing off with age. **Leaf bud:** alternate phyllotaxis, somewhat appressed, conical, length 0.23 inch (5.9 mm), width 0.16 inch (4.0 mm); scales brown, overlaid with grayish-white scarfskin, light-gray pubescence protruding from scale margins. **Flower bud:** length 0.52 inch (13.3 mm), width 0.20 inch (5.2 mm), conical; scales dark brown and partially covered with grayish-white scarfskin, pubescence from ventral sides protrudes along margins. Buds borne terminally on 0.50- to 0.75-inch (12.7- to 19.1-mm) spurs arising from 3- or 4-year-old wood, old spur systems, and 1-year-old shoots; a very few are borne laterally on 1-year-old shoots. Lenticels on the spurs are small, round to elliptical, raised, rough, tan, and many have longitudinal fissures.



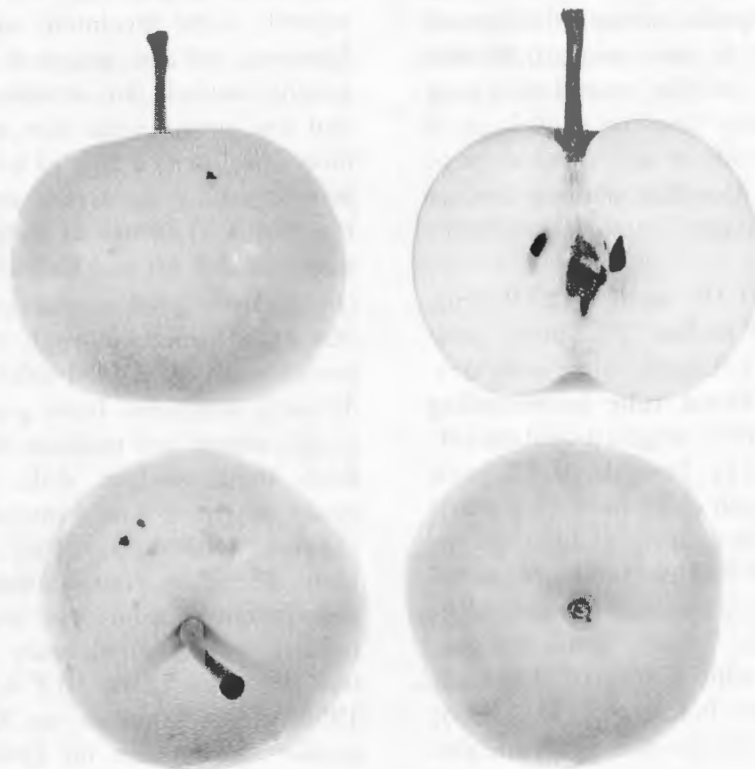
Kumoi. Left: old spurs bearing flower buds; second from left: 2- or 3-year-old wood bearing terminal and lateral spurs; third and fourth from left: spurs bearing flower buds. Photographed during dormant period (February).



Kumoi flower cluster, and flowers and petals.



Kumoi leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Kumoi fruits, mature (eating-ripe).

LEAF (from current season's shoots). **Blade:** length 4.93 inches (125.4 mm); width 3.06 inches (77.8 mm); majority folded upward from ventral midrib; ovate to oblong; apex variable, some acuminate, others acute or mucronate; base usually rounded, but may be obtuse or acute; medium thick, moderately stiff and leathery; ventral (upper) surface green with yellowish-green mottling in some specimens; dorsal (lower) surface pale green; both surfaces pubescent in young leaves, in older leaves ventral surface subglabrous and dorsal surface glabrous; new foliage may have a faint reddish cast; midrib light green, ventral surface pubescent and speckled with minute, nearly black trichomes, dorsal surface subglabrous or glabrous; margins serrulate to sharply setose, teeth length 0.03 to 0.05 inch (0.8 to 1.3 mm), sinuses shallow with nearly flat or slightly angular bases. **Petiole:** length 1.42 inches (36.0 mm), mid-diameter 0.09 inch (2.4 mm); light green, sometimes pink near base on dorsal side; pubescent in young leaves, subglabrous or glabrous in older ones; channel narrow with medium depth; some specimens have small, 0.04- to 0.08-inch (1.0- to 2.0-mm) stipules on ventral side near base of blade, others have long, 0.59-inch (15.0-mm) stipules on the ventral side near the base of the petiole.

INFLORESCENCE. Corymb, with an average of six flowers.

FLOWER. Width 1.10 inches (27.9 mm). **Pedicel:** length 1.08 inches (27.5 mm), mid-diameter 0.04 inch (1.0 mm), light green, very lightly pubescent. **Floral tube** (surrounding ovary): light green, slightly pubescent. **Sepals:** acuminate; length 0.17 inch (4.3 mm), basal width 0.13 inch (3.2 mm); usually reflexed, some upright; light green; ventral side matted with light tan hairs, dorsal side slightly pubescent and coarsely textured; margins with small, brown glandular trichomes. **Petals:** white; length 0.51 inch (12.9 mm), width 0.45 inch (11.5 mm); roundish to oval; many concave; margins

slightly undulate, some entire, few clefted. **Stamens:** 20 to 24 per flower, length places anthers slightly below stigmas, filaments white, anthers light purplish red (Plate 4 F 2, Maerz and Paul, 1950). **Pistil:** with five glabrous, pale-green styles separated to ovary; ovary usually with five carpels.

FRUIT. **Size:** variable, length 2.46 inches (62.6 mm), diameter 2.84 inches (72.2 mm), weight 189.4 grams. **Shape:** uniform, oblate in longitudinal section, circular in transverse section. **Stem** (pedicel): length 1.70 inches (43.3 mm), mid-diameter 0.11 inch (2.9 mm); gently curved; broadened at cavity; green (Plate 14 L 3, "Warbler green", Maerz and Paul, 1950); glabrous with small, raised, rough, roundish or elliptical, light tan lenticels. The unusually rough lenticels are a distinguishing characteristic of this variety. **Cavity:** semi-obtuse; shallow to medium depth, medium breadth; sides nearly smooth except some specimens have 2 to 4 shallow furrows; surface russeted; lenticels small, numerous, light tan. **Basin:** usually circular, sometimes angular; sides sloping and usually smooth, some specimens with 2 to 4 shallow furrows; surface russeted but smooth to touch; lenticels are smaller, more numerous and less conspicuous than those in cavity. In most specimens a ring of brown scar tissue is present where the sepals were attached, and the exposed surface of the calyx tube is also russeted and brown. **Calyx:** deciduous. **Skin** (ripe fruits): predominantly tan (Plate 12 I 7, "Desert", Maerz and Paul, 1950), but may be greenish tan on shaded side; somewhat bitter, detracts somewhat from general flesh flavor; tough, coarse and medium thick; adhesion to flesh tight; surface dull, overspread with russet which is fairly smooth to touch, but appears rough and netted under magnification; lenticels conspicuous, medium-sized, slightly raised, numerous, angular, often pentagonal or hexagonal, scaly under magnification, light tan (Plate 10 F 4, Maerz and Paul, 1950). (The lenticels on Kumoi fruits are smaller than those on Doitsu fruits which

they closely resemble.) Calyx tube (cavity beneath the calyx lobes as seen in longitudinal midsection): funnel shaped, short and narrow, remnants of styles present. Stamens: deciduous. Core line: faint, clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often hexagonal, in transverse midsection. Core: length 1.44 inches (36.5 mm), width 1.20 inches (30.6 mm), median position, medium to large in relation to fruit size. Carpels: five in number, obovate, usually abaxile and closed. Axial sac: wide. Seeds: length 0.33 inch (8.5 mm), width 0.20 inch (5.1 mm), plump on one side and nearly flat on the other, marginal groove on flat side, apex acute, seed coat dark brown or nearly black, average number 7.4. Flesh: white (Plate 11 A 1, Maerz and Paul, 1950); mildly sweet with a trace of tartness; soluble solids 12.0 percent; aroma very faint or lacking; texture firm, tender, crisp, juicy, slightly coarse and pulpy; less stone cells than most other Asian pear varieties. The relatively few stone cells near the core line are a distinguishing characteristic of this variety. **Quality:** fair.

HARVEST. August 3 through 10 at Davis. Pick when eating ripe, usually when the skin turns yellowish tan.

SEASON. From harvest through December if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Kumoi sets an occasional fruit as a result of self-pollination or vegetative parthenocarpy, but cross-pollination is required for commercial crops. Kumoi flowers, bagged to prevent cross-pollination, failed to set fruits at Davis in 1966, 1973, and 1976; but emasculated and self-pollinated Kumoi flowers set a few fruits in 1973 and 1976. Flowers emasculated but not pollinated set a few parthenocarpic fruits in 1966 and 1971, but similar emasculated controls set no fruits in 1967 and 1976. Good fruit-sets were obtained when Kumoi flowers were emasculated and cross-pollinated with pollen from Shinseiki, Chojuro, Twentieth Century, Kikusui, Seigyoku, Ya Li, and Tsu Li. The bloom periods of Seigyoku and Kikusui have good overlap with that of Kumoi for cross-pollination. Also, there is enough overlap in the bloom periods of Twentieth Century, Chojuro, and Shinseiki with that of Kumoi for adequate cross-pollination in most years. Ya Li and Tsu Li usually bloom too early to serve as satisfactory pollenizers for Kumoi.

Kumoi is a poor pollenizer for other pear varieties because its flowers produce only scanty amounts of pollen. Although a few Kumoi pollen grains germinated on an aqueous sugar-agar medium, hardly any fruit-set resulted when Kumoi pollen was applied to the emasculated flowers of other varieties.

OKUSANKICHI

SYNONYMS. Bansankichi. In China, the Okusankichi pear is known as "Wan San Chi" (Hu, 1937).

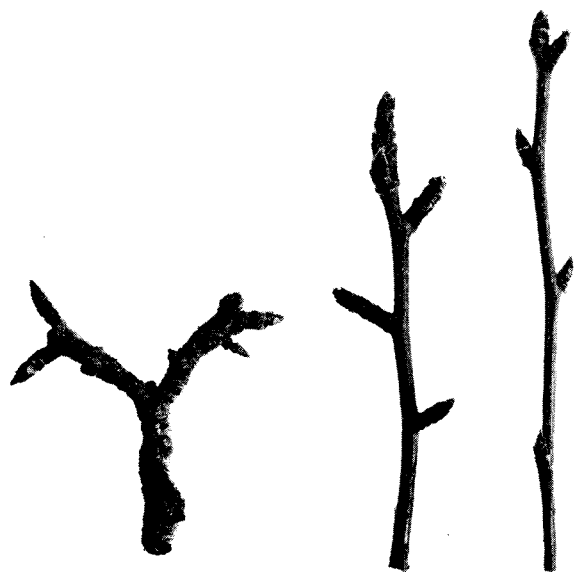
ORIGIN. Chance seedling of Wasesankichi, found in Naka Kambara, Niigata Prefecture, Japan, date not given (Kubo, 1962).

SOURCE. U.S. Department of Agriculture from the Horticultural Institution, Department of Agriculture, Kyoto Imperial University, Kyoto, Japan, received February 24, 1930 and numbered P. I. 119217 (USDA Plant Inventory No. 129, 1941). We obtained scions from Dr. Catherine H. Bailey, Agricultural Experiment Station, New Brunswick, New Jersey in February 1970.

Okusankichi has been grown in the Loomis—Newcastle district of Placer County for many years, and is known as the "late salad pear", "late Japanese pear", "October salad pear", or "October Japanese pear". It is also grown in Tulare County where it is known as "Nihon Nashi" (Japanese pear).

Horticultural Description

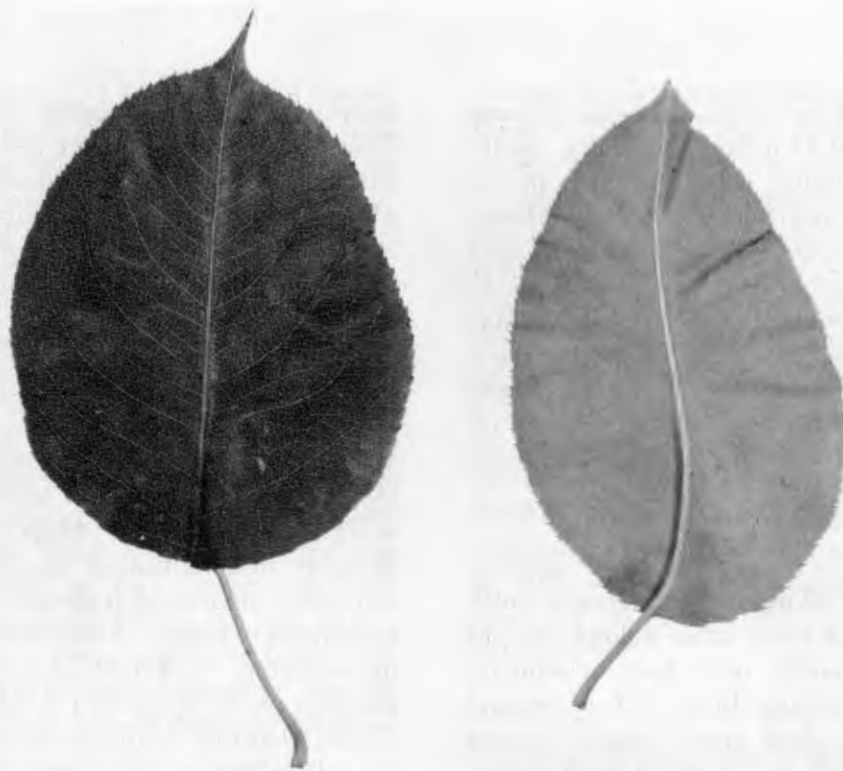
TREE. Relatively large, very vigorous, upright, spreading, dense, productive. **Trunk:** large diameter; bark rough and shaggy with dark brown under-color overlaid with scaling, grayish cork tissue. **Branch:** medium diameter; bark smooth with dark, greenish-brown under-color overspread with ash-gray cork tissue; lenticels numerous, conspicuous, raised, rough, large, elliptical, tan. **Branchlet:** diameter medium to thick; internode length 1.61 inches (41.0 mm); bark smooth, glabrous, light brown to brown with grayish-white scarfskin; lenticels elongated, elliptical, slightly raised, medium-sized, tan. **Leaf bud:** alternate phyllotaxis; free; conical; length 0.20 inch (5.2 mm), width 0.16 inch (4.1 mm); scales dark brown, fine, grayish-tan



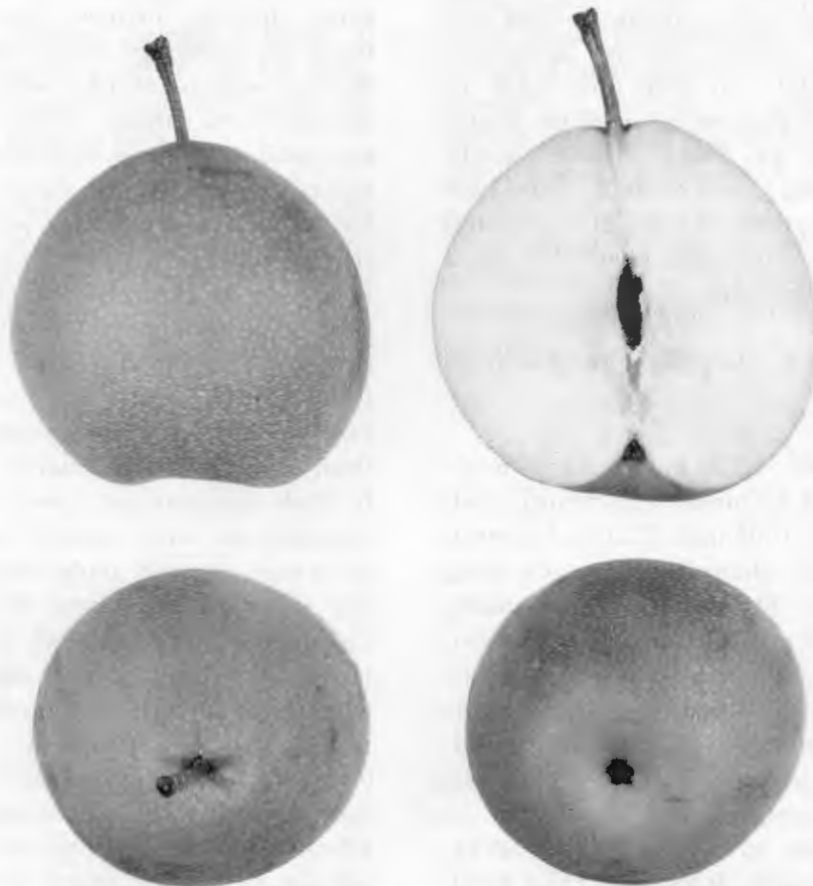
Okusankichi. Left: old spurs; center: 2-year-old wood bearing young spurs; right: 1-year-old shoot bearing terminal and lateral buds. Photographed during dormant period.



Okusankichi flower cluster, and flowers and petals.



Okusankichi leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Okusankichi fruits, mature (eating-ripe).

hairs protruding from margins. Flower bud: length 0.47 inch (11.9 mm), width 0.21 inch (5.4 mm); conical; scales brown with scattered covering of grayish scarfskin, grayish hairs protrude along margins, apex tufted. Buds borne terminally on 0.47- to 0.79-inch (12.0- to 20.0-mm) spurs arising from 2- or 3-year-old wood, old spur systems, and on 1-year-old shoots; a few are borne laterally on 1-year-old shoots. Lenticels on spurs are round or elliptical, medium-sized, raised, and tan.

LEAF (from current season's shoots). Blade: length 4.20 inches (106.8 mm), width 2.86 inches (72.8 mm); often folded upward from ventral midrib; oval; apex acuminate; base rounded; medium thick, leathery; ventral (upper) surface dark green, dorsal (lower) surface light green; young leaves finely pubescent on both surfaces, older leaves glabrous; midrib light green, ventral surface finely pubescent, dorsal surface glabrous; veins pinnately netted; margins serrate, setaceous, teeth length 0.04 to 0.06 inch (1.0 to 1.5 mm), sinuses shallow or medium depth, wide, angular at bases. Petiole: length 1.0 inch (25.4 mm), mid-diameter 0.06 inch (1.6 mm), light green, pubescent on ventral side, glabrous on dorsal side, channeled, small stipules on some specimens.

INFLORESCENCE. Corymb, with an average of seven flowers.

FLOWER. Width 1.13 inches (28.6 mm). Pedicel: length 1.14 inches (29.0 mm), mid-diameter 0.04 to 0.05 inch (1.0 to 1.2 mm); light green; nearly glabrous with a few long, very fine hairs. Floral tube (surrounding ovary): light green, glabrous. Sepals: acuminate; length 0.20 inch (5.0 mm), width 0.09 inch (2.2 mm); usually reflexed; light green to greenish yellow; ventral side pubescent with light tan hairs, dorsal side glabrous; margins appear serrated due to presence of small, brown, glandular trichomes. Petals: white, length 0.59 inch (15.1 mm), width 0.53 inch (13.6 mm), roundish or

truncate to oval, margins wavy or gently lobed. Stamens: 16 to 21 per flower; length variable, longest extend anthers to or slightly above level of stigmas; filaments white; anthers light purplish red (Plate 6 A 5, "Vernonia purple", Maerz and Paul, 1950). Pistil: with five glabrous, light green styles of various lengths and separated to the ovary; ovary usually with five carpels.

FRUIT. Size: variable, length 3.40 inches (86.4 mm), diameter 3.64 inches (92.6 mm), weight 389.9 grams. Shape: turbinate or globular in longitudinal section, circular to somewhat angular in transverse section. Stem (pedicel): length 1.39 inches (35.4 mm), mid-diameter 0.13 inch (3.3 mm); relatively straight; green (Plate 23 J 3, Maerz and Paul, 1950); glabrous; lenticels raised, tan, circular or elliptical, with longitudinal fissures. Cavity: acute, narrow with medium depth, sides slightly angular, surface with two or three shallow furrows, lenticels similar to those on expanded areas. Basin: circular or slightly angular, narrow with medium depth, sloping sides, surface smooth or with one or two shallow furrows, lenticels smaller and less conspicuous than in other areas of skin. Calyx: deciduous, partly persistent, or persistent, open when persistent; lobes narrow, medium in length, erect. Skin (ripe fruits): tannish green (Plate 13 L 5, "Bistre green", Maerz and Paul, 1950) to tan (Plate 13 L 7, "Tinsel deep tone", Maerz and Paul, 1950); somewhat bitter, detracts from flesh flavor; tough, relatively thick; adhesion to flesh tight; surface russeted, dull; lenticels conspicuous, large, raised, numerous, round or hexagonal, scaly under magnification, light tan (Plate 12 J 7, Maerz and Paul, 1950). Calyx tube (cavity beneath the calyx lobes as seen in longitudinal midsection): cone shaped, relatively short, medium width, remnants of styles present. Stamens: often deciduous, marginal when present. Core line: distinct, slightly clasping (clasps calyx tube) as seen in longitudinal midsection; angular, often pentagonal, in transverse midsection; outlined by relatively few, large stone

Chinese Pears

TSU LI

SYNONYMS. Tzu Li.

ORIGIN. Hu (1937) reported that Tsu Li is an old and famous variety in the Shantung Province of Northeastern China, and that production of the variety is restricted to the Chucheng, Laiyang, and Penglai districts of the province. Kubo (1970) stated that Tsu Li was introduced into Japan from Laiyang, Shantung Province, China, in 1912 by Dr. Tetsuya Onta.

SOURCE. U.S. Department of Agriculture from the Faculty of Agriculture, Tokyo University, Hongo, Tokyo, Japan; received March 10, 1955 and numbered P. I. 224088 (USDA Plant Inventory No. 163, 1964). We obtained our scions from the USDA in 1957.

Horticultural Description

TREE. Large, vigorous, upright, dense, moderately productive. Trunk: medium diameter; bark slightly rough with dark brown under-color overlaid with thin, scaling, grayish-white cork tissue. Branch: medium diameter; bark slightly rough with dark brown under-color overlaid with a thin layer of shedding, grayish-white cork tissue; lenticels large, numerous, raised, rough, oblate, light brown. Branchlet: medium diameter; internode length 2.03 inches (51.7 mm); bark smooth, greenish brown; lenticels numerous, raised, round to elliptical, large, tan. Leaf bud: alternate phyllotaxis; free; conical; length 0.35 inch (8.9 mm); width 0.22 inch (5.6 mm); scales brown, covered with whitish-gray scarfskin. Flower bud: length 0.63 inch (16.1 mm); width 0.24 inch (6.2 mm); conical; scales brown with sparse covering of grayish-white



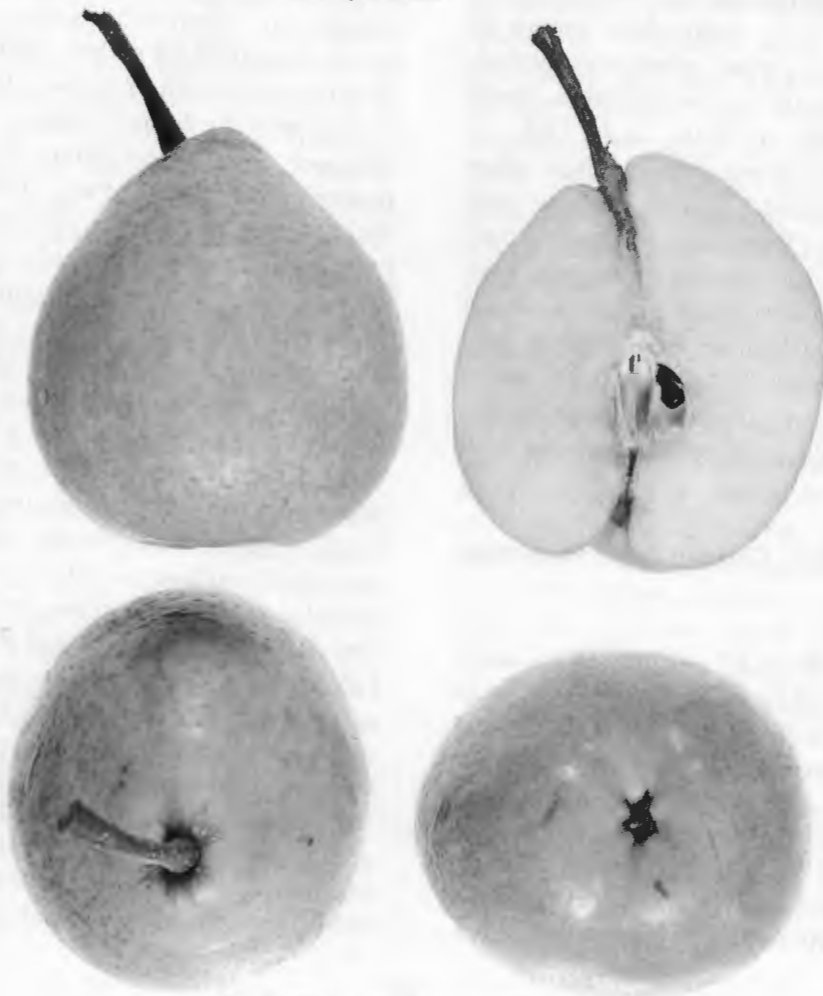
Tsu Li. Left: Spur bearing a terminal and a lateral flower bud; second and third from left: 2- or 3-year-old wood with young spurs bearing flower buds; extreme right: 1-year-old shoot bearing three flower buds. Photographed during dormant period (February).



Tsu Li flower cluster, and flowers and petals.



Tsu Li leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Tsu Li fruits, mature (eating-ripe).

scarfskin; tan pubescence from ventral sides protruding along margins; apex tufted. Buds borne terminally on 0.75- to 1.25-inch (19.0- to 31.8-mm) spurs arising from 2- and 3-year-old wood, old spur systems, and 1-year-old shoots; a few borne laterally on 1-year-old shoots. Lenticels on spurs range from small to large, are oval to round, raised, tan, many with median longitudinal fissures.

LEAF (from current season's shoots). **Blade:** length 5.0 inches (127.0 mm); width 2.94 inches (74.8 mm); most folded upward from ventral midrib; ovate to oblanceolate; apex acuminate to caudate; base acute to rounded; thick, leathery; ventral (upper) surface dark green, dorsal (lower) surface light green and glabrous; young leaves with reddish cast and pubescent ventral surface, becoming subglabrous with maturity; midrib light green, both surfaces pubescent in young leaves, lower surface glabrous in old leaves, ventral surface speckled with many dark brown or black trichomes; veins pinnately netted; margins with sharply setose serration, teeth fine, length 0.02 to 0.06 inch (0.6 to 1.5 mm), inclined forward more than other Asian pear varieties, sinuses narrow and rounded at bases. (The teeth on Tsu Li leaves are shorter and the sinuses narrower than those on Ya Li leaves which they resemble.) **Petiole:** length 2.04 inches (51.8 mm); mid-diameter 0.07 inch (1.9 mm); pale green; pubescent in young leaves, glabrous in old leaves; channel deep; a few specimens with stipules.

INFLORESCENCE. Corymb, with an average of five flowers.

FLOWER. Width 1.12 inches (28.2 mm). **Pedicel:** length 0.71 inch (18.1 mm), mid-diameter 0.05 inch (1.2 mm); light green, lightly pubescent. **Floral tube** (surrounding ovary): light green, slightly pubescent. **Sepals:** acuminate; length 0.30 inch (7.6 mm); basal width 0.17 inch (4.3 mm); slightly reflexed to erect; light green; ventral surface pubescent with very fine, white hairs,

dorsal surface glabrous; margins appear serrated due to small, brown, glandular trichomes. **Petals:** white with pink margins; length 0.53 inch (13.6 mm); width 0.41 inch (10.4 mm); oval to roundish; concave; margins undulate with some lobed or clefted. (Prior to anthesis, Tsu Li flowers are much more pink than flowers of Ya Li or the Japanese pear varieties.) **Stamens:** 17 to 19 per flower; length places most anthers below stigmas, diminishing the chance of self-pollination; filaments white; anthers purplish red. **Pistil:** with five long styles plus one to three short, vestigial styles; styles glabrous, light green and separated to the ovary; ovary usually with five carpels.

FRUIT. **Size:** variable, length 3.48 inches (88.5 mm), diameter 2.95 inches (74.9 mm), weight 241.8 grams. **Shape:** somewhat variable; ovate-pyriform in longitudinal section, neck obscure in some specimens; circular to angular in transverse section. **Stem (pedicel):** length 1.64 inches (40.2 mm); mid-diameter 0.12 inch (3.0 mm); broadened near cavity, may be lipped; slightly curved, often obliquely set; brown (Plate 15 A 12, "Burnt umber", Maerz and Paul, 1950) or brown with a faint olive-green tint; lenticels raised, numerous, medium-sized, elliptical, tan. **Cavity:** acute in most specimens, obtuse in others; narrow and shallow; may be lipped; sides usually furrowed and angular; surface partly or completely covered with smooth, brown russet; lenticels large, conspicuous, scaly, angular, tan. **Basin:** angular; medium depth and breadth if calyx persists, deep and broad if calyx is deciduous; sides sloping and furrowed; surface usually free of russet and speckled with numerous, small, inconspicuous, elliptical or diamond-shaped lenticels. **Calyx:** may be deciduous, partly persistent, or persistent; persistent calyx partly open or open, lobes erect and connivent. In specimens with a deciduous calyx, scarred area where the sepals were attached is light brown and pentagonal or hexagonal in shape. Surface of the calyx tube, exposed when the sepals were shed, is rough, russeted, and light brown. **Skin**

(ripe fruits): light green to yellowish green (Plate 13 L 1, Maerz and Paul, 1950); skin at the periphery of the lenticels remains a darker green than that between lenticels; slightly bitter, detracts somewhat from general flesh flavor; relatively tough and thick; adhesion to flesh tight; surface semiglossy, but the lenticels make it appear rough and dull; lenticels conspicuous, small to very large, raised, numerous, roundish or polygonal, scaly under magnification, tan (Plate 11 L 4, "Wax yellow", Maerz and Paul, 1950), some with a dot of dark brown cork near their centers. Calyx tube (cavity beneath the calyx lobes as seen in longitudinal midsection): urn shaped, variable size, remnants of styles present in specimens with persistent calyx. Stamens: often deciduous, marginal when present. Core line: faint, outlined with stone cells concentrated near calyx tube; meeting or slightly clasping the calyx tube as seen in longitudinal midsection; angular, often hexagonal, in transverse midsection. Core: length 1.19 inches (30.2 mm), width 1.29 inches (32.8 mm), distant from stem, small to medium in relation to fruit size. Carpels: five in number, obovate, elongated, abaxile, open or partly open to axis. Axial sac: wide, with white, callus-like substance on inner surface. Seeds: length 0.34 inch (8.6 mm); width 0.19 inch (4.8 mm); plump on one side and flattened on the other; apex ranges from acute to acuminate; seed coat brown or dark brown, usually lighter on flat side; average seed number 4.1. Flesh: white with faint tint of yellow (Plate 10 B 1, "Oyster white", Maerz and Paul, 1950); sweet, trace of tartness, refreshingly mild; soluble solids 13.1 percent; aroma distinct and peculiar to the variety; texture firm, tender, crisp, juicy, somewhat coarse and pulpy. (The flesh of Tsu Li fruits has more stone cells than that of Ya Li fruits.) Quality: good. Hu (1937) included Tsu Li and Ya Li with the best three or four Chinese pear varieties in respect to flavor and juiciness, and rated the flesh texture of Tsu Li as very tender and the best of all Chinese pears.

HARVEST. September 10 through 23 at Davis. Pick when eating ripe, usually when skin becomes yellowish green.

SEASON. From harvest through January if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Tsu Li apparently is self-incompatible and self-unfruitful in most years, and requires cross-pollination for commercial fruit-set. In tests at Davis, Tsu Li flowers bagged to prevent cross-pollination, or emasculated but not pollinated, failed to set any fruits in 1965, 1966, and 1973. In 1976, however, Tsu Li flowers emasculated, self-pollinated, and bagged, set fruits at the rate of 6.2 percent. The fruits apparently resulted from self-compatibility since they contained seeds.

In contrast, a heavy fruit-set was obtained when Tsu Li flowers were emasculated and cross-pollinated with Ya Li pollen. Only poor to fair fruit-sets were obtained when other varieties were tested as pollenizers for Tsu Li. Since open-pollinated control branches gave relatively heavy fruit-sets, it was assumed that injury resulting from the emasculation process may have been partly responsible for the relatively poor fruit-sets following most of the cross-pollinations.

Ya Li pollen gave the best fruit-set on Tsu Li, and the bloom periods of these varieties have good overlap for cross-pollination. Most of the varieties bloom too late for good overlap with Tsu Li. However, the overlap of the last part of Tsu Li bloom with the first part of the Shinseiki, Chojuro, or Twentieth Century bloom period may provide enough cross-pollination for a commercial crop on Tsu Li trees in some years.

Tsu Li produces viable pollen which, in tests at Davis, gave good fruit-sets on Shinseiki, Chojuro, Twentieth Century, Doitsu, Kikusui, Seigyoku, Kumoi, Ishiiwase, and Ya Li.

YA LI

SYNONYMS. Yarr Li.

ORIGIN. Ya Li is an old variety, commonly cultivated in the Shansi, Hopeh, Shantung, and Honan Provinces of Northeastern China (Hu, 1937). Kubo (1962) stated that the origin of Ya Li is uncertain. However, according to Dr. Hirotaka Torikata, Faculty of Agriculture, Nagoya University, Nagoya, Japan (personal correspondence with Dr. Kay Ryugo, December 4, 1972) the variety was introduced into Japan from China in 1872 by the National Experiment Station.

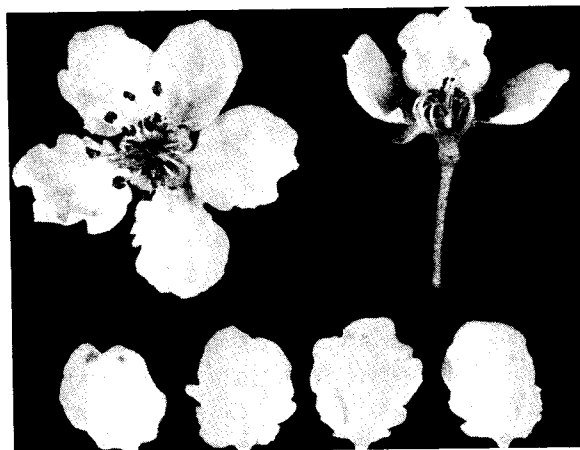
SOURCE. U.S. Department of Agriculture from the Faculty of Agriculture, Tokyo University, Hongo, Tokyo, Japan, received March 10, 1955 and numbered P. I. 224090 (USDA Plant Inventory No. 163, 1964). We obtained scions from the USDA in 1957.

Horticultural Description

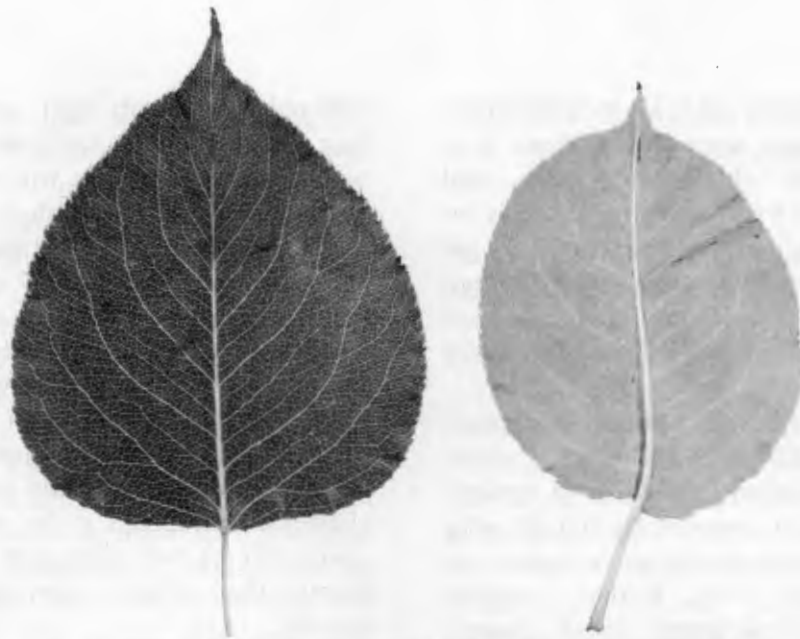
TREE. Large, vigorous, upright, somewhat spreading, dense, productive. Trunk: medium diameter; bark somewhat shaggy with dark brown under-color overlaid with scaling, grayish-white cork tissue. Branch: medium diameter; bark smooth with dark, greenish-brown under-color overlaid with thin, shedding, grayish-white cork tissue; lenticels numerous, large, oblate, tan. Branchlet: medium diameter, internode length 2.31 inches (58.7 mm); bark smooth, light brown with covering of grayish-white scarfskin; lenticels medium-sized, elliptical, tan; new growth pubescent. Leaf bud: alternate phyllotaxis; free; conical; length 0.22 inch (5.5 mm); width 0.19 inch (4.8 mm); scales brown with partial covering of whitish-gray scarfskin, tan pubescence protruding from margins. Flower bud: length 0.52 inch (13.3 mm); width 0.22 inch (5.7 mm); conical; plump; scales brown with sparse covering of grayish-white scarfskin, margins fringed with fine, tan hairs protruding from ventral surfaces; apex tufted.



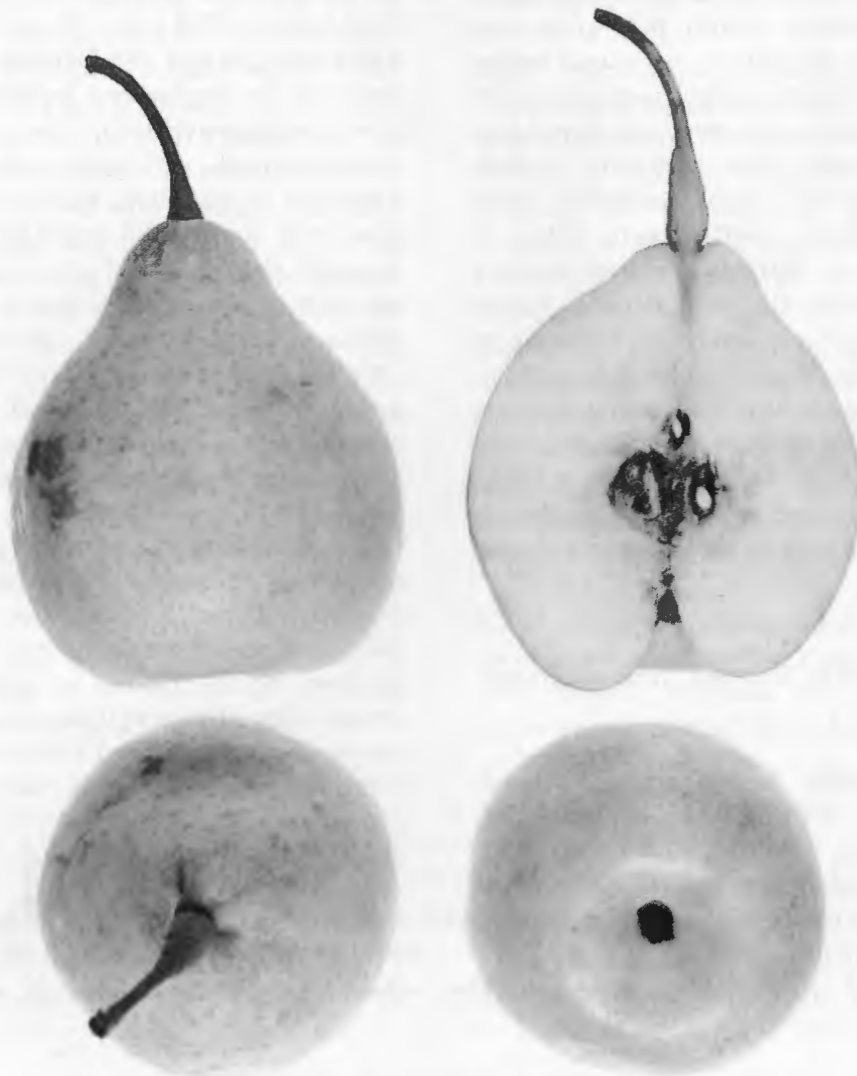
Ya Li. Left to right: first three are spurs bearing flower buds; extreme right: 1-year-old shoot bearing terminal and lateral flower buds. Photographed during dormant season (February).



Ya Li flower cluster, and flowers and petals.



Ya Li leaves from current season's shoots. Left: upper (ventral) surface; right: lower (dorsal) surface.



Ya Li fruits, mature (eating-ripe).

Buds borne terminally on 0.75- to 1.25-inches (19.0- to 31.8-mm) spurs arising from 2- or 3-year-old wood, old spur systems, and 1-year-old shoots; a few are borne laterally on 1-year-old shoots. Lenticels on the spurs are small to medium-sized, elliptical to round, sparsely scattered, raised, tan, and many have median longitudinal fissures.

LEAF (from current season's shoots). **Blade:** length 3.82 inches (97.0 mm); width 3.07 inches (78.0 mm); some folded upward from ventral midrib, some nearly flat; broadly ovate; apex acuminate; base rounded to obtuse; medium thick, leathery; ventral (upper) surface dark green, dorsal (lower) surface light green; new foliage with a reddish cast; young leaves pubescent on both surfaces, old leaves glabrous; midrib pale green and pubescent on both surfaces of young leaves, in older leaves ventral surface pubescent with sprinkling of black trichomes, and dorsal surface subglabrous; veins pinnately netted; margins with sharply setose serration, teeth incline forward, teeth length 0.06 to 0.12 inch (1.5 to 3.0 mm), sinuses narrow, lobed or rounded at bases. **Petiole:** length 1.47 inches (37.3 mm); mid-diameter 0.07 inch (1.8 mm); light green, some specimens with pinkish tint on ventral surface; pubescent in young leaves, glabrous in old leaves; channel deep. Petioles of young leaves may have one or two needle-like stipules on ventral side near base of blade; stipules slough off as leaf ages.

INFLORESCENCE. Corymb, with an average of eight flowers.

FLOWER. Width 1.18 inches (30.1 mm). **Pedicele:** length 0.94 inch (24.0 mm), mid-diameter 0.04 to 0.06 inch (1.0 to 1.5 mm), light green, pubescent. **Floral tube** (surrounding ovary): light green, pubescent. **Sepals:** acuminate; length 0.34 inch (8.5 mm); basal width 0.13 inch (3.3 mm);

reflexed downward; light green; ventral surface pubescent with tan hairs, dorsal surface with scattered, nearly white hairs; margins appear finely serrated due to presence of small, brown, glandular trichomes. **Petals:** white; length 0.57 inch (14.6 mm); width 0.50 inch (12.7 mm); oval or roundish; concave; margins undulate, entire, or clefted. **Stamens:** average 21 per flower, length sufficient to place anthers even with or slightly below level of stigmas, filaments white, anthers purplish red. **Pistil:** with four to six glabrous, faint-green styles separated to the ovary, one or two styles may be considerably shorter than others; ovary usually with five carpels.

FRUIT. **Size:** somewhat variable, length 3.24 inches (82.4 mm), diameter 2.74 inches (69.5 mm), weight 198.5 grams. **Shape:** fairly uniform; in longitudinal section turbinate to globular-acute-pyriform, some specimens with a distinct neck, neck obscure in others, often lopsided; in transverse section circular. **Stem** (pedicel): length 1.85 inches (46.9 mm); mid-diameter 0.11 inch (2.7 mm); curved; broader at cavity; fleshy, often lipped; light brown (Plate 14 L 9, "Bronze", Maerz and Paul, 1950), some with greenish tint; lenticels small, elliptical, slightly raised, sparsely scattered, tan. **Cavity:** obtuse; very shallow and narrow; sometimes lipped; sides may be smooth, furrowed, or grooved; surface dominated by streaks of russet radiating from the stem and obscuring the medium-sized, tan lenticels. **Basin:** angular; deep and broad; sides sloping and generally smooth, except for shallow, broad furrows in some specimens; surface free of russet; lenticels very small and nearly obscure; exposed surface of calyx tube rough, russeted. **Calyx:** deciduous; scars remaining after the sepals were shed make up the angular, often pentagonal, border of the calyx tube. **Skin** (ripe fruits): light greenish yellow (Plate 12 L 1, "Oil yellow", Maerz and Paul, 1950); bland, does not detract from flesh flavor; moderately tough, medium thick;

adhesion to flesh tight; surface smooth, dull to semiglossy, slightly waxy; lenticels conspicuous, small to medium, slightly raised, numerous, pentagonal or hexagonal, scaly under magnification, tan (Plate 12 J 6, "Honey middle stone", Maerz and Paul, 1950), some with light-green centers, others with a dot of brown cork. (Ya Li fruits have an exceptionally attractive, clean appearance and are usually completely free of russet except at the cavity.) Calyx tube (cavity beneath the calyx lobes as seen in longitudinal midsection): funnel- or urn-shaped, medium length, narrow, remnants of styles may be present. Stamens: deciduous. Core line: distinct; relatively few stone cells near line; clasping (clasps calyx tube) as seen in longitudinal midsection; angular, pentagonal or hexagonal, in transverse midsection. Core: length 1.30 inches (32.9 mm), width 1.20 inches (30.6 mm), distant from stem, large in relation to fruit size. Carpels: five in number, obovate, usually abaxile and closed. Axial sac: wide, lined with a white, callus-like substance. Seeds: length 0.32 inch (8.2 mm); width 0.20 inch (5.0 mm); relatively plump, some specimens three-sided; apex acute; seed coat brown to nearly black, light and dark areas on some specimens, slightly gelatinous; average number 7.4. Flesh: white (Plate 9 B 1, Maerz and Paul, 1950); mildly sweet, slight trace of tartness; soluble solids 11.7 percent; aroma distinctively fragrant; texture tender, crisp, juicy, slightly pulpy and coarse, relatively few stone cells. Quality: good to excellent. Hu (1937) stated, "The Chinese pear is sweet and slightly tart. It is also juicy and crisp. The flavor of Tsu Li, Ya Li, and Chiu Pei Li is best."

HARVEST. September 8 through 23 at Davis. Pick when eating ripe, usually when skin shows some yellow.

SEASON. From harvest through December if held at approximately 32° F (0° C).

POLLINATION REQUIREMENTS. Ya Li is self-incompatible and self-unfruitful in most years, and requires cross-pollination for commercial crops. Ya Li flowers bagged to prevent cross-pollination, failed to set any fruits at Davis in 1965, 1966, 1970, and 1973, but set at the rate of 0.4 percent in 1976. Flowers emasculated but not pollinated set a few parthenocarpic fruits in 1966, but similar emasculated controls set no fruits in 1965, 1967, 1971, and 1976.

Good fruit-sets were obtained when Ya Li flowers were emasculated and cross-pollinated with pollen from Twentieth Century, Kikusui, Chojuro, Bartlett, Shinseiki, or Tsu Li. Imamura Aki and Seigyoku pollens gave fair fruit-sets on Ya Li. The bloom period for Tsu Li has good overlap with that of Ya Li for cross-pollination, but the other varieties bloom too late to have more than a partial overlap with Ya Li. However, the overlap of the last part of Ya Li bloom with the first part of the Imamura Aki, Shinseiki, Chojuro, or Twentieth Century bloom may provide enough cross-pollination for a commercial crop on Ya Li in some years.

Ya Li produces viable pollen which, in tests at Davis, gave good fruit-sets on Twentieth Century, Chojuro, Shinseiki, Kikusui, Kumoi, Tsu Li, Seigyoku, and Imamura Aki.

Table 3 (next page) is included to facilitate comparison of certain data regarding the Asian pear varieties. Data for Bartlett pear are also included.

Table 3.

DATES OF FULL BLOOM, HARVEST DATES, AND FRUIT CHARACTERISTICS OF ASIAN AND BARTLETT PEARS

(Values are averages for 3 to 5 years at Davis, California)

Type of pear and variety	Full bloom date	Harvest dates	Fruit characteristics at harvest								Quality	
			Fruit			Stem		Core		Flesh firmness		Soluble solids
			Weight (g)	Length (mm)	Diam (mm)	Length (mm)	Diam (mm)	Length (mm)	Diam (mm)	(lb)	(%)	
Japanese (Green to yellow skin)												
Shinseiki	Mar 23	7/25– 8/15	153	57	67	19	2.6	28	28	8.3	12.7	Good to excellent
Seigyoku	Mar 28	8/ 1– 8/15	213	62	76	24	2.5	29	28	7.7	12.6	Good to very good
Kikusui	Mar 27	8/10– 8/19	185	58	73	31	2.4	30	32	7.6	14.4	Good to very good
58 Twentieth Century	Mar 25	8/10– 8/20	146	55	66	25	2.6	30	29	7.0	12.3	Good to excellent
(Russet skin)												
Kumoi	Mar 30	8/ 3– 8/10	189	63	72	43	2.9	36	31	6.4	12.0	Fair
Ishiiwase	Apr 2	8/ 6– 8/15	200	62	74	35	2.8	32	32	7.6	12.7	Fair to good
Chojuro	Mar 24	8/ 9– 8/19	150	54	66	28	2.5	24	26	10.9	13.4	Good
Doitsu	Mar 25	8/10– 8/25	152	54	69	29	2.7	23	24	7.4	13.1	Fair
Imamura Aki	Mar 22	9/18–10/ 2	260	68	81	30	2.8	30	32	8.6	12.8	Fair
Okusankichi	Mar 27	9/20–10/15	390	86	93	35	3.3	38	31	7.8	12.0	Fair
Chinese												
Ya Li	Mar 17	9/ 8– 9/23	198	82	70	47	2.7	33	31	6.8	11.7	Good to excellent
Tsu Li	Mar 18	9/10– 9/23	242	88	75	40	3.0	30	33	8.0	13.1	Good
Common												
Bartlett	Mar 30	8/ 2– 8/ 7	215	93	73	33	3.3	32	27	17.7	11.7	Good to excellent

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