Figs

by W. B. Storey

The common fig (*Ficus carica* L.; family Moraceae; 2n = 26) has been cultivated as a fruit tree in the eastern Mediterranean regions of Europe and Africa and the southwestern regions of Asia from time immemorial. Even the approximate date of its beginnings as a cultivated crop is lost in antiquity.

Today, the fig is an important fruit crop in many parts of the world. It is especially so in countries bordering on the Mediterranean Sea, the Red Sea, and the Arabian Sea. The people of these countries eat the fruit fresh, dried, as paste, and baked in pastries. Several countries export it dried or as paste. Principal exporting countries, their long-term average annual production of dried figs and paste in metric tons, and exports to the United States in 1970 and 1971 are given in Table 1.

TABLE 1. Long-term average annual production of fig products by principal producing countries, and 1970 and 1971 exports to the United States, in metric tons (California Fig Institute, 1972).

Country	Average annual production (metric tons)	Exports to the U.S. (metric tons)	
		1970	1971
Spain	82,555	1,837	2,839
Italy	76,205	23	27
Turkey	30,845	1,616	437
Greece	21,866	1,272	1,177
Portugal	8,427	3,997	2,909
Others	ca. 20,000	7	4
Total	239,898	8,752	7,393

Figs are cultivated around the world in subtropical and tropical regions and to some extent in moderate climatic regions of the Temperate Zones. Production is limited in most countries, and usually the fruit is consumed fresh locally or in dried, canned, and preserved form.

The only significant plantings outside the Mediterranean-Asian region are in the United States, principally the state of California. In 1972 approximately 8,800 ha of land in the United States were planted with fig trees, 7,000 ha of which were in California, mostly in the San Joaquin Valley. The remainder were in Texas, Louisiana, Florida, other southeastern states, and in southern Oregon. Of California's production, 85% is marketed as dried figs, 12% as canned figs and fig juice, and 3% as fresh fruit. Fruit produced by other states is eaten fresh, canned, or made into preserve.

Total United States utilization of dried figs and fig paste in 1972 was 20,025 mt. California's contribution of 12,720 mt accounted for 63% of the total. Foreign imports of 7,933 mt accounted for the remaining 37%. All but a small fraction of the total of dried figs and paste utilized goes into the making of fig bars.

From 1923 to 1952, the United States ranked

fourth among fig producing nations; now it ranks sixth. California's land area in figs, the amount of fruit produced, and monetary return to growers in 1969 represent the culmination of a steady decline of the industry since its heyday in 1943 when there were 14,269 ha in orchards, production was 40,269 mt, average farm return was $322/mt, and total farm return was $10,716,000. In 1969, California produced 11,930 mt of dried fruit, and 6,713 mt of fresh fruit (2,467 mt equivalent dry weight), 5,444 mt of which were canned. The average farm price was about $240/mt, and the year's farm value was $3,085,350.

Causes for the decline included competition from imported figs from countries with low cost labor, increasing local labor costs, encroachment of residential and industrial developments into the principal producing areas, which happen to be near large cities, and a tax structure which taxes land on market value as determined by adjacent properties rather than on actual agricultural use, making economical production impossible in some localities.

Since 1969 there has been a resurgence of activity in the California fig industry. This was generated by the 1967 Arab-Israeli War which resulted in closing the Suez Canal, disrupting shipping in the Mediterranean Sea, and shutting off supplies from countries east of Suez. Since then, the entire California crop has been marketed annually at satisfactory prices. Completion of the California Aqueduct down the west side of San Joaquin Valley in 1971 brought water from northern California, opening vast areas to irrigated agriculture. Since fig trees grow rapidly and come into bearing quickly, they are being planted to produce income for defraying taxes and stand-by water charges. About 194 ha were planted in 1968, about 190 ha in 1969, about 223 ha in 1970, and as many as 405 ha in 1971.

Revitalization of the fig industry in California has brought a need for stepped-up research in all phases of fig culture, including development of new superior cultivars to enhance the growers' economic position.

Origin and Early Development

Early History

According to Greek mythology, Zeus was pursuing Ge and her son Sykeus in the war of the Titans, when Ge, in order to save Sykeus, metamorphosed him into a fig tree. The city of Sykea in the ancient country of Cilicia derived its name from this myth.

An Athenian myth credits the goddess Demeter with having been the first to reveal the "fruit of autumn" to humans, who named it *fig*. The word *sycophant* is derived from the Greek words *sykon* (fig) and *phanein* (to show). The original connotation is obscure, but is thought to have alluded to a person who accused another falsely. In modern usage it connotes a parasitic or servile hanger-on or flatterer.

According to Aigremont (1908), the fig is a symbol of fertility and propagation in oriental countries. Among the Hellenes it was sacred to the sensuous, flabby, procreative god Dionysius who, in order to keep a promise to Polyhymnos, placed a phallus of fig wood on the latter's grave and kept the promised favor for himself. The phallus carried at Dionysian festivals was carved out of fig wood. The fig became the tree of phallic worshippers of India and Italy where people still use the gesture "fico," with the thumb inserted between the first two fingers. In modern times it has become an obscene gesture of contempt. However, it also represents the letter *T* in a one-hand dactylic alphabet for communicating with deaf persons.

Botanists believe that the fig was first brought into cultivation by inhabitants of the fertile region of southern Arabia, where wild trees still are to be seen. It was mentioned by King Urukagina in the Sumerian Era ca. 2900 B.C., and became known to the Assyrians as early as 2000 B.C.

In time, it spread in cultivation through Asia Minor and into all countries of the Mediterranean Region. The specific epithet *carica* refers to Caria, an ancient region in Asia Minor noted for its figs. It was known on Crete early as 1600 B.C. Homer, ca. 850 B.C., mentions it several times in his *Iliad* and *Odyssey*.

A Roman legend recounts that Romulus and Remus, who founded Rome, (ca. 746 B.C.,) were

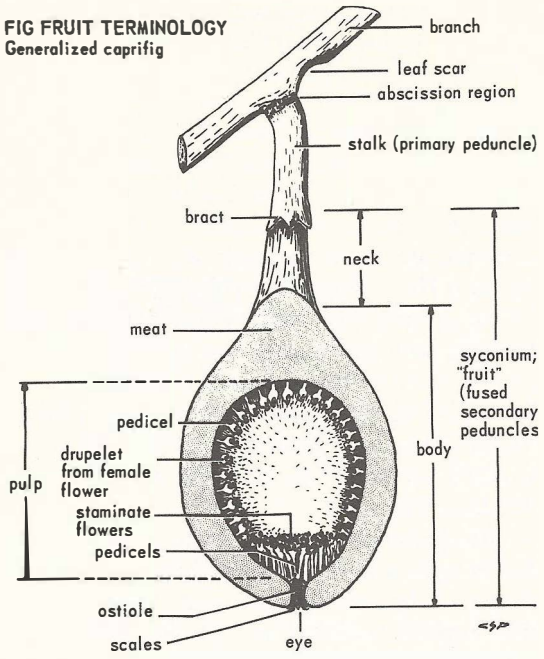

FIG. 1. Diagram of *Ficus carica* syconium.

sheltered in infancy by a sacred fig tree, *ficus Ruminalis*, while being nursed and cared for by a she-wolf and a woodpecker. The tree was named for Ruminia, a goddess who watched over suckling animals.

The spread of fig culture eastward in Asia went slowly, for the species, which thrives in arid subtropical climates, is not well adapted to the humid tropics of India and southeastern Asia. It is said to have reached China no earlier than the Tang period, 618–907 A.D. Its spread southward in Africa was still slower, and it seems not to have reached South Africa until sometime in the nineteenth century.

During the great age of exploration that followed "discovery" of the New World by Christopher Columbus in 1492, the fig spread in cultivation to all parts of the tropical, subtropical, and moderately temperate regions of the Americas. European cultivars were established in the West Indies in 1520, in Peru by 1526, and in Florida about 1575. By 1683 trees had been established in Baja California, Mexico. Franciscan missionaries led by Junipero Serra planted the first figs in California when they established the mission at San Diego in 1769. The commercial cultivar 'Franciscana', or 'Mission' as it is commonly called, owes its name to this event.

Systematic Position

The family Moraceae includes 60 genera and more than 2000 species of trees, shrubs, vines, and a few herbs. Familiar members of the family are: *Morus alba*, L., and *M. nigra*, L., the white and black mulberries; *Broussonetia papyrifera* (L.) Vent., the paper mulberry or wauke, a widely used ornamental tree in California; *Artocarpus altilis* (Parkins) Fosb., the breadfruit, and *A. heterophyllus* Lam., the jak fruit; and numerous *Ficus* species, including the banyans. The genus *Ficus* comprises about 1000 species, several of which have edible fruit (Condit, 1969). Corner (1965) divided the genus into 48 subgenera on the basis of characteristics which delineate one group of closely allied species from another.

F. carica belongs to the subgenus Eusyce, which is characterized by species having unisexual flowers only and by gynodioecism. Some of the allied species resemble *F. carica* in growth form, and in leaf and fruit characters. Several are hosts to *Blastophaga psenes* Cavolini, the fig wasp, which is the instrument of pollination. Forms intermediate between valid species of *Ficus* suggest natural hybridization, which explains the diversity of opinions among systematic botanists with respect to species delineation and typification. However, the following are regarded as probably being valid

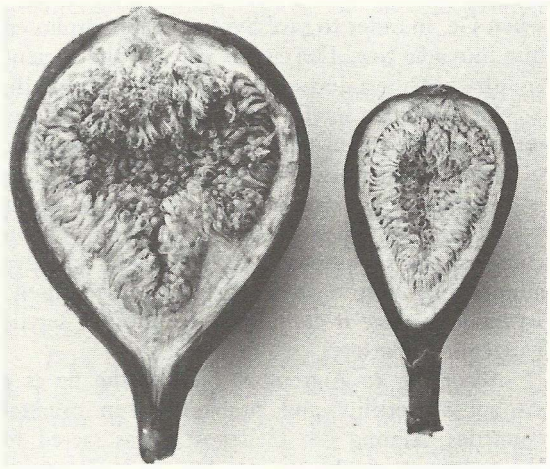

FIG. 2. *F. carica* syconia at time of pollination. Left, monoecious caprifig syconium with staminate flowers in anthesis; right, pistillate fig syconium with flowers in anthesis.

species: *F. geranifolia* Miq.; *F. palmata* Forsk.; *F. pseudo-carica* Miq.; and *F. serrata* Forsk.

The characteristic inflorescence of all *Ficus spp.* is the syconium (Figs. 1, 2). It is a complex, enlarged, fleshy, hollow peduncle bearing closely massed flowers on the entire inner wall. It has an apical pore, the ostiole, which forms a passage between the hollow interior and the outer air. The canal of the ostiole is lined with numerous scales, and the external orifice or eye is sheathed by overlapping scale-like bracts.

Pomologically, the fig fruit is the mature ("ripe"), succulent syconium. Botanically, however, it is a spurious fruit consisting entirely of vegetative peduncular tissue. The true fruits are tiny pedicellate drupelets within. In fruit classifications, the fig usually is included with the multiple or collective fruits.

In fig literature, the syconium frequently is called a "hollow receptacle." Although the term *receptacle* is used in the dictionary sense that it is a structure that can receive and contain something, its use to denote the syconium is unfortunate, for persons are known to have interpreted it as being homologous to the receptacle of an aggregate fruit such as the strawberry (*Fragaria x ananassa* Bailey, family Rosaceae) and papaw (*Asimina triloba* Dunal., family Annonaceae), the fruits of which consist of the more or less fleshy receptable of an individual flower bearing few to many carpels. Each fig flower within a syconium has its own receptacle.

Horticultural Classification

F. carica is a gynodioecious species, having two distinct forms of trees, the caprifig which is monoecious, and the fig which is pistillate.

Fig flowers are minute. Typically, they are pedicellate, hypogynous, and unisexual, with a single five-parted perianth. There are three kinds of flowers: short-styled pistillate; long-styled pistillate; and staminate (Fig. 3). Both kinds of pistillate flowers are single-carpelled with a usually bifid stigma. The short-styled pistillate flower has a more nearly globose ovary, and a style about 0.70 mm long; it is adapted for oviposition by the fig wasp. Commonly, it is called a gall flower, but Condit and Flanders (1945) considered this term to be a misnomer. The long-styled flower has a more or less ovoid or ellipsoid ovary, and a style about 1.75 mm long; it is not adapted for oviposition by the fig wasp. Both kinds of pistillate flowers

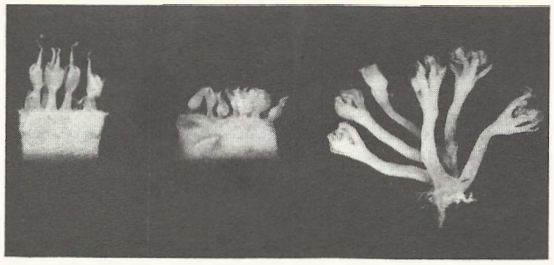

FIG. 3. Fig flowers. From left: long-style pistillate, short-style pistillate, staminate.

are fertile, and, following pollination and syngamy, each develops into a drupelet which is the true fruit of the fig. In vernacular language, these are "fig seeds." The staminate flower is longer pedicelled than the pistillate flowers, has a five-parted perianth, five stamens, and a vestigial pistil.

The caprifig tree is typified by syconia which contain short-styled pistillate flowers and staminate flowers. The pistillate flowers are distributed over most of the inner wall. The staminate flowers are massed around the interior end of the ostiolar canal (Fig. 2). The pistillate fig tree is typified by syconia which contain only long-styled pistillate flowers.

The caprifig produces three crops of syconia annually: 1) the mamme crop, which is initiated on current vegetative growth in fall, remains dormant through winter, and matures in spring; 2) the *profichi*, which is initiated in spring from latent buds on the previous season's wood, matures in summer, and supplies the grower with pollen-carrying wasps which pollinate figs of the Smyrna type, described later; 3) the *mammoni*, which is initiated on current growth in summer and matures in fall.

The fig may produce two crops a year or it may produce only one, depending on the cultivar and prevailing climatic conditions. The first crop appears in spring from latent buds on the previous season's growth. It is known as a *breba* crop. It matures in June and July in California. The second crop appears on current growth from May to July, and matures from August to December, depending on the cultivar. This crop has acquired no special name and is known simply as "the main or second crop." The relationship of the caprifig and fig crops to one another, to the life cycle of the fig wasp, and to fig breeding is covered more fully in the section on floral biology.

Horticulturists and breeders regard the caprifig

as a single type with about 20 cultivars which have been grown commercially for producing profichi for use in caprification. Presently, only the following five are grown for this purpose: 'Brawley', 'Milco', 'Roeding 3', 'Samson', and 'Stanford'.

Fig cultivars are classified into three horticultural types, Smyrna, San Pedro, and Common. The types are described below.

Cultivars of the Smyrna type usually do not produce breba crop. A few, such as 'Sari Lop' (syn. 'Calimyrna'), and 'Taranimt' may produce scanty to fair breba crops in some years. The syconia that reach maturity are seedless, flaccid, and insipid in flavor. Adequate main crops are initiated, but the syconia shrivel and fall from the tree at the end of the period of anthesis unless the flowers are pollinated. A fertilized ovule develops into a viable seed within the thin, shell-like, brittle endocarp, with endosperm surrounding the embryo. Condit (1955) described 116 named cultivars of this type. Only 'Sari Lop', which was renamed 'Calimyrna' for promotional purposes, is commercially important in California. In 1971 the area in producing 'Calimyrna' trees in California was 3,366 ha or 48% of the total of 7,000 ha. Important cultivars of the Mediterranean Region that are being evaluated as commercial types or for use in breeding in California are 'Azendjar', 'Cheker Injir', 'Marabout', 'Tameriout', 'Taranimt', and 'Zidi'.

Fig trees of the San Pedro type initiate fair to large breba crops. These persist to maturity without any known stimulus and ripen into palatable fruits. An adequate second crop of syconia is initiated, but usually only those in which the flowers have been fertilized develop to maturity. Condit (1955) described 21 named cultivars in this class. The only ones produced commercially in California for the early fresh fruit market are 'Gentile', 'King', and 'San Pedro'. Three important French cultivars are: 'Dauphine', 'Drap d'Or', and 'Pied de Boeuf'. 'Lampeira' is an important Portuguese cultivar.

Common type fig trees may or may not initiate breba crops which develop to maturity without any known stimulus. Some cultivars, e.g., 'Dottato' (syn. 'Kadota'), 'Beall', 'Archipel', and 'Franciscana' (syn. 'Mission'), mature fair to good annual breda crops regularly; others, such as 'Verdone' (syn. 'Adriatic'), 'Brunswick' (syn. 'Magnolia'), and 'San Piero' (syn. 'Brown Turkey' in California trade), may produce small to fair crops in some years, no crops in other years; and a few, such as 'Marseilles', 'Panachée', and 'Vernino', produce no breba crops at all. Most common fig cultivars produce fair to large main, or second, crops which develop to maturity without pollination or any other known stimulus. Condit (1955) described 470 named cultivars in this class. The important ones commercially or for breeding are 'Archipel', 'Beall', 'Conadria', 'Dottato', 'Genoa', 'Marseilles', and 'Verdone'.

Condit (1955) described 627 named cultivars of the fig. Doubtless, there are many obscure ones in various parts of the world that escaped notice. The synonyms for cultivars in widespread cultivation are legion.

History of Improvement

Excepting the modern hybrid 'Conadria' (Condit and Warner, 1956), all fig cultivars grown today owe their origins to selection by unknown persons in Asia and Europe in past centuries among wild seedling trees and volunteer seedlings of cultivated trees. These have been maintained clonally by rooted cuttings and, in the course of time, have acquired names.

The earliest attempts to create new improved cultivars by breeding were those reported by Swingle (1908, 1912), Hunt (1911, 1912), Burbank (1914), Rixford (1918, 1926), Noble (1922), and Condit (1928).

In 1922 R. E. Smith initiated a fig breeding project at the University of California, Davis. It was transferred to the Citrus Experiment Station in Riverside (now the Citrus Research Center and Agricultural Experiment Station) in 1928, and Ira J. Condit (Fig. 4) was appointed project leader. The project encompasses various studies as indicated by its title: "Genetics, Cytology, Morphology, and Breeding of Fig (*Ficus carica*), with

FIG. 4. Dr. Ira J. Condit (1883–), premier fig breeder, known affectionately to his colleagues as the "High Priest of the Fig."

Emphasis on Improving Varieties." Condit served as project leader from 1928 to 1968. W. B. Storey has been project leader since Condit's retirement in 1968. Storey and Condit (1969) contributed a chapter on fig breeding to *Outlines of Perennial Crop Breeding in the Tropics*, published by the Agricultural University, Wageningen, The Netherlands.

Material presented in this chapter is based largely on Condit's findings from more than 300 hybrid progenies totaling more than 30,000 seedlings. Insofar as is known, 'Conadria', which he and Warner introduced into the trade in 1956, is the only cultivar in commercial production that was developed in a planned breeding program. More than 267 ha are planted with 'Conadria' in Fresno and Merced Counties, California (Fig. 5).

Besides the writer, E. N. O'Rourke, Jr., is carrying on fig breeding at Louisiana State University, Baton Rouge, Louisiana. The only fig breeder listed for any other country besides the United States by the Food and Agricultural Organization's *World List of Plant Breeders* (1961, 1965, 1967) is G. N. Slykov of the All-Union Institute of Plant Industry, Leningrad, U.S.S.R.

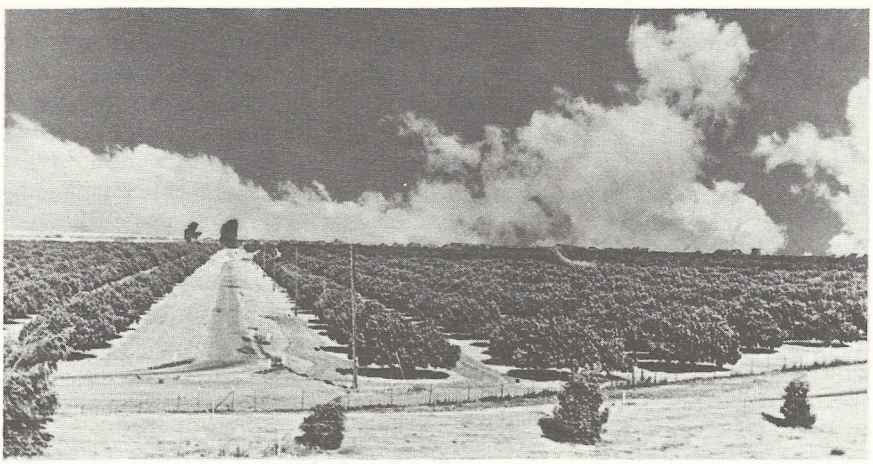

FIG. 5. Fig orchard at Chowchilla, California. Trees to the right of the road are a portion of 267 ha planted with 'Conadria'.

Modern Breeding Objectives

Maximum Productivity

Yields per hectare of marketable dry figs differ among cultivars, as well as being affected by location, the vagaries of climate, and orchard management. In San Joaquin Valley, the yield of 'Verdone' ranges all the way from 3.7 to 7.4 mt/ha and of 'Sari Lop' all the way from 1.1 to 5.1 mt/a. A well managed 5.3 ha 'Verdone' orchard consistently produced around 7.2 mt/ha annually over a span of several years.

California's 1972 production of 12,720 mt on 7,000 bearing hectares averaged 1.82 mt/ha. Customary orchard spacing is 10.7 x 10.7 m between trees which provides for 89 trees/ha. Average yield per tree was 21.2 kg. This corresponds closely to the 18.2–22.7 kg per tree average in Turkey's Meander Valley, which is considered to be the world's prime producing region.

Higher yield per unit area is desirable, but this seems more likely to be achieved by closer planting and better orchard management than by breeding. In fact, production in well-managed 'Sari Lop' orchards has to be controlled to prevent overloading, which causes branches to bend or break and reduces the size of the figs. Growers do this by following a system which prorates the number of profichi caprifigs placed in the trees for caprification according to the size of tree (Condit, 1920).

Fruit Quality

Today's objectives in fig breeding are dictated primarily by the requirements of the industry. Growers and processors alike would like a fig for California with all of the good attributes of 'Calimyrna' (i.e., 'Sari Lop') which would not require caprification. The ideal fruit would have golden skin, white meat, amber pulp, the distinctive flavor of 'Sari Lop' which is due in part to the endosperm of the fertile seeds, attractive size and shape, and skin not easily bruised when fresh fruit is handled.

In Louisiana, breeding is directed toward development of an improved type resembling 'Celeste', which is favored by growers (O'Rourke, 1966). Success or failure of a new fig cultivar depends upon its fruit, which must process into a high-quality, readily marketable product, and horticultural characteristics which conform to growers' requirements.

The subject is covered more fully in the section on breeding for specific characters.

Elimination of Caprification

'Sari Lop', a cultivar of the Smyrna type, is the finest fig produced in California, where it is known as 'Calimyrna'. It must be caprified, of course, in order to set a crop. Caprification is the transfer of caprifig pollen to fig flowers by fig wasps. To accomplish it commercially, profichi syconia of the caprifig are placed in branches of fig trees. It is a costly, time-consuming, and inconvenient practice, which growers would like to have eliminated. The procedures followed in caprification have been described in detail by Condit (1920).

Perhaps the worst feature of caprification is that it may result in fruit spoilage by endosepsis, or internal rot caused by *Fusarium moniliforme* Sheld. var. *fici* Caldis, a fungus which is transmitted to figs from infected caprifigs by female blastophagas.

Resistance to Insects and Nematodes

The only serious insect problem in California is entrance into the syconia by species of vinegar flies (*Drosophila* spp.), dried-fruit beetles (*Carpophilus* spp.), and thrips (*Thrips* spp., and *Franklinilla* spp.). They lay eggs which hatch into larvae inside the figs, and also carry in yeasts which cause souring. A solution is to breed figs with small ostiolar eyes which are tightly closed by scales. Tightly closed eyes prevent the insects mentioned above from entering the syconium, but are no barrier to the fig wasp.

A root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood var. *acrita* Chitwood, causes severe damage to the roots of fig trees in California, Louisiana, and Florida, especially trees on light, sandy soils. Many *Ficus* spp. are virtually immune or highly tolerant to the nematode. One of the objectives of breeding is to obtain interspecific hybrids which will result ultimately in a cultivar combining desirable tree and fruit characters with nematode resistance. Another objective is to determine which of the numerous *Ficus* spp. available may be both nematode resistant and graft-congenial with *F. carica* for possible use as rootstocks for fig cultivars.

Breeding Techniques

Floral Biology

There is a pronounced dichogamy in the development of the flowers of the caprifig tree. The flowers are protogynous, the pistillate flowers coming into anthesis three or more months ahead of the staminate flowers. Ordinarily, only the stamens of the profichi or summer crop of caprifigs develop to full maturity and shed pollen.

As noted previously, the caprifig tree bears three crops of syconia a year: The mamme, or spring crop; the profichi or summer crop; and the mammoni, or fall crop. The times of ripening vary from year to year, and from one locality to another, usually as the result of the vagaries of climate. The annual cycle in Riverside, California, where most of the breeding is done, is essentially as described below.

Syconia of the mamme crop are initiated on current growth in August, September, and October. The pistillate flowers come into anthesis and are receptive to oviposition by the fig wasp in October and November. Staminate flowers are initiated but seldom develop to maturity. Syconia which wasps fail to enter soon cease development and fall from the tree. Syconia which have been entered, and in the ovules of which eggs have been laid and larval development begun, remain on the tree and begin developing. Development is stopped by cold weather, but the syconia remain on the tree through the winter season. They resume development with the coming of warm weather, and ripen in March and April. The male wasps hatch from their enclosing drupelets, and cut the drupelets containing the females, releasing them and mating with them as they emerge. The females leave the syconium through the ostiole, and enter the young syconia of the profichi crop.

The syconia of the profichi crop are initiated on the previous season's wood in February and March. The pistillate flowers are in anthesis when the wasps are emerging from the mamme crop in March and April. Again the syconia drop when not inhabited by wasps, but remain on the tree if inhabited. This crop matures in June and July. At this time, the stamens are fully developed, shedding pollen which adheres to the emerging female wasps. This is the crop which furnishes syconia for caprifying, i.e., pollinating the commercial crop of the otherwise nonpersistent Smyrna type of fig, as well as pollen for use in breeding.

The mammoni syconia are initiated on current growth in June and July and are receptive to the wasps emerging toward the end of the profichi crop. Inhabited mammoni syconia ripen in October and November, when the wasps emerge and enter the developing mamme syconia, thus completing the cycle. Caprifig trees in which the fig wasp can complete the cycle are said to be *colonized*. Inhabited mammoni syconia sometimes contain seeds from flowers which escaped oviposition, but received pollen. The staminate flowers of the mammoni crop seldom develop to maturity.

A breba crop matures on fig trees in June and July. This crop generally escapes caprification because it is initiated at the time the mamme crop, which produces no pollen, is ripening. All fig cultivars produce a main crop or summer crop on current growth, which matures from August to December, depending on the cultivar.

Pollen Collection

The profichi crop which ripens in June and July is the only one of the three caprifig crops in which the stamens develop to anthesis. Ripe caprifigs are harvested and taken to a warm, dry place where there is little air circulation, split open longitudinally, and spread out to dry on kraft or similar paper on a table or laboratory bench. In a few days, the fruit is dry, and all of the anthers have dehisced. The pollen is collected on a piece of bond or similar paper by holding the opened fig over it and thumping it with a finger or giving it some hard taps with a pencil. By shaking the paper, one can winnow parts of stamens, wasps, and other detritus from the pollen, which can then be put into a cork-stoppered or screw-capped vial (Fig. 6–B) and stored until ready for use. Pollen stored in a refrigerator at 8–10 C remains viable for as long as 120 days.

Pollen from different parental caprifig trees preferably is collected in separate rooms or on separate days, for fig pollen is so fine and light and so easily airborne that one runs the risk of contaminating one lot by another if several are collected in the same room, especially if the air is stirring.

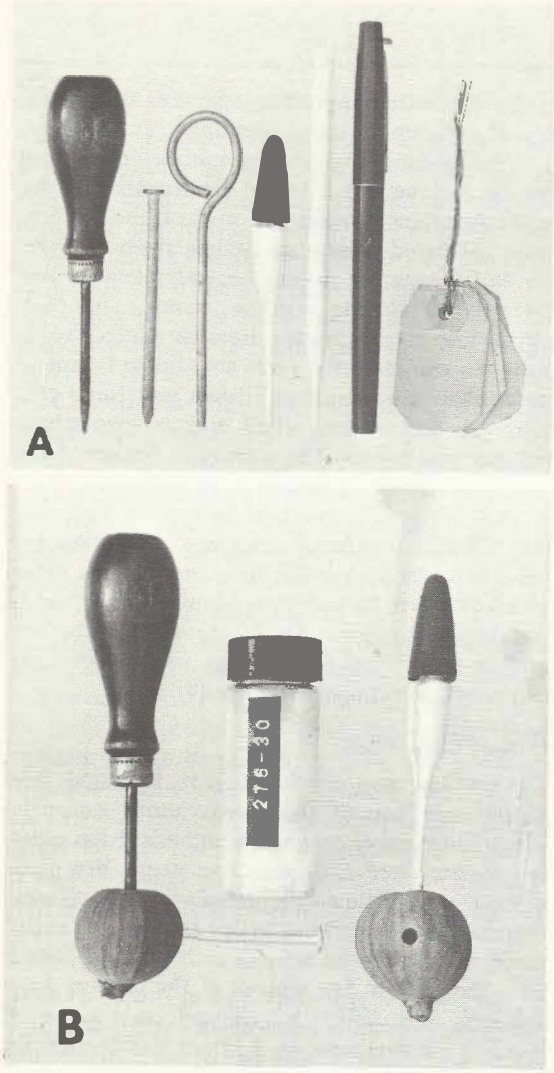

FIG. 6. Fig pollination. (A) Instruments for puncturing, inserting pollen into syconium, and labeling. (B) Fig pollen in vial and procedure for puncturing and pollinating.

Pollination

Only a few simple instruments and supplies are needed for breeding figs (Fig. 6-A). An awl, gimlet, 10-penny nail, or similar sharp-pointed object is needed for puncturing the syconium. Small pipettes or droppers from dropping bottles or medicine bottles are needed for introducing pollen into syconia. Small paper marking tags and a pen with indelible ink are useful for identifying pollinated syconia and recording the parentage and date of the cross.

Fig syconia of the main or summer crop are initiated on current growth from May until growth ceases in August or September on most cultivars. The flowers are in anthesis and receptive to pollination of each syconium successively from the middle of June into August in the order of initiation. Receptive syconia are light green in color and yield slightly to light pressure when squeezed between the thumb and forefinger. Pollination for breeding is done in late June and early July.

Two holes are punched into the interior of the syconium with the pointed instrument. One may be through the ostiole, the other through the side wall (Fig. 6–B), or both through the side wall (Fig. 9). The tapered end of a pipette is dipped in pollen, and inserted into one of the holes. The pollen is puffed in by mouth or by squeezing a rubber bulb on the large end. The other hole serves simply as an air vent which allows for puffing the pollen in easily. Puncturing the syconia does not damage them enough to cause them to drop. The marking tag containing desired data is tied by its string to the branch at the base of the pollinated syconium.

O'Rourke (1966) splits the syconium to be pollinated longitudinally about one third of the distance from apex to base with a knife. He then picks up a bit of pollen on the knife point and blows it over the flowers.

If there are caprifig trees in the vicinity of cultivars to be bred, one should remove all of the caprifigs of the profichi crop to preclude contamination by pollen-carrying wasps. Generally, however, caprifigs are not grown within flight distance of common figs or cultivars grown for use in breeding. No bagging of a pollinated syconium need be done, for blastophagas do not enter syconia that have been pollinated and begun development.

Each progeny of a season's successful crosses is assigned a progeny number. Every seedling of a hybrid progeny that is planted or budded into an old tree for rearing to fruiting is identified by a plant label bearing the progeny number and the seedling number, from 1 to as many as desired for evaluation. These constitute pedigree numbers.

Seed Collection

Ovule development begins a few days after introduction of pollen into the syconium, and effectively plugs the puncture holes. The syconium

ripens in the normal season; i.e., August to September. When the figs are in the last stages of maturity prior to ripening, it may be necessary to enclose them in cloth or fine mesh nylon bags to protect them from being eaten by birds. Ripe fruits are broken up and dropped into beakers or jars of water for fermenting. In a few days, drupelets with viable seeds sink to the bottom. Empty drupelets and the fermented flesh float, and are decanted off. After being washed in two or three changes of water and spread out on a piece of paper to dry, the good drupelets may be used for planting. A single syconium yields 300 to 500 drupelets, which are "seeds" when the fleshy portions of the pericarp, i.e., exocarp and mesocarp, have been washed off.

Germination and Growth of Seedlings

Seeds are set for germination soon after collection in August or September. They are sown on a relatively fine grade of vermiculite in plastic trays and covered lightly with the same material. The trays are put into a warm glasshouse. By December when they are 5.1 to 7.6 cm tall, with several leaves, they are transplanted to 345 ml styrofoam tumblers filled with good potting soil, and provided with a punched-out hole for water drainage. By the end of January, most are 10 to 25 cm tall, and 5 to 7.5 mm thick toward the base. At this time, they are set outside in the cold to induce dormancy.

Shortening the Period of Juvenility

Fig seedlings growing on their own roots take five to seven years to come into bearing from the time of germination. The period can be reduced to one to three years by grafting buds or scions from seedlings on the branches of three- to 20-year-old or even older trees. Grafting is done during March and April, when stock trees are beginning their spring flush of vegetative growth and sap is flowing freely. The branches of the stock tree are cut back severely (Fig. 7) and buds or scionwood inserted. The simple bark graft is preferred, because it is the easiest and fastest method. Two or three scions of the same seedling are topworked on each branch. The cut surface of the branch is coated with a pruning compound. The scions are enclosed in a plastic bag to keep them from drying out, and the plastic bag is covered with a larger kraft paper bag to prevent sunburning. Each grafted branch is tagged with an embossed metal label

FIG. 7. Hybrid fig seedlings topworked to stock tree to shorten period of juvenility.

bearing the progeny and seedling number. This is attached to a staple on the branch by a short length of copper wire.

Buds begin to break on the scions in two to three weeks, and, as soon as the stems begin to elongate and leaves develop, the bags may be removed. Despite the small caliper of many seedlings, some being no thicker than an ordinary match stick, at least 90% of the scions unite with the stock and grow. Growth is rapid, and some seedlings produce fruit the first season. Most fruit in the second season, and just about all fruit by the third season.

In addition to circumventing juvenility, the method has three other advantages: 1) as many as 20 seedlings can be worked into large trees with many branches, saving considerable land area over what would be required for seedlings growing on their own roots even when as closely spaced as 1 m apart in a row; 2) seedlings have the undesirable characteristic of sending up numerous sucker stems from the crown every year for several years which interfere with maintenance and must be pruned off; 3) as soon as the seedlings have been evaluated, the branches bearing the discards can

be cut back and reused for topworking a new set of seedlings the following year.

Seedling Evaluation and Selection

Seedlings are evaluated initially on the basis of obvious fresh fruit characters: i.e., size, shape, skin color, pulp color, flavor, size of eye, and freedom from splitting. Criteria for selection are covered later in the section on breeding for fruit characters. Additional evaluations are made later for dried fig and paste color and flavor.

Three other characters judged are vigor of the seedling, potential productivity, and ripening period in the crop season.

After two or three seasons of evaluation, only a few seedlings usually remain which are considered to be worthy of further evaluation as potential commercial cultivars. In the fourth bearing season all growers and processors who wish to do so may serve on an appraisal committee sponsored by the California Fig Institute, which assists the breeder in making final evaluations and selections, if any, in the field planting. Final selections are tested in the laboratory to see if they meet processors' criteria. Propagation material of selections which seem to meet growers and processors' requirements is distributed to interested growers for growing in a large scale trial and to nursery firms which wish to multiply them as clones. The material is distributed through the agricultural extension service by the farm adviser who includes the fig among the crops he services. It is distributed under its pedigree number, and is given no horticultural cultivar name until its commercial success seems reasonably assured. This tends to preclude proliferating an already enormous directory of cultivars with names of new cultivars which may never go into production or may have a short-time existence.

The philosophy behind having growers and processors participate in selection is based on the fact that as a result of many years of experience, they have rather definite ideas as to just what they want in a commercial fig. It is thought best, therefore, to let them make the final selection of types that they want rather than for the breeder to try to coerce them into accepting something he thinks they ought to have.

Figs for home planting or for possible production as fresh fruit usually are evaluated, selected, and tested by the breeder usually according to his own criteria. Trees are placed with cooperators for growing under various climatic conditions. If performance and quality of a selection are satisfactory in most localities, the tree is given a cultivar name, and propagation material is furnished to nurserymen for multiplication and sale of trees.

Inducing Mutations

Insofar as is known, the only attempts to induce mutations have been with the use of colchicine, mostly on germinating seeds. Mutations have resulted, but these generally have been slow-growing, with malformed foliage, and sparsely fruiting. The fruit on those still growing is late in ripening and very poor in quality.

No natural polyploid is known among named cultivars, and despite the tens of thousands of seedlings that have been reared, no polyploid has ever been found among them. A matter of interest is: what would tetraploid plants and fruits of some of the commonly grown cultivars be like? In 1970, an experiment was initiated on treating flushing axillary buds on a few cultivars with colchicine using customary concentrations and procedures. The appearance of some of the shoots suggests that they may be polyploid, but at this writing they have yet to be examined cytologically.

Breeding Systems

Sex Determination

Sex appears to be determined in fig by two closely linked pairs of alleles on a presently unidentified pair of chromosomes. They are symbolized as follows:

G, dominant allele for gynoecious flowers with short-styled pistils.

g, recessive allele for gynoecious flowers with long-styled pistils.

A, dominant allele for presence of the androecium.

a, recessive allele for suppression of the androecium.

The caprifig homologue is GA and genotypes of caprifig trees are GA/GA and GA/ga. The pis-

tillate homologue is ga, and the trees always have the genotype ga/ga.

Table 2 shows the genetics of sex determination in *F. carica*, hypothesized from the results of genetical analysis.

TABLE 2. Sex determination in *F. carica*, with ratios of genotypes shown.

Seed parent	Pollen parent: Homozygous caprifig G A/G A	Pollen parent: Heterozygous caprifig G A/g a
Homozygous caprifig G A/G A	All homozygous caprifig G A/G A	1 Homozygous caprifig G A/G A 1 Heterozygous caprifig G A/g a
Heterozygous caprifig G A/g a	1 Homozygous caprifig G A/G A 1 Heterozygous caprifig G A/g a	1 Homozygous caprifig G A/G A 2 Heterozygous caprifigs G A/ g a 1 fig g a/g a
Fig g a/g a	All heterozygous caprifig G A/g a	1 Heterozygous caprifig G A/g a 1 fig g a/g a

Two crosses of fig x caprifig made with seedling caprifigs from the progeny of a caprifig x caprifig cross yielded progenies 100% caprifig, demonstrating the existence of the homozygous *GA/GA* genotype. One cross involved 'Mission', which produced a seedling progeny of 79 individuals, all caprifigs. The other cross involved 'Partridge Eye', which produced a seedling progeny of 45 individuals, also all caprifigs.

All commercial caprifigs probably originated from fig seeds and, therefore, are heterozygous. When used for breeding, they produce progenies which segregate into the ratio of 1 caprifig: 1 fig. It follows that, in fig breeding, every cross involves a caprifig. Productivity and fruit characters of caprifigs are important, therefore, in the selection of parents for further breeding.

No way is known for distinguishing caprifigs from figs in the young seedling stage; consequently, one must wait until they produce their first syconia and "declare." Since virtually all caprifigs are worthless from the standpoint of fig fruit selection, one must reconcile himself to the fact that one-half of every seedling population is wasted on this account. Discovering a juvenile sex-linked character or inducing one by radiation or other means would serve the useful purpose of enabling one to discard the caprifigs from the progenies to be evaluated.

Fertility and Sterility

Both the short-styled pistillate flowers of the caprifig and the long-styled pistillate flowers of the fig are sexually functional and capable of setting seed when pollinated. Furthermore, no caprifig tree has ever been found in which the staminate flowers of the profichi are incapable of functioning.

The following situations do occur, however, with respect to pistillate flower development and maturation.

1) Without pollination or a wasp larva developing in the ovule, the flower aborts soon after anthesis. Abortive flowers are the cause of "blank" caprifigs and "seedless" figs.

2) Following pollination and syngamy, the flower develops normally, the ovary maturing into a drupelet containing a viable seed consisting of an embryo surrounded by endosperm. In the vernacular, the drupelet with exocarp and mesocarp removed is the "seed."

3) Without pollination, the flowers on some trees develop parthenocarpically. They mature as empty drupelets or cenocarps, commonly referred to in the trade as "seedlike bodies."

4) Following oviposition, the flower develops with a blastophaga larva in the ovule which devours the embryo and endosperm as it grows. Eventually, the entire interior of the drupelet is inhabited by a single mature wasp. Drupelets which contain wasps are called *psenocarps*.

Persistent vs. Caducous Syconia

The three horticultural types of figs are classified primarily by whether their syconia persist on the tree without any known form of stimulus or drop soon after anthesis (Fig. 8). In vernacular usage, the common type of fig is said to be completely parthenocarpic. The San Pedro type is said to have a parthenocarpic breba crop. The Smyrna type is said to be completely nonparthenocarpic.

Use of the term *parthenocarpic* is unfortunate, for mature "ripe" caprifigs and seedless figs consist of a fruit-like vegetative structure entirely

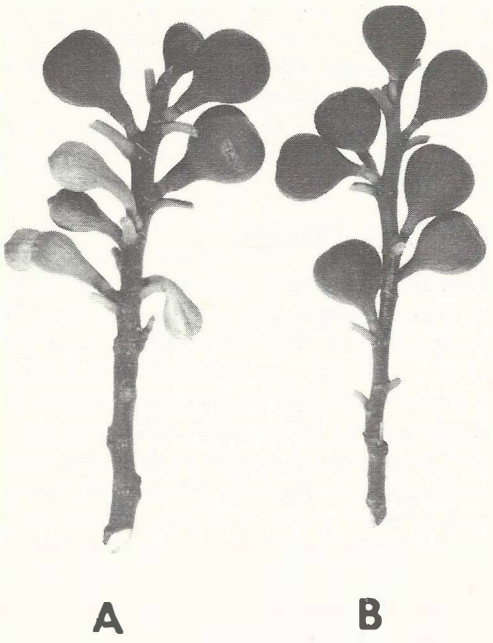

FIG. 8. Caprifig branches. (A) Branch from a caducous type of tree showing lower, undeveloped, light-colored, uninhabited syconia about to drop, and upper, large, dark, inhabited syconia developing normally. (B) Branch from persistent type of tree showing uninhabited syconia developing normally.

devoid of carpellary tissue. The terms *persistent* for syconia that develop to maturity without some form of stimulation and *caducous* for those that drop prematurely would seem to be more accurate botanically. Sometimes, syconia of Smyrna and main crop San Pedro fig trees which otherwise would fall can be made to persist simply by venting them and blowing air into them through one of the vents by means of a pipette. Gibberellin and (2-chloroethyl)phosphonic acid (ethephon) solutions sprayed on them have the same effect. (Crane, Marei, and Nelson, 1970a, 1970*b*; Gerdts and Obenauf, 1972).

Parthenocarpy

Parthenocarpy *per se* refers to development of the carpels of the flowers without syngamy, resulting in cenocarps. There are two genetically determined forms of parthenocarpy, stimulative and vegetative.

Stimulative parthenocarpy is induced by a stimulus introduced into the syconium from outside. One such stimulus is entry of the female fig wasp and her ovipositing into the embryo sac. Other effective factors are blowing air into the syconium, introducing dead pollen, and invasion by thrips and other insects. Parthenocarpy by stimulation prevents dropping of the syconium, allowing it to develop to maturity. Ovaries containing wasps develop into psenocarps; other stimulated ovaries develop into cenocarps.

Vegetative parthenocarpy needs no known stimulus. It is characteristic of all common type figs in cultivation and of persistent caprifigs, which almost always have some cenocarps. Trees lacking this trait produce blank syconia in caprifigs and "seedless fruits" in figs.

The tree characters of caducous syconia and persistent syconia are genetically controlled (Saleeb, 1965). Saleeb analyzed the progenies of the four possible combinations of crosses, i.e., caducous x caducous, caducous x persistent, persistent x caducous, and persistent x persistent, comprising 2,473 individuals. He reported the segregation ratios that are given in Table 3.

TABLE 3. Compositions of progenies from crosses of caducous and persistent figs with caducous and persistent caprifigs.

Fig		Caprifig		Progeny
Caducous	x	caducous	→	all caducous
Caducous	x	persistent	→	1 caducous:1 persistent
Persistent	x	caducous	→	all caducous
Persistent	x	persistent	→	1 caducous:1 persistent

The results are determined by a single pair of alleles, one of which is an egg lethal. These are symbolized as follows:

+, wild type allele for caducous syconia and normal ovule development.

P, mutant allele for persistence of syconia, and ovule abortion; dominant to +.

The genotype of trees with caducous syconia is ++; the genotype for trees with persistant syconia is + *P*.

The genetics of the four combinations shown above is as shown in Table 4.

Selection of Parents

Parent trees for fig breeding are selected primarily on the basis of fruit characters. The greatest need

TABLE 4. Genetics of caducous vs. persistent syconia in *F. carica*, corresponding to phenotypes in Table 3.

Fig		Caprifig		
Geno-type	Eggs	Geno-type	Pollen	Progeny
++	All +	++	All +	All ++
++	All +	+P	1+:1*P*	1++:1+*P*
+*P*	1+:1*P* (lethal)	++	All +	All ++
+*P*	1+:1*P* (lethal)	+P	1+:1*P*	1++:1+*P*

is for a new cultivar that will have all the desirable characters of 'Sari Lop' and will have persistent syconia, obviating the need for caprification. 'Sari Lop', therefore, is one of the cultivars commonly selected as a seed parent. Other light-skinned cultivars, including 'Conadria', 'Verdone', 'Dottato', 'Genoa', 'Marseilles', and 'Verdal Longue', were used in the early stages of the program.

The several caprifigs used for breeding today are types with persistent syconia which trace their pedigrees back to 'Croisic', a type having persistent syconia with greenish yellow skin and white edible pulp, which was brought to California from France by an unknown person and planted at Cordelia, California, sometime prior to 1893.

Size of Progeny

As with many tree fruit crops, the principal factor limiting progeny size is availability of land. In the early days of breeding, seedling trees were planted in orchard rows, with the trees spaced 2 m in the row and the rows 7 m apart. This was as close as seedlings could be lined out for easy maintenance until they fruited after three to seven or more years in the ground. This spacing limited the number of trees to 900 trees/ha.

Stock trees, remnants of a hybrid seedling planting at the University of California Horticultural Field Station in San Joaquin Valley, are spaced 3 m in rows, 7 m apart. These spacings provide for about 538/ha. The numbers of work able branches vary from as few as three on some trees to 20 on others. In 1971, the stock trees in a 0.4 ha planting were supporting more than 1,200 seedlings. Excepting the few that are selected for further evaluation by the end of the third crop year after grafting, there is a complete replacement of seedlings for observation.

A single pollinated syconium yields 300 to 500 seeds, so obtaining an adequate supply for growing seedlings for testing is no problem. The practice at the University of California is to make about ten crosses using five selected figs as seed parents and two selected caprifigs as pollen parents. About 100 seedlings from each progeny, i.e., a total of about 1,000, are tested each year, which is all the space available will allow for.

With emphasis on the common type, i.e., persistent fig, one must accept the fact that only 25% of a seedling progeny will be material for selection. Figs comprise only 50% of the progeny, and 50% of these will be the caducous type.

Breeding for Specific Characters

Fig Tree Characters

With present objectives in breeding, persistence of syconia to ripeness is a prime requisite.

Vigorous trees that grow large are desired. Since fruit for the dried fig industry is harvested from the ground, large size is no object. Except for shaping and repairing wind or other damage, fig trees grown for dried figs are not pruned.

Trees with numerous branches and round heads are preferred to low broadly spreading trees.

The tree must be productive within limits. Some trees overbear, and branches droop or break.

Maturing and dropping the crop early in the season is a desirable character. In August and early September, the weather is hot and dry, and the probability of dew formation, fog, and rain is virtually nil. This is the period of highest quality. By late September, dew formation and "tule" fogs are likely as the weather cools, and the probability of rain showers increases. Temperatures below a critical low of about 13 to 15 C and saturation of the soil which has purposely been allowed to go dry after mid-July cause excessive splitting and souring, as well as a drop in fruit quality.

Fig Fruit Characters

So-called "white figs", i.e., figs with greenish-yellow or golden-yellow skins, are preferred by the indus-

try both for canning and drying. They dry to a light straw color and present a more attractive appearance than dark-skinned figs in fancy packs of dehydrated figs, and in paste which is baked in fig bars and made into preserves.

Figs with white meat and amber pulp are preferable to those with strawberry or reddish colored meat and pulp, because they yield a light amber or straw-colored paste.

Flavor of figs, as of many other fruits, defies accurate description. Growers and processors, however, recognize what might be called a distinctive fig flavor.

All of the commercial cultivars serve the dual purpose of furnishing some fruit to the fresh fruit market and the rest to processors as dried fruit. For this reason fresh fruit flavor is important.

Dried fruit and paste flavor are determined by the flavor of the fresh fruit. Like the fresh fruit, they should have the distinctive fig flavor and no "wild taste." They are sweeter than fresh fruits because of the concentration of sugars by drying.

Medium-sized figs, i.e., figs measuring about 5 cm in diameter and 7.5 cm in length, are preferred. Such figs number 20/kg. Shape may be fully rounded globose, oblate spheroidal, ovoid, and pyriform since these pack easily, uniformly, and attractively in confectionery packages. Overly flattened oblate and elongated pyriform are undesirable from the standpoint of sorting and packing.

Caprifigs

The first requirement in selecting a caprifig tree for use in improving fruit quality by breeding is that it carry the allele for persistence. As shown in Table 3, persistence can be transmitted to the offspring by the caprifig only. As mentioned earlier, all caprifig trees used for this purpose are descendants of 'Croisic'. Otherwise, the looked-for characters are the same as for the fig.

To be selected for use in caprification, a seedling caprifig tree must be of the caducous syconia type. This is dictated by the fact that few commercial fig growers produce their own caprifigs for pollinating 'Sari Lop'. In the main, caprifigs are produced in separate orchards removed many miles from the commercial fig growing region, as a precaution against spreading endosepsis, i.e., the internal fruit rot caused by the fungus *Fusarium moniliforme* var. *fici*. In the spring all mamme caprifigs are harvested at maturity, split open, treated with a fungicide, and stored. They are distributed among the caprifig trees when the profichi crop is receptive to colonization by the wasp. Growers then buy caprifigs from the producer according to their needs for caprifying 'Sari Lop'. However, not all caprifig cultivars are well colonized. Some, such as 'Roeding 1', 'Excelsior', and 'Forbes', produce large numbers of "blanks" which persist to maturity and are not easily distinguished from the syconia inhabited by wasps. The buyer wants to be assured that every caprifig he buys contains wasps; hence, the requirement for caducous types. For the grower, the cultivar must yield a heavy profichi crop of well-inhabited syconia.

Another consideration is time of maturity of the profichi syconia during the season of fig syconia receptivity. Early, medium, and late cultivars are required to spread fruit set and to provide overlapping during the season to compensate for fig and caprifig crops being thrown out of phase by the vagaries of climate. The syconium must be dry for satisfactory hatching of blastophagas and emergence of the females. 'Croisic' type caprifigs are unsuitable, because the pulp is juicy when the syconium is ripe and tends to preclude the wasps' getting out. It is also important that the syconium be hollow for satisfactory hatching and exiting of blastophagas.

Interspecific Hybridization

Trabut (1922) crossed *F. carica* with *F. palmata* and *F. pseudo-carica*, closely related species in the subgenus *Eusyce*, and grew numerous seedlings at the Montpellier Garden in Algeria, but does not appear to have reported later on their behavior or value.

Condit (1947) made the same crosses later, and reported the following: When caprifigs of the two species are used as the pollen parents, the Smyrna type (i.e., the caducous character) is dominant; when persistent *F. carica* caprifigs are used as the pollen parents, the progenies segregate into

persistent and caducous phenotypes among both the figs and the caprifigs; the figs are edible, but of poor quality and worthless commercially; the seedlings tend to be precocious, many producing syconia in the same season in which the buds are grafted on mother trees.

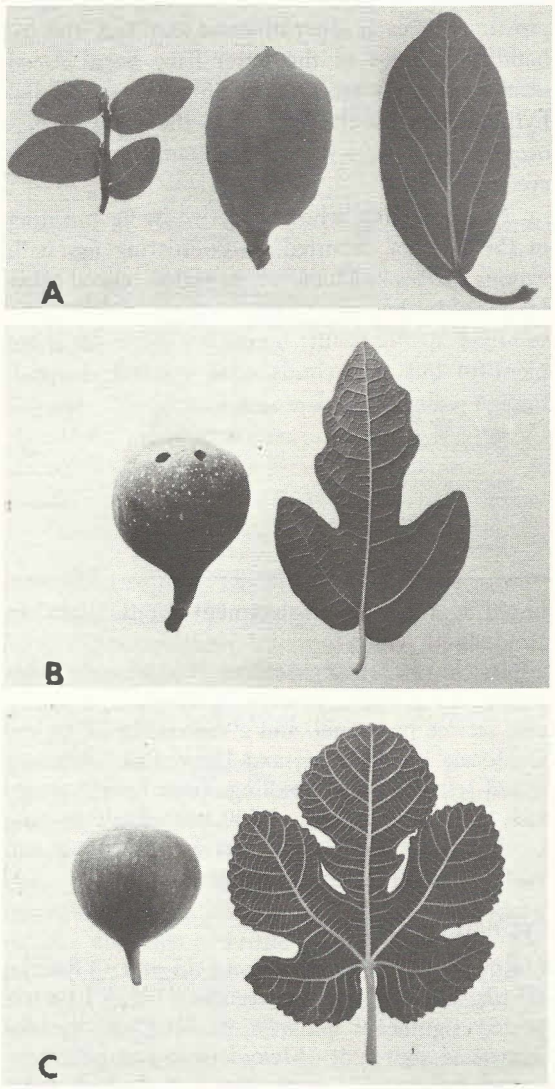

FIG. 9. Interspecific hybridization in *Ficus*. (A) *F. pumila*, juvenile leaves on vegetative branch, syconium, and leaf from fruiting branch. (B) *F. pumila* x *carica* F_1 syconium and leaf. The punctures near the apex of the syconium were made for pollinating with *F. carica*. (C) *Ficus carica*, caprifig syconium. (Not to scale.)

'Brawley', a caprifig cultivar which was selected from a cross of *F. carica* x *pseudo-carica* by the hybridizer Francis Heiny of Brawley, California, is still used by growers. It is a good caprifig, but is no longer propagated because many fig growers did not like its small-sized syconia.

Condit (1950) reported hybridizing *F. pumila* with *F. carica*, using pollen from a caprifig of the latter species. I remade the cross in 1965, using pollen from a caprifig tree having light yellow persistent syconia (Fig. 9). Certain characters of the parents make the cross especially intriguing.

F. pumila, which is called "climbing fig," is an evergreen clinging vine with dimorphic branches. Juvenile branches cling to walls, fences, buildings, trees, and other upright structures. They are thin and wiry, and have small simple leaves arranged in the ½ phyllotaxy. Fruiting branches project horizontally for 30 to 60 cm, are thick and woody, and have larger leaves arranged in the ⅖ phyllotaxy. Generally, a fruiting branch has only

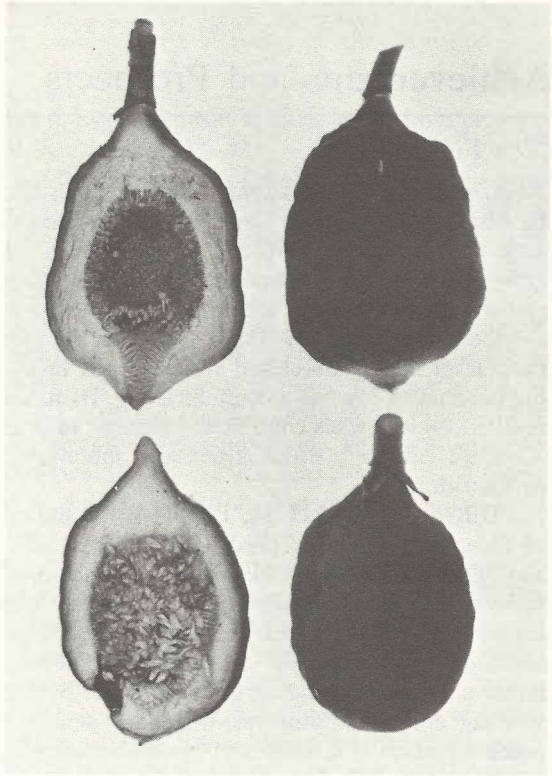

FIG. 10. *F. pumila*. At top, unpollinated syconium; bottom, seed-filled syconium after pollinating with *F. carica*.

one to three syconia. The syconia tend to persist to maturity without pollination. The mature syconium has purple skin color, and tough leathery texture. Pollinated ones are full of seeds (Fig. 10).

F. carica is a moderate-sized deciduous tree with stout, deliquescent, monomorphic branches which produce numerous syconia that are succulent at maturity. The leaves are large, palmately lobed, and arranged on the branches in the ⅗ phyllotaxy.

Some seedlings of the F_1 progeny are deciduous, some evergreen; most are vine-like, but some are weeping; none is tree-like; all bear fleshy, succulent, purple syconia. They segregate sexually into a 1:1 ratio of pistillate plants to monoecious plants.

An F_1 pistillate plant was backcrossed successfully with an *F. carica* caprifig in 1970. Scions of 30 seedlings of the backcross progeny were grafted on mother stock trees in the spring of 1971. Attempts will be made to obtain an F_2 progeny for the promise it would offer in terms of recombinations of characters.

An accomplishment one would hope to achieve ultimately from such a cross is development of vines bearing palatable figs which could be espaliered on walls or trained on trellises—evergreen vines for tropics and subtropics, hardy deciduous vines for temperate regions.

Although *F. pumila* and *F. carica* grow in close proximity to each other in some localities, and inhabited caprifigs of the latter have been placed near syconia on vines of the former, no natural hyrbidization by the agency of the fig wasp has occurred, nor have wasps been found in cut-open syconia.

N. K. Arendt, who was active in fig breeding in the Crimea, reported on pollinating figs with various species in Moraceae, as well as several other families. In her most recent report (1969), she summed up the results by stating viable seeds are plentiful but no hybrids were realized. Instead, foreign pollens stimulate apomixis.

Achievements and Prospects

New Fig Cultivars

To date, the most significant achievement of the fig breeding program in California is the acceptance of four hybrid cultivars by commercial fig growers and by nurserymen catering to the home garden trade. The fruits are described in Table 5.

'Conadria' (Ped. 143–5; Fig 11-A) was the first cultivar in history developed in a planned breeding program to become a commercial fig. Its name resulted from growers continually referring to it as 'Condit's Adriatic', which eventually abbreviated to 'Conadria'.

'DiRedo' (Ped. 143–38; Fig. 11-B), a sibling of 'Conadria', 'Flanders' (Ped. 151–37; Fig. 11-C), and 'Excel' (Ped. 195–36; Fig. 11-D) acquired their names from popular usage. 'DiRedo' was introduced into commercial production by Nicholas and Joseph DiRedo of Fresno, California, father and son cooperating growers in the hybrid seedling evaluation program. 'Flanders' attracted much attention as a fresh fruit fig on the property of Stanley E. Flanders of Riverside, California. 'Excel', a 'Dottato' hybrid, was so named by I. J. Condit because it excels its parent as a fresh fruit cultivar in southern California. It is now being tested as a possible replacement for 'Dottato' in San Joaquin Valley.

In the 1974 crop season, the project leader assisted by growers, processors, agricultural extension service personnel, and a representative of the California Fig Institute and Dried Fruit Advisory Board selected seven seedlings from hybrid progenies totaling more than 1,500 individuals fruiting at that time. Fruit characters are described and tentative cultivar names are given in Table 6.

Nematode Resistance

O'Rourke (1966), Puls, Birchfield and O'Rourke (1967), and Puls and O'Rourke (1967) have reported significant progress in breeding figs for nematode root-knot (*Meloidogyne incognita* var. *acrita*) resistance in Louisiana. A fairly high order of resistance was found in individual seedlings in progenies of the commercially grown cultivars 'Hunt' and 'Celeste'.

No special attention has been given to nematode resistance among hybrid fig seedlings in California because of the practice of grafting the seedlings on established trees. However, tree vigor, and the small size and paucity of root-knots on three

TABLE 5. Fruit characters of four hybrid fig cultivars.

Cultivar	Pedigree number	Skin color	Meat color	Pulp color	Shape	Eye	Avg. no. fresh figs/kg	Wt. (g)	Remarks
Conadria (Fig. 11-A)	143-5	light yellowish-green	white	light strawberry	pyriform with thick neck	very small; tight	20	45–55 avg. 50	Good Verdone-like type for drying in hot interior valleys, & for table use fresh. Resistant to splitting.
DiRedo (Fig. 11-B)	143-38	light yellowish-green	white	amber	globose —short, thick neck	small, tight	18	50–60 avg. 55	Good Verdone-like type for drying in hot interior valleys; dries light in color; some splitting in adverse weather.
Flanders (Fig. 11-C)	151-37	light tawny w/violet stripes & scattered white flecks	white	light strawberry	pyriform —long slender neck	medium tight	20	45–54 avg. 50	Excellent fresh fruit fig for the home garden. Virtually no splitting. Dried figs dark, commercially unattractive.
Excel (Fig. 11-D)	195-36	light yellow	white	amber	ovoid to globose	medium, tight	24	35–50 avg. 42	Excellent Dottato-like type for fresh fruit, canning, and drying. Virtually no splitting.

introduced cultivars namely 'Azendjar', 'Taranimt', and 'Zidi' suggest a high order of tolerance. These are being tested more intensively in a locale with soil highly infested with the root-knot nematode.

Achievements with Caprifigs

Three superior caprifig trees having persistant syconia have been selected as pollen parents for breeding for fruit quality. All bear heavy crops of syconia with green skin, white meat, and amber pulp. The syconia are of medium size and oblate spheroidal shape. The staminate flowers produce copious amounts of fertile pollen. They have the following pedigree numbers: 228–20; 271–1; and 276–31. These three have been responsible for all of the hybrid selections listed in Table 6.

Pedigree 228–20 is a good, productive, medium-sized, fleshy, persistent caprifig with green skin and amber pulp. It was selected from progeny of 'Conadria' x ('Monstreuse' x 'Croisic').

Pedigree 271–1 is a highly productive, medium-sized, fleshy, persistent caprifig. It has green skin and amber pulp and was selected from progeny of 'Beall' x 228–20.

Pedigree 276–31 is an attractive, fleshy, persistent, productive caprifig. Its skin is yellowish green, its pulp amber. It was selected from progeny of 'Sari Lop' x 228–20.

One caprifig tree of the caducous type has been selected for use in caprifying 'Sari Lop'. The syconia are large, obturbinate, hollow, and dry, and generally the profichi crop is abundant. Its chief advantage over commercially grown caprifigs now in use is the later season of the profichi crop. It should prove especially useful in years when synchrony of anthesis in caprifigs and figs is out of phase with the caprifigs maturing before the figs are receptive for pollination. This caprifig bears Pedigree 113–66. It was selected from a progeny of *F. palmata* x ('Brown Turkey' x 'Roedings 3').

The Future

Much has yet to be done in fig breeding, but the prospects for attaining desired goals in the not-too-distant future are bright. Some of the objectives are discussed below.

1) A prime objective is development of a persistent-type fig having the attractive appearance and high quality of 'Sari Lop', a small tight eye, resistance to splitting, and less susceptibility to internal spoilage. Such a type would obviate the need for the time-consuming, expensive practice of

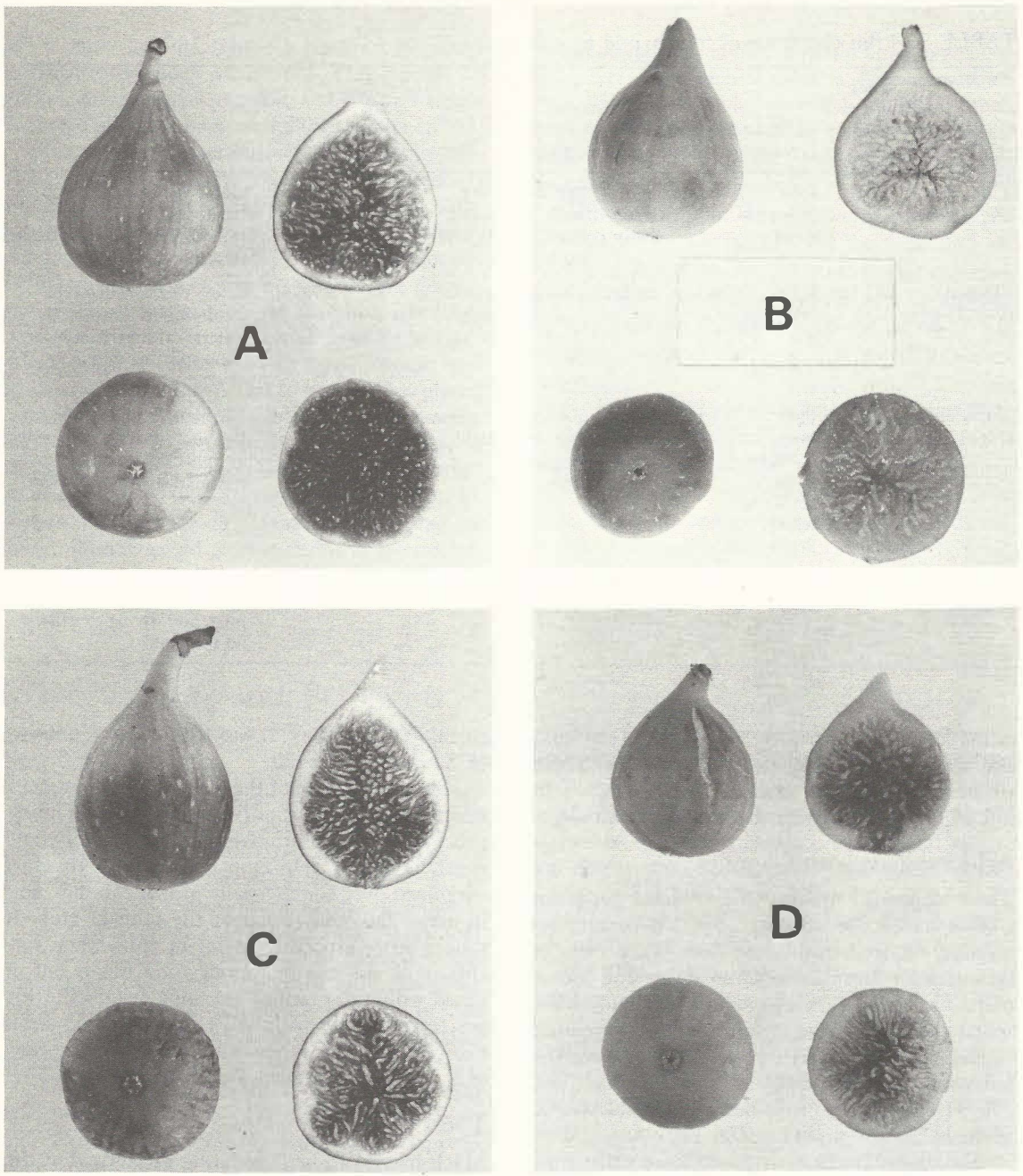

FIG. 11. Hybrid fig cultivars. (A) 'Conadria'. (B) 'DiRedo'. (C) 'Flanders'. (D) 'Excel'.

caprification, as well as splitting and internal spoilage which follow the entrance of contaminated fig wasps. The unique flavor of 'Sari Lop' is due in large measure to the oily nutlike endosperms of the fertile seeds. Ordinarily, the common type figs produce cenocarps only, but some tend to develop parthenogenetic endosperms (Condit, 1932). Possibly, this tendency can be bred into a persistent-syconia 'Sari Lop' derivative. Or it might be induced by the use of a plant growth regulating chemical.

Progenies resulting from parents both of which

TABLE 6. Proposed names and fruit characters of seven hybrid fig seedlings selected in 1971.

Pedigree number	Parentage	Proposed name	Skin color	Meat color	Pulp color	Shape	Eye	Wt. (g)	Avg. no. fresh figs/kg	Remarks
233-10	'Conadria' x ('Dottato' x 'Croisic')	Yvonne	canary yellow	white	light strawberry	obovoid	medium, tight	45–55 avg. 50	20	matures early, all figs dropping in a short time; virtually no splitting
276-7	'Sari-Lop' x 228-20	Saleeb	light green	white	pale pink	oblate	medium, tight	48–60 avg. 53	19	matures early, yields well, no splitting
279-57	158-46 x 271-1	Tena	greenish	white	light strawberry	oblate	medium, tight	45–60 avg. 52	19	mid-season, attractive, no splitting
284-11	276-14 x 276-1	Nardine	light yellow	white	amber	oblate	medium, tight	43–58 avg. 50	20	mid-season, attractive, yields well, few split
291-8	233-10 x 271-1	Deanna	light yellow	white	amber	oblate	medium, tight	45–56 avg. 50	20	mid-season, yields well, attractive, no splitting
291-30	233-10 x 271-1	Gulbun	light yellow	white	light pink	oblate	medium, tight	65–78 avg. 72	14	large, mid-season, yields well, few split
291-50	233-10 x 271-1	Evrem	light yellow	white	greenish	oblate	medium, tight	43–55 avg. 50	20	mid-season, attractive, yields well, no splitting

have 'Sari Lop' in their ancestry are now available, e.g., pedigrees 276 and 278. Such progenies contain persistent-syconia segregants of both fig and caprifig. By judicious selection, sibling pollination, and back-crossing to 'Sari Lop', presumably all of the desirable characters of 'Sari Lop' can be restored through recombination, excepting, probably, the development of endosperm-containing seeds. Sibmating Pedigree 276–14 fig with 276–31 caprifig yielded progeny 284, the first ever to have 'Sari Lop' genes from both parents. A superior 'Sari Lop'-like selection, Pedigree 284–11, has been made from this progeny (see Table 6).

2) Continued selection of well-flavored figs with light green or yellow skin color, white meat, and amber pulp for drying and canning.

3) Figs with small eyes tightly closed by bracts precluding entrance by species of vinegar flies, souring beetles, thrips, and other insects.

4) "Seedless fruit," i.e., fruit lacking fertile drupelets or cenocarps but having good flavor. This kind of fruit would be a boon to persons wearing dentures or dental bridges who like figs but avoid them because they find the hard drupelets distressing. Trees with syconia completely lacking any sort of carpel development are found occasionally in hybrid seedling progenies.

5) Fruit with skin that does not crack readily and that is tough enough to resist bruising or tearing in handling.

6) Induction of polyploidy with the use of colchicine or by some other means. Although polyploid seedlings have been produced by germinating seeds in colchicine, attempts to induce polyploidy in established cultivars have been singularly unsuccessful. The few polyploid seedlings that have fruited have been worthless. It would be interesting to see what polyploids of various cultivars would be like.

7) Development of clones resistant to root-knot nematode. Three cultivars from North African sources, 'Azendjar', 'Taranimt', and 'Zidi',

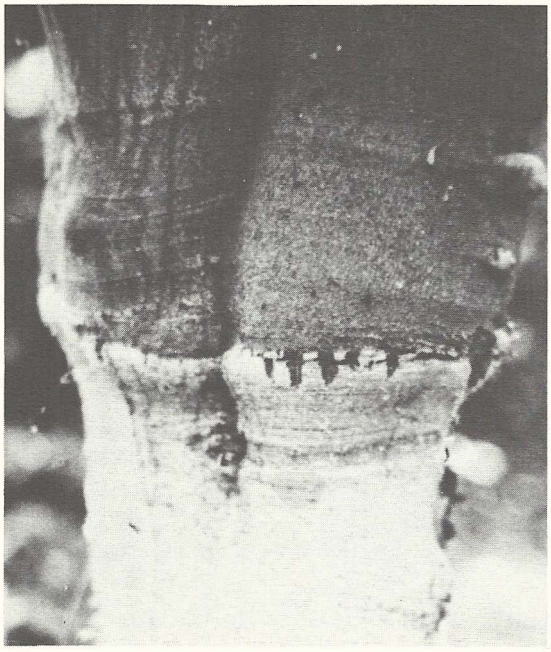

FIG. 12. Ten-year-old bud union of *F. carica* topworked on *F. cocculifolia*.

appear to be highly resistant and are being tested in a heavily infested nematode plot in San Joaquin Valley. O'Rourke (1966), Puls and O'Rourke (1967), and Puls, Birchfield, and O'Rourke (1967) have developed some resistant seedlings in Louisiana.

Some *Ficus* spp., such as *F. cocculifolia* Baker, *F. pumila* L., and *F.* racemosa L. are nematode resistant. Graft-congenial species might well serve as rootstocks for commercial fruit cultivars (Fig. 12). The area of graft-congeniality has scarcely been touched.

8) Production of interspecific hybrids such as the one already achieved between *F. pumila* and *F. carica*. Attempts at interspecific hybridization is an area of fig breeding that is largely untouched. As many as 100 species of *Ficus* are available for the purpose in southern California.

As mentioned previously, the ultimate aim of the *F. pumila* x *F. carica* cross is to develop evergreen vines bearing palatable fruit which could be grown on trellises or espaliered on the walls of buildings and other structures in the tropics and subtropics, and hardy deciduous vines for similar use in temperate regions.

Resurgence of interest in commercial fig production in recent years presages increasing growth of the industry and the concommitant demand by growers and processors for indicated research on problems which arise. In many of these problems, breeding may play a major role.

Literature Cited

Aigremont. 1908. *Volkserotik und Pflanzenwelt*. Halle: S. Trensigner. (Feige. 1:74–78). Cited from Condit, 1947.

Arendt, N. K. 1969. The use of apomixis in fig breeding (in Russian). *Trud. Nikit. Bot. Sad.* [*Trans. Nikita Bot Gdn.* 1969] 40:95–120. Abstr. 8761 in *Plant Br. Abstr.* 41 (4). 1971.

Burbank, L. 1914. *Luther Burbank* 4:297. New York: Burbank Press.

California Fig Institute. 1972. *Statistical review of the California dried fig industry*. Fresno.

Condit, I. J. 1920. Caprifigs and caprification. *Calif. Agr. Expt. Sta. Bul.* 319:341–377.

———. 1928. Fig breeding. *J. Hered.* 19:417–424.

———. 1932. The structure and development of flowers in *Ficus carica* L. *Hilgardia* 6:443–481.

———. 1947. The fig. Waltham: Chronica Botanica.

———. 1950. An interspecific hybrid in *Ficus*. *J. Hered.* 41:165–168.

———. 1955. Fig varieties: a monograph. *Hilgardia* 11:323–538.

———. 1969. *Ficus: the exotic species*. Berkeley: Univ. of Calif. Div. Agr. Sci.

Condit, I. J., and Flanders, S. E. 1945. "Gall-flower" of the fig, a misnomer. *Science* 102:128–130.

Condit, I. J., and Warner, R. M. 1956. Promising new seedling fig. *Calif. Agr.* 10:4, 14.

Corner, E. J. H. 1965. Check list of *Ficus* in Asia and Australasia. *Gardener's Bul. Singapore* 21:1–186.

Crane, J. C., Marei, Nash, and Nelson, M. M. 1970a. Ethrel speeds growth and maturity of figs. *Calif. Agr.* 24(3):8–10.

———. 1970*b*. Growth and maturation of fig fruits stimulated by 2 chloroethyl phosphonic acid. *J. Amer. Soc. Hort. Sci.* 95:367–370.

Food and Agricultural Organization of the United Nations. 1961. *World list of plant breeders. Sup. 1.* 1965. *Sup.* 2. 1967. Rome.

Gerdts, M., and Obenauf, G. 1972. Effects of preharvest applications of ethephon on maturation and quality of Calimyrna figs. *Calif. Agr.* 26(5):8–9.

Hunt, W. B. 1911. Fig breeding. *Univ. of Ga. Bul.* 11: 146–148.

———. 1912. Fig breeding. *Univ. of Ga. Bul.* 12:107–110.

Noble, E. G. The work of the Yuma Reclamation Proj-

ect Experiment Farm in 1919 and 1920. *USDA Cir.* 221:3–37.

O'Rourke, E. N., Jr. 1966. Breeding new figs for Louisiana. *La. Soc. Hort. Res.* 3:35–41.

Puls, E. E., Jr., Birchfield, W., and O'Rourke, E. N., Jr. 1967. Evidence of root-knot nematode resistance in fig seedlings. *Proc. So. Agr. Workers* 14:227.

Puls, E. E., and O'Rourke, E. N., Jr. 1967. Root-knot nematode resistance in fig seedlings. *La. Agr.* 10(4): 14–15.

Rixford, G. P. 1918. Smyrna fig culture. *USDA Bul.* 732:1–43.

———. 1926. Work with seedling figs. *Calif. Ann. Fig Inst. Proc.* 10:6–9.

Saleeb, W. F. 1965. *Genetics and cytology of syconium persistence in Ficus carica.* Ph.D. dissertation, Univ. of Calif.

Storey, W. B., and Condit, I. J. 1969. Fig (*Ficus carica* L.). In F. P. Ferwerda and F. Wit, eds. *Outlines of perennial crop breeding in the tropics.* p. 259–267. *Misc. Pap. 4* Wageningen, The Netherlands: Landbouwhogeschool.

Swingle, W. T. 1908. Some points in the history of caprification and its bearing on the Smyrna fig industry in this country. *Calif. Fruit Growers Conv. Proc.* 34:178–187.

———. 1912. Cooperative distribution of new varieties of Smyrna figs and caprifigs. *USDA Bur. Plant Ind. Bul.* 537. (Second rev. of *Bul.* 438. 1909.)

Trabut, L. 1922. On the origins of the fig (in French). *Rev. Bot. Appl. Agr. Colon.* 2:393–396.